

HAZUS-MH: Earthquake Event Report



Region Name: *Grand County*

Earthquake Scenario: *1882 M6.6 Rocky Mtn National Park*

Print Date: *January 26, 2006*

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):

Colorado

Note:

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

The geographical size of the region is 1,867.09 square miles and contains 2 census tracts. There are over 5 thousand households in the region and has a total population of 12,442 people (2000 Census Bureau data). The distribution of population by State and County is provided in Appendix B.

There are an estimated 7 thousand buildings in the region with a total building replacement value (excluding contents) of 1,371 (millions of dollars). Approximately 98.00 % of the buildings (and 86.00% of the building value) are associated with residential housing.

The replacement value of the transportation and utility lifeline systems is estimated to be 1,281 and 324 (millions of dollars) , respectively.

Building and Lifeline Inventory

Building Inventory

HAZUS estimates that there are 7 thousand buildings in the region which have an aggregate total replacement value of 1,371 (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 65% 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 1 hospitals in the region with a total bed capacity of 19 beds. There are 0 schools, 0 fire stations, 2 police stations and 0 emergency operation facilities. With respect to HPL facilities, there are 54 dams identified within the region. Of these, 10 of the dams are classified as 'high hazard'. The inventory also includes 5 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 1,605.00 (millions of dollars). This inventory includes over 274 kilometers of highways, 68 bridges, 7,736 kilometers of pipes.

Table 2: Transportation System Lifeline Inventory

System	Component	# locations/ # Segments	Replacement value (millions of dollars)
Highway	Bridges	68	33.10
	Segments	21	1,081.00
	Tunnels	0	0.00
	Subtotal		1,114.10
Railways	Bridges	6	0.60
	Facilities	2	4.20
	Segments	66	91.70
	Tunnels	0	0.00
	Subtotal		96.50
Light Rail	Bridges	0	0.00
	Facilities	0	0.00
	Segments	0	0.00
	Tunnels	0	0.00
	Subtotal		0.00
Bus	Facilities	0	0.00
	Subtotal		0.00
Ferry	Facilities	0	0.00
	Subtotal		0.00
Port	Facilities	0	0.00
	Subtotal		0.00
Airport	Facilities	2	10.60
	Runways	2	60.30
	Subtotal		70.90
		Total	1,281.50

Table 3: Utility System Lifeline Inventory

System	Component	# Locations / Segments	Replacement value (millions of dollars)
Potable Water	Distribution Lines	NA	77.40
	Facilities	0	0.00
	Pipelines	0	0.00
	Subtotal		77.40
Waste Water	Distribution Lines	NA	46.40
	Facilities	5	323.00
	Pipelines	0	0.00
	Subtotal		369.40
Natural Gas	Distribution Lines	NA	30.90
	Facilities	1	1.10
	Pipelines	0	0.00
	Subtotal		32.00
Oil Systems	Facilities	0	0.00
	Pipelines	0	0.00
	Subtotal		0.00
Electrical Power	Facilities	0	0.00
	Subtotal		0.00
Communication	Facilities	2	0.20
	Subtotal		0.20
	Total		479.00

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 M6.6 Rocky Mtn National Park
Type of Earthquake	Arbitrary
Fault Name	NA
Historical Epicenter ID #	NA
Probabilistic Return Period	NA
Longitude of Epicenter	-105.74
Latitude of Epicenter	40.41
Earthquake Magnitude	6.60
Depth (Km)	10.00
Rupture Length (Km)	21.58
Rupture Orientation (degrees)	45.00
Attenuation Function	CEUS Event

Building Damage

Building Damage

HAZUS estimates that about 930 buildings will be at least moderately damaged. This is over 12.00 % of the total number of buildings in the region. There are an estimated 9 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	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Commercial	73	1.36	19	1.23	16	2.10	5	3.04	0	4.66
Education	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Government	1	0.02	0	0.02	0	0.04	0	0.05	0	0.06
Industrial	4	0.08	1	0.08	1	0.14	0	0.22	0	0.25
Other Residential	743	13.90	304	19.60	245	31.76	39	26.09	2	22.58
Religion	3	0.05	1	0.05	1	0.07	0	0.08	0	0.10
Single Family	4,524	84.59	1,224	79.01	509	65.90	105	70.52	7	72.34
Total	5,348		1,549		773		148		9	

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

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Wood	3,725	69.66	1065	68.79	297	38.39	28	19.18	1	14.64
Steel	36	0.68	9	0.57	8	1.08	2	1.31	0	1.85
Concrete	31	0.58	9	0.60	7	0.89	2	1.03	0	0.70
Precast	8	0.16	2	0.15	3	0.37	1	0.80	0	0.67
RM	947	17.70	183	11.80	201	25.96	66	44.45	2	16.11
URM	100	1.86	48	3.09	41	5.36	16	10.89	4	47.49
MH	501	9.37	232	15.00	216	27.96	33	22.34	2	18.54
Total	5,348		1,549		773		148		9	

*Note:

RM Reinforced Masonry
URM Unreinforced Masonry
MH Manufactured Housing

Essential Facility Damage

Before the earthquake, the region had 19 hospital beds available for use. On the day of the earthquake, the model estimates that only 12 hospital beds (65.00%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, 91.00% of the beds will be back in service. By 30 days, 100.00% 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	1	0	0	1
Schools	0	0	0	0
EOCs	0	0	0	0
PoliceStations	2	0	0	2
FireStations	0	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

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	Segments	21	0	0	21	21
	Bridges	68	0	0	68	68
	Tunnels	0	0	0	0	0
Railways	Segments	66	0	0	66	66
	Bridges	6	0	0	6	6
	Tunnels	0	0	0	0	0
	Facilities	2	0	0	2	2
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	0	0	0	0	0
Ferry	Facilities	0	0	0	0	0
Port	Facilities	0	0	0	0	0
Airport	Facilities	2	0	0	2	2
	Runways	2	0	0	2	2

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

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

Table 8 : Expected Utility System Facility Damage

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

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

System	Total Pipelines Length (kms)	Number of Leaks	Number of Breaks
Potable Water	3,868	41	10
Waste Water	2,321	32	8
Natural Gas	1,547	34	9
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	5,075	0	0	0	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 2 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 22 households to be displaced due to the earthquake. Of these, 4 people (out of a total population of 12,442) 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	0	0	0	0
	Commuting	0	0	0	0
	Educational	0	0	0	0
	Hotels	1	0	0	0
	Industrial	0	0	0	0
	Other-Residential	3	0	0	0
	Single Family	5	1	0	0
	Total	9	1	0	0
2 PM	Commercial	6	1	0	0
	Commuting	0	0	0	0
	Educational	1	0	0	0
	Hotels	0	0	0	0
	Industrial	1	0	0	0
	Other-Residential	0	0	0	0
	Single Family	1	0	0	0
	Total	9	2	0	0
5 PM	Commercial	5	1	0	0
	Commuting	0	0	0	0
	Educational	0	0	0	0
	Hotels	0	0	0	0
	Industrial	0	0	0	0
	Other-Residential	1	0	0	0
	Single Family	2	0	0	0
	Total	9	2	0	0

Economic Loss

The total economic loss estimated for the earthquake is 110.19 (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 63.25 (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 76 % 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 Losses							
	Wage	0.00	0.76	2.08	0.03	0.05	2.92
	Capital-Related	0.00	0.33	2.40	0.02	0.01	2.76
	Rental	0.87	1.66	0.72	0.00	0.02	3.28
	Relocation	0.09	0.03	0.03	0.00	0.01	0.15
	Subtotal	0.96	2.77	5.23	0.06	0.09	9.11
Capital Stock Losses							
	Structural	3.99	1.53	1.10	0.16	0.16	6.94
	Non_Structural	17.08	10.46	3.98	0.63	0.52	32.67
	Content	7.61	3.51	2.49	0.39	0.35	14.36
	Inventory	0.00	0.00	0.07	0.10	0.01	0.17
	Subtotal	28.69	15.51	7.64	1.27	1.04	54.14
	Total	29.65	18.28	12.87	1.33	1.13	63.25

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	1,081.00	\$0.00	0.00
	Bridges	33.13	\$0.25	0.77
	Tunnels	0.00	\$0.00	0.00
	Subtotal	1114.10	0.30	
Railways	Segments	91.69	\$0.00	0.00
	Bridges	0.58	\$0.00	0.00
	Tunnels	0.00	\$0.00	0.00
	Facilities	4.23	\$0.92	21.83
	Subtotal	96.50	0.90	
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	0.00	\$0.00	0.00
	Subtotal	0.00	0.00	
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	10.57	\$2.52	23.86
	Runways	60.30	\$0.00	0.00
	Subtotal	70.90	2.50	
	Total	1281.50	3.70	

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	0.00	\$0.00	0.00
	Distribution Line	77.40	\$0.18	0.24
	Subtotal	77.37	\$0.18	
Waste Water	Pipelines	0.00	\$0.00	0.00
	Facilities	323.00	\$42.69	13.22
	Distribution Line	46.40	\$0.14	0.31
	Subtotal	369.43	\$42.84	
Natural Gas	Pipelines	0.00	\$0.00	0.00
	Facilities	1.10	\$0.05	5.08
	Distribution Line	30.90	\$0.15	0.50
	Subtotal	32.00	\$0.21	
Oil Systems	Pipelines	0.00	\$0.00	0.00
	Facilities	0.00	\$0.00	0.00
	Subtotal	0.00	\$0.00	
Electrical Power	Facilities	0.00	\$0.00	0.00
	Subtotal	0.00	\$0.00	
Communication	Facilities	0.20	\$0.01	5.88
	Subtotal	0.19	\$0.01	
	Total	479.00	\$43.24	

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

	LOSS	Total	%
First Year			
	Employment Impact	0	0.00
	Income Impact	0	-0.46
Second Year			
	Employment Impact	0	0.00
	Income Impact	(1)	-1.39
Third Year			
	Employment Impact	0	0.00
	Income Impact	(2)	-1.79
Fourth Year			
	Employment Impact	0	0.00
	Income Impact	(2)	-1.79
Fifth Year			
	Employment Impact	0	0.00
	Income Impact	(2)	-1.79
Years 6 to 15			
	Employment Impact	0	0.00
	Income Impact	(2)	-1.79

Appendix A: County Listing for the Region

Grand,CO

Appendix B: Regional Population and Building Value Data

State	County Name	Population	Building Value (millions of dollars)		
			Residential	Non-Residential	Total
Colorado	Grand	12,442	1,183	187	1,371
Total State		12,442	1,183	187	1,371
Total Region		12,442	1,183	187	1,371

HAZUS-MH: Earthquake Event Report



Region Name: *Grand County*

Earthquake Scenario: *Frontal M7.0 CEUS Event*

Print Date: *January 26, 2006*

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	Subtotal		1,114.10
Railways	Bridges	6	0.60
	Facilities	2	4.20
	Segments	66	91.70
	Tunnels	0	0.00
	Subtotal		96.50
Light Rail	Bridges	0	0.00
	Facilities	0	0.00
	Segments	0	0.00
	Tunnels	0	0.00
	Subtotal		0.00
Bus	Facilities	0	0.00
	Subtotal		0.00
Ferry	Facilities	0	0.00
	Subtotal		0.00
Port	Facilities	0	0.00
	Subtotal		0.00
Airport	Facilities	2	10.60
	Runways	2	60.30
	Subtotal		70.90
		Total	1,281.50

Table 3: Utility System Lifeline Inventory

System	Component	# Locations / Segments	Replacement value (millions of dollars)
Potable Water	Distribution Lines	NA	77.40
	Facilities	0	0.00
	Pipelines	0	0.00
	Subtotal		77.40
Waste Water	Distribution Lines	NA	46.40
	Facilities	5	323.00
	Pipelines	0	0.00
	Subtotal		369.40
Natural Gas	Distribution Lines	NA	30.90
	Facilities	1	1.10
	Pipelines	0	0.00
	Subtotal		32.00
Oil Systems	Facilities	0	0.00
	Pipelines	0	0.00
	Subtotal		0.00
Electrical Power	Facilities	0	0.00
	Subtotal		0.00
Communication	Facilities	2	0.20
	Subtotal		0.20
	Total		479.00

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	Frontal M7.0 CEUS Event
Type of Earthquake	Arbitrary
Fault Name	NA
Historical Epicenter ID #	NA
Probabilistic Return Period	NA
Longitude of Epicenter	-106.16
Latitude of Epicenter	39.68
Earthquake Magnitude	7.00
Depth (Km)	10.00
Rupture Length (Km)	42.66
Rupture Orientation (degrees)	156.00
Attenuation Function	CEUS Event

Building Damage

Building Damage

HAZUS estimates that about 1,337 buildings will be at least moderately damaged. This is over 17.00 % of the total number of buildings in the region. There are an estimated 72 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	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Commercial	68	1.36	18	1.20	18	1.84	7	2.35	2	2.97
Education	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Government	1	0.03	0	0.02	0	0.03	0	0.02	0	0.01
Industrial	4	0.08	1	0.08	1	0.12	1	0.18	0	0.26
Other Residential	693	13.93	272	17.89	252	26.54	90	28.71	26	36.22
Religion	3	0.05	1	0.04	0	0.05	0	0.04	0	0.01
Single Family	4,203	84.55	1,226	80.76	679	71.42	216	68.69	44	60.54
Total	4,971		1,518		950		315		72	

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

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Wood	3,534	71.09	1069	70.41	431	45.35	75	23.84	8	11.59
Steel	34	0.69	8	0.55	9	0.92	3	0.99	1	1.23
Concrete	30	0.60	9	0.60	7	0.75	2	0.68	0	0.53
Precast	8	0.15	2	0.14	3	0.30	2	0.50	0	0.51
RM	840	16.90	175	11.55	231	24.34	126	40.08	24	33.74
URM	89	1.80	44	2.89	42	4.45	22	6.88	12	16.92
MH	436	8.77	210	13.86	227	23.89	85	27.03	26	35.48
Total	4,971		1,518		950		315		72	

*Note:

RM Reinforced Masonry
URM Unreinforced Masonry
MH Manufactured Housing

Essential Facility Damage

Before the earthquake, the region had 19 hospital beds available for use. On the day of the earthquake, the model estimates that only 1 hospital beds (10.00%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, 32.00% of the beds will be back in service. By 30 days, 78.00% 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	1	1	0	0
Schools	0	0	0	0
EOCs	0	0	0	0
PoliceStations	2	0	0	1
FireStations	0	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

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	21	0	0	21	21
	Bridges	68	5	0	63	65
	Tunnels	0	0	0	0	0
Railways	Segments	66	0	0	66	66
	Bridges	6	0	0	6	6
	Tunnels	0	0	0	0	0
	Facilities	2	0	0	2	2
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	0	0	0	0	0
Ferry	Facilities	0	0	0	0	0
Port	Facilities	0	0	0	0	0
Airport	Facilities	2	0	0	2	2
	Runways	2	0	0	2	2

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

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

Table 8 : Expected Utility System Facility Damage

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

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

System	Total Pipelines Length (kms)	Number of Leaks	Number of Breaks
Potable Water	3,868	277	69
Waste Water	2,321	219	55
Natural Gas	1,547	235	59
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	5,075	28	0	0	0	0
Electric Power		769	427	150	25	1

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 1 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 67 households to be displaced due to the earthquake. Of these, 13 people (out of a total population of 12,442) 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	0	0	0	0
	Commuting	0	0	0	0
	Educational	0	0	0	0
	Hotels	3	1	0	0
	Industrial	0	0	0	0
	Other-Residential	8	2	0	0
	Single Family	16	3	0	1
	Total	27	6	1	1
2 PM	Commercial	15	4	1	1
	Commuting	0	0	0	0
	Educational	3	1	0	0
	Hotels	1	0	0	0
	Industrial	3	1	0	0
	Other-Residential	1	0	0	0
	Single Family	3	1	0	0
	Total	25	6	1	2
5 PM	Commercial	13	3	0	1
	Commuting	0	0	1	0
	Educational	0	0	0	0
	Hotels	1	0	0	0
	Industrial	2	0	0	0
	Other-Residential	3	1	0	0
	Single Family	6	1	0	0
	Total	25	6	2	2

Economic Loss

The total economic loss estimated for the earthquake is 157.11 (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 85.06 (millions of dollars); 17 % 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 73 % 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 Losses							
	Wage	0.00	1.28	3.23	0.07	0.10	4.69
	Capital-Related	0.00	0.55	3.73	0.04	0.02	4.34
	Rental	1.56	2.23	1.15	0.01	0.05	5.01
	Relocation	0.16	0.03	0.04	0.00	0.01	0.26
	Subtotal	1.73	4.10	8.16	0.12	0.19	14.29
Capital Stock Losses							
	Structural	7.19	2.38	2.12	0.32	0.32	12.33
	Non_Structural	24.57	11.20	5.94	1.03	0.86	43.60
	Content	7.78	2.92	2.89	0.58	0.43	14.60
	Inventory	0.00	0.00	0.10	0.13	0.01	0.24
	Subtotal	39.54	16.49	11.05	2.07	1.62	70.77
	Total	41.27	20.59	19.21	2.19	1.81	85.06

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	1,081.00	\$0.00	0.00
	Bridges	33.13	\$1.85	5.58
	Tunnels	0.00	\$0.00	0.00
	Subtotal	1114.10	1.80	
Railways	Segments	91.69	\$0.00	0.00
	Bridges	0.58	\$0.00	0.55
	Tunnels	0.00	\$0.00	0.00
	Facilities	4.23	\$1.19	28.04
	Subtotal	96.50	1.20	
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	0.00	\$0.00	0.00
	Subtotal	0.00	0.00	
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	10.57	\$3.12	29.47
	Runways	60.30	\$0.00	0.00
	Subtotal	70.90	3.10	
	Total	1281.50	6.20	

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	0.00	\$0.00	0.00
	Distribution Line	77.40	\$1.25	1.61
	Subtotal	77.37	\$1.25	
Waste Water	Pipelines	0.00	\$0.00	0.00
	Facilities	323.00	\$62.02	19.20
	Distribution Line	46.40	\$0.99	2.13
	Subtotal	369.43	\$63.01	
Natural Gas	Pipelines	0.00	\$0.00	0.00
	Facilities	1.10	\$0.53	50.27
	Distribution Line	30.90	\$1.06	3.41
	Subtotal	32.00	\$1.59	
Oil Systems	Pipelines	0.00	\$0.00	0.00
	Facilities	0.00	\$0.00	0.00
	Subtotal	0.00	\$0.00	
Electrical Power	Facilities	0.00	\$0.00	0.00
	Subtotal	0.00	\$0.00	
Communication	Facilities	0.20	\$0.05	24.43
	Subtotal	0.19	\$0.05	
	Total	479.00	\$65.89	

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

	LOSS	Total	%
First Year			
	Employment Impact	0	0.00
	Income Impact	(1)	-0.65
Second Year			
	Employment Impact	0	0.00
	Income Impact	(2)	-1.97
Third Year			
	Employment Impact	0	0.00
	Income Impact	(3)	-2.53
Fourth Year			
	Employment Impact	0	0.00
	Income Impact	(3)	-2.53
Fifth Year			
	Employment Impact	0	0.00
	Income Impact	(3)	-2.53
Years 6 to 15			
	Employment Impact	0	0.00
	Income Impact	(3)	-2.53

Appendix A: County Listing for the Region

Grand,CO

Appendix B: Regional Population and Building Value Data

State	County Name	Population	Building Value (millions of dollars)		
			Residential	Non-Residential	Total
Colorado	Grand	12,442	1,183	187	1,371
Total State		12,442	1,183	187	1,371
Total Region		12,442	1,183	187	1,371

HAZUS-MH: Earthquake Event Report



Region Name: *Grand County*

Earthquake Scenario: *Mosquito M7.0 CEUS Event*

Print Date: *January 26, 2006*

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):

Colorado

Note:

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

The geographical size of the region is 1,867.09 square miles and contains 2 census tracts. There are over 5 thousand households in the region and has a total population of 12,442 people (2000 Census Bureau data). The distribution of population by State and County is provided in Appendix B.

There are an estimated 7 thousand buildings in the region with a total building replacement value (excluding contents) of 1,371 (millions of dollars). Approximately 98.00 % of the buildings (and 86.00% of the building value) are associated with residential housing.

The replacement value of the transportation and utility lifeline systems is estimated to be 1,281 and 324 (millions of dollars) , respectively.

Building and Lifeline Inventory

Building Inventory

HAZUS estimates that there are 7 thousand buildings in the region which have an aggregate total replacement value of 1,371 (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 65% 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 1 hospitals in the region with a total bed capacity of 19 beds. There are 0 schools, 0 fire stations, 2 police stations and 0 emergency operation facilities. With respect to HPL facilities, there are 54 dams identified within the region. Of these, 10 of the dams are classified as 'high hazard'. The inventory also includes 5 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 1,605.00 (millions of dollars). This inventory includes over 274 kilometers of highways, 68 bridges, 7,736 kilometers of pipes.

Table 2: Transportation System Lifeline Inventory

System	Component	# locations/ # Segments	Replacement value (millions of dollars)
Highway	Bridges	68	33.10
	Segments	21	1,081.00
	Tunnels	0	0.00
	Subtotal		1,114.10
Railways	Bridges	6	0.60
	Facilities	2	4.20
	Segments	66	91.70
	Tunnels	0	0.00
	Subtotal		96.50
Light Rail	Bridges	0	0.00
	Facilities	0	0.00
	Segments	0	0.00
	Tunnels	0	0.00
	Subtotal		0.00
Bus	Facilities	0	0.00
	Subtotal		0.00
Ferry	Facilities	0	0.00
	Subtotal		0.00
Port	Facilities	0	0.00
	Subtotal		0.00
Airport	Facilities	2	10.60
	Runways	2	60.30
	Subtotal		70.90
		Total	1,281.50

Table 3: Utility System Lifeline Inventory

System	Component	# Locations / Segments	Replacement value (millions of dollars)
Potable Water	Distribution Lines	NA	77.40
	Facilities	0	0.00
	Pipelines	0	0.00
	Subtotal		77.40
Waste Water	Distribution Lines	NA	46.40
	Facilities	5	323.00
	Pipelines	0	0.00
	Subtotal		369.40
Natural Gas	Distribution Lines	NA	30.90
	Facilities	1	1.10
	Pipelines	0	0.00
	Subtotal		32.00
Oil Systems	Facilities	0	0.00
	Pipelines	0	0.00
	Subtotal		0.00
Electrical Power	Facilities	0	0.00
	Subtotal		0.00
Communication	Facilities	2	0.20
	Subtotal		0.20
	Total		479.00

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	Mosquito M7.0 CEUS Event
Type of Earthquake	Arbitrary
Fault Name	NA
Historical Epicenter ID #	NA
Probabilistic Return Period	NA
Longitude of Epicenter	-106.16
Latitude of Epicenter	39.38
Earthquake Magnitude	7.00
Depth (Km)	10.00
Rupture Length (Km)	42.66
Rupture Orientation (degrees)	9.00
Attenuation Function	CEUS Event

Building Damage

Building Damage

HAZUS estimates that about 430 buildings will be at least moderately damaged. This is over 5.00 % of the total number of buildings in the region. There are an estimated 3 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	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Commercial	92	1.40	11	1.36	8	2.16	2	3.01	0	4.42
Education	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Government	2	0.03	0	0.02	0	0.03	0	0.03	0	0.02
Industrial	5	0.08	1	0.10	1	0.16	0	0.27	0	0.35
Other Residential	966	14.72	205	24.60	141	38.87	19	30.59	1	34.48
Religion	3	0.05	0	0.04	0	0.05	0	0.05	0	0.04
Single Family	5,496	83.72	615	73.88	213	58.73	42	66.06	2	60.69
Total	6,565		832		363		64		4	

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

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Wood	4,534	69.07	488	58.62	89	24.53	6	9.60	0	2.27
Steel	46	0.71	5	0.58	3	0.96	1	1.04	0	1.65
Concrete	40	0.60	6	0.68	3	0.81	1	0.79	0	0.61
Precast	11	0.16	2	0.20	2	0.45	1	0.86	0	0.72
RM	1,137	17.32	121	14.54	108	29.92	30	47.28	1	19.18
URM	138	2.10	37	4.46	25	6.99	8	11.97	2	42.70
MH	659	10.04	174	20.93	132	36.34	18	28.46	1	32.88
Total	6,565		832		363		64		4	

*Note:

RM Reinforced Masonry
URM Unreinforced Masonry
MH Manufactured Housing

Essential Facility Damage

Before the earthquake, the region had 19 hospital beds available for use. On the day of the earthquake, the model estimates that only 8 hospital beds (47.00%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, 80.00% 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	1	0	0	0
Schools	0	0	0	0
EOCs	0	0	0	0
PoliceStations	2	0	0	2
FireStations	0	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

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	21	0	0	21	21
	Bridges	68	0	0	68	68
	Tunnels	0	0	0	0	0
Railways	Segments	66	0	0	66	66
	Bridges	6	0	0	6	6
	Tunnels	0	0	0	0	0
	Facilities	2	0	0	2	2
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	0	0	0	0	0
Ferry	Facilities	0	0	0	0	0
Port	Facilities	0	0	0	0	0
Airport	Facilities	2	0	0	2	2
	Runways	2	0	0	2	2

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

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

Table 8 : Expected Utility System Facility Damage

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

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

System	Total Pipelines Length (kms)	Number of Leaks	Number of Breaks
Potable Water	3,868	47	12
Waste Water	2,321	37	9
Natural Gas	1,547	40	10
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	5,075	0	0	0	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 1 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 7 households to be displaced due to the earthquake. Of these, 1 people (out of a total population of 12,442 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	0	0	0	0
	Commuting	0	0	0	0
	Educational	0	0	0	0
	Hotels	1	0	0	0
	Industrial	0	0	0	0
	Other-Residential	2	0	0	0
	Single Family	2	0	0	0
	Total	5	1	0	0
2 PM	Commercial	3	0	0	0
	Commuting	0	0	0	0
	Educational	1	0	0	0
	Hotels	0	0	0	0
	Industrial	0	0	0	0
	Other-Residential	0	0	0	0
	Single Family	0	0	0	0
	Total	5	1	0	0
5 PM	Commercial	2	0	0	0
	Commuting	0	0	0	0
	Educational	0	0	0	0
	Hotels	0	0	0	0
	Industrial	0	0	0	0
	Other-Residential	1	0	0	0
	Single Family	1	0	0	0
	Total	4	1	0	0

Economic Loss

The total economic loss estimated for the earthquake is 47.21 (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 21.02 (millions of 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 71 % 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 Losses							
	Wage	0.00	0.31	0.95	0.02	0.03	1.30
	Capital-Related	0.00	0.13	1.09	0.01	0.01	1.24
	Rental	0.36	0.64	0.36	0.00	0.01	1.37
	Relocation	0.04	0.01	0.01	0.00	0.00	0.07
	Subtotal	0.40	1.08	2.41	0.03	0.05	3.97
Capital Stock Losses							
	Structural	1.69	0.67	0.57	0.09	0.08	3.11
	Non_Structural	5.51	2.92	1.43	0.24	0.19	10.29
	Content	1.90	0.72	0.72	0.13	0.10	3.58
	Inventory	0.00	0.00	0.02	0.03	0.00	0.06
	Subtotal	9.10	4.32	2.75	0.50	0.38	17.04
	Total	9.49	5.40	5.16	0.53	0.43	21.02

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	1,081.00	\$0.00	0.00
	Bridges	33.13	\$0.32	0.96
	Tunnels	0.00	\$0.00	0.00
	Subtotal	1114.10	0.30	
Railways	Segments	91.69	\$0.00	0.00
	Bridges	0.58	\$0.00	0.10
	Tunnels	0.00	\$0.00	0.00
	Facilities	4.23	\$0.66	15.56
	Subtotal	96.50	0.70	
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	0.00	\$0.00	0.00
	Subtotal	0.00	0.00	
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	10.57	\$2.00	18.96
	Runways	60.30	\$0.00	0.00
	Subtotal	70.90	2.00	
	Total	1281.50	3.00	

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	0.00	\$0.00	0.00
	Distribution Line	77.40	\$0.21	0.27
	Subtotal	77.37	\$0.21	
Waste Water	Pipelines	0.00	\$0.00	0.00
	Facilities	323.00	\$22.46	6.95
	Distribution Line	46.40	\$0.17	0.36
	Subtotal	369.43	\$22.63	
Natural Gas	Pipelines	0.00	\$0.00	0.00
	Facilities	1.10	\$0.19	18.12
	Distribution Line	30.90	\$0.18	0.58
	Subtotal	32.00	\$0.37	
Oil Systems	Pipelines	0.00	\$0.00	0.00
	Facilities	0.00	\$0.00	0.00
	Subtotal	0.00	\$0.00	
Electrical Power	Facilities	0.00	\$0.00	0.00
	Subtotal	0.00	\$0.00	
Communication	Facilities	0.20	\$0.01	4.33
	Subtotal	0.19	\$0.01	
	Total	479.00	\$23.21	

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

	LOSS	Total	%
First Year			
	Employment Impact	0	0.00
	Income Impact	0	-0.15
Second Year			
	Employment Impact	0	0.00
	Income Impact	0	-0.47
Third Year			
	Employment Impact	0	0.00
	Income Impact	(1)	-0.61
Fourth Year			
	Employment Impact	0	0.00
	Income Impact	(1)	-0.61
Fifth Year			
	Employment Impact	0	0.00
	Income Impact	(1)	-0.61
Years 6 to 15			
	Employment Impact	0	0.00
	Income Impact	(1)	-0.61

Appendix A: County Listing for the Region

Grand,CO

Appendix B: Regional Population and Building Value Data

State	County Name	Population	Building Value (millions of dollars)		
			Residential	Non-Residential	Total
Colorado	Grand	12,442	1,183	187	1,371
Total State		12,442	1,183	187	1,371
Total Region		12,442	1,183	187	1,371

HAZUS-MH: Earthquake Event Report



Region Name: *Grand County*

Earthquake Scenario: *N Sawatch M7.0 CEUS Event*

Print Date: *January 26, 2006*

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):

Colorado

Note:

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

The geographical size of the region is 1,867.09 square miles and contains 2 census tracts. There are over 5 thousand households in the region and has a total population of 12,442 people (2000 Census Bureau data). The distribution of population by State and County is provided in Appendix B.

There are an estimated 7 thousand buildings in the region with a total building replacement value (excluding contents) of 1,371 (millions of dollars). Approximately 98.00 % of the buildings (and 86.00% of the building value) are associated with residential housing.

The replacement value of the transportation and utility lifeline systems is estimated to be 1,281 and 324 (millions of dollars) , respectively.

Building and Lifeline Inventory

Building Inventory

HAZUS estimates that there are 7 thousand buildings in the region which have an aggregate total replacement value of 1,371 (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 65% 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 1 hospitals in the region with a total bed capacity of 19 beds. There are 0 schools, 0 fire stations, 2 police stations and 0 emergency operation facilities. With respect to HPL facilities, there are 54 dams identified within the region. Of these, 10 of the dams are classified as 'high hazard'. The inventory also includes 5 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 1,605.00 (millions of dollars). This inventory includes over 274 kilometers of highways, 68 bridges, 7,736 kilometers of pipes.

Table 2: Transportation System Lifeline Inventory

System	Component	# locations/ # Segments	Replacement value (millions of dollars)
Highway	Bridges	68	33.10
	Segments	21	1,081.00
	Tunnels	0	0.00
	Subtotal		1,114.10
Railways	Bridges	6	0.60
	Facilities	2	4.20
	Segments	66	91.70
	Tunnels	0	0.00
	Subtotal		96.50
Light Rail	Bridges	0	0.00
	Facilities	0	0.00
	Segments	0	0.00
	Tunnels	0	0.00
	Subtotal		0.00
Bus	Facilities	0	0.00
	Subtotal		0.00
Ferry	Facilities	0	0.00
	Subtotal		0.00
Port	Facilities	0	0.00
	Subtotal		0.00
Airport	Facilities	2	10.60
	Runways	2	60.30
	Subtotal		70.90
		Total	1,281.50

Table 3: Utility System Lifeline Inventory

System	Component	# Locations / Segments	Replacement value (millions of dollars)
Potable Water	Distribution Lines	NA	77.40
	Facilities	0	0.00
	Pipelines	0	0.00
	Subtotal		77.40
Waste Water	Distribution Lines	NA	46.40
	Facilities	5	323.00
	Pipelines	0	0.00
	Subtotal		369.40
Natural Gas	Distribution Lines	NA	30.90
	Facilities	1	1.10
	Pipelines	0	0.00
	Subtotal		32.00
Oil Systems	Facilities	0	0.00
	Pipelines	0	0.00
	Subtotal		0.00
Electrical Power	Facilities	0	0.00
	Subtotal		0.00
Communication	Facilities	2	0.20
	Subtotal		0.20
	Total		479.00

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	N Sawatch M7.0 CEUS Event
Type of Earthquake	Arbitrary
Fault Name	NA
Historical Epicenter ID #	NA
Probabilistic Return Period	NA
Longitude of Epicenter	-106.39
Latitude of Epicenter	39.15
Earthquake Magnitude	7.00
Depth (Km)	10.00
Rupture Length (Km)	42.66
Rupture Orientation (degrees)	147.00
Attenuation Function	CEUS Event

Building Damage

Building Damage

HAZUS estimates that about 274 buildings will be at least moderately damaged. This is over 4.00 % of the total number of buildings in the region. There are an estimated 1 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	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Commercial	98	1.40	9	1.54	5	2.20	1	3.01	0	4.38
Education	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Government	2	0.03	0	0.02	0	0.03	0	0.02	0	0.02
Industrial	6	0.08	1	0.11	0	0.17	0	0.28	0	0.30
Other Residential	1,049	15.05	166	28.28	106	44.25	12	35.03	1	41.98
Religion	4	0.05	0	0.04	0	0.05	0	0.04	0	0.04
Single Family	5,808	83.38	410	70.00	128	53.32	21	61.61	1	53.28
Total	6,966		586		240		34		2	

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

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Wood	4,753	68.24	312	53.16	49	20.53	3	9.06	0	4.97
Steel	48	0.69	4	0.74	3	1.09	0	1.18	0	2.16
Concrete	43	0.62	4	0.65	2	0.67	0	0.63	0	0.37
Precast	12	0.17	1	0.21	1	0.44	0	0.86	0	0.49
RM	1,228	17.64	88	15.06	66	27.73	14	41.92	0	7.56
URM	157	2.25	30	5.10	18	7.41	4	13.29	1	43.99
MH	724	10.40	147	25.08	101	42.14	11	33.07	1	40.46
Total	6,966		586		240		34		2	

*Note:

RM Reinforced Masonry
URM Unreinforced Masonry
MH Manufactured Housing

Essential Facility Damage

Before the earthquake, the region had 19 hospital beds available for use. On the day of the earthquake, the model estimates that only 10 hospital beds (56.00%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, 86.00% 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	1	0	0	1
Schools	0	0	0	0
EOCs	0	0	0	0
PoliceStations	2	0	0	2
FireStations	0	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

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	Segments	21	0	0	21	21
	Bridges	68	0	0	68	68
	Tunnels	0	0	0	0	0
Railways	Segments	66	0	0	66	66
	Bridges	6	0	0	6	6
	Tunnels	0	0	0	0	0
	Facilities	2	0	0	2	2
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	0	0	0	0	0
Ferry	Facilities	0	0	0	0	0
Port	Facilities	0	0	0	0	0
Airport	Facilities	2	0	0	2	2
	Runways	2	0	0	2	2

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

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

Table 8 : Expected Utility System Facility Damage

System	# of Locations				
	Total #	With at Least Moderate Damage	With Complete Damage	with Functionality > 50 %	
				After Day 1	After Day 7
Potable Water	0	0	0	0	0
Waste Water	5	0	0	4	5
Natural Gas	1	0	0	1	1
Oil Systems	0	0	0	0	0
Electrical Power	0	0	0	0	0
Communication	2	0	0	2	2

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

System	Total Pipelines Length (kms)	Number of Leaks	Number of Breaks
Potable Water	3,868	32	8
Waste Water	2,321	26	6
Natural Gas	1,547	27	7
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	5,075	0	0	0	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 0 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 (3 households to be displaced due to the earthquake. Of these, 0 people (out of a total population of 12,442 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	0	0	0	0
	Commuting	0	0	0	0
	Educational	0	0	0	0
	Hotels	0	0	0	0
	Industrial	0	0	0	0
	Other-Residential	1	0	0	0
	Single Family	1	0	0	0
	Total	3	0	0	0
2 PM	Commercial	2	0	0	0
	Commuting	0	0	0	0
	Educational	0	0	0	0
	Hotels	0	0	0	0
	Industrial	0	0	0	0
	Other-Residential	0	0	0	0
	Single Family	0	0	0	0
	Total	3	0	0	0
5 PM	Commercial	1	0	0	0
	Commuting	0	0	0	0
	Educational	0	0	0	0
	Hotels	0	0	0	0
	Industrial	0	0	0	0
	Other-Residential	0	0	0	0
	Single Family	1	0	0	0
	Total	2	0	0	0

Economic Loss

The total economic loss estimated for the earthquake is 24.12 (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 11.47 (millions of dollars); 21 % of the estimated losses were related to the business interruption of the region. By far, the largest loss was sustained by the residential occupancies which made up over 69 % 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 Losses							
	Wage	0.00	0.17	0.58	0.01	0.02	0.78
	Capital-Related	0.00	0.07	0.68	0.01	0.00	0.76
	Rental	0.20	0.36	0.22	0.00	0.01	0.79
	Relocation	0.02	0.01	0.01	0.00	0.00	0.04
	Subtotal	0.22	0.61	1.49	0.02	0.03	2.37
Capital Stock Losses							
	Structural	0.96	0.42	0.34	0.06	0.05	1.82
	Non_Structural	2.95	1.55	0.78	0.13	0.11	5.52
	Content	0.90	0.33	0.37	0.07	0.05	1.72
	Inventory	0.00	0.00	0.01	0.02	0.00	0.03
	Subtotal	4.81	2.30	1.51	0.28	0.21	9.09
	Total	5.03	2.91	2.99	0.30	0.24	11.47

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	1,081.00	\$0.00	0.00
	Bridges	33.13	\$0.20	0.60
	Tunnels	0.00	\$0.00	0.00
	Subtotal	1114.10	0.20	
Railways	Segments	91.69	\$0.00	0.00
	Bridges	0.58	\$0.00	0.00
	Tunnels	0.00	\$0.00	0.00
	Facilities	4.23	\$0.31	7.24
	Subtotal	96.50	0.30	
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	0.00	\$0.00	0.00
	Subtotal	0.00	0.00	
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	10.57	\$1.45	13.75
	Runways	60.30	\$0.00	0.00
	Subtotal	70.90	1.50	
	Total	1281.50	2.00	

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	0.00	\$0.00	0.00
	Distribution Line	77.40	\$0.15	0.19
	Subtotal	77.37	\$0.15	
Waste Water	Pipelines	0.00	\$0.00	0.00
	Facilities	323.00	\$10.24	3.17
	Distribution Line	46.40	\$0.12	0.25
	Subtotal	369.43	\$10.36	
Natural Gas	Pipelines	0.00	\$0.00	0.00
	Facilities	1.10	\$0.07	6.15
	Distribution Line	30.90	\$0.12	0.40
	Subtotal	32.00	\$0.19	
Oil Systems	Pipelines	0.00	\$0.00	0.00
	Facilities	0.00	\$0.00	0.00
	Subtotal	0.00	\$0.00	
Electrical Power	Facilities	0.00	\$0.00	0.00
	Subtotal	0.00	\$0.00	
Communication	Facilities	0.20	\$0.00	1.86
	Subtotal	0.19	\$0.00	
	Total	479.00	\$10.69	

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

	LOSS	Total	%
First Year			
	Employment Impact	0	0.00
	Income Impact	0	-0.08
Second Year			
	Employment Impact	0	0.00
	Income Impact	0	-0.26
Third Year			
	Employment Impact	0	0.00
	Income Impact	0	-0.33
Fourth Year			
	Employment Impact	0	0.00
	Income Impact	0	-0.33
Fifth Year			
	Employment Impact	0	0.00
	Income Impact	0	-0.33
Years 6 to 15			
	Employment Impact	0	0.00
	Income Impact	0	-0.33

Appendix A: County Listing for the Region

Grand,CO

Appendix B: Regional Population and Building Value Data

State	County Name	Population	Building Value (millions of dollars)		
			Residential	Non-Residential	Total
Colorado	Grand	12,442	1,183	187	1,371
Total State		12,442	1,183	187	1,371
Total Region		12,442	1,183	187	1,371

HAZUS-MH: Earthquake Event Report



Region Name: *Grand County*

Earthquake Scenario: *Williams Fork M6.75 CEUS Event*

Print Date: *June 30, 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.

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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):

Colorado

Note:

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

The geographical size of the region is 1,867.09 square miles and contains 2 census tracts. There are over 5 thousand households in the region and has a total population of 12,442 people (2000 Census Bureau data). The distribution of population by State and County is provided in Appendix B.

There are an estimated 7 thousand buildings in the region with a total building replacement value (excluding contents) of 1,371 (millions of dollars). Approximately 98.00 % of the buildings (and 86.00% of the building value) are associated with residential housing.

The replacement value of the transportation and utility lifeline systems is estimated to be 1,281 and 324 (millions of dollars) , respectively.

Building and Lifeline Inventory

Building Inventory

HAZUS estimates that there are 7 thousand buildings in the region which have an aggregate total replacement value of 1,371 (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 65% 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 1 hospitals in the region with a total bed capacity of 19 beds. There are 0 schools, 0 fire stations, 2 police stations and 0 emergency operation facilities. With respect to HPL facilities, there are 54 dams identified within the region. Of these, 10 of the dams are classified as 'high hazard'. The inventory also includes 5 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 1,605.00 (millions of dollars). This inventory includes over 274 kilometers of highways, 68 bridges, 7,736 kilometers of pipes.

Table 2: Transportation System Lifeline Inventory

System	Component	# locations/ # Segments	Replacement value (millions of dollars)
Highway	Bridges	68	33.10
	Segments	21	1,081.00
	Tunnels	0	0.00
	Subtotal		1,114.10
Railways	Bridges	6	0.60
	Facilities	2	4.20
	Segments	66	91.70
	Tunnels	0	0.00
	Subtotal		96.50
Light Rail	Bridges	0	0.00
	Facilities	0	0.00
	Segments	0	0.00
	Tunnels	0	0.00
	Subtotal		0.00
Bus	Facilities	0	0.00
	Subtotal		0.00
Ferry	Facilities	0	0.00
	Subtotal		0.00
Port	Facilities	0	0.00
	Subtotal		0.00
Airport	Facilities	2	10.60
	Runways	2	60.30
	Subtotal		70.90
		Total	1,281.50

Table 3: Utility System Lifeline Inventory

System	Component	# Locations / Segments	Replacement value (millions of dollars)
Potable Water	Distribution Lines	NA	77.40
	Facilities	0	0.00
	Pipelines	0	0.00
	Subtotal		77.40
Waste Water	Distribution Lines	NA	46.40
	Facilities	5	323.00
	Pipelines	0	0.00
	Subtotal		369.40
Natural Gas	Distribution Lines	NA	30.90
	Facilities	1	1.10
	Pipelines	0	0.00
	Subtotal		32.00
Oil Systems	Facilities	0	0.00
	Pipelines	0	0.00
	Subtotal		0.00
Electrical Power	Facilities	0	0.00
	Subtotal		0.00
Communication	Facilities	2	0.20
	Subtotal		0.20
	Total		479.00

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	Williams Fork M6.75 CEUS Event
Type of Earthquake	Arbitrary
Fault Name	NA
Historical Epicenter ID #	NA
Probabilistic Return Period	NA
Longitude of Epicenter	-106.15
Latitude of Epicenter	39.87
Earthquake Magnitude	6.75
Depth (Km)	10.00
Rupture Length (Km)	27.86
Rupture Orientation (degrees)	140.00
Attenuation Function	CEUS Event

Building Damage

Building Damage

HAZUS estimates that about 1,389 buildings will be at least moderately damaged. This is over 18.00 % of the total number of buildings in the region. There are an estimated 111 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	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Commercial	72	1.44	16	1.13	15	1.57	7	2.00	3	2.66
Education	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Government	1	0.03	0	0.02	0	0.02	0	0.01	0	0.00
Industrial	4	0.08	1	0.08	1	0.10	1	0.16	0	0.24
Other Residential	734	14.64	253	17.80	219	23.48	88	25.52	38	34.38
Religion	3	0.06	1	0.04	0	0.04	0	0.03	0	0.00
Single Family	4,199	83.75	1,152	80.92	699	74.78	249	72.28	70	62.71
Total	5,013		1,424		934		345		111	

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

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Wood	3,490	69.61	1013	71.17	483	51.69	113	32.77	18	16.60
Steel	37	0.74	7	0.52	7	0.76	3	0.82	1	1.10
Concrete	32	0.64	8	0.58	6	0.63	2	0.54	1	0.50
Precast	8	0.17	2	0.14	2	0.27	1	0.39	1	0.45
RM	876	17.47	157	11.04	202	21.65	123	35.67	39	35.27
URM	99	1.98	40	2.84	37	3.94	19	5.57	14	12.21
MH	471	9.40	195	13.71	197	21.07	84	24.24	38	33.86
Total	5,013		1,424		934		345		111	

*Note:

RM Reinforced Masonry
URM Unreinforced Masonry
MH Manufactured Housing

Essential Facility Damage

Before the earthquake, the region had 19 hospital beds available for use. On the day of the earthquake, the model estimates that only 1 hospital beds (8.00%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, 27.00% of the beds will be back in service. By 30 days, 73.00% 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	1	1	0	0
Schools	0	0	0	0
EOCs	0	0	0	0
PoliceStations	2	0	0	1
FireStations	0	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

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	21	0	0	21	21
	Bridges	68	5	2	63	65
	Tunnels	0	0	0	0	0
Railways	Segments	66	0	0	66	66
	Bridges	6	0	0	6	6
	Tunnels	0	0	0	0	0
	Facilities	2	0	0	2	2
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	0	0	0	0	0
Ferry	Facilities	0	0	0	0	0
Port	Facilities	0	0	0	0	0
Airport	Facilities	2	1	0	2	2
	Runways	2	0	0	2	2

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

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

Table 8 : Expected Utility System Facility Damage

System	# of Locations				
	Total #	With at Least Moderate Damage	With Complete Damage	with Functionality > 50 %	
				After Day 1	After Day 7
Potable Water	0	0	0	0	0
Waste Water	5	3	0	0	4
Natural Gas	1	1	0	0	0
Oil Systems	0	0	0	0	0
Electrical Power	0	0	0	0	0
Communication	2	2	0	1	2

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

System	Total Pipelines Length (kms)	Number of Leaks	Number of Breaks
Potable Water	3,868	390	98
Waste Water	2,321	309	77
Natural Gas	1,547	330	82
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	5,075	125	3	0	0	0
Electric Power		929	617	280	59	1

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 2 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 94 households to be displaced due to the earthquake. Of these, 18 people (out of a total population of 12,442) 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	0	0	0	0
	Commuting	0	0	0	0
	Educational	0	0	0	0
	Hotels	3	1	0	0
	Industrial	0	0	0	0
	Other-Residential	10	2	0	0
	Single Family	21	5	1	1
	Total	35	8	1	2
2 PM	Commercial	17	5	1	1
	Commuting	0	0	0	0
	Educational	4	1	0	0
	Hotels	1	0	0	0
	Industrial	3	1	0	0
	Other-Residential	2	0	0	0
	Single Family	4	1	0	0
	Total	31	8	1	2
5 PM	Commercial	16	4	1	1
	Commuting	0	0	1	0
	Educational	0	0	0	0
	Hotels	1	0	0	0
	Industrial	2	1	0	0
	Other-Residential	4	1	0	0
	Single Family	8	2	0	1
	Total	31	8	2	2

Economic Loss

The total economic loss estimated for the earthquake is 184.15 (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 98.27 (millions of dollars); 15 % of the estimated losses were related to the business interruption of the region. By far, the largest loss was sustained by the residential occupancies which made up over 74 % 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 Losses							
	Wage	0.00	1.36	3.21	0.07	0.11	4.76
	Capital-Related	0.00	0.58	3.70	0.04	0.02	4.35
	Rental	1.82	2.27	1.15	0.01	0.06	5.31
	Relocation	0.19	0.03	0.04	0.00	0.01	0.29
	Subtotal	2.01	4.24	8.11	0.13	0.21	14.70
Capital Stock Losses							
	Structural	8.43	2.53	2.27	0.35	0.35	13.93
	Non_Structural	30.21	12.45	6.92	1.28	1.04	51.90
	Content	9.41	3.31	3.46	0.74	0.53	17.44
	Inventory	0.00	0.00	0.13	0.16	0.01	0.30
	Subtotal	48.05	18.28	12.79	2.53	1.93	83.58
	Total	50.05	22.52	20.90	2.66	2.14	98.27

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	1,081.00	\$0.00	0.00
	Bridges	33.13	\$2.05	6.18
	Tunnels	0.00	\$0.00	0.00
	Subtotal	1114.10	2.00	
Railways	Segments	91.69	\$0.00	0.00
	Bridges	0.58	\$0.00	0.48
	Tunnels	0.00	\$0.00	0.00
	Facilities	4.23	\$1.28	30.33
	Subtotal	96.50	1.30	
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	0.00	\$0.00	0.00
	Subtotal	0.00	0.00	
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	10.57	\$3.73	35.29
	Runways	60.30	\$0.00	0.00
	Subtotal	70.90	3.70	
	Total	1281.50	7.10	

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	0.00	\$0.00	0.00
	Distribution Line	77.40	\$1.76	2.27
	Subtotal	77.37	\$1.76	
Waste Water	Pipelines	0.00	\$0.00	0.00
	Facilities	323.00	\$73.52	22.76
	Distribution Line	46.40	\$1.39	2.99
	Subtotal	369.43	\$74.91	
Natural Gas	Pipelines	0.00	\$0.00	0.00
	Facilities	1.10	\$0.61	57.37
	Distribution Line	30.90	\$1.48	4.80
	Subtotal	32.00	\$2.09	
Oil Systems	Pipelines	0.00	\$0.00	0.00
	Facilities	0.00	\$0.00	0.00
	Subtotal	0.00	\$0.00	
Electrical Power	Facilities	0.00	\$0.00	0.00
	Subtotal	0.00	\$0.00	
Communication	Facilities	0.20	\$0.05	27.63
	Subtotal	0.19	\$0.05	
	Total	479.00	\$78.81	

Table 15. Indirect Economic Impact with outside aid

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

LOSS	Total	%

Appendix A: County Listing for the Region

Grand,CO

Appendix B: Regional Population and Building Value Data

State	County Name	Population	Building Value (millions of dollars)		
			Residential	Non-Residential	Total
Colorado	Grand	12,442	1,183	187	1,371
Total State		12,442	1,183	187	1,371
Total Region		12,442	1,183	187	1,371