OREGON DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
INTERPRETIVE MAP SERIES 24

GEOLOGIC HAZARDS, EARTHQUAKE AND LANDSLIDE HAZARD MAPS, AND FUTURE EARTHQUAKE DAMAGE ESTIMATES FOR SIX COUNTIES IN THE MID/SOUTHERN WILLAMETTE VALLEY INCLUDING YAMHILL, MARION, POLK, BENTON, LINN, AND LANE COUNTIES AND THE CITY OF ALBANY, OREGON

APPENDIX C:
LANE COUNTY

CRUSTAL EARTHQUAKE SCENARIO DETAILS FOR LANE COUNTY

Crustal Earthquake Scenario: A magnitude 6.5 earthquake on an Arbitrary Eugene Fault.

For the magnitude 6.5 earthquake on the Arbitrary Eugene Fault scenario, we defined the fault source using the "deterministic arbitrary" option within HAZUS-MH (Figure C1) (FEMA, 2003b). In general, a worst-case scenario was developed. In particular, this event was selected because of the proximity to the major metropolitan area in Lane County (Eugene-Springfield). Figure C1 has the location of the fault, shown as the dark line, and the census tracts within Lane County. Figure C2 displays the peak ground acceleration (PGA) for the crustal scenario.

Scenario Name	Corvallis Fault M6.5
Type of Earthquake	Arbitrary
Fault Name	Arbitrary Eugene Fault
Historical Epicenter ID #	NA
Probabilistic Return Period	NA
Longitude of Epicenter	–123.053
Latitude of Epicenter	44.085
Earthquake Magnitude	6.5
Depth (km)	10
Rupture Length (km)	22.38
Rupture Orientation (degrees)	165
Attenuation Function	Reverse-Slip

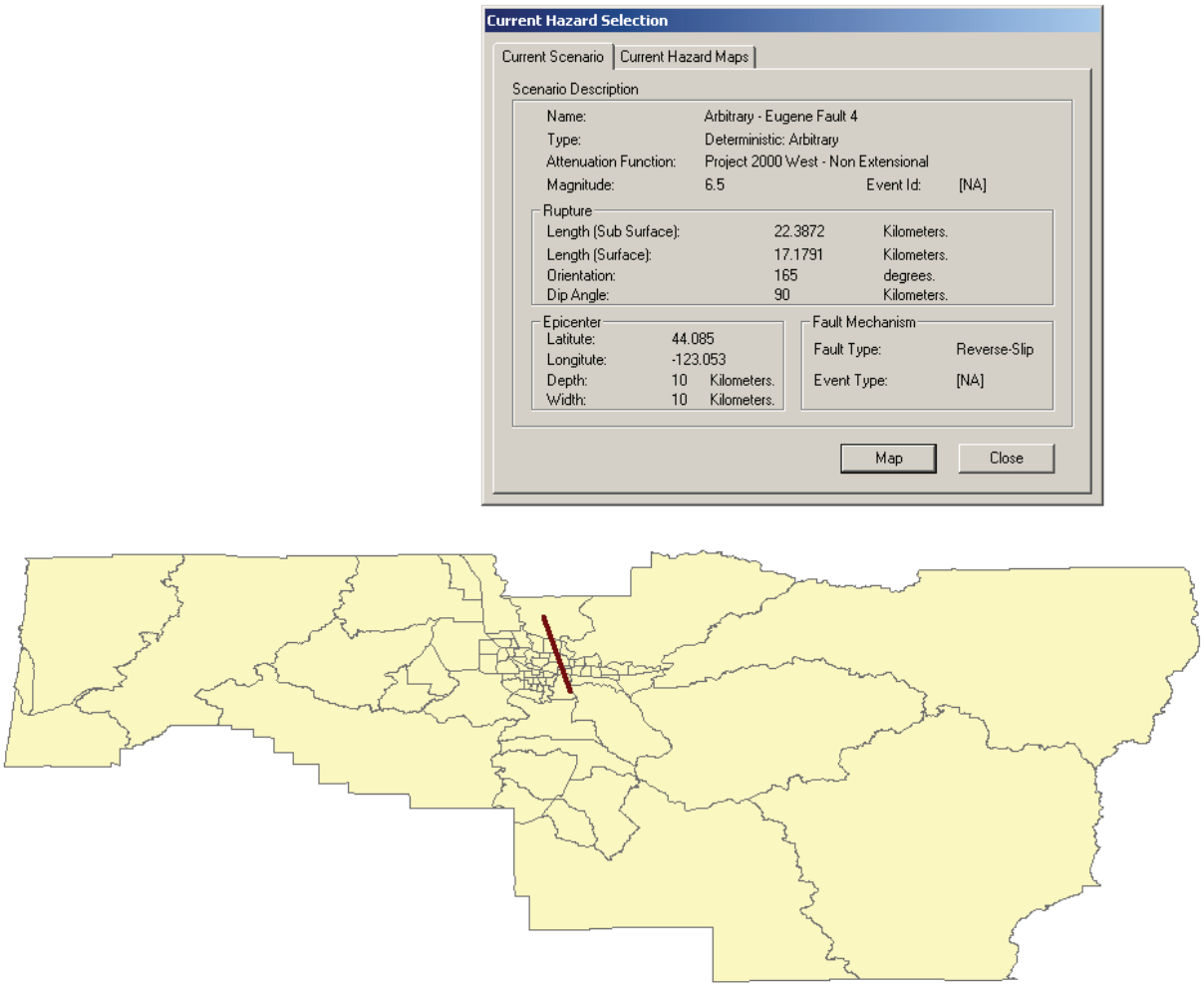

Figure C1. Arbitrary Eugene Fault details from HAZUS-MH (FEMA, 2003b). The location of the fault is shown as the dark line.

Crustal Earthquake Scenario Ground Motion Map

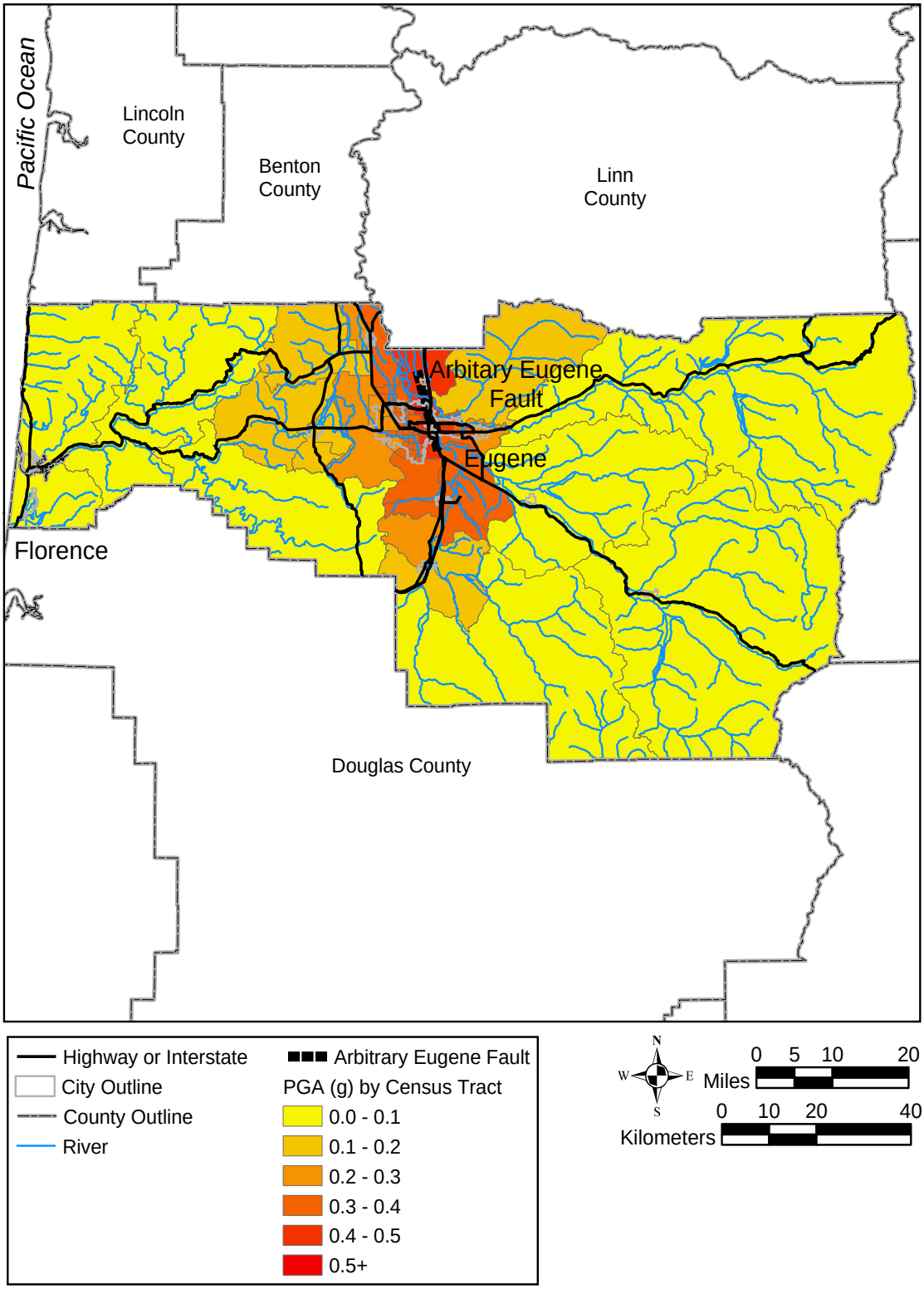

Figure C2. Peak ground acceleration (PGA) by census tracts map for the crustal earthquake scenario, Lane County, Oregon (FEMA, 2003b).

SUBDUCTION ZONE EARTHQUAKE SCENARIO DETAILS FOR LANE COUNTY

Subduction Zone Scenario: A magnitude 9.0 earthquake on the Cascadia Subduction Zone was selected for the subduction zone earthquake scenario.

For the Cascadia Subduction Zone earthquake scenario, we used the "user-defined event" option within HAZUS-MH to incorporate ground motion maps developed by the Cascadia Region Earthquake Workgroup (CREW) to model damage and loss from a magnitude 9.0 earthquake (Figure C3). The CREW maps were developed from ground motion data provided by the U.S. Geological Survey. The CREW earthquake scenario required the input of four sets of GIS files that are included within the HAZUS-MH study region: regional peak ground acceleration (PGA), peak ground velocity (PGV), and the spectral velocity at 0.3 s and 1.0 s (CREW, 2003). Figure C4 displays the PGA for the subduction zone scenario.

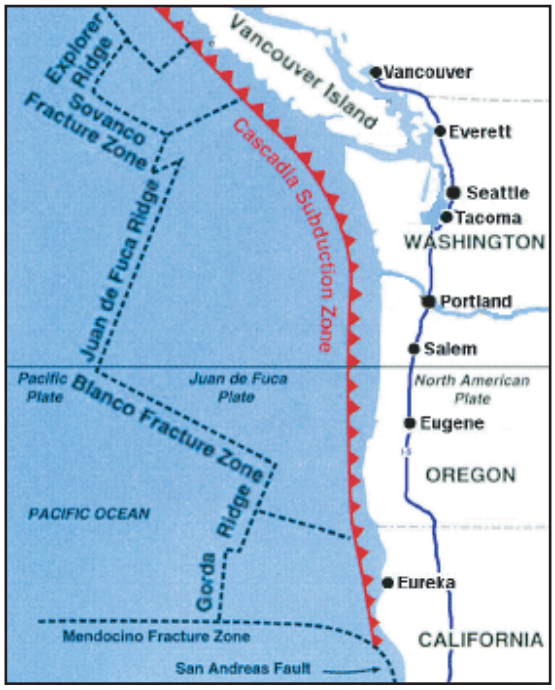

Figure C3. Location of the Cascadia Subduction Zone (CREW, 2003).

Subduction Zone Earthquake Scenario Ground Motion Map

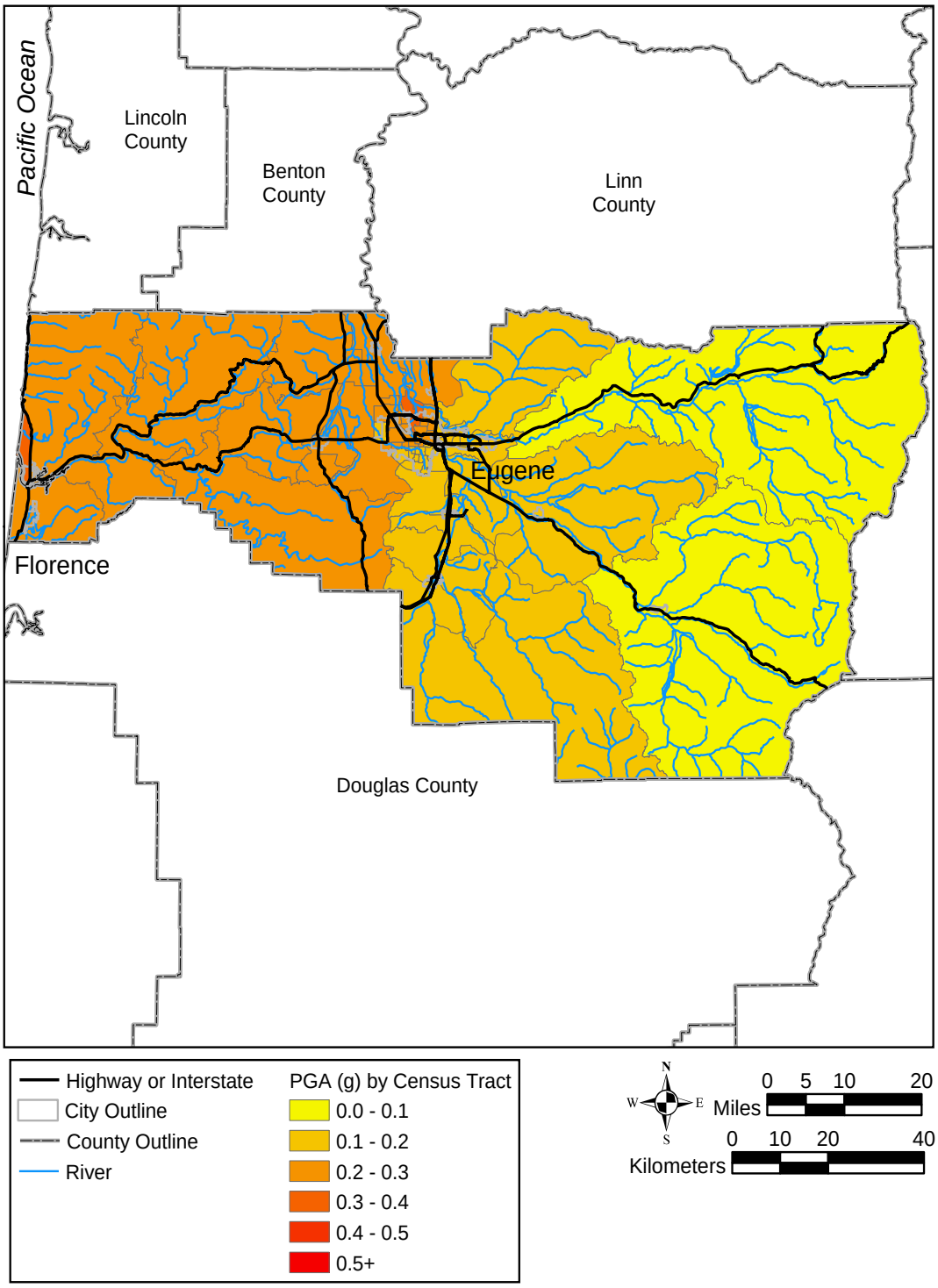

Figure C4. Peak ground acceleration (PGA) by census tracts map for the Cascadia Subduction Zone earthquake scenario, Lane County, Oregon (FEMA, 2003b).

GEOLOGIC HAZARD MAPS

Relative Ground-Shaking Amplification Susceptibility Map

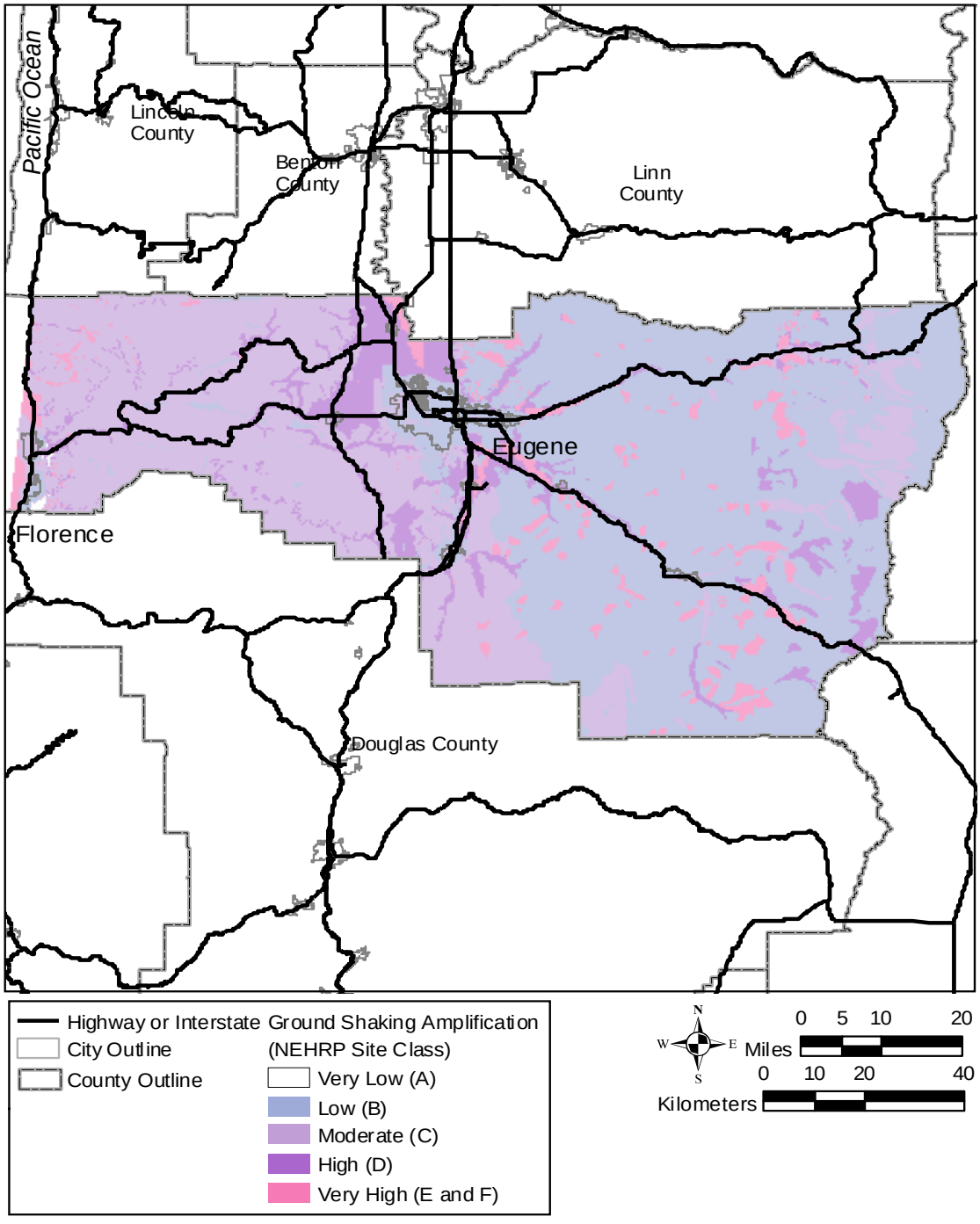

Figure C5. Relative ground-shaking amplification susceptibility map for Lane County, Oregon.

Relative Liquefaction Hazard Susceptibility Map

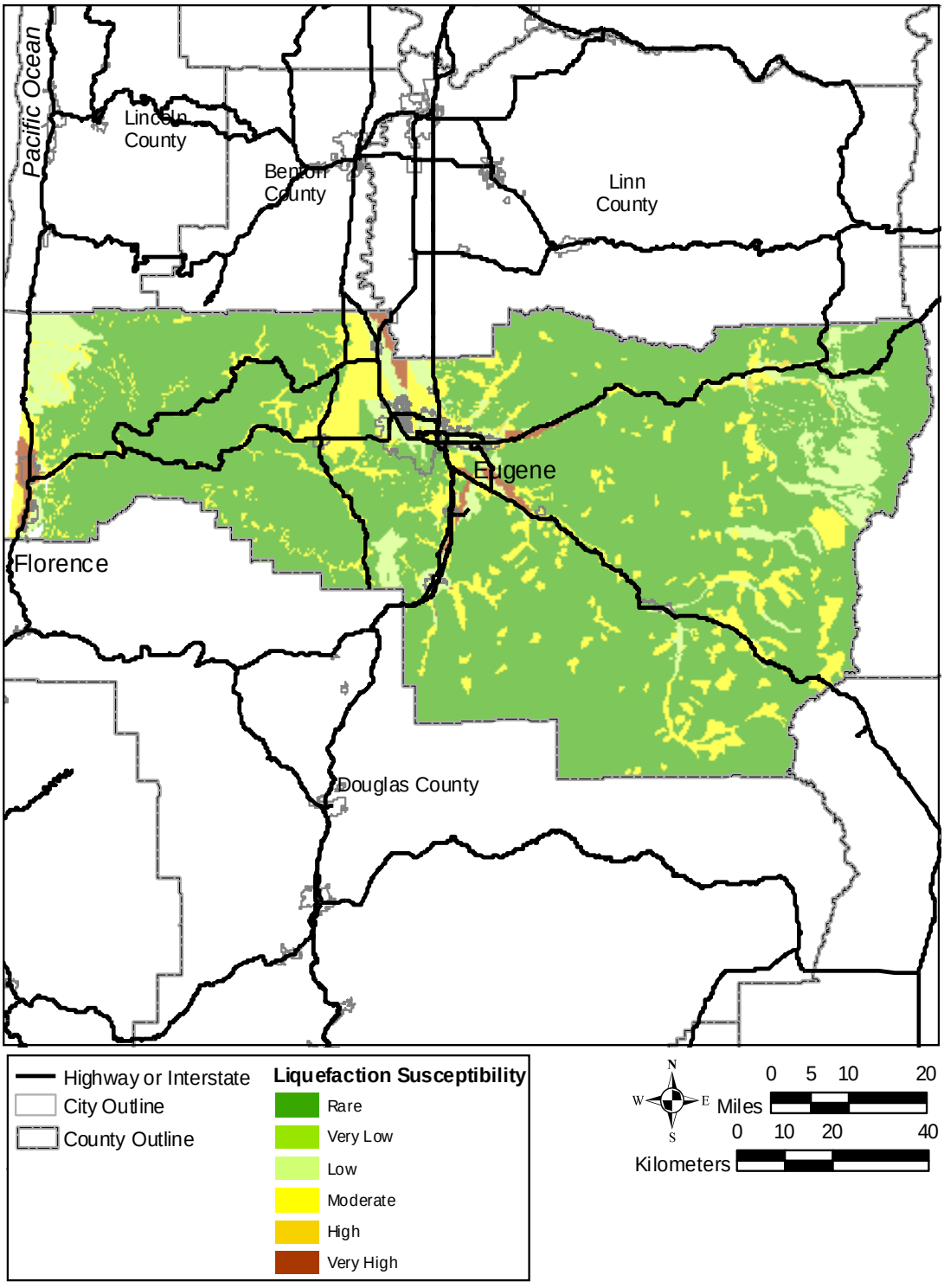

Figure C6. Relative liquefaction susceptibility map for Lane County, Oregon.

Relative Earthquake-Induced Landslide Susceptibility Map

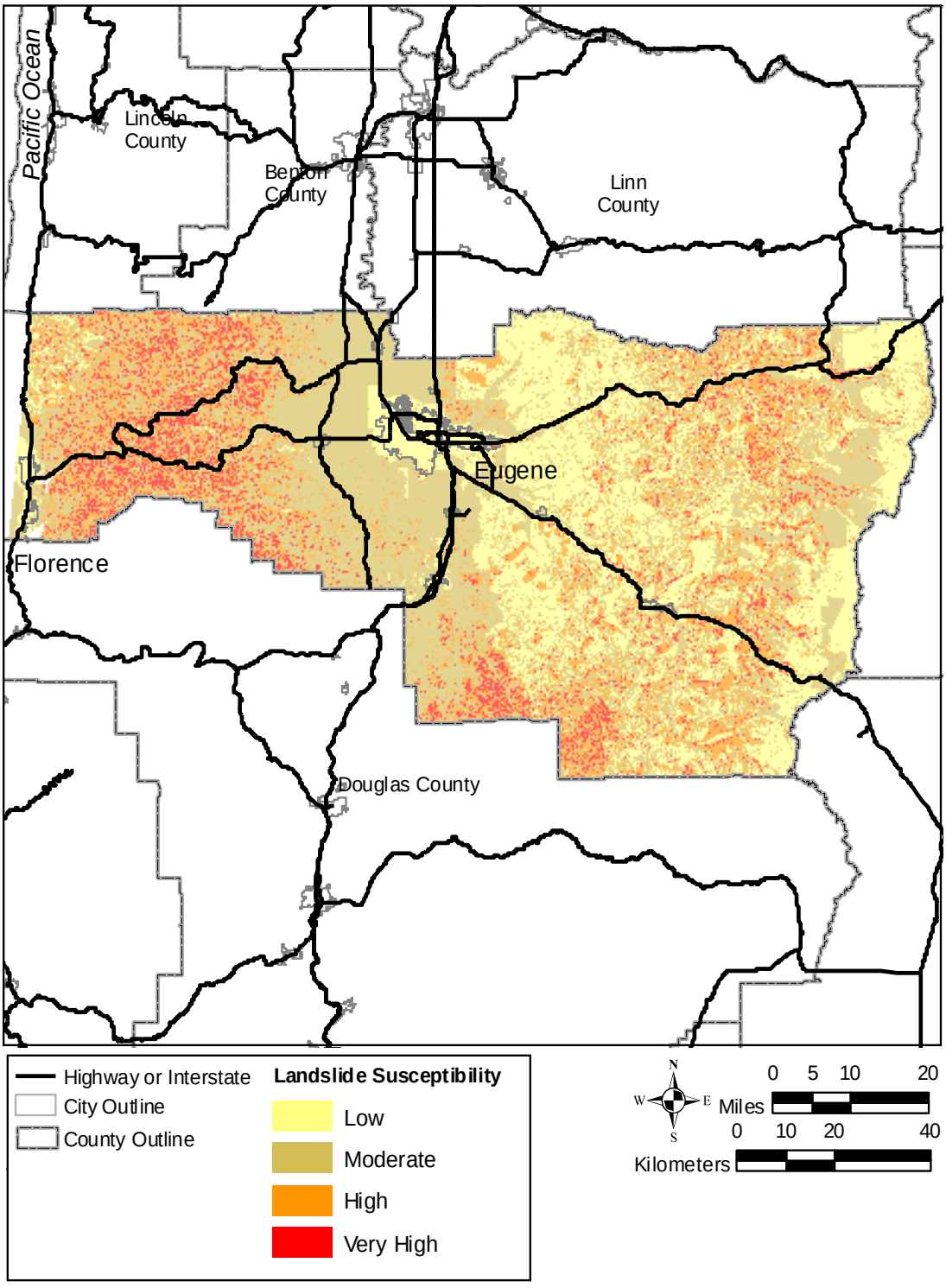

Figure C7. Relative earthquake-induced landslide susceptibility map for Lane County, Oregon.

Identified Landslide Areas Map

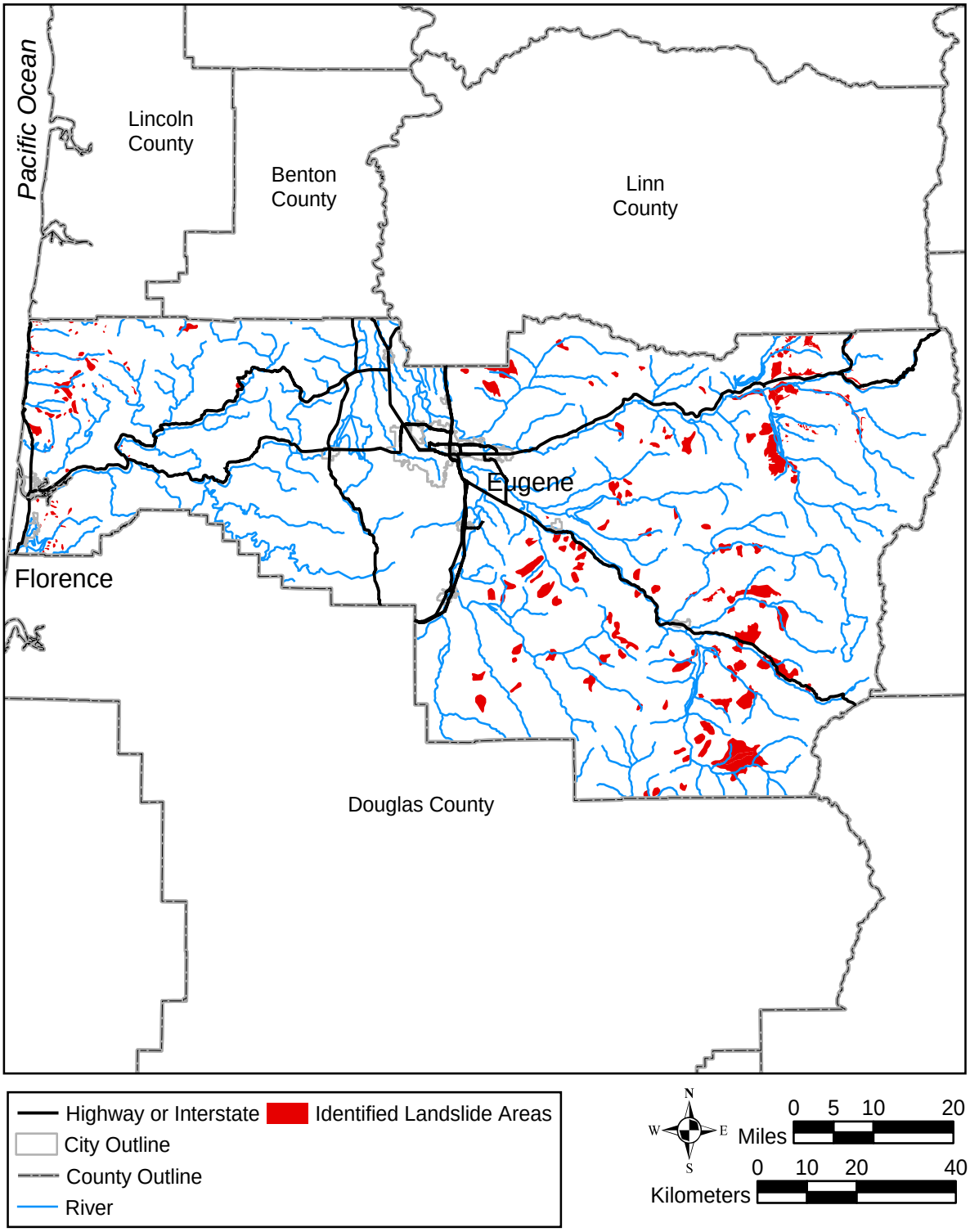

Figure C8. Identified landslide map for Lane County, Oregon.

HAZUS-MH: Earthquake Event Report

Region Name: ***Lane Crustal 3***

Earthquake Scenario: ***Arbitrary - Eugene Fault 4***

Print Date: ***September 07, 2005***

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):

Oregon

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

The geographical size of the region is 4,607.85 square miles and contains 78 census tracts. There are over 130 thousand households in the region and has a total population of 322,959 people (2000 Census Bureau data). The distribution of population by State and County is provided in Appendix B.

There are an estimated 113 thousand buildings in the region with a total building replacement value (excluding contents) of 21,055 (millions of dollars). Approximately 98.00 % of the buildings (and 79.00% of the building value) are associated with residential housing.

The replacement value of the transportation and utility lifeline systems is estimated to be 6,494 and 1,372 (millions of dollars) , respectively.

Building and Lifeline Inventory

Building Inventory

HAZUS estimates that there are 113 thousand buildings in the region which have an aggregate total replacement value of 21,055 (millions of dollars) . Appendix B provides a general distribution of the building value by State and County.

In terms of building construction types found in the region, wood frame construction makes up 83% 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 4 hospitals in the region with a total bed capacity of 586 beds. There are 158 schools, 12 fire stations, 11 police stations and 2 emergency operation facilities. With respect to HPL facilities, there are 35 dams identified within the region. Of these, 10 of the dams are classified as 'high hazard'. The inventory also includes 91 hazardous material sites, 0 military installations and 0 nuclear power plants.

Transportation and Utility Lifeline Inventory

Within HAZUS, the lifeline inventory is divided between transportation and utility lifeline systems. There are seven (7) transportation systems that include highways, railways, light rail, bus, ports, ferry and airports. There are six (6) utility systems that include potable water, wastewater, natural gas, crude & refined oil, electric power and communications. The lifeline inventory data are provided in Tables 2 and 3.

The total value of the lifeline inventory is over 7,866.00 (millions of dollars). This inventory includes over 614 kilometers of highways, 199 bridges, 34,067 kilometers of pipes.

Table 2: Transportation System Lifeline Inventory

System	Component	# locations/ # Segments	Replacement value (millions of dollars)
Highway	Bridges	199	3,407.20
	Segments	83	2,094.40
	Tunnels	2	10.40
		Subtotal	**5,512.00**
Railways	Bridges	0	0.00
	Facilities	4	9.90
	Segments	146	355.60
	Tunnels	0	0.00
		Subtotal	**365.50**
Light Rail	Bridges	0	0.00
	Facilities	0	0.00
	Segments	0	0.00
	Tunnels	0	0.00
		Subtotal	**0.00**
Bus	Facilities	3	3.70
		Subtotal	**3.70**
Ferry	Facilities	0	0.00
		Subtotal	**0.00**
Port	Facilities	0	0.00
		Subtotal	**0.00**
Airport	Facilities	14	86.20
	Runways	15	526.80
		Subtotal	**613.00**
		Total	**6,494.20**

Table 3: Utility System Lifeline inventory

System	Component	# Locations / Segments	Replacement value (millions of dollars)
Potable Water	Distribution Lines	NA	340.70
	Facilities	7	263.40
	Pipelines	0	0.00
		Subtotal	**604.10**
Waste Water	Distribution Lines	NA	204.40
	Facilities	13	978.40
	Pipelines	0	0.00
		Subtotal	**1,182.80**
Natural Gas	Distribution Lines	NA	136.30
	Facilities	2	2.50
	Pipelines	0	0.00
		Subtotal	**138.70**
Oil Systems	Facilities	1	0.10
	Pipelines	0	0.00
		Subtotal	**0.10**
Electrical Power	Facilities	1	124.30
		Subtotal	**124.30**
Communication	Facilities	37	4.20
		Subtotal	**4.20**
		Total	**2,054.20**

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	Arbitrary - Eugene Fault 4
Type of Earthquake	Arbitrary
Fault Name	NA
Historical Epicenter ID #	NA
Probabilistic Return Period	NA
Longitude of Epicenter	-123.05
Latitude of Epicenter	44.08
Earthquake Magnitude	6.50
Depth (Km)	10.00
Rupture Length (Km)	17.18
Rupture Orientation (degrees)	165.00
Attenuation Function	Project 2000 West - Non Extensional

Building Damage

Building Damage

HAZUS estimates that about 28,447 thousand buildings will be at least moderately damaged. This is over 25.00 % of the total number of buildings in the region. There are an estimated 4,874 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	(%)
Agriculture	2	0.00	2	0.01	3	0.01	2	0.03	1	0.03
Commercial	464	0.82	307	1.08	447	2.41	266	5.30	195	4.01
Education	1	0.00	1	0.00	1	0.01	1	0.01	1	0.01
Government	19	0.03	11	0.04	16	0.09	8	0.16	5	0.10
Industrial	41	0.07	25	0.09	39	0.21	26	0.51	23	0.48
Other Residential	7,951	14.03	3,643	12.76	4,502	24.26	2,010	40.09	1,107	22.71
Religion	17	0.03	11	0.04	13	0.07	7	0.13	5	0.09
Single Family	48,165	85.00	24,551	85.99	13,540	72.95	2,694	53.76	3,538	72.57
Total	**56,661**		**28,551**		**18,561**		**5,012**		**4,875**	

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

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Concrete	195	0.03	8	0.03	16	0.09	8	0.15	5	0.11
MH*	6,510	11.49	2591	9.08	3,743	20.17	1,760	35.11	882	18.09
Precast	117	0.16	55	0.19	115	0.62	100	2.00	61	1.25
RM*	28	0.05	10	0.04	20	0.11	15	0.30	6	0.13
Steel	182	0.04	13	0.05	35	0.19	34	0.68	16	0.33
UM*	522	0.92	341	1.19	430	2.32	267	5.32	223	4.57
Wood	49,108	86.53	25263	88.48	13,834	74.53	2,659	53.05	3,566	73.15
Total	**56,661**		**28,551**		**18,561**		**5,012**		**4,875**	

*Note:
RM Reinforced Masonry
URM Unreinforced Masonry
MH Manufactured Housing

Essential Facility Damage

Before the earthquake, the region had 586 hospital beds available for use. On the day of the earthquake, the model estimates that only 293 hospital beds (50.00%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, 75.00% of the beds will be back in service. By 30 days, 94.00% will be operational.

Table 6: Expected Damage to Essential Facilities

Classification	Total	# Facilities		
		Least Moderate Damage > 50%	Complete Damage > 50%	# likely Functional on day 1
Hospitals	4	0	0	4
Schools	158	2	0	156
EOCs	2	0	0	2
PoliceStations	11	1	0	10
FireStations	12	0	0	12

Transportation and Utility Lifeline Damage

Table 7 provides damage estimates for the transportation system.

Table 7: Expected Damage to the Transportation Systems

System	Component	Number of Locations				
		Locations/ Segments	With at Least Mod. Damage	With Complete Damage	With Functionality > 50 %	
					After Day 1	After Day 7
Highway	Segments	83	0	0	83	83
	Bridges	199	6	0	193	195
	Tunnels	2	0	0	2	2
Railways	Segments	146	0	0	146	146
	Bridges	0	0	0	0	0
	Tunnels	0	0	0	0	0
	Facilities	4	1	0	4	4
Light Rail	Segments	0	0	0	0	0
	Bridges	0	0	0	0	0
	Tunnels	0	0	0	0	0
	Facilities	0	0	0	0	0
Bus	Facilities	3	1	0	3	3
Ferry	Facilities	0	0	0	0	0
Port	Facilities	0	0	0	0	0
Airport	Facilities	14	2	0	14	14
	Runways	15	0	0	15	15

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

Tables 8-10 provide information on the damage to the utility lifeline systems. Table 8 provides damage to the utility system facilities. Table 9 provides estimates on the number of leaks and breaks by the pipelines of the utility systems. For electric power and potable water, HAZUS performs a simplified system performance analysis. Table 10 provides a summary of the system performance information.

Table 8 : Expected Utility System Facility Damage

System	# of Locations				
	Total #	With at Least Moderate Damage	With Complete Damage	with Functionality > 50 %	
				After Day 1	After Day 7
Potable Water	7	3	0	4	7
Waste Water	13	4	0	8	13
Natural Gas	2	2	0	0	2
Oil Systems	1	1	0	0	1
Electrical Power	1	1	0	0	1
Communication	37	28	0	37	37

Table 9 : Expected Utility System Pipeline Damage (Site Specific)

System	Total Pipelines Length (kms)	Number of Leaks	Number of Breaks
Potable Water	17,034	284	225
Waste Water	10,220	225	178
Natural Gas	6,813	240	190
Oil	0	0	0

Table 10: Expected Potable Water and Electric Power System Performance

	Total # of Households	Number of Households without Service				
		At Day 1	At Day 3	At Day 7	At Day 30	At Day 90
Potable Water	130,453	774	288	0	0	0
Electric Power		16,489	9,155	3,223	553	26

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 8 ignitions that will burn about 0.16 sq. mi 0.00 % of the region's total area.) The model also estimates that the fires will displace about 525 people and burn about 46 (millions of dollars) of building value.

Debris Generation

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

The model estimates that a total of 1 million tons of debris will be generated. Of the total amount, Brick/Wood comprises 40.00% of the total, with the remainder being Reinforced Concrete/Steel. If the debris tonnage is converted to an estimated number of truckloads, it will require 40,000 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 (7,716 households to be displaced due to the earthquake. Of these, 2,030 people (out of a total population of 322,959 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	Commercial	16	5	1	1
	Commuting	0	0	0	0
	Educational	0	0	0	0
	Hotels	19	5	1	1
	Industrial	22	6	1	2
	Other-Residential	491	119	12	23
	Single Family	738	163	10	17
	Total	**1,285**	**297**	**25**	**45**
2 PM	Commercial	958	271	43	83
	Commuting	0	0	0	0
	Educational	237	67	10	20
	Hotels	4	1	0	0
	Industrial	163	48	8	15
	Other-Residential	79	19	2	3
	Single Family	142	31	2	3
	Total	**1,582**	**436**	**65**	**125**
5 PM	Commercial	736	209	33	64
	Commuting	4	5	9	2
	Educational	56	16	2	5
	Hotels	6	2	0	0
	Industrial	102	30	5	9
	Other-Residential	188	46	5	9
	Single Family	295	65	5	7
	Total	**1,388**	**373**	**60**	**96**

Economic Loss

The total economic loss estimated for the earthquake is 3,615.77 (millions of dollars), which includes building and lifeline related losses based on the region's available inventory. The following three sections provide more detailed information about these losses.

Building-Related Losses

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

The total building-related losses were 3,351.03 (millions of dollars); 10 % 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 61 % 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	Single Family	Other Residential	Commercial	Industrial	Others	Total
Income Loses							
	Wage	0.00	9.16	99.92	4.22	3.14	116.43
	Capital-Related	0.00	3.90	72.07	2.52	0.87	79.36
	Rental	42.08	51.12	46.46	1.47	1.69	142.81
	Relocation	4.78	1.40	2.93	0.08	0.47	9.65
	Subtotal	**46.85**	**65.57**	**221.38**	**8.28**	**6.17**	**348.25**
Capital Stock Loses							
	Structural	224.12	75.01	203.64	18.97	14.09	535.83
	Non_Structural	902.65	374.64	413.39	71.38	37.33	1,799.39
	Content	263.96	88.87	217.32	47.02	19.73	636.89
	Inventory	0.00	0.00	17.38	12.69	0.59	30.66
	Subtotal	**1,390.73**	**538.53**	**851.72**	**150.06**	**71.74**	**3,002.77**
	Total	**1,437.59**	**604.10**	**1,073.10**	**158.33**	**77.91**	**3,351.03**

Transportation and Utility Lifeline Losses

For the transportation and utility lifeline systems, HAZUS computes the direct repair cost for each component only. There are no losses computed by HAZUS for business interruption due to lifeline outages. Tables 13 & 14 provide a detailed breakdown in the expected lifeline losses.

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

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

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Highway	Segments	2,094.41	$6.69	0.32
	Bridges	3,407.19	$99.51	2.92
	Tunnels	10.38	$0.00	0.00
	Subtotal	**5512.00**	**106.20**	
Railways	Segments	355.60	$0.13	0.04
	Bridges	0.00	$0.00	0.00
	Tunnels	0.00	$0.00	0.00
	Facilities	9.85	$1.74	17.67
	Subtotal	**365.50**	**1.90**	
Light Rail	Segments	0.00	$0.00	0.00
	Bridges	0.00	$0.00	0.00
	Tunnels	0.00	$0.00	0.00
	Facilities	0.00	$0.00	0.00
	Subtotal	**0.00**	**0.00**	
Bus	Facilities	3.70	$0.85	23.10
	Subtotal	**3.70**	**0.90**	
Ferry	Facilities	0.00	$0.00	0.00
	Subtotal	**0.00**	**0.00**	
Port	Facilities	0.00	$0.00	0.00
	Subtotal	**0.00**	**0.00**	
Airport	Facilities	86.22	$14.78	17.14
	Runways	526.81	$1.22	0.23
	Subtotal	**613.00**	**16.00**	
	Total	**6494.20**	**124.90**	

Table 14: Utility System Economic Losses

(Millions of dollars)

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Potable Water	Pipelines	0.00	$0.00	0.00
	Facilities	263.40	$20.44	7.76
	Distribution Line	340.70	$5.63	1.65
	Subtotal	**604.07**	**$26.07**	
Waste Water	Pipelines	0.00	$0.00	0.00
	Facilities	978.40	$82.32	8.41
	Distribution Line	204.40	$4.45	2.18
	Subtotal	**1,182.76**	**$86.77**	
Natural Gas	Pipelines	0.00	$0.00	0.00
	Facilities	2.50	$0.67	27.03
	Distribution Line	136.30	$4.76	3.49
	Subtotal	**138.73**	**$5.43**	
Oil Systems	Pipelines	0.00	$0.00	0.00
	Facilities	0.10	$0.03	22.48
	Subtotal	**0.11**	**$0.03**	
Electrical Power	Facilities	124.30	$20.89	16.80
	Subtotal	**124.30**	**$20.89**	
Communication	Facilities	4.20	$0.63	15.01
	Subtotal	**4.18**	**$0.63**	
	Total	**2,054.16**	**$139.81**	

Table 15. Indirect Economic Impact with outside aid
(Employment as # of people and Income in millions of $)

	LOSS	Total	%
First Year			
	Employment Impact	827	0.87
	Income Impact	(188)	-4.40
Second Year			
	Employment Impact	346	0.37
	Income Impact	(248)	-5.81
Third Year			
	Employment Impact	8	0.01
	Income Impact	(274)	-6.41
Fourth Year			
	Employment Impact	0	0.00
	Income Impact	(275)	-6.42
Fifth Year			
	Employment Impact	0	0.00
	Income Impact	(275)	-6.42
Years 6 to 15			
	Employment Impact	0	0.00
	Income Impact	(275)	-6.42

Appendix A: County Listing for the Region

Lane,OR

Appendix B: Regional Population and Building Value Data

State	County Name	Population	Building Value (millions of dollars)		
			Residential	Non-Residential	Total
Oregon	Lane	322,959	16,735	4,319	21,055
Total State		**322,959**	**16,735**	**4,319**	**21,055**
Total Region		**322,959**	**16,735**	**4,319**	**21,055**

HAZUS-MH: Earthquake Event Report

Region Name: ***Lane Cascadia 2***

Earthquake Scenario: ***Cascadia***

Print Date: ***September 20, 2005***

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):

Oregon

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

The geographical size of the region is 4,607.85 square miles and contains 78 census tracts. There are over 130 thousand households in the region and has a total population of 322,959 people (2000 Census Bureau data). The distribution of population by State and County is provided in Appendix B.

There are an estimated 113 thousand buildings in the region with a total building replacement value (excluding contents) of 21,055 (millions of dollars). Approximately 98.00 % of the buildings (and 79.00% of the building value) are associated with residential housing.

The replacement value of the transportation and utility lifeline systems is estimated to be 6,494 and 1,372 (millions of dollars) , respectively.

Building and Lifeline Inventory

Building Inventory

HAZUS estimates that there are 113 thousand buildings in the region which have an aggregate total replacement value of 21,055 (millions of dollars) . Appendix B provides a general distribution of the building value by State and County.

In terms of building construction types found in the region, wood frame construction makes up 83% 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 4 hospitals in the region with a total bed capacity of 586 beds. There are 158 schools, 12 fire stations, 11 police stations and 2 emergency operation facilities. With respect to HPL facilities, there are 35 dams identified within the region. Of these, 10 of the dams are classified as 'high hazard'. The inventory also includes 91 hazardous material sites, 0 military installations and 0 nuclear power plants.

Transportation and Utility Lifeline Inventory

Within HAZUS, the lifeline inventory is divided between transportation and utility lifeline systems. There are seven (7) transportation systems that include highways, railways, light rail, bus, ports, ferry and airports. There are six (6) utility systems that include potable water, wastewater, natural gas, crude & refined oil, electric power and communications. The lifeline inventory data are provided in Tables 2 and 3.

The total value of the lifeline inventory is over 7,866.00 (millions of dollars). This inventory includes over 614 kilometers of highways, 199 bridges, 34,067 kilometers of pipes.

Table 2: Transportation System Lifeline Inventory

System	Component	# locations/ # Segments	Replacement value (millions of dollars)
Highway	Bridges	199	3,407.20
	Segments	83	2,094.40
	Tunnels	2	10.40
		Subtotal	**5,512.00**
Railways	Bridges	0	0.00
	Facilities	4	9.90
	Segments	146	355.60
	Tunnels	0	0.00
		Subtotal	**365.50**
Light Rail	Bridges	0	0.00
	Facilities	0	0.00
	Segments	0	0.00
	Tunnels	0	0.00
		Subtotal	**0.00**
Bus	Facilities	3	3.70
		Subtotal	**3.70**
Ferry	Facilities	0	0.00
		Subtotal	**0.00**
Port	Facilities	0	0.00
		Subtotal	**0.00**
Airport	Facilities	14	86.20
	Runways	15	526.80
		Subtotal	**613.00**
		Total	**6,494.20**

Table 3: Utility System Lifeline inventory

System	Component	# Locations / Segments	Replacement value (millions of dollars)
Potable Water	Distribution Lines	NA	340.70
	Facilities	7	263.40
	Pipelines	0	0.00
		Subtotal	**604.10**
Waste Water	Distribution Lines	NA	204.40
	Facilities	13	978.40
	Pipelines	0	0.00
		Subtotal	**1,182.80**
Natural Gas	Distribution Lines	NA	136.30
	Facilities	2	2.50
	Pipelines	0	0.00
		Subtotal	**138.70**
Oil Systems	Facilities	1	0.10
	Pipelines	0	0.00
		Subtotal	**0.10**
Electrical Power	Facilities	1	124.30
		Subtotal	**124.30**
Communication	Facilities	37	4.20
		Subtotal	**4.20**
		Total	**2,054.20**

Earthquake Scenario

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

Scenario Name	Cascadia
Type of Earthquake	User-defined
Fault Name	NA
Historical Epicenter ID #	NA
Probabilistic Return Period	NA
Longitude of Epicenter	NA
Latitude of Epicenter	NA
Earthquake Magnitude	8.50
Depth (Km)	NA
Rupture Length (Km)	NA
Rupture Orientation (degrees)	NA
Attenuation Function	NA

Building Damage

Building Damage

HAZUS estimates that about 32,521 thousand buildings will be at least moderately damaged. This is over 29.00 % of the total number of buildings in the region. There are an estimated 6,688 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	(%)
Agriculture	2	0.00	2	0.01	2	0.01	2	0.02	3	0.04
Commercial	105	0.20	155	0.53	396	2.24	479	5.88	545	8.14
Education	1	0.00	1	0.00	1	0.01	1	0.02	1	0.02
Government	4	0.01	5	0.02	13	0.08	17	0.21	19	0.28
Industrial	7	0.01	11	0.04	34	0.19	46	0.57	55	0.82
Other Residential	2,450	4.74	2,555	8.67	4,620	26.14	5,321	65.20	4,267	63.81
Religion	8	0.02	7	0.02	10	0.06	12	0.15	14	0.22
Single Family	49,086	95.01	26,740	90.72	12,597	71.28	2,281	27.95	1,783	26.66
Total	**51,662**		**29,477**		**17,673**		**8,160**		**6,688**	

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

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Concrete	28	0.00	1	0.00	8	0.04	17	0.21	24	0.36
MH*	931	1.80	1615	5.48	4,013	22.71	4,999	61.26	3,928	58.73
Precast	15	0.03	19	0.06	78	0.44	135	1.66	177	2.64
RM*	5	0.01	4	0.01	17	0.10	28	0.34	26	0.39
Steel	14	0.00	1	0.00	12	0.07	30	0.36	75	1.12
UM*	272	0.53	296	1.01	460	2.60	373	4.57	380	5.68
Wood	50,396	97.52	27438	93.08	12,759	72.20	2,151	26.36	1,617	24.18
Total	**51,662**		**29,477**		**17,673**		**8,160**		**6,688**	

*Note:
RM Reinforced Masonry
URM Unreinforced Masonry
MH Manufactured Housing

Essential Facility Damage

Before the earthquake, the region had 586 hospital beds available for use. On the day of the earthquake, the model estimates that only 193 hospital beds (33.00%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, 53.00% of the beds will be back in service. By 30 days, 87.00% will be operational.

Table 6: Expected Damage to Essential Facilities

Classification	Total	# Facilities		
		Least Moderate Damage > 50%	Complete Damage > 50%	# likely Functional on day 1
Hospitals	4	3	0	1
Schools	158	0	0	158
EOCs	2	0	0	2
PoliceStations	11	0	0	11
FireStations	12	0	0	12

Transportation and Utility Lifeline Damage

Table 7 provides damage estimates for the transportation system.

Table 7: Expected Damage to the Transportation Systems

System	Component	Number of Locations				
		Locations/ Segments	With at Least Mod. Damage	With Complete Damage	With Functionality > 50 %	
					After Day 1	After Day 7
Highway	Segments	83	0	0	83	83
	Bridges	199	32	0	167	190
	Tunnels	2	0	0	2	2
Railways	Segments	146	0	0	146	146
	Bridges	0	0	0	0	0
	Tunnels	0	0	0	0	0
	Facilities	4	0	0	4	4
Light Rail	Segments	0	0	0	0	0
	Bridges	0	0	0	0	0
	Tunnels	0	0	0	0	0
	Facilities	0	0	0	0	0
Bus	Facilities	3	0	0	3	3
Ferry	Facilities	0	0	0	0	0
Port	Facilities	0	0	0	0	0
Airport	Facilities	14	0	0	14	14
	Runways	15	0	0	15	15

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

Tables 8-10 provide information on the damage to the utility lifeline systems. Table 8 provides damage to the utility system facilities. Table 9 provides estimates on the number of leaks and breaks by the pipelines of the utility systems. For electric power and potable water, HAZUS performs a simplified system performance analysis. Table 10 provides a summary of the system performance information.

Table 8 : Expected Utility System Facility Damage

System	# of Locations				
	Total #	With at Least Moderate Damage	With Complete Damage	with Functionality > 50 %	
				After Day 1	After Day 7
Potable Water	7	1	0	5	7
Waste Water	13	2	0	3	13
Natural Gas	2	0	0	2	2
Oil Systems	1	0	0	1	1
Electrical Power	1	0	0	1	1
Communication	37	2	0	37	37

Table 9 : Expected Utility System Pipeline Damage (Site Specific)

System	Total Pipelines Length (kms)	Number of Leaks	Number of Breaks
Potable Water	17,034	1177	419
Waste Water	10,220	931	331
Natural Gas	6,813	995	354
Oil	0	0	0

Table 10: Expected Potable Water and Electric Power System Performance

	Total # of Households	Number of Households without Service				
		At Day 1	At Day 3	At Day 7	At Day 30	At Day 90
Potable Water	130,453	5,543	3,903	1,457	0	0
Electric Power		0	0	0	0	0

Induced Earthquake Damage

Fire Following Earthquake

Fires often occur after an earthquake. Because of the number of fires and the lack of water to fight the fires, they can often burn out of control. HAZUS uses a Monte Carlo simulation model to estimate the number of ignitions and the amount of burnt area. For this scenario, the model estimates that there will be 11 ignitions that will burn about 0.10 sq. mi 0.00 % of the region's total area.) The model also estimates that the fires will displace about 149 people and burn about 11 (millions of dollars) of building value.

Debris Generation

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

The model estimates that a total of 2 million tons of debris will be generated. Of the total amount, Brick/Wood comprises 30.00% of the total, with the remainder being Reinforced Concrete/Steel. If the debris tonnage is converted to an estimated number of truckloads, it will require 80,000 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 (7,663 households to be displaced due to the earthquake. Of these, 2,021 people (out of a total population of 322,959 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	Commercial	42	13	2	4
	Commuting	0	0	0	0
	Educational	0	0	0	0
	Hotels	31	9	1	3
	Industrial	58	18	3	6
	Other-Residential	1,009	260	29	55
	Single Family	463	95	7	12
	Total	**1,603**	**395**	**43**	**80**
2 PM	Commercial	2,557	786	132	259
	Commuting	1	1	1	0
	Educational	585	180	30	59
	Hotels	6	2	0	1
	Industrial	425	130	21	42
	Other-Residential	185	47	5	9
	Single Family	94	19	2	3
	Total	**3,852**	**1,164**	**191**	**371**
5 PM	Commercial	1,956	599	101	194
	Commuting	10	13	22	4
	Educational	119	36	6	12
	Hotels	9	3	0	1
	Industrial	266	82	13	26
	Other-Residential	376	98	11	21
	Single Family	184	38	3	5
	Total	**2,919**	**868**	**158**	**264**

Economic Loss

The total economic loss estimated for the earthquake is 5,042.48 (millions of dollars), which includes building and lifeline related losses based on the region's available inventory. The following three sections provide more detailed information about these losses.

Building-Related Losses

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

The total building-related losses were 4,652.34 (millions of dollars); 14 % 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 40 % 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	Single Family	Other Residential	Commercial	Industrial	Others	Total
Income Loses							
	Wage	0.00	12.33	225.67	8.70	7.66	254.37
	Capital-Related	0.00	5.26	168.55	5.18	1.98	180.97
	Rental	29.97	72.32	96.95	3.01	4.18	206.44
	Relocation	3.56	2.03	5.66	0.16	1.10	12.51
	Subtotal	**33.53**	**91.94**	**496.84**	**17.06**	**14.93**	**654.29**
Capital Stock Loses							
	Structural	156.80	135.69	428.49	42.65	33.26	796.88
	Non_Structural	627.30	550.18	906.13	151.70	89.33	2,324.64
	Content	165.25	107.23	413.67	94.27	39.64	820.07
	Inventory	0.00	0.00	31.68	23.75	1.03	56.46
	Subtotal	**949.35**	**793.10**	**1,779.96**	**312.37**	**163.26**	**3,998.05**
	Total	**982.88**	**885.04**	**2,276.80**	**329.43**	**178.19**	**4,652.34**

Transportation and Utility Lifeline Losses

For the transportation and utility lifeline systems, HAZUS computes the direct repair cost for each component only. There are no losses computed by HAZUS for business interruption due to lifeline outages. Tables 13 & 14 provide a detailed breakdown in the expected lifeline losses.

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

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

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Highway	Segments	2,094.41	$4.96	0.24
	Bridges	3,407.19	$205.83	6.04
	Tunnels	10.38	$0.18	1.77
	Subtotal	**5512.00**	**211.00**	
Railways	Segments	355.60	$0.46	0.13
	Bridges	0.00	$0.00	0.00
	Tunnels	0.00	$0.00	0.00
	Facilities	9.85	$1.89	19.14
	Subtotal	**365.50**	**2.30**	
Light Rail	Segments	0.00	$0.00	0.00
	Bridges	0.00	$0.00	0.00
	Tunnels	0.00	$0.00	0.00
	Facilities	0.00	$0.00	0.00
	Subtotal	**0.00**	**0.00**	
Bus	Facilities	3.70	$0.52	14.08
	Subtotal	**3.70**	**0.50**	
Ferry	Facilities	0.00	$0.00	0.00
	Subtotal	**0.00**	**0.00**	
Port	Facilities	0.00	$0.00	0.00
	Subtotal	**0.00**	**0.00**	
Airport	Facilities	86.22	$12.55	14.55
	Runways	526.81	$0.72	0.14
	Subtotal	**613.00**	**13.30**	
	Total	**6494.20**	**227.10**	

Table 14: Utility System Economic Losses

(Millions of dollars)

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Potable Water	Pipelines	0.00	$0.00	0.00
	Facilities	263.40	$23.99	9.11
	Distribution Line	340.70	$13.08	3.84
	Subtotal	**604.07**	**$37.07**	
Waste Water	Pipelines	0.00	$0.00	0.00
	Facilities	978.40	$98.57	10.08
	Distribution Line	204.40	$10.34	5.06
	Subtotal	**1,182.76**	**$108.91**	
Natural Gas	Pipelines	0.00	$0.00	0.00
	Facilities	2.50	$0.19	7.55
	Distribution Line	136.30	$11.06	8.11
	Subtotal	**138.73**	**$11.24**	
Oil Systems	Pipelines	0.00	$0.00	0.00
	Facilities	0.10	$0.01	8.41
	Subtotal	**0.11**	**$0.01**	
Electrical Power	Facilities	124.30	$5.45	4.39
	Subtotal	**124.30**	**$5.45**	
Communication	Facilities	4.20	$0.33	7.90
	Subtotal	**4.18**	**$0.33**	
	Total	**2,054.16**	**$163.02**	

Table 15. Indirect Economic Impact with outside aid
(Employment as # of people and Income in millions of $)

	LOSS	Total	%
First Year			
	Employment Impact	1,098	1.16
	Income Impact	(197)	-4.60
Second Year			
	Employment Impact	464	0.49
	Income Impact	(277)	-6.47
Third Year			
	Employment Impact	10	0.01
	Income Impact	(311)	-7.27
Fourth Year			
	Employment Impact	0	0.00
	Income Impact	(312)	-7.28
Fifth Year			
	Employment Impact	0	0.00
	Income Impact	(312)	-7.28
Years 6 to 15			
	Employment Impact	0	0.00
	Income Impact	(312)	-7.28

Appendix A: County Listing for the Region

Lane,OR

Appendix B: Regional Population and Building Value Data

State	County Name	Population	Building Value (millions of dollars)		
			Residential	Non-Residential	Total
Oregon	Lane	322,959	16,735	4,319	21,055
Total State		**322,959**	**16,735**	**4,319**	**21,055**
Total Region		**322,959**	**16,735**	**4,319**	**21,055**