

Hazus-MH: Earthquake Event Report

Region Name: Denver County Rampart fault 2010Census

Earthquake Scenario: Rampart Range fault 7.0

Print Date: March 11, 2013

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

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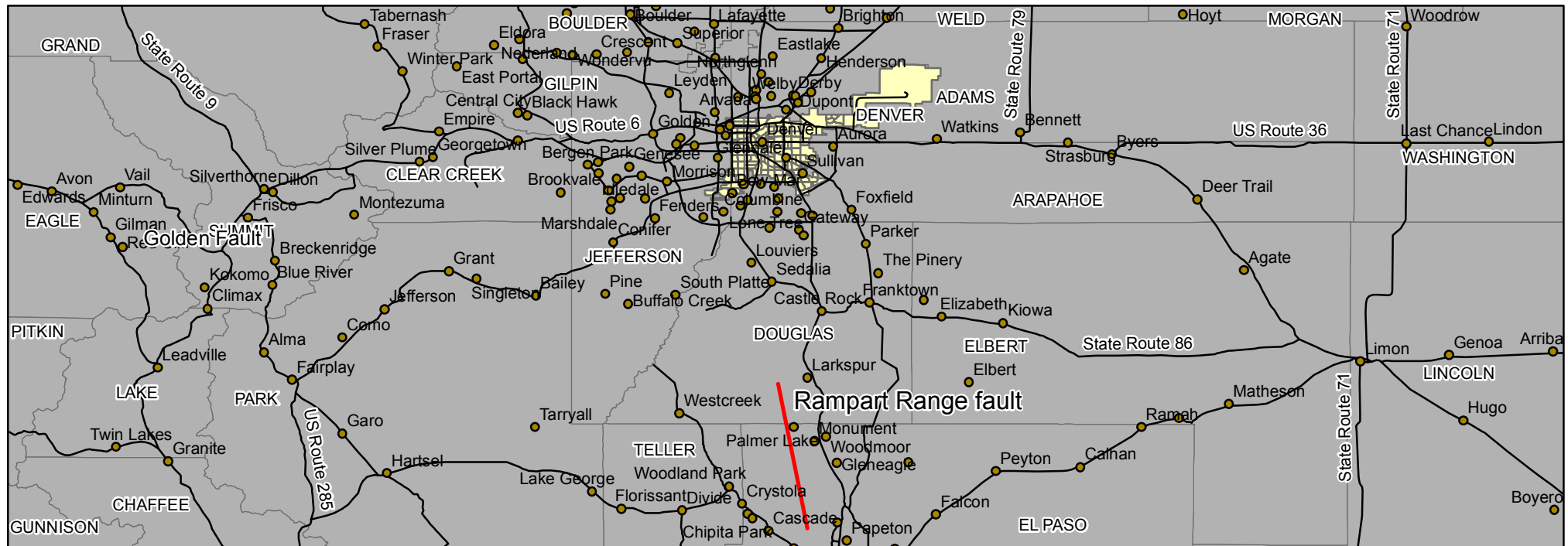
Disclaimer:

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.

Study Region: Denver County

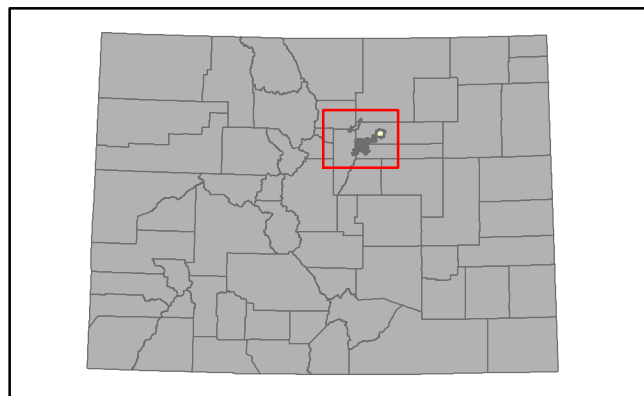
Overview Map

Hazard Scenario: Rampart Range Fault 7



Legend

- Cities
- Roads
- Fault
- Study Region Tract



Created by: Colorado Geological Survey

Team: Matt Morgan and Scot Fitzgerald

Date Created: March 2013

Location: Denver County Colorado

Fault Parameters: arbitrary, magnitude 7, depth 10km

Data: Changed to CGS Landslides and CGS/FEMA Soils data

Projection: GCS North American 1983

0 15 30 60 Miles



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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 154.74 square miles and contains 136 census tracts. There are over 262 thousand households in the region which has a total population of 599,931 people (2002 Census Bureau data). The distribution of population by State and County is provided in Appendix B.

There are an estimated 301 thousand buildings in the region with a total building replacement value (excluding contents) of 61,419 (millions of dollars). Approximately 93.00 % of the buildings (and 68.00% of the building value) are associated with residential housing.

The replacement value of the transportation and utility lifeline systems is estimated to be 4,203 and 52 (millions of dollars) , respectively.

Building and Lifeline Inventory

Building Inventory

Hazus estimates that there are 301 thousand buildings in the region which have an aggregate total replacement value of 61,419 (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 71% 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 13 hospitals in the region with a total bed capacity of 0 beds. There are 215 schools, 33 fire stations, 15 police stations and 1 emergency operation facilities. With respect to high potential loss facilities (HPL), there are 8 dams identified within the region. Of these, 5 of the dams are classified as 'high hazard'. The inventory also includes 74 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 1 and 2.

The total value of the lifeline inventory is over 4,255.00 (millions of dollars). This inventory includes over 292 kilometers of highways, 426 bridges, 5,376 kilometers of pipes.

Table 1: Transportation System Lifeline Inventory

System	Component	# Locations/ # Segments	Replacement value (millions of dollars)
Highway	Bridges	426	1,461.00
	Segments	357	2,265.10
	Tunnels	0	0.00
	Subtotal		3,726.10
Railways	Bridges	25	2.00
	Facilities	10	26.60
	Segments	208	120.00
	Tunnels	0	0.00
	Subtotal		148.70
Light Rail	Bridges	1	0.30
	Facilities	26	69.20
	Segments	28	14.30
	Tunnels	0	0.00
	Subtotal		83.80
Bus	Facilities	6	6.30
	Subtotal		6.30
Ferry	Facilities	0	0.00
	Subtotal		0.00
Port	Facilities	0	0.00
	Subtotal		0.00
Airport	Facilities	1	10.70
	Runways	6	227.80
	Subtotal		238.40
		Total	4,203.40

Table 2: Utility System Lifeline Inventory

System	Component	# Locations / Segments	Replacement value (millions of dollars)
Potable Water	Distribution Lines	NA	65.10
	Facilities	0	0.00
	Pipelines	0	0.00
	Subtotal		65.10
Waste Water	Distribution Lines	NA	39.10
	Facilities	0	0.00
	Pipelines	0	0.00
	Subtotal		39.10
Natural Gas	Distribution Lines	NA	26.00
	Facilities	1	0.00
	Pipelines	99	33.40
	Subtotal		59.50
Oil Systems	Facilities	2	0.00
	Pipelines	47	18.60
	Subtotal		18.60
Electrical Power	Facilities	25	0.00
	Subtotal		0.00
Communication	Facilities	2	0.20
	Subtotal		0.20
		Total	182.40

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	Rampart Range fault 7.0
Type of Earthquake	Arbitrary
Fault Name	NA
Historical Epicenter ID #	NA
Probabilistic Return Period	NA
Longitude of Epicenter	-104.92
Latitude of Epicenter	39.06
Earthquake Magnitude	7.00
Depth (Km)	10.00
Rupture Length (Km)	35.48
Rupture Orientation (degrees)	171.00
Attenuation Function	Central & East US (CEUS 2008)

Building Damage

Building Damage

Hazus estimates that about 92,820 buildings will be at least moderately damaged. This is over 31.00 % of the buildings in the region. There are an estimated 20,118 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	167	0.12	79	0.12	82	0.18	82	0.30	82	0.41
Commercial	2,747	1.95	1,560	2.29	3,268	7.13	3,428	12.76	2,989	14.86
Education	75	0.05	31	0.05	42	0.09	45	0.17	41	0.20
Government	68	0.05	46	0.07	112	0.24	143	0.53	124	0.62
Industrial	709	0.50	385	0.57	817	1.78	903	3.36	838	4.16
Other Residential	55,884	39.67	30,906	45.42	20,303	44.29	11,604	43.20	9,672	48.07
Religion	325	0.23	154	0.23	212	0.46	236	0.88	210	1.04
Single Family	80,880	57.42	34,884	51.27	21,006	45.82	10,420	38.79	6,164	30.64
Total	140,855		68,046		45,841		26,861		20,118	

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

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Wood	120,911	85.84	59,617	87.61	27,560	60.12	4,744	17.66	674	3.35
Steel	978	0.69	512	0.75	1,657	3.61	2,935	10.93	4,054	20.15
Concrete	2,033	1.44	1,209	1.78	2,743	5.98	3,371	12.55	3,047	15.14
Precast	752	0.53	315	0.46	829	1.81	1,183	4.40	1,396	6.94
RM	12,714	9.03	3,712	5.46	8,854	19.31	10,929	40.69	8,012	39.82
URM	2,344	1.66	1,689	2.48	2,293	5.00	1,646	6.13	1,138	5.66
MH	1,123	0.80	993	1.46	1,906	4.16	2,053	7.64	1,796	8.93
Total	140,855		68,046		45,841		26,861		20,118	

*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 (14.00%) 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, 62.00% 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	13	11	0	2
Schools	215	151	1	61
EOCs	1	0	0	1
PoliceStations	15	0	0	7
FireStations	33	0	0	19

Transportation and Utility Lifeline Damage

Table 6 provides damage estimates for the transportation system.

Table 6: 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	357	0	0	357	357
	Bridges	426	28	0	400	405
	Tunnels	0	0	0	0	0
Railways	Segments	208	0	0	208	208
	Bridges	25	0	0	25	25
	Tunnels	0	0	0	0	0
	Facilities	10	0	0	10	10
Light Rail	Segments	28	0	0	28	28
	Bridges	1	0	0	1	1
	Tunnels	0	0	0	0	0
	Facilities	26	0	0	26	26
Bus	Facilities	6	0	0	6	6
Ferry	Facilities	0	0	0	0	0
Port	Facilities	0	0	0	0	0
Airport	Facilities	1	0	0	1	1
	Runways	6	0	0	6	6

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	0	0	0	0	0
Waste Water	0	0	0	0	0
Natural Gas	1	0	0	1	1
Oil Systems	2	0	0	1	2
Electrical Power	25	9	0	10	25
Communication	2	0	0	2	2

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

System	Total Pipelines Length (kms)	Number of Leaks	Number of Breaks
Potable Water	3,254	1153	288
Waste Water	1,953	579	145
Natural Gas	99	6	1
Oil	71	7	2

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	262,995	105,548	81,350	28,144	0	0
Electric Power		138,861	55,860	11,651	1,262	263

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 6 ignitions that will burn about 0.02 sq. mi 0.01 % of the region's total area.) The model also estimates that the fires will displace about 182 people and burn about 9 (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 7.00 million tons of debris will be generated. Of the total amount, Brick/Wood comprises 20.00% 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 280,080 truckloads (@25 tons/truck) to remove the debris generated by the earthquake.

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 23,809 households to be displaced due to the earthquake. Of these, 12,785 people (out of a total population of 599,931) 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 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	119	37	6	13
	Commuting	0	0	0	0
	Educational	0	0	0	0
	Hotels	44	13	2	4
	Industrial	116	36	6	12
	Other-Residential	1,388	402	62	121
	Single Family	1,750	521	90	178
	Total	3,418	1,009	166	327
2 PM	Commercial	6,455	2,005	342	675
	Commuting	1	2	3	1
	Educational	3,164	997	174	340
	Hotels	9	3	0	1
	Industrial	855	265	44	86
	Other-Residential	243	69	11	20
	Single Family	323	94	16	31
	Total	11,049	3,434	590	1,155
5 PM	Commercial	4,240	1,309	224	436
	Commuting	55	69	121	23
	Educational	729	232	41	80
	Hotels	13	4	1	1
	Industrial	534	165	28	54
	Other-Residential	529	152	23	45
	Single Family	679	199	34	66
	Total	6,780	2,130	472	705

Economic Loss

The total economic loss estimated for the earthquake is 16,744.70 (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 16,632.10 (millions of dollars); 23 % 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 35 % 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	28.93	723.05	23.04	115.03	890.05
	Capital-Related	0.00	12.33	648.52	15.43	39.48	715.75
	Rental	78.60	195.20	320.90	10.24	63.00	667.94
	Relocation	276.43	120.09	535.39	43.10	511.20	1,486.21
	Subtotal	355.03	356.54	2,227.86	91.82	728.70	3,759.96
Capital Stock Losses							
	Structural	609.74	315.24	799.20	159.93	321.83	2,205.93
	Non_Structural	1,836.92	1,626.62	2,336.55	532.01	1,434.07	7,766.17
	Content	453.01	345.01	1,017.44	335.70	662.44	2,813.60
	Inventory	0.00	0.00	25.13	60.18	1.13	86.45
	Subtotal	2,899.67	2,286.87	4,178.32	1,087.82	2,419.47	12,872.15
	Total	3,254.70	2,643.41	6,406.18	1,179.64	3,148.17	16,632.10

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	2,265.14	\$0.00	0.00
	Bridges	1,460.99	\$81.95	5.61
	Tunnels	0.00	\$0.00	0.00
	Subtotal	3726.10	82.00	
Railways	Segments	120.03	\$0.00	0.00
	Bridges	2.03	\$0.07	3.58
	Tunnels	0.00	\$0.00	0.00
	Facilities	26.63	\$5.82	21.85
	Subtotal	148.70	5.90	
Light Rail	Segments	14.27	\$0.00	0.00
	Bridges	0.32	\$0.00	1.39
	Tunnels	0.00	\$0.00	0.00
	Facilities	69.24	\$14.33	20.70
	Subtotal	83.80	14.30	
Bus	Facilities	6.34	\$1.10	17.39
	Subtotal	6.30	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	10.65	\$0.59	5.50
	Runways	227.78	\$0.00	0.00
	Subtotal	238.40	0.60	
	Total	4203.40	103.90	

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	0.00	\$0.00	0.00
	Distribution Lines	65.10	\$5.19	7.97
	Subtotal	65.08	\$5.19	
Waste Water	Pipelines	0.00	\$0.00	0.00
	Facilities	0.00	\$0.00	0.00
	Distribution Lines	39.10	\$2.61	6.67
	Subtotal	39.05	\$2.61	
Natural Gas	Pipelines	33.40	\$0.01	0.04
	Facilities	0.00	\$0.00	0.00
	Distribution Lines	26.00	\$0.89	3.43
	Subtotal	59.47	\$0.91	
Oil Systems	Pipelines	18.60	\$0.01	0.07
	Facilities	0.00	\$0.00	0.00
	Subtotal	18.64	\$0.01	
Electrical Power	Facilities	0.00	\$0.00	0.00
	Subtotal	0.00	\$0.00	
Communication	Facilities	0.20	\$0.01	4.54
	Subtotal	0.19	\$0.01	
	Total	182.44	\$8.72	

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

Denver,CO

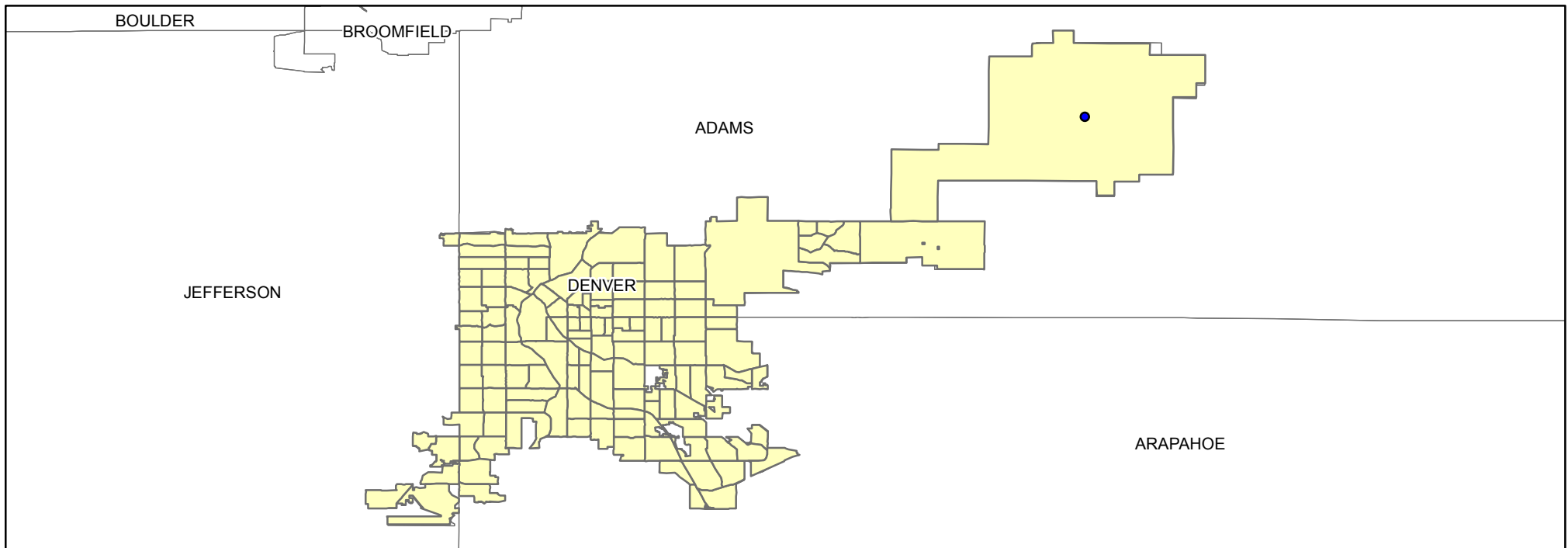
Appendix B: Regional Population and Building Value Data

State	County Name	Population	Building Value (millions of dollars)		
			Residential	Non-Residential	Total
Colorado	Denver	599,931	42,070	19,348	61,419
Total State		599,931	42,070	19,348	61,419
Total Region		599,931	42,070	19,348	61,419

Study Region: Denver County

Hazard Scenario: Rampart Range Fault 7

Airports Map



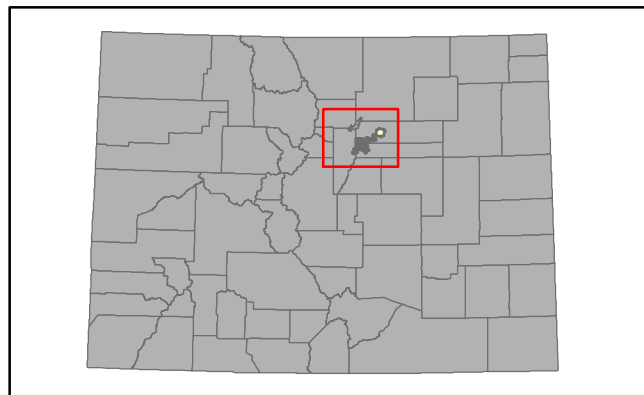
Legend

Airports

Probability Damage > Extensive

- 0 - 10%
- 10 - 20%
- 20 - 30%
- 30 - 40%
- 40 - 50%
- 50 - 70%
- 70 - 100%

Study Region Tract



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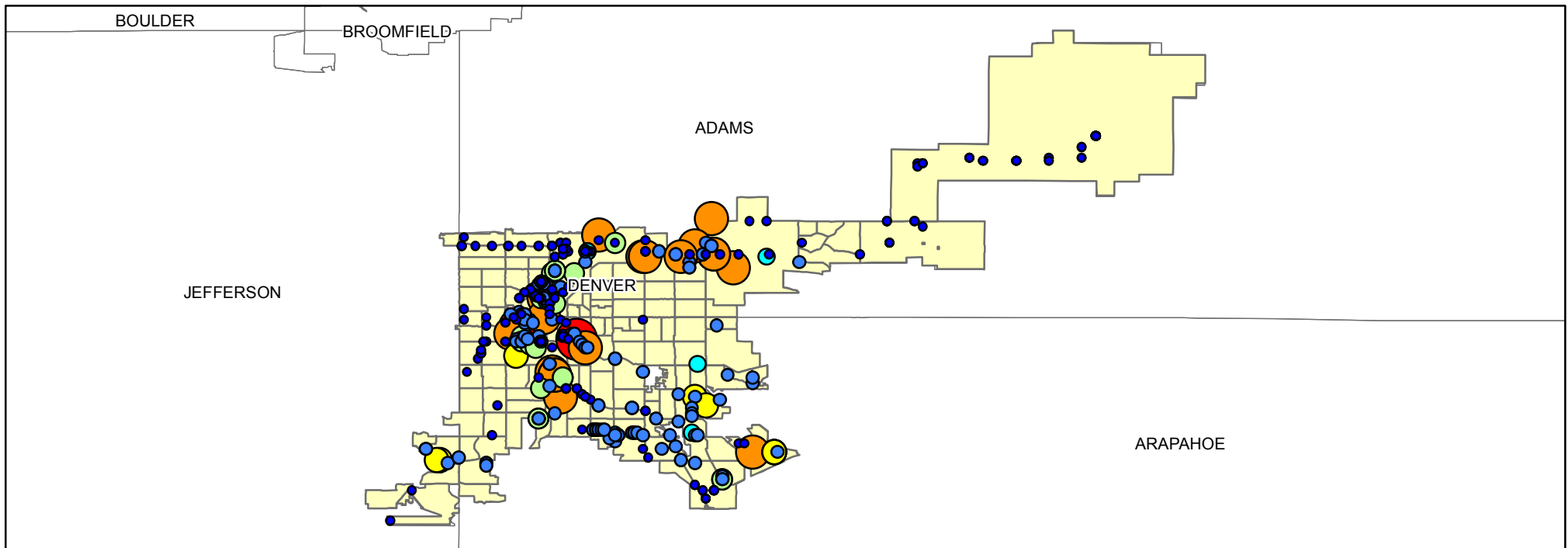
0 5 10 20 Miles



Study Region: Denver County

Bridges Map

Hazard Scenario: Rampart Range Fault 7



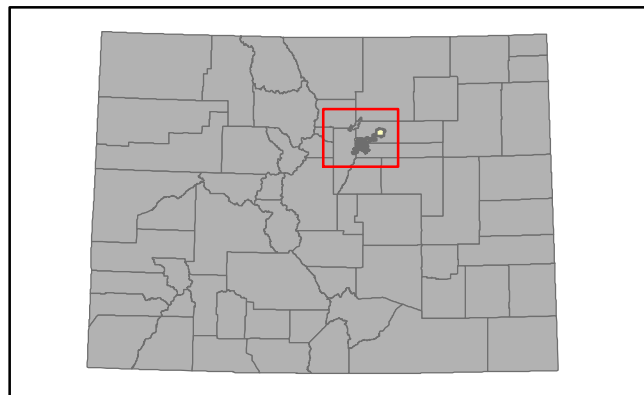
Legend

Bridges

Probability Damage > Extensive

- 0 - 10%
- 10 - 20%
- 20 - 30%
- 30 - 40%
- 40 - 50%
- 50 - 70%
- 70 - 100%

Study Region Tract



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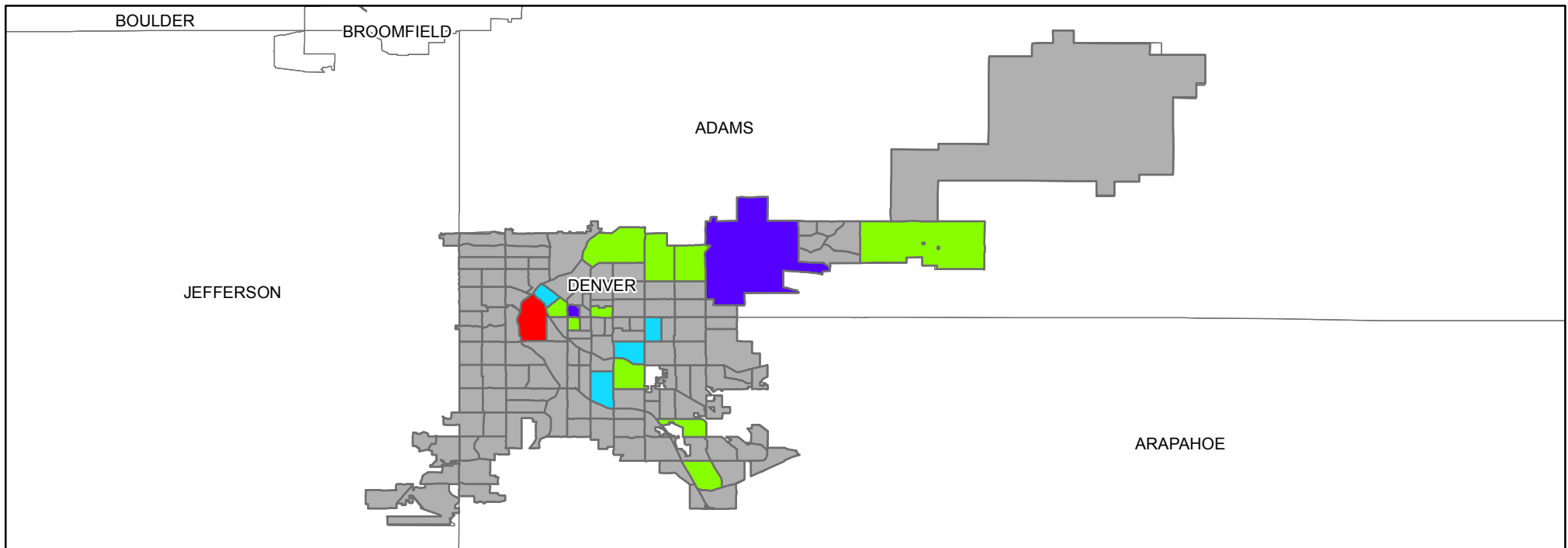


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Study Region: Denver County

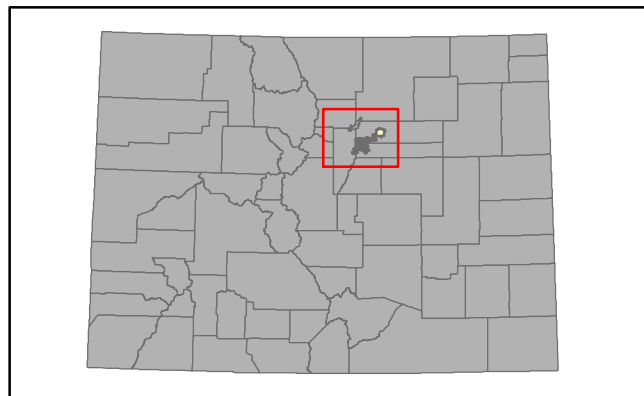
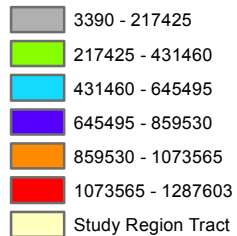
Hazard Scenario: Rampart Range Fault 7

Building Economic Loss Map



Legend

**Building Economic Loss
in Thousands of Dollars**



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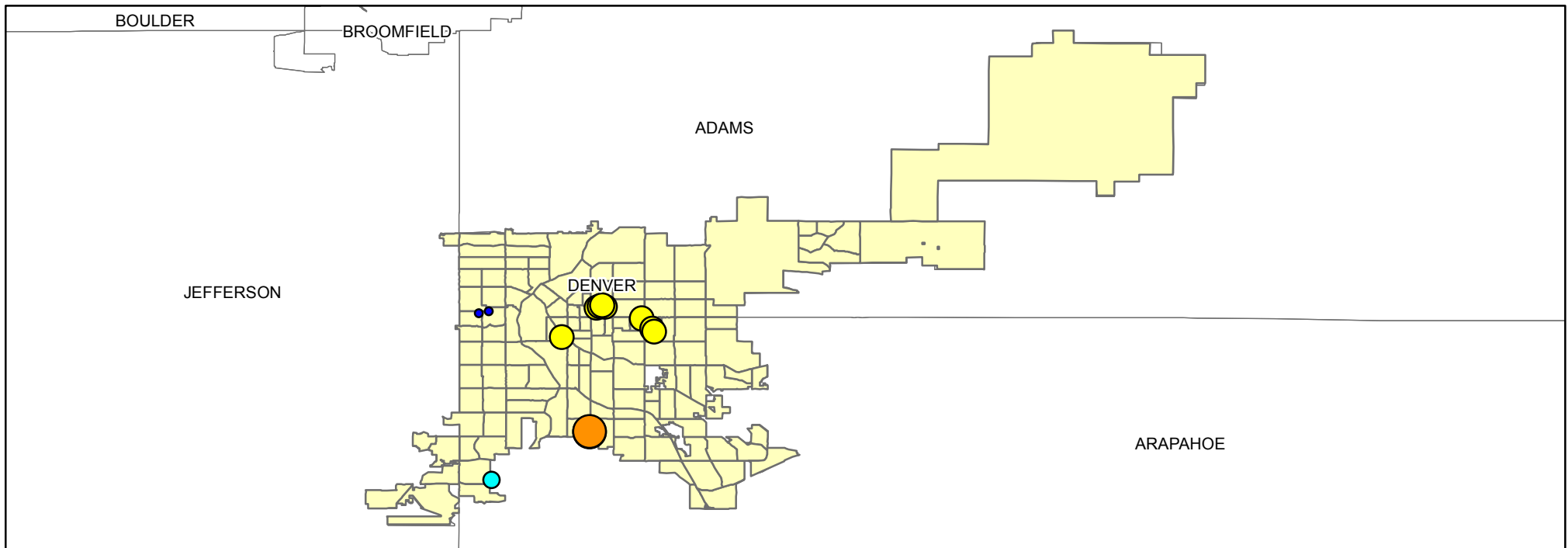


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Study Region: Denver County

Hazard Scenario: Rampart Range Fault 7

Care Facilities Map



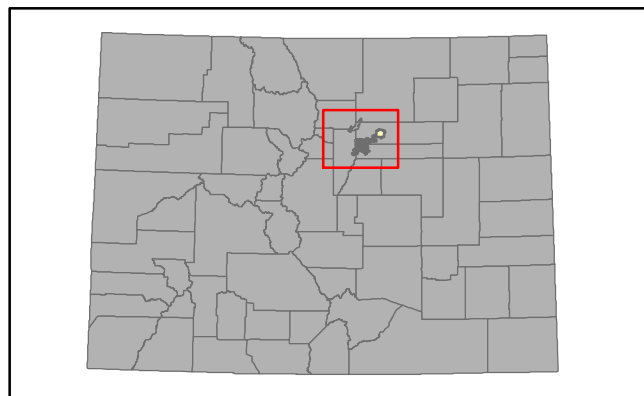
Legend

Care Facilities

Probability Damage > Extensive

- 0 - 10%
- 10 - 20%
- 20 - 30%
- 30 - 40%
- 40 - 50%
- 50 - 70%
- 70 - 100%

Study Region Tract



Created by: Colorado Geological Survey

Team: Matt Morgan and Scot Fitzgerald

Date Created: March 2013

Location: Denver County Colorado

Fault Parameters: arbitrary, magnitude 7, depth 10km

Data: Changed to CGS Landslides and CGS/FEMA Soils data

Projection: GCS North American 1983

0 5 10 20 Miles

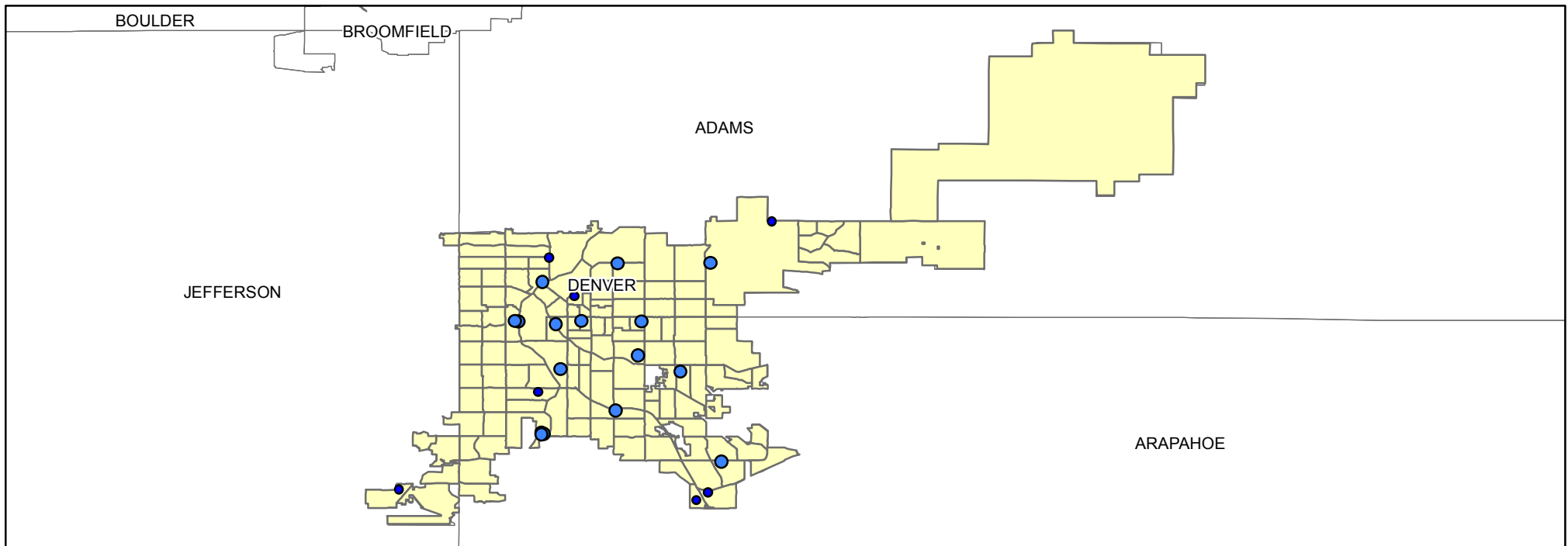


HAZUS
EARTHQUAKE • WIND • FLOOD

Study Region: Denver County

Electrical Facilities Map

Hazard Scenario: Rampart Range Fault 7

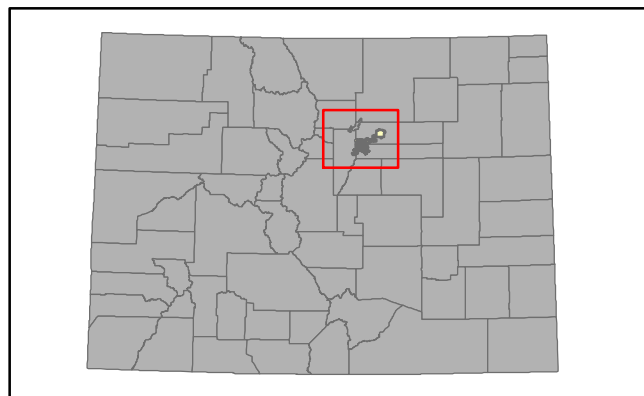


Legend

Electrical Power Facilities Probability Damage > Extensive

- 0 - 10%
- 10 - 20%
- 20 - 30%
- 30 - 40%
- 40 - 50%
- 50 - 70%
- 70 - 100%

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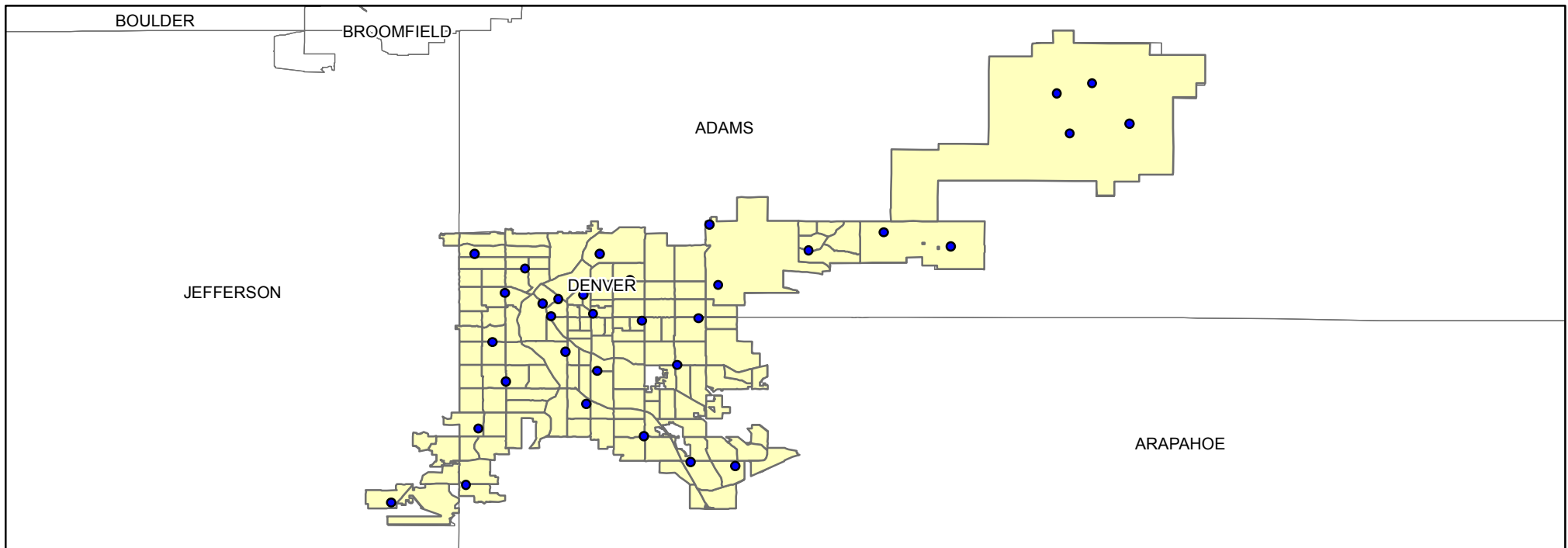


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Study Region: Denver County

Fire Stations Map

Hazard Scenario: Rampart Range Fault 7



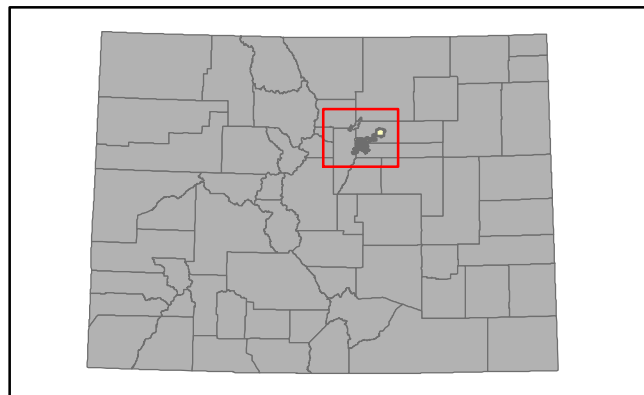
Legend

Fire Stations

Probability Damage > Extensive

- 0 - 10%
- 10 - 20%
- 20 - 30%
- 30 - 40%
- 40 - 50%
- 50 - 70%
- 70 - 100%

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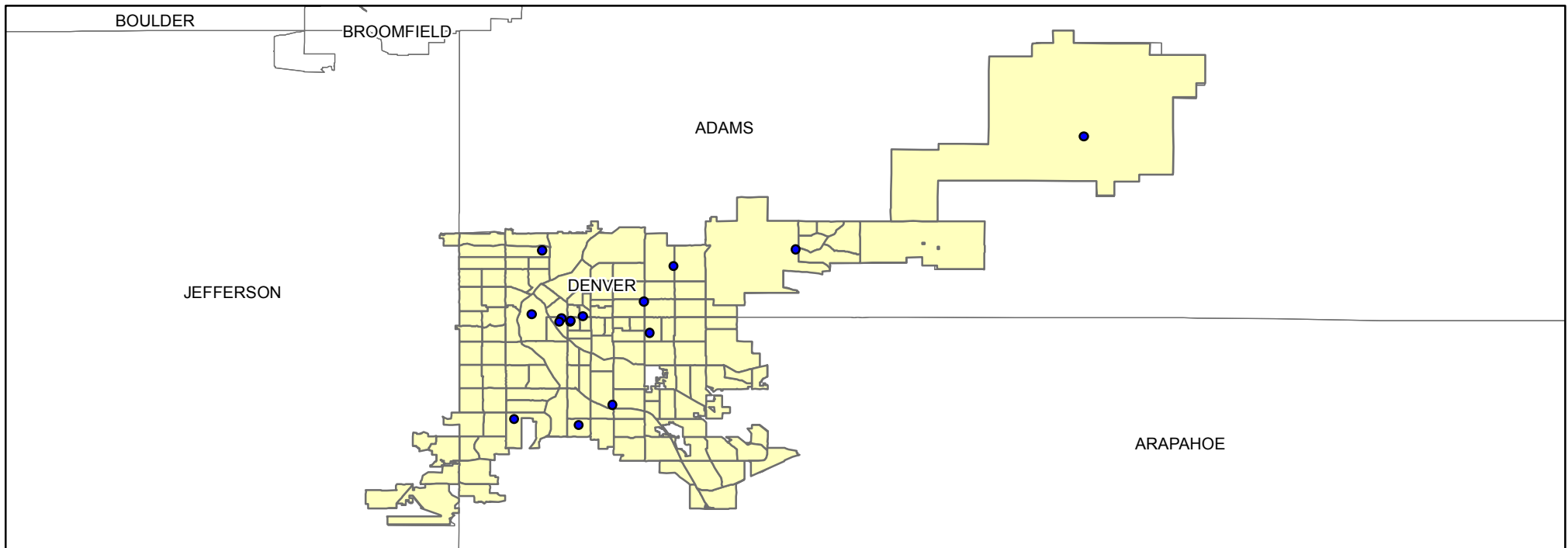


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Study Region: Denver County

Police Stations Map

Hazard Scenario: Rampart Range Fault 7



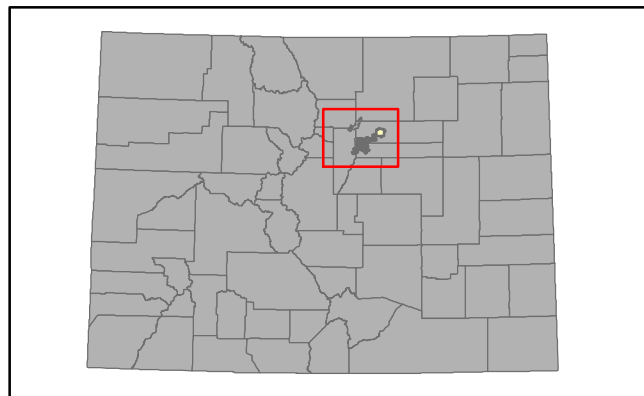
Legend

Police Stations

Probability Damage > Extensive

- 0 - 10%
- 10 - 20%
- 20 - 30%
- 30 - 40%
- 40 - 50%
- 50 - 70%
- 70 - 100%

Study Region Tract



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0 5 10 20 Miles

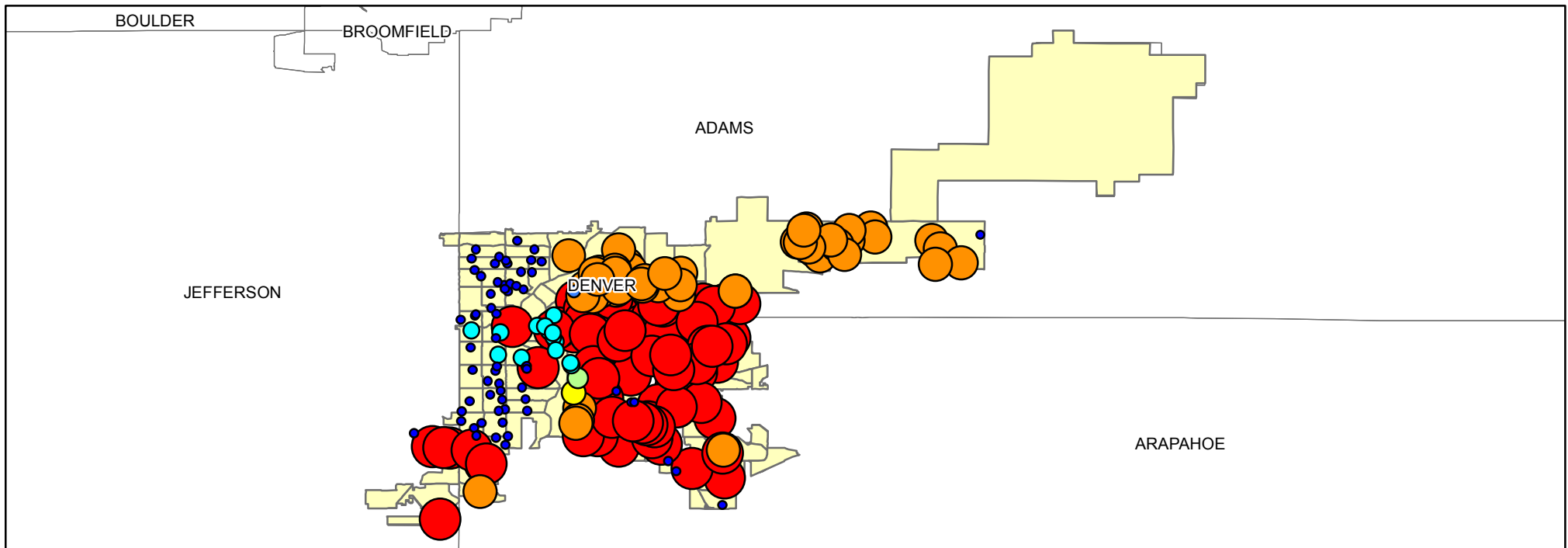


HAZUS
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Study Region: Denver County

Hazard Scenario: Rampart Range Fault 7

Schools Map



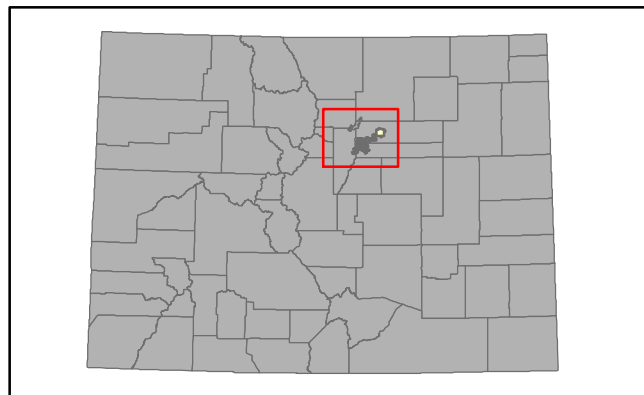
Legend

Schools

Probability Damage > Extensive

- 0 - 10%
- 10 - 20%
- 20 - 30%
- 30 - 40%
- 40 - 50%
- 50 - 70%
- 70 - 100%

Study Region Tract



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Date Created: March 2013

Location: Denver County Colorado

Fault Parameters: arbitrary, magnitude 7, depth 10km

Data: Changed to CGS Landslides and CGS/FEMA Soils data

Projection: GCS North American 1983

0 5 10 20 Miles

