HAZUS-MH: Earthquake Event Report

Region Name: *State of Colorado*

Earthquake Scenario: *1882 M7.2 State Piceance Basin epc CEUS*

Print Date: *June 30, 2005*

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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 63 county(ies) from the following state(s):

Colorado

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

The geographical size of the region is 103,979.78 square miles and contains 1,062 census tracts. There are over 1,658 thousand households in the region and has a total population of 4,301,261 people (2000 Census Bureau data). The distribution of population by State and County is provided in Appendix B.

There are an estimated 1,373 thousand buildings in the region with a total building replacement value (excluding contents) of 253,527 (millions of dollars). Approximately 99.00 % of the buildings (and 0.00% of the building value) are associated with residential housing.

The replacement value of the transportation and utility lifeline systems is estimated to be 77,869 and 19,265   (millions of dollars) , respectively.

Building and Lifeline Inventory

Building Inventory

HAZUS estimates that there are 1,373 thousand buildings in the region which have an aggregate total replacement value of 253,527 (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 70% 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 81 hospitals in the region with a total bed capacity of 11,042 beds. There are 1,695 schools, 206 fire stations, 275 police stations and 10 emergency operation facilities. With respect to HPL facilities, there are 1,633 dams identified within the region. Of these, 320 of the dams are classified as 'high hazard'. The inventory also includes 613 hazardous material sites, 0 military installations and 1 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 97,134.00 (millions of dollars). This inventory includes over 14,981 kilometers of highways, 7,750 bridges, 461,345 kilometers of pipes.

Table 2: Transportation System Lifeline Inventory

System	Component	# locations/ # Segments	Replacement value (millions of dollars)
Highway	Bridges	7,750	7,441.40
	Segments	1,782	56,078.90
	Tunnels	30	123.70
	Subtotal		**63,644.00**
Railways	Bridges	132	17.30
	Facilities	30	63.40
	Segments	2,682	4,133.20
	Tunnels	0	0.00
	Subtotal		**4,214.00**
Light Rail	Bridges	1	0.30
	Facilities	0	0.00
	Segments	3	6.90
	Tunnels	0	0.00
	Subtotal		**7.20**
Bus	Facilities	34	35.90
	Subtotal		**35.90**
Ferry	Facilities	0	0.00
	Subtotal		**0.00**
Port	Facilities	0	0.00
	Subtotal		**0.00**
Airport	Facilities	249	1,316.30
	Runways	287	8,652.40
	Subtotal		**9,968.70**
	Total		**77,869.80**

Table 3: Utility System Lifeline Inventory

System	Component	# Locations / Segments		Replacement value (millions of dollars)
Potable Water	Distribution Lines	NA		4,613.50
	Facilities	29		936.70
	Pipelines	0		0.00
			Subtotal	**5,550.20**
Waste Water	Distribution Lines	NA		2,768.10
	Facilities	189		12,209.80
	Pipelines	0		0.00
			Subtotal	**14,977.80**
Natural Gas	Distribution Lines	NA		1,845.40
	Facilities	311		328.80
	Pipelines	0		0.00
			Subtotal	**2,174.20**
Oil Systems	Facilities	38		3.70
	Pipelines	0		0.00
			Subtotal	**3.70**
Electrical Power	Facilities	54		5,761.80
			Subtotal	**5,761.80**
Communication	Facilities	250		24.30
			Subtotal	**24.30**
			Total	**28,492.00**

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	1882 M7.2 State Piceance Basin epc CEUS
Type of Earthquake	Arbitrary
Fault Name	NA
Historical Epicenter ID #	NA
Probabilistic Return Period	NA
Longitude of Epicenter	-108.00
Latitude of Epicenter	40.50
Earthquake Magnitude	7.20
Depth (Km)	10.00
Rupture Length (Km)	59.98
Rupture Orientation (degrees)	110.00
Attenuation Function	CEUS Event

Building Damage

Building Damage

HAZUS estimates that about 6,174 buildings will be at least moderately damaged. This is over 0.00 % of the total number of buildings in the region. There are an estimated 219 buildings that will be damaged beyond repair. The definition of the 'damage states' is provided in Volume 1: Chapter 5 of the HAZUS technical manual. Table 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	89	0.01	1	0.01	1	0.02	0	0.03	0	0.04
Commercial	16,272	1.20	140	1.53	93	1.96	27	2.30	5	2.35
Education	68	0.01	0	0.00	0	0.00	0	0.00	0	0.00
Government	682	0.05	6	0.07	4	0.09	1	0.11	0	0.12
Industrial	1,520	0.11	11	0.12	8	0.16	2	0.17	0	0.11
Other Residential	136,550	10.05	2,769	30.32	2,064	43.27	483	40.73	101	45.83
Religion	758	0.06	5	0.05	3	0.06	1	0.07	0	0.06
Single Family	1,202,150	88.52	6,201	67.89	2,597	54.45	671	56.60	113	51.49
Total	1,358,089		9,134		4,769		1,186		219	

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

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Wood	948,009	69.80	4852	53.12	1,412	29.60	236	19.94	30	13.79
Steel	6,781	0.50	62	0.68	48	1.01	13	1.06	2	1.04
Concrete	6,493	0.48	61	0.67	33	0.70	8	0.65	1	0.44
Precast	2,984	0.22	22	0.24	21	0.43	8	0.65	1	0.43
RM	259,507	19.11	1218	13.33	1,025	21.49	372	31.38	53	24.12
URM	37,956	2.79	433	4.74	267	5.60	86	7.27	33	15.14
MH	96,358	7.10	2485	27.21	1,964	41.18	463	39.05	99	45.03
Total	1,358,089		9,134		4,769		1,186		219	

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

Essential Facility Damage

Before the earthquake, the region had 11,042 hospital beds available for use. On the day of the earthquake, the model estimates that only 9,609 hospital beds (87.00%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, 96.00% of the beds will be back in service. By 30 days, 99.00% will be operational.

Table 6: Expected Damage to Essential Facilities

Classification	Total	# Facilities		
		At Least Moderate Damage > 50%	Complete Damage > 50%	With Functionality > 50% on day 1
Hospitals	81	1	0	77
Schools	1,695	78	0	1,614
EOCs	10	0	0	10
PoliceStations	275	5	0	256
FireStations	206	1	0	205

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	1,782	0	0	1,782	1,782
	Bridges	7,750	17	4	7,733	7,741
	Tunnels	30	0	0	30	30
Railways	Segments	2,682	0	0	2,682	2,682
	Bridges	132	0	0	132	132
	Tunnels	0	0	0	0	0
	Facilities	30	0	0	30	30
Light Rail	Segments	3	0	0	3	3
	Bridges	1	0	0	1	1
	Tunnels	0	0	0	0	0
	Facilities	0	0	0	0	0
Bus	Facilities	34	0	0	34	34
Ferry	Facilities	0	0	0	0	0
Port	Facilities	0	0	0	0	0
Airport	Facilities	249	1	0	249	249
	Runways	287	0	0	287	287

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	29	0	0	29	29
Waste Water	189	1	0	188	189
Natural Gas	311	7	0	300	310
Oil Systems	38	0	0	38	38
Electrical Power	54	1	0	53	54
Communication	250	2	0	249	250

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

System	Total Pipelines Length (kms)	Number of Leaks	Number of Breaks
Potable Water	230,673	3257	814
Waste Water	138,404	2576	644
Natural Gas	92,269	2753	688
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	1,658,238	1,619	1,454	1,123	0	0
Electric Power		3,690	2,357	1,043	231	5

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 0.00 sq. mi 0.00 % of the region's total area.) The model also estimates that the fires will displace about 0 people and burn about 0 (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 0.00 million tons of debris will be generated. Of the total amount, Brick/Wood comprises 0.00% 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 0 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 (295 households to be displaced due to the earthquake. Of these, 66 people (out of a total population of 4,301,261 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	1	0	0	0
	Commuting	0	0	0	0
	Educational	0	0	0	0
	Hotels	3	1	0	0
	Industrial	2	0	0	0
	Other-Residential	43	7	0	1
	Single Family	63	12	1	3
	Total	**112**	**19**	**2**	**4**
2 PM	Commercial	63	13	2	3
	Commuting	0	0	0	0
	Educational	11	3	0	1
	Hotels	1	0	0	0
	Industrial	12	2	0	1
	Other-Residential	8	1	0	0
	Single Family	12	2	0	1
	Total	**107**	**22**	**3**	**5**
5 PM	Commercial	51	11	1	3
	Commuting	3	4	7	1
	Educational	1	0	0	0
	Hotels	1	0	0	0
	Industrial	7	1	0	0
	Other-Residential	15	2	0	0
	Single Family	25	5	1	1
	Total	**103**	**23**	**9**	**6**

Economic Loss

The total economic loss estimated for the earthquake is 464.05 (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 294.08 (millions of 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 67 % 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	1.74	13.53	0.30	0.54	16.11
	Capital-Related	0.00	0.74	12.50	0.18	0.12	13.54
	Rental	5.23	5.41	5.88	0.04	0.19	16.75
	Relocation	0.54	0.14	0.32	0.01	0.06	1.07
	Subtotal	**5.77**	**8.03**	**32.23**	**0.53**	**0.91**	**47.47**
Capital Stock Loses							
	Structural	24.56	9.02	11.15	1.44	1.73	47.91
	Non_Structural	81.07	34.40	24.82	3.79	3.80	147.88
	Content	25.14	7.87	12.43	2.28	2.00	49.71
	Inventory	0.00	0.00	0.52	0.54	0.07	1.12
	Subtotal	**130.77**	**51.29**	**48.91**	**8.05**	**7.60**	**246.62**
	Total	**136.54**	**59.32**	**81.15**	**8.57**	**8.51**	**294.08**

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	56,078.87	$0.00	0.00
	Bridges	7,441.42	$6.96	0.09
	Tunnels	123.75	$0.00	0.00
	Subtotal	**63644.00**	**7.00**	
Railways	Segments	4,133.19	$0.00	0.00
	Bridges	17.32	$0.00	0.00
	Tunnels	0.00	$0.00	0.00
	Facilities	63.44	$0.32	0.51
	Subtotal	**4214.00**	**0.30**	
Light Rail	Segments	6.87	$0.00	0.00
	Bridges	0.32	$0.00	0.00
	Tunnels	0.00	$0.00	0.00
	Facilities	0.00	$0.00	0.00
	Subtotal	**7.20**	**0.00**	
Bus	Facilities	35.95	$0.13	0.37
	Subtotal	**35.90**	**0.10**	
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	1,316.34	$11.86	0.90
	Runways	8,652.36	$0.00	0.00
	Subtotal	**9968.70**	**11.90**	
	Total	**77869.80**	**19.30**	

<p align="center">**Table 14: Utility System Economic Losses**</p>
<p align="center">(Millions of dollars)</p>

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Potable Water	Pipelines	0.00	$0.00	0.00
	Facilities	936.70	$1.22	0.13
	Distribution Line	4,613.50	$14.66	0.32
	Subtotal	**5,550.18**	**$15.88**	
Waste Water	Pipelines	0.00	$0.00	0.00
	Facilities	12,209.80	$52.44	0.43
	Distribution Line	2,768.10	$11.59	0.42
	Subtotal	**14,977.85**	**$64.03**	
Natural Gas	Pipelines	0.00	$0.00	0.00
	Facilities	328.80	$3.84	1.17
	Distribution Line	1,845.40	$12.39	0.67
	Subtotal	**2,174.20**	**$16.23**	
Oil Systems	Pipelines	0.00	$0.00	0.00
	Facilities	3.70	$0.00	0.11
	Subtotal	**3.69**	**$0.00**	
Electrical Power	Facilities	5,761.80	$54.41	0.94
	Subtotal	**5,761.80**	**$54.41**	
Communication	Facilities	24.30	$0.13	0.55
	Subtotal	**24.25**	**$0.13**	
	Total	**28,491.97**	**$150.69**	

Table 15. Indirect Economic Impact with outside aid

(Employment as # of people and Income in millions of $)

LOSS	Total	%
First Year		
Employment Impact	54,960	3.49
Income Impact	176	0.22
Second Year		
Employment Impact	19,106	1.21
Income Impact	85	0.11
Third Year		
Employment Impact	435	0.03
Income Impact	16	0.02
Fourth Year		
Employment Impact	23	0.00
Income Impact	(8)	-0.01
Fifth Year		
Employment Impact	0	0.00
Income Impact	(9)	-0.01
Years 6 to 15		
Employment Impact	0	0.00
Income Impact	(9)	-0.01

Appendix A: County Listing for the Region

Adams,CO

Alamosa,CO

Arapahoe,CO

Archuleta,CO

Baca,CO

Bent,CO

Boulder,CO

Chaffee,CO

Cheyenne,CO

Clear Creek,CO

Conejos,CO

Costilla,CO

Crowley,CO

Custer,CO

Delta,CO

Denver,CO

Dolores,CO

Douglas,CO

Eagle,CO

Elbert,CO

El Paso,CO

Fremont,CO

Garfield,CO

Gilpin,CO

Grand,CO

Gunnison,CO

Hinsdale,CO

Huerfano,CO

Jackson,CO

Jefferson,CO

Kiowa,CO

Kit Garson,CO

Lake,CO

La Plata,CO

Larimer,CO

Las Animas,CO

Lincoln,CO

Logan,CO

Mesa,CO

Mineral,CO

Moffat,CO

Montezuma,CO

Montrose,CO

Morgan,CO

Otero,CO

Ouray,CO

Park,CO

Phillips,CO

Pitkin,CO

Prowers,CO

Pueblo,CO

Rio Blanco,CO

Rio Grande,CO

Routt,CO

Saguache,CO

San Juan,CO

San Miguel,CO

Sedgwick,CO

Summit,CO

Teller,CO

Washington,CO

Weld,CO

Yuma,CO

Appendix B: Regional Population and Building Value Data

State	County Name	Population	Building Value (millions of dollars)		
			Residential	Non-Residential	Total
Colorado					
	Adams	363,857	14,434	2,435	16,869
	Alamosa	14,966	570	308	878
	Arapahoe	487,967	24,792	5,126	29,919
	Archuleta	9,898	589	110	700
	Baca	4,517	222	28	251
	Bent	5,998	237	25	262
	Boulder	291,288	14,239	3,523	17,762
	Chaffee	16,242	831	179	1,011
	Cheyenne	2,231	106	25	131
	Clear Creek	9,322	615	92	708
	Conejos	8,400	330	23	353
	Costilla	3,663	151	23	174
	Crowley	5,518	169	13	182
	Custer	3,503	295	28	323
	Delta	27,834	1,172	186	1,359
	Denver	554,636	28,051	8,182	36,233
	Dolores	1,844	107	13	120
	Douglas	175,766	10,657	1,135	11,792
	Eagle	41,659	2,328	675	3,003
	Elbert	19,872	944	85	1,029
	El Paso	516,929	23,988	4,117	28,105
	Fremont	46,145	1,727	221	1,948
	Garfield	43,791	1,793	467	2,260
	Gilpin	4,757	391	34	426
	Grand	12,442	1,183	187	1,371
	Gunnison	13,956	940	181	1,122
	Hinsdale	790	140	6	146
	Huerfano	7,862	440	56	496
	Jackson	1,577	111	13	124
	Jefferson	527,056	28,329	4,126	32,456
	Kiowa	1,622	77	6	83
	Kit Carson	8,011	336	62	399
	Lake	7,812	373	38	411
	La Plata	43,941	2,036	526	2,563
	Larimer	251,494	12,774	2,441	15,215
	Las Animas	15,207	738	125	863
	Lincoln	6,087	253	37	290
	Logan	20,504	859	139	999
	Mesa	116,255	4,746	1,069	5,816
	Mineral	831	115	10	125
	Moffat	13,184	544	86	631
	Montezuma	23,830	929	218	1,148
	Montrose	33,432	1,306	319	1,626
	Morgan	27,171	1,011	2,438	3,450

Otero	20,311	880	128	1,009
Ouray	3,742	236	56	292
Park	14,523	1,165	73	1,238
Phillips	4,480	210	32	243
Pitkin	14,872	1,150	348	1,499
Prowers	14,483	565	103	669
Pueblo	141,472	6,109	990	7,100
Rio Blanco	5,986	306	73	379
Rio Grande	12,413	580	85	666
Routt	19,690	1,205	310	1,515
Saguache	5,917	243	22	265
San Juan	558	68	13	82
San Miguel	6,594	521	125	646
Sedgwick	2,747	144	18	162
Summit	23,548	2,399	405	2,805
Teller	20,555	1,164	180	1,345
Washington	4,926	224	18	243
Weld	180,936	6,699	1,005	7,704
Yuma	9,841	437	62	500
Total State	**4,301,261**	**210,283**	**43,182**	**253,494**
Total Region	**4,301,261**	**210,283**	**43,182**	**253,494**