Hazus-MH: Earthquake Event Report

Region Name   Cheraw

Earthquake Scenario: Cheraw fault 7.0

Print Date: June 06, 2013

Totals only reflect data for those census tracts/blocks included in the user's study region.

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 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 1,972 thousand households in the region which has a total population of 5,029,191 people (2002 Census Bureau data). The distribution of population by State and County is provided in Appendix B.

There are an estimated 2,336 thousand buildings in the region with a total building replacement value (excluding contents) of 470,159 (millions of dollars). Approximately 93.00 % of the buildings (and 76.00% of the building value) are associated with residential housing.

The replacement value of the transportation and utility lifeline systems is estimated to be 94,500 and 21,887 (millions of dollars) , respectively.

Building Inventory

Hazus estimates that there are 2,336 thousand buildings in the region which have an aggregate total replacement value of 470,159 (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 68% 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 facilities (HPL). 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 110 hospitals in the region with a total bed capacity of 0 beds. There are 2,163 schools, 928 fire stations, 340 police stations and 100 emergency operation facilities. With respect to high potential loss facilities (HPL), 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 1 and 2.

The total value of the lifeline inventory is over 116,387.00 (millions of dollars). This inventory includes over 16,175 kilometers of highways, 7,750 bridges, 396,385 kilometers of pipes.

Table 1: Transportation System Lifeline Inventory

System	Component	# Locations/ # Segments	Replacement value (millions of dollars)
Highway	Bridges	7,750	7,441.40
	Segments	2,803	77,879.70
	Tunnels	30	123.70
	Subtotal		**85,444.80**
Railways	Bridges	132	17.30
	Facilities	33	87.90
	Segments	2,457	4,865.10
	Tunnels	0	0.00
	Subtotal		**4,970.30**
Light Rail	Bridges	1	0.30
	Facilities	31	82.60
	Segments	33	23.40
	Tunnels	0	0.00
	Subtotal		**106.20**
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	53	564.50
	Runways	89	3,378.80
	Subtotal		**3,943.30**
	Total		**94,500.70**

Table 2: 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	181	0.00
	Pipelines	20,449	7,372.70
	Subtotal		**9,218.00**
Oil Systems	Facilities	21	0.00
	Pipelines	1,430	1,344.10
	Subtotal		**1,344.10**
Electrical Power	Facilities	694	0.00
	Subtotal		**0.00**
Communication	Facilities	250	24.30
	Subtotal		**24.30**
	Total		**31,114.40**

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	Cheraw fault 7.0
Type of Earthquake	Arbitrary
Fault Name	NA
Historical Epicenter ID #	NA
Probabilistic Return Period	NA
Longitude of Epicenter	-103.42
Latitude of Epicenter	38.28
Earthquake Magnitude	7.00
Depth (Km)	10.00
Rupture Length (Km)	35.48
Rupture Orientation (degrees)	44.00
Attenuation Function	Central & East US (CEUS 2008)

Building Damage

Hazus estimates that about 43,883 buildings will be at least moderately damaged. This is over 2.00 % of the buildings in the region. There are an estimated 2,117 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 3 below summarizes the expected damage by general occupancy for the buildings in the region. Table 4 below summarizes the expected damage by general building type.

Table 3: Expected Building Damage by Occupancy

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Agriculture	8,065	0.37	449	0.45	254	0.72	70	1.12	42	1.96
Commercial	91,308	4.16	5,972	5.94	3,045	8.58	691	11.00	275	13.01
Education	2,029	0.09	122	0.12	65	0.18	16	0.25	9	0.42
Government	3,582	0.16	217	0.22	118	0.33	33	0.53	23	1.10
Industrial	28,986	1.32	1,896	1.89	1,029	2.90	212	3.37	54	2.56
Other Residential	613,863	28.00	31,924	31.77	12,453	35.10	1,765	28.09	609	28.79
Religion	6,763	0.31	402	0.40	203	0.57	47	0.75	29	1.36
Single Family	1,437,734	65.58	59,506	59.22	18,316	51.62	3,448	54.88	1,075	50.79
Total	**2,192,331**		**100,488**		**35,484**		**6,282**		**2,117**	

Table 4: Expected Building Damage by Building Type (All Design Levels)

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Wood	1,532,138	69.89	57241	56.96	9,298	26.20	1,096	17.45	291	13.76
Steel	50,791	2.32	3814	3.80	2,444	6.89	512	8.16	167	7.90
Concrete	59,123	2.70	3712	3.69	1,448	4.08	231	3.68	113	5.34
Precast	28,134	1.28	1868	1.86	1,444	4.07	379	6.03	94	4.43
RM	354,002	16.15	15537	15.46	10,319	29.08	2,293	36.50	744	35.14
URM	58,353	2.66	7258	7.22	3,974	11.20	958	15.25	291	13.76
MH	109,789	5.01	11056	11.00	6,557	18.48	812	12.93	417	19.67
Total	2,192,331		100,488		35,484		6,282		2,117	

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

Essential Facility Damage

Before the earthquake, the region had 0 hospital beds available for use. On the day of the earthquake, the model estimates that only 0 hospital beds (86.00%) 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 5: Expected Damage to Essential Facilities

Classification	Total	# Facilities		
		At Least Moderate Damage > 50%	Complete Damage > 50%	With Functionality > 50% on day 1
Hospitals	110	1	0	109
Schools	2,163	28	18	2,117
EOCs	100	0	0	97
PoliceStations	340	0	0	333
FireStations	928	2	0	917

Transportation and Utility Lifeline Damage

Table 6 provides damage estimates for the transportation system.

Table 6: Expected Damage to the Transportation Systems

System	Component	Locations/ Segments	Number of Locations		With Functionality > 50 %	
			With at Least Mod. Damage	With Complete Damage	After Day 1	After Day 7
Highway	Segments	2,803	0	0	2,803	2,803
	Bridges	7,750	75	25	7,680	7,699
	Tunnels	30	0	0	30	30
Railways	Segments	2,457	0	0	2,457	2,457
	Bridges	132	0	0	132	132
	Tunnels	0	0	0	0	0
	Facilities	33	1	0	33	33
Light Rail	Segments	33	0	0	33	33
	Bridges	1	0	0	1	1
	Tunnels	0	0	0	0	0
	Facilities	31	0	0	31	31
Bus	Facilities	34	1	0	34	34
Ferry	Facilities	0	0	0	0	0
Port	Facilities	0	0	0	0	0
Airport	Facilities	53	1	0	52	52
	Runways	89	0	0	89	89

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 7-9 provide information on the damage to the utility lifeline systems. Table 7 provides damage to the utility system facilities. Table 8 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 9 provides a summary of the system performance information.

Table 7 : 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	1	0	28	29
Waste Water	189	2	0	186	188
Natural Gas	181	0	0	181	181
Oil Systems	21	0	0	21	21
Electrical Power	694	21	0	678	694
Communication	250	3	0	248	250

Table 8 : Expected Utility System Pipeline Damage (Site Specific)

System	Total Pipelines Length (kms)	Number of Leaks	Number of Breaks
Potable Water	230,673	8246	2061
Waste Water	138,404	4142	1036
Natural Gas	22,675	288	72
Oil	4,635	214	53

Table 9: 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	1,972,869	8,616	6,603	5,770	0	0
Electric Power		91,403	14,936	4,072	2,209	1,888

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 1.27 million tons of debris will be generated. Of the total amount, Brick/Wood comprises 38.00% 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 50,800 truckloads (@25 tons/truck) to remove the debris generated by the earthquake.

<u>Shelter Requirement</u>

Hazus estimates the number of households that are expected to be displaced from their homes due to the earthquake and the number of displaced people that will require accommodations in temporary public shelters. The model estimates 2,065 households to be displaced due to the earthquake. Of these, 1,426 people (out of a total population of 5,029,191) will seek temporary shelter in public shelters.

<u>Casualties</u>

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 10 provides a summary of the casualties estimated for this earthquake

Table 10: Casualty Estimates

		Level 1	Level 2	Level 3	Level 4
2 AM	Commercial	7	1	0	0
	Commuting	0	0	0	0
	Educational	0	0	0	0
	Hotels	5	1	0	0
	Industrial	7	1	0	0
	Other-Residential	230	45	5	9
	Single Family	489	103	14	28
	Total	**739**	**151**	**20**	**37**
2 PM	Commercial	452	93	13	25
	Commuting	1	2	3	1
	Educational	596	140	21	41
	Hotels	1	0	0	0
	Industrial	54	9	1	2
	Other-Residential	50	10	1	2
	Single Family	101	23	3	6
	Total	**1,255**	**277**	**42**	**76**
5 PM	Commercial	369	79	11	21
	Commuting	46	58	102	20
	Educational	88	20	3	6
	Hotels	2	0	0	0
	Industrial	34	6	1	1
	Other-Residential	86	17	2	3
	Single Family	190	40	6	11
	Total	**814**	**220**	**124**	**62**

The total economic loss estimated for the earthquake is 3,306.26 (millions of dollars), which includes building and lifeline related losses based on the region's available inventory. The following three sections provide more detailed information about these losses.

Building-Related Losses

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

The total building-related losses were 3,014.77 (millions of dollars); 24 % 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 53 % of the total loss. Table 11 below provides a summary of the losses associated with the building damage.

Table 11: Building-Related Economic Loss Estimates

(Millions of dollars)

Category	Area	Single Family	Other Residential	Commercial	Industrial	Others	Total
Income Losses							
	Wage	0.00	8.41	122.89	3.33	22.18	156.81
	Capital-Related	0.00	3.56	99.63	2.02	5.91	111.12
	Rental	32.47	29.70	59.53	1.50	8.00	131.22
	Relocation	118.12	26.91	98.07	8.23	75.47	326.80
	Subtotal	**150.59**	**68.59**	**380.13**	**15.09**	**111.56**	**725.96**
Capital Stock Losses							
	Structural	245.36	57.69	111.17	18.77	65.41	498.39
	Non_Structural	681.41	209.27	252.62	39.35	183.13	1,365.78
	Content	157.77	39.48	114.40	22.97	81.45	416.06
	Inventory	0.00	0.00	2.73	4.98	0.87	8.58
	Subtotal	**1,084.54**	**306.43**	**480.92**	**86.07**	**330.85**	**2,288.81**
	Total	**1,235.13**	**375.02**	**861.05**	**101.16**	**442.41**	**3,014.77**

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 12 & 13 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 14 presents the results of the region for the given earthquake.

Table 12: Transportation System Economic Losses
(Millions of dollars)

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Highway	Segments	77,879.68	$0.00	0.00
	Bridges	7,441.42	$93.86	1.26
	Tunnels	123.75	$0.00	0.00
	Subtotal	**85444.80**	**93.90**	
Railways	Segments	4,865.14	$0.00	0.00
	Bridges	17.32	$0.07	0.38
	Tunnels	0.00	$0.00	0.00
	Facilities	87.88	$2.74	3.12
	Subtotal	**4970.30**	**2.80**	
Light Rail	Segments	23.37	$0.00	0.00
	Bridges	0.32	$0.00	0.06
	Tunnels	0.00	$0.00	0.00
	Facilities	82.55	$1.77	2.15
	Subtotal	**106.20**	**1.80**	
Bus	Facilities	35.95	$1.09	3.05
	Subtotal	**35.90**	**1.10**	
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	564.50	$19.13	3.39
	Runways	3,378.80	$0.00	0.00
	Subtotal	**3943.30**	**19.10**	
	Total	**94500.70**	**118.70**	

Table 13: 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	936.70	$9.66	1.03
	Distribution Line	4,613.50	$37.11	0.80
	Subtotal	**5,550.18**	**$46.77**	
Waste Water	Pipelines	0.00	$0.00	0.00
	Facilities	12,209.80	$99.61	0.82
	Distribution Line	2,768.10	$18.64	0.67
	Subtotal	**14,977.85**	**$118.25**	
Natural Gas	Pipelines	7,372.70	$0.75	0.01
	Facilities	0.00	$0.00	0.00
	Distribution Line	1,845.40	$6.39	0.35
	Subtotal	**9,218.05**	**$7.14**	
Oil Systems	Pipelines	1,344.10	$0.45	0.03
	Facilities	0.00	$0.00	0.00
	Subtotal	**1,344.11**	**$0.45**	
Electrical Power	Facilities	0.00	$0.00	0.00
	Subtotal	**0.00**	**$0.00**	
Communication	Facilities	24.30	$0.22	0.93
	Subtotal	**24.25**	**$0.22**	
	Total	**31,114.44**	**$172.83**	

Table 14. Indirect Economic Impact with outside aid
(Employment as # of people and Income in millions of $)

LOSS		Total	%

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 Carson,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	469,765	27,724	7,864	35,589
	Alamosa	15,445	875	649	1,525
	Arapahoe	572,179	40,061	12,154	52,216
	Archuleta	12,084	1,181	209	1,390
	Baca	3,788	277	175	452
	Bent	6,499	323	78	402
	Boulder	318,008	24,494	9,001	33,495
	Chaffee	17,807	1,392	442	1,835
	Cheyenne	1,836	161	80	242
	Clear Creek	9,088	930	205	1,135
	Conejos	8,256	518	187	705
	Costilla	3,525	268	82	351
	Crowley	5,823	230	48	278
	Custer	4,255	491	81	572
	Delta	30,952	1,868	518	2,386
	Denver	599,931	42,070	19,348	61,419
	Dolores	2,064	196	38	234
	Douglas	285,467	25,824	4,320	30,144
	Eagle	52,197	4,725	971	5,696
	Elbert	23,086	1,920	353	2,273
	El Paso	622,262	43,740	13,503	57,243
	Fremont	46,824	2,621	722	3,343
	Garfield	56,389	3,377	1,152	4,529
	Gilpin	5,443	602	97	699
	Grand	14,843	2,379	473	2,853
	Gunnison	15,324	1,566	512	2,078
	Hinsdale	843	275	22	297
	Huerfano	6,711	705	195	900
	Jackson	1,394	135	37	172
	Jefferson	537,539	42,271	10,571	52,842
	Kiowa	1,398	133	134	267
	Kit Carson	8,270	457	230	687
	Lake	7,310	570	202	773
	La Plata	51,333	3,655	1,364	5,019
	Larimer	299,630	19,529	6,775	26,304
	Las Animas	15,507	1,077	399	1,477
	Lincoln	5,467	332	162	494
	Logan	22,708	1,321	503	1,824
	Mesa	146,723	8,464	2,855	11,320
	Mineral	712	212	20	233
	Moffat	13,793	749	235	984
	Montezuma	25,535	1,480	469	1,949
	Montrose	41,276	2,357	823	3,180
	Morgan	28,159	1,520	620	2,140

Otero	18,831	1,285	511	1,797
Ouray	4,436	394	117	512
Park	16,208	2,248	214	2,463
Phillips	4,442	287	202	490
Pitkin	17,148	1,977	652	2,629
Prowers	12,551	778	309	1,088
Pueblo	159,063	10,036	3,063	13,099
Rio Blanco	6,666	501	272	774
Rio Grande	11,982	897	312	1,210
Routt	23,511	2,269	564	2,834
Saguache	6,108	456	163	620
San Juan	699	114	55	170
San Miguel	7,359	907	188	1,095
Sedgwick	2,379	174	154	329
Summit	27,994	4,176	750	4,926
Teller	23,350	2,062	463	2,526
Washington	4,814	352	106	458
Weld	254,159	14,260	4,009	18,269
Yuma	10,043	563	326	890
Total State	**5,029,191**	**358,791**	**111,308**	**470,125**
Total Region	**5,029,191**	**358,791**	**111,308**	**470,125**