

Hazus-MH: Earthquake Event Report

Region Name: Arapahoe 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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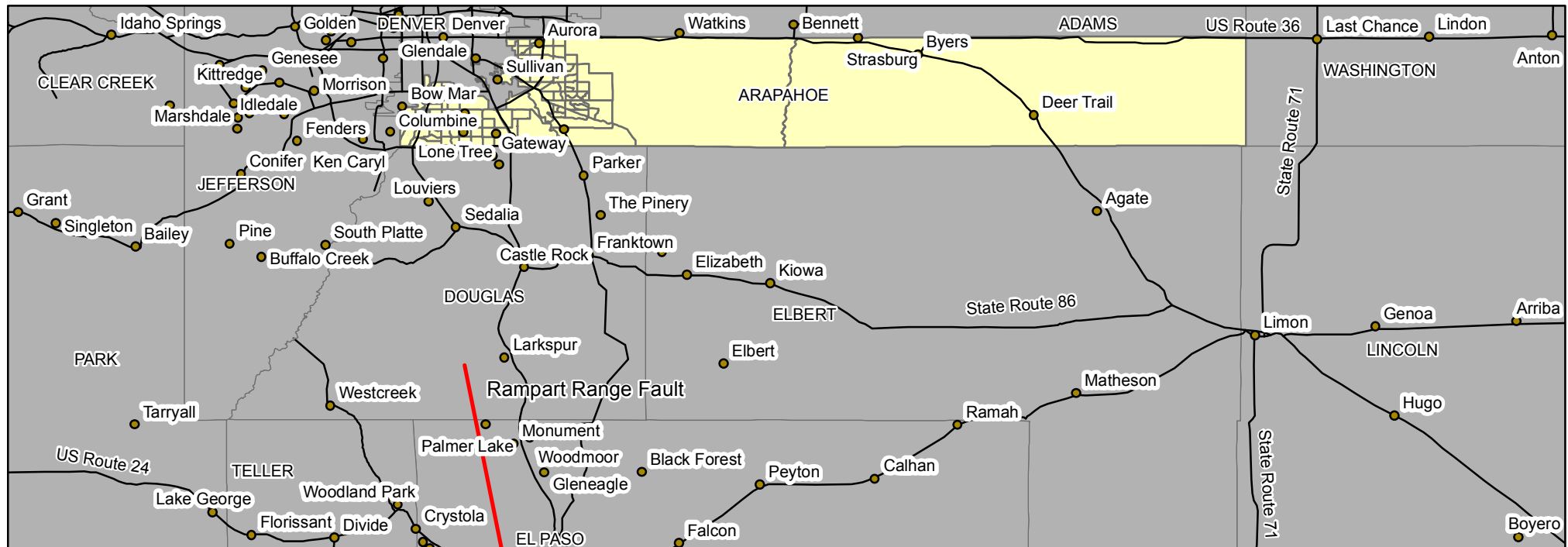
Disclaimer:

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: Arapahoe County

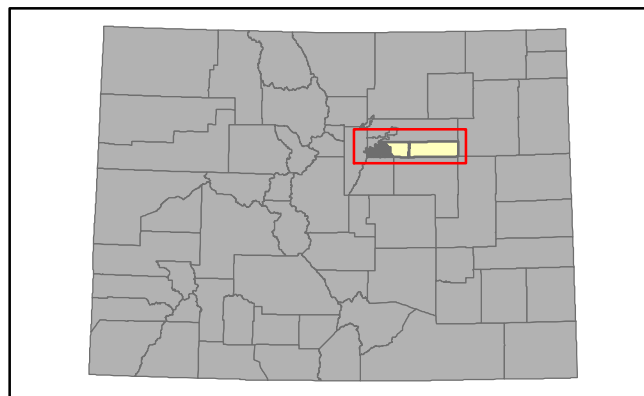
Hazard Scenario: Rampart Range Fault 7

Overview Map



Legend

- Cities
- Roads
- Fault
- Counties
- Study Region Tract



Created by: Colorado Geological Survey

Team: Matt Morgan and Scot Fitzgerald

Date Created: March 2013

Location: Arapahoe 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 10 20 40 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 804.43 square miles and contains 121 census tracts. There are over 224 thousand households in the region which has a total population of 572,179 people (2002 Census Bureau data). The distribution of population by State and County is provided in Appendix B.

There are an estimated 249 thousand buildings in the region with a total building replacement value (excluding contents) of 52,216 (millions of dollars). Approximately 94.00 % of the buildings (and 77.00% of the building value) are associated with residential housing.

The replacement value of the transportation and utility lifeline systems is estimated to be 3,255 and 542 (millions of dollars) , respectively.

Building and Lifeline Inventory

Building Inventory

Hazus estimates that there are 249 thousand buildings in the region which have an aggregate total replacement value of 52,216 (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 8 hospitals in the region with a total bed capacity of 0 beds. There are 191 schools, 39 fire stations, 16 police stations and 9 emergency operation facilities. With respect to high potential loss facilities (HPL), there are 18 dams identified within the region. Of these, 6 of the dams are classified as 'high hazard'. The inventory also includes 22 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 3,797.00 (millions of dollars). This inventory includes over 386 kilometers of highways, 290 bridges, 7,773 kilometers of pipes.

Table 1: Transportation System Lifeline Inventory

System	Component	# Locations/ # Segments	Replacement value (millions of dollars)
Highway	Bridges	290	392.20
	Segments	179	2,600.90
	Tunnels	1	0.30
	Subtotal		2,993.30
Railways	Bridges	10	1.90
	Facilities	0	0.00
	Segments	27	63.90
	Tunnels	0	0.00
	Subtotal		65.80
Light Rail	Bridges	0	0.00
	Facilities	5	13.30
	Segments	5	9.10
	Tunnels	0	0.00
	Subtotal		22.40
Bus	Facilities	1	1.10
	Subtotal		1.10
Ferry	Facilities	0	0.00
	Subtotal		0.00
Port	Facilities	0	0.00
	Subtotal		0.00
Airport	Facilities	2	21.30
	Runways	4	151.90
	Subtotal		173.20
		Total	3,255.80

Table 2: Utility System Lifeline Inventory

System	Component	# Locations / Segments	Replacement value (millions of dollars)
Potable Water	Distribution Lines	NA	87.40
	Facilities	1	32.30
	Pipelines	0	0.00
	Subtotal		119.70
Waste Water	Distribution Lines	NA	52.40
	Facilities	4	258.40
	Pipelines	0	0.00
	Subtotal		310.90
Natural Gas	Distribution Lines	NA	35.00
	Facilities	8	0.00
	Pipelines	493	184.40
	Subtotal		219.30
Oil Systems	Facilities	0	0.00
	Pipelines	54	66.40
	Subtotal		66.40
Electrical Power	Facilities	16	0.00
	Subtotal		0.00
Communication	Facilities	8	0.80
	Subtotal		0.80
		Total	717.10

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 74,865 buildings will be at least moderately damaged. This is over 30.00 % of the buildings in the region. There are an estimated 17,376 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	179	0.15	79	0.14	79	0.21	69	0.34	82	0.47
Commercial	2,359	1.98	1,243	2.23	2,190	5.89	2,157	10.63	2,256	12.98
Education	60	0.05	27	0.05	35	0.10	36	0.18	40	0.23
Government	54	0.05	25	0.04	38	0.10	39	0.19	42	0.24
Industrial	684	0.58	350	0.63	636	1.71	637	3.14	706	4.06
Other Residential	34,288	28.84	19,675	35.25	13,451	36.17	7,712	37.99	7,096	40.84
Religion	201	0.17	98	0.18	126	0.34	132	0.65	148	0.85
Single Family	81,064	68.19	34,313	61.48	20,635	55.49	9,517	46.88	7,008	40.33
Total	118,889		55,810		37,189		20,299		17,377	

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

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Wood	100,080	84.18	48,808	87.45	23,425	62.99	4,256	20.97	647	3.72
Steel	785	0.66	433	0.78	1,134	3.05	1,699	8.37	2,678	15.41
Concrete	1,434	1.21	801	1.44	1,636	4.40	2,003	9.87	2,146	12.35
Precast	649	0.55	255	0.46	574	1.54	725	3.57	1,013	5.83
RM	12,898	10.85	3,407	6.11	7,091	19.07	8,471	41.73	7,970	45.86
URM	2,011	1.69	1,301	2.33	1,737	4.67	1,338	6.59	1,217	7.00
MH	1,033	0.87	805	1.44	1,593	4.28	1,807	8.90	1,707	9.82
Total	118,889		55,810		37,189		20,299		17,377	

*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 (3.00%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, 12.00% of the beds will be back in service. By 30 days, 50.00% 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	8	8	0	0
Schools	191	119	41	26
EOCs	9	0	0	6
PoliceStations	16	0	0	10
FireStations	39	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	Locations/ Segments	Number of Locations_			
			With at Least Mod. Damage	With Complete Damage	With Functionality > 50 %	
					After Day 1	After Day 7
Highway	Segments	179	0	0	179	179
	Bridges	290	43	6	247	258
	Tunnels	1	0	0	1	1
Railways	Segments	27	0	0	27	27
	Bridges	10	0	0	10	10
	Tunnels	0	0	0	0	0
	Facilities	0	0	0	0	0
Light Rail	Segments	5	0	0	5	5
	Bridges	0	0	0	0	0
	Tunnels	0	0	0	0	0
	Facilities	5	0	0	5	5
Bus	Facilities	1	0	0	1	1
Ferry	Facilities	0	0	0	0	0
Port	Facilities	0	0	0	0	0
Airport	Facilities	2	0	0	2	2
	Runways	4	0	0	4	4

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	1	1	0	0	1
Waste Water	4	2	0	1	4
Natural Gas	8	0	0	7	8
Oil Systems	0	0	0	0	0
Electrical Power	16	5	0	6	16
Communication	8	4	0	8	8

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

System	Total Pipelines Length (kms)	Number of Leaks	Number of Breaks
Potable Water	4,371	1369	342
Waste Water	2,622	688	172
Natural Gas	535	42	11
Oil	246	18	4

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	224,104	79,167	63,100	29,001	0	0
Electric Power		129,468	55,322	12,422	1,409	224

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 4 ignitions that will burn about 0.45 sq. mi 0.06 % of the region's total area.) The model also estimates that the fires will displace about 1,741 people and burn about 158 (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 4.80 million tons of debris will be generated. Of the total amount, Brick/Wood comprises 23.00% 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 191,800 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 18,560 households to be displaced due to the earthquake. Of these, 11,172 people (out of a total population of 572,179) 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	89	28	5	10
	Commuting	0	0	0	0
	Educational	0	0	0	0
	Hotels	16	5	1	2
	Industrial	54	16	3	5
	Other-Residential	1,134	331	50	98
	Single Family	2,120	650	113	224
	Total	3,412	1,030	172	338
2 PM	Commercial	4,914	1,548	266	524
	Commuting	2	2	4	1
	Educational	3,083	983	172	338
	Hotels	3	1	0	0
	Industrial	396	119	19	38
	Other-Residential	204	59	9	17
	Single Family	349	105	18	35
	Total	8,950	2,818	489	953
5 PM	Commercial	3,436	1,076	185	360
	Commuting	61	79	136	26
	Educational	464	149	26	51
	Hotels	5	1	0	0
	Industrial	247	74	12	24
	Other-Residential	431	125	19	36
	Single Family	823	248	43	83
	Total	5,467	1,752	422	581

Economic Loss

The total economic loss estimated for the earthquake is 11,578.48 (millions of dollars), which includes building and lifeline related losses based on the region's available inventory. The following three sections provide more detailed information about these losses.

Building-Related Losses

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

The total building-related losses were 11,485.11 (millions of dollars); 20 % 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 47 % 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	24.64	463.71	12.26	50.86	551.47
	Capital-Related	0.00	10.36	398.57	7.43	17.63	434.00
	Rental	82.72	128.33	198.10	3.56	18.64	431.35
	Relocation	289.84	83.00	332.41	16.25	211.08	932.58
	Subtotal	372.56	246.34	1,392.79	39.50	298.20	2,349.39
Capital Stock Losses							
	Structural	651.76	211.45	467.15	63.78	225.79	1,619.93
	Non_Structural	2,029.88	1,101.48	1,463.42	219.79	785.56	5,600.13
	Content	510.17	234.74	655.47	132.36	336.27	1,869.02
	Inventory	0.00	0.00	14.24	30.88	1.51	46.63
	Subtotal	3,191.82	1,547.67	2,600.28	446.82	1,349.12	9,135.71
	Total	3,564.38	1,794.01	3,993.07	486.32	1,647.33	11,485.11

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	2,600.88	\$0.00	0.00
	Bridges	392.21	\$35.98	9.17
	Tunnels	0.26	\$0.01	3.97
	Subtotal	2993.30	36.00	
Railways	Segments	63.92	\$0.00	0.00
	Bridges	1.92	\$0.08	4.37
	Tunnels	0.00	\$0.00	0.00
	Facilities	0.00	\$0.00	0.00
	Subtotal	65.80	0.10	
Light Rail	Segments	9.10	\$0.00	0.00
	Bridges	0.00	\$0.00	0.00
	Tunnels	0.00	\$0.00	0.00
	Facilities	13.32	\$3.39	25.45
	Subtotal	22.40	3.40	
Bus	Facilities	1.06	\$0.29	27.68
	Subtotal	1.10	0.30	
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	21.30	\$3.23	15.18
	Runways	151.86	\$0.00	0.00
	Subtotal	173.20	3.20	
	Total	3255.80	43.00	

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	32.30	\$5.77	17.87
	Distribution Lines	87.40	\$6.16	7.05
	Subtotal	119.71	\$11.93	
Waste Water	Pipelines	0.00	\$0.00	0.00
	Facilities	258.40	\$34.04	13.17
	Distribution Lines	52.40	\$3.10	5.90
	Subtotal	310.85	\$37.14	
Natural Gas	Pipelines	184.40	\$0.11	0.06
	Facilities	0.00	\$0.00	0.00
	Distribution Lines	35.00	\$1.06	3.03
	Subtotal	219.34	\$1.17	
Oil Systems	Pipelines	66.40	\$0.04	0.06
	Facilities	0.00	\$0.00	0.00
	Subtotal	66.38	\$0.04	
Electrical Power	Facilities	0.00	\$0.00	0.00
	Subtotal	0.00	\$0.00	
Communication	Facilities	0.80	\$0.10	12.99
	Subtotal	0.78	\$0.10	
	Total	717.07	\$50.38	

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

Arapahoe,CO

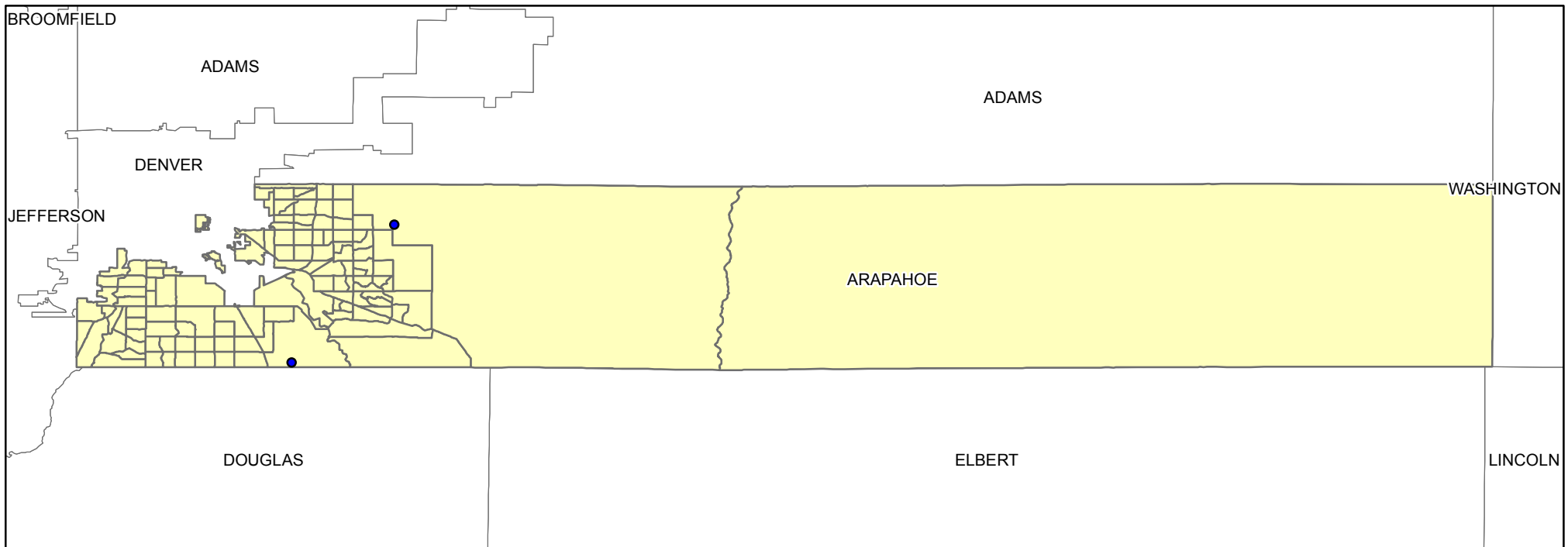
Appendix B: Regional Population and Building Value Data

State	County Name	Population	Building Value (millions of dollars)		
			Residential	Non-Residential	Total
Colorado	Arapahoe	572,179	40,061	12,154	52,216
Total State		572,179	40,061	12,154	52,216
Total Region		572,179	40,061	12,154	52,216

Study Region: Arapahoe County

Hazard Scenario: Rampart Range Fault 7

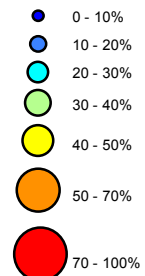
Airports Map



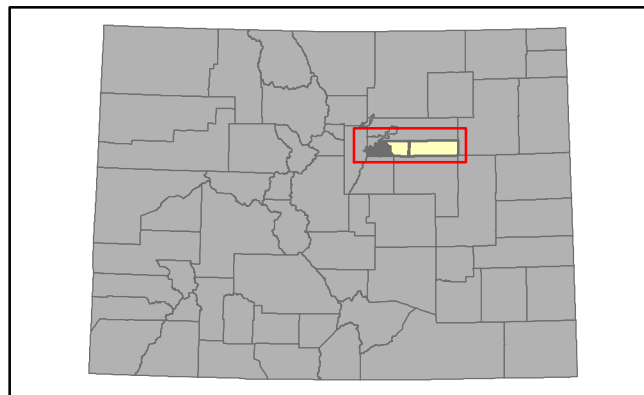
Legend

Airports

Probability Damage > Extensive



Counties
Study Region Tract



Created by: Colorado Geological Survey
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Date Created: March 2013
Location: Arapahoe 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

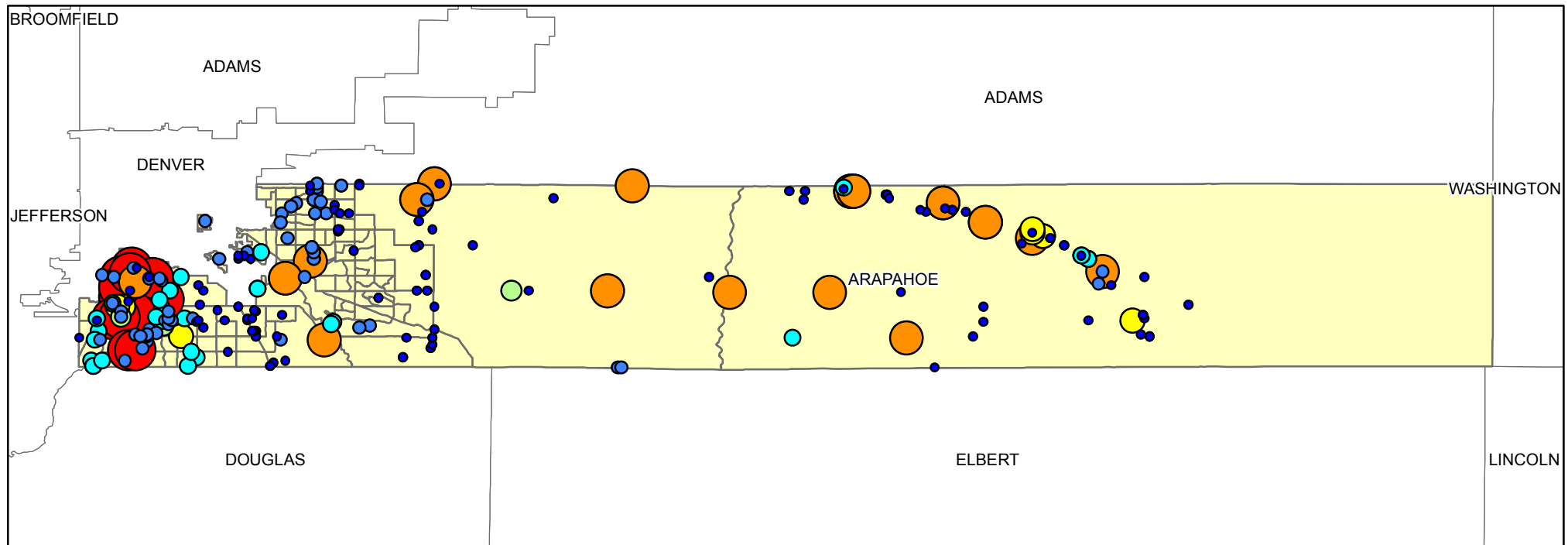


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Study Region: Arapahoe County

Bridges Map

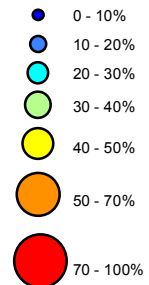
Hazard Scenario: Rampart Range Fault 7



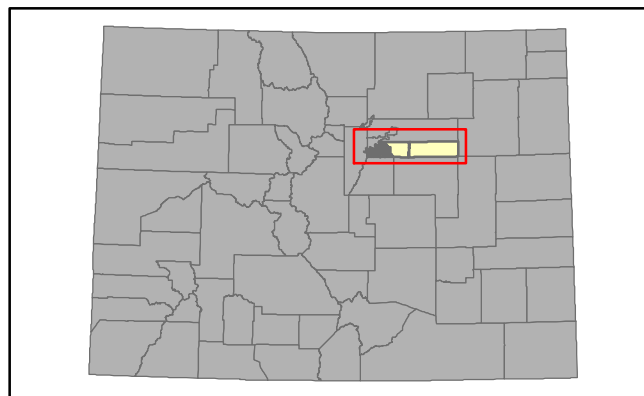
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Bridges

Probability Damage > Extensive



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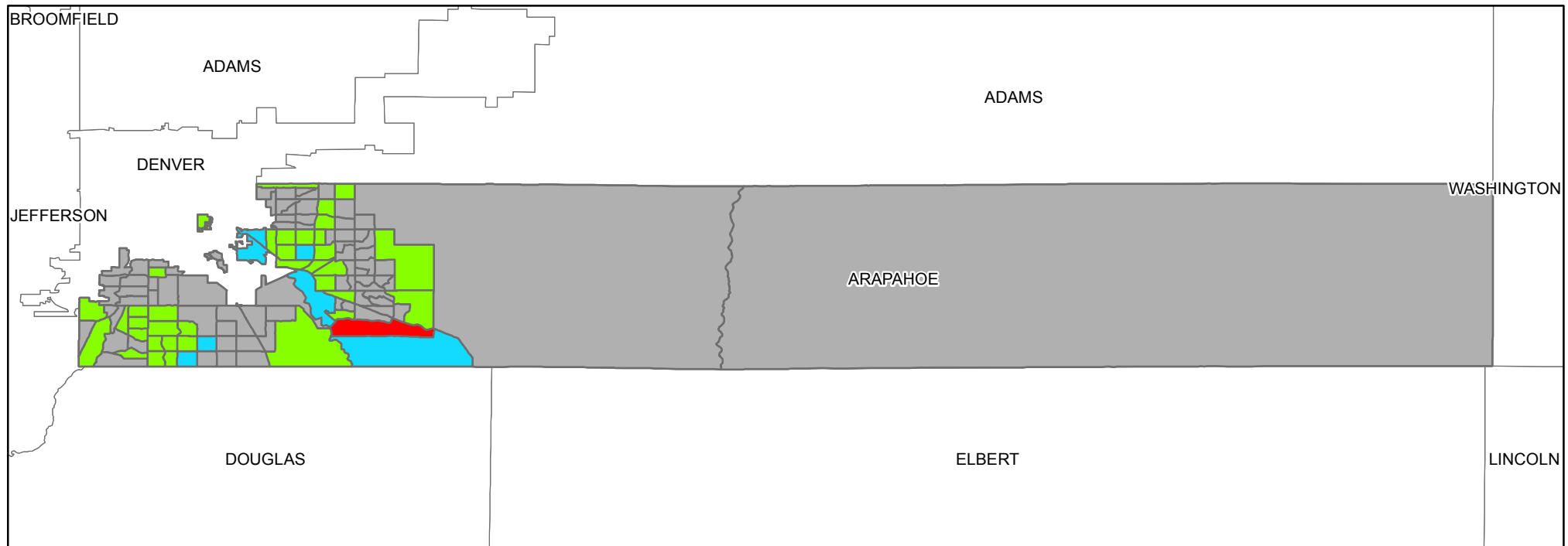


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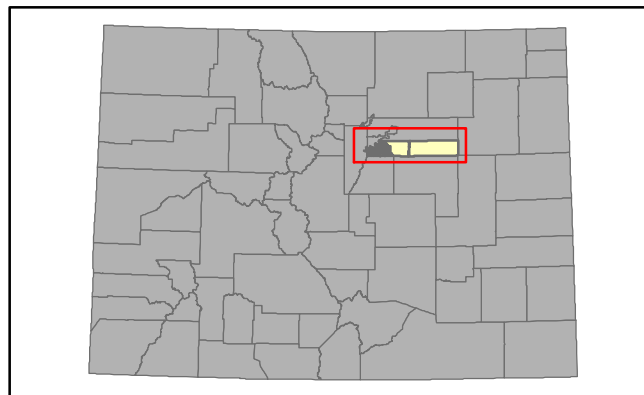
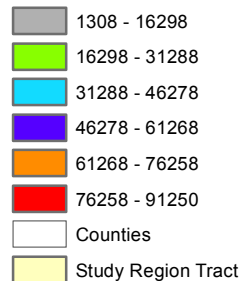
Hazard Scenario: Rampart Range Fault 7

Building Economic Loss Map



Legend

Building Economic Loss in Thousands of Dollars



Created by: Colorado Geological Survey

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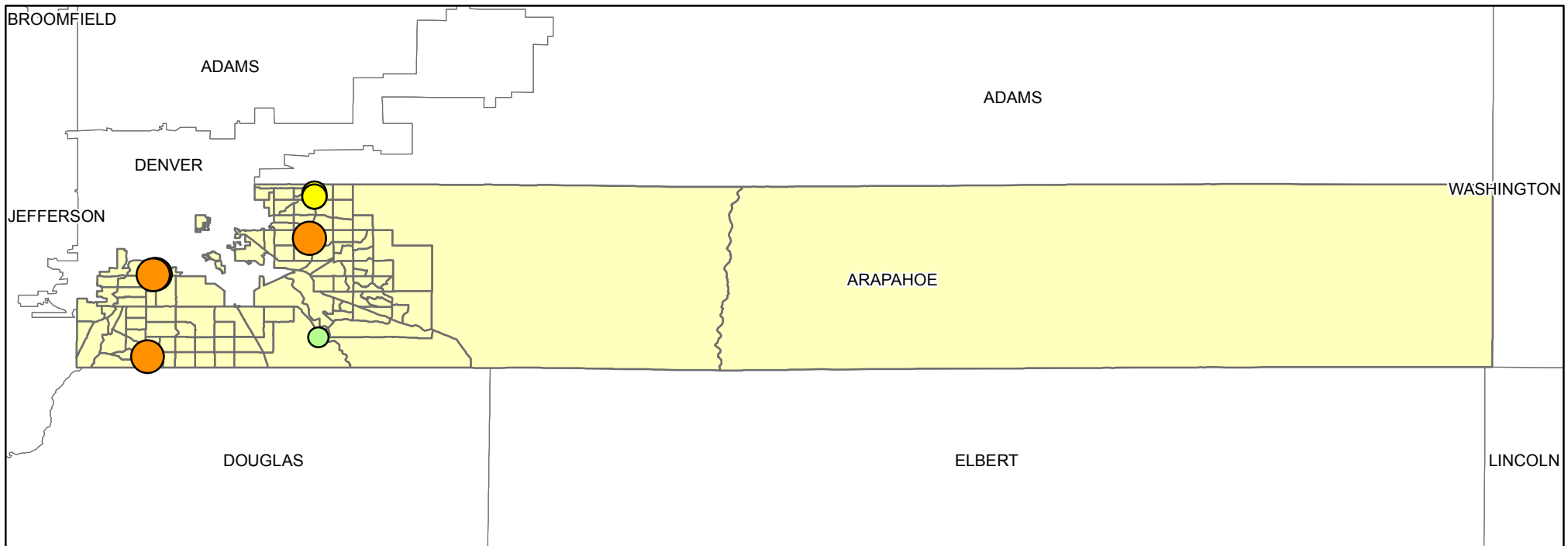


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Study Region: Arapahoe County

Hazard Scenario: Rampart Range Fault 7

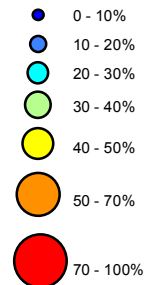
Care Facilities Map



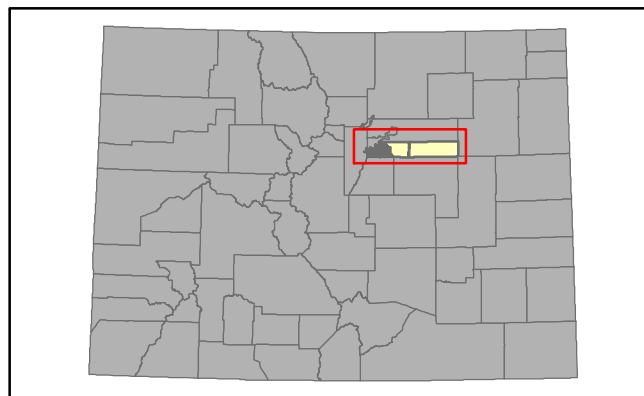
Legend

Care Facilities

Probability Damage > Extensive



Counties
Study Region Tract



Created by: Colorado Geological Survey
Team: Matt Morgan and Scot Fitzgerald
Date Created: March 2013
Location: Arapahoe 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

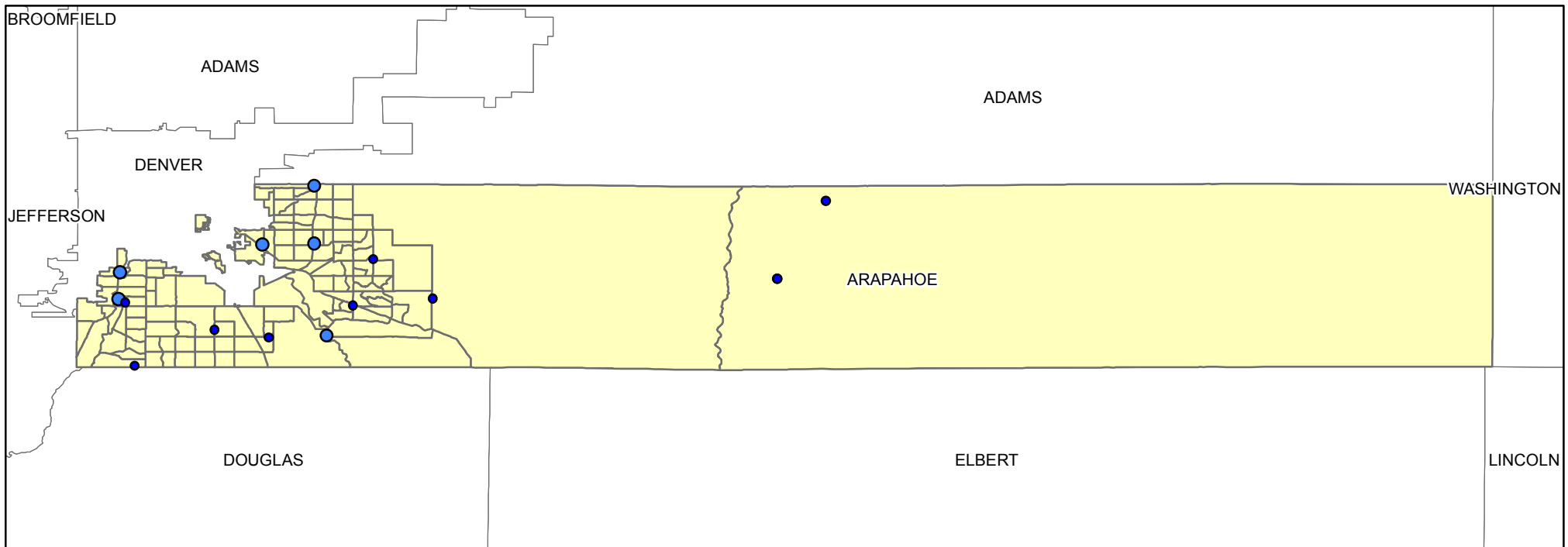


HAZUS
EARTHQUAKE • WIND • FLOOD **MH**

Study Region: Arapahoe County

Electrical Facilities Map

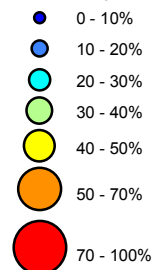
Hazard Scenario: Rampart Range Fault 7



Legend

Electrical Power Facilities

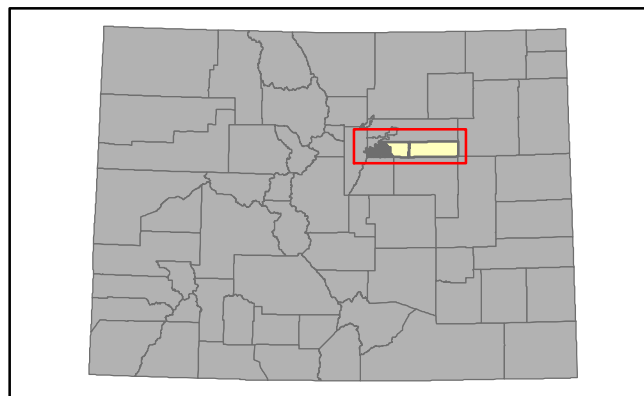
Probability Damage > Extensive



70 - 100%

Counties

Study Region Tract



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0 5 10 20 Miles

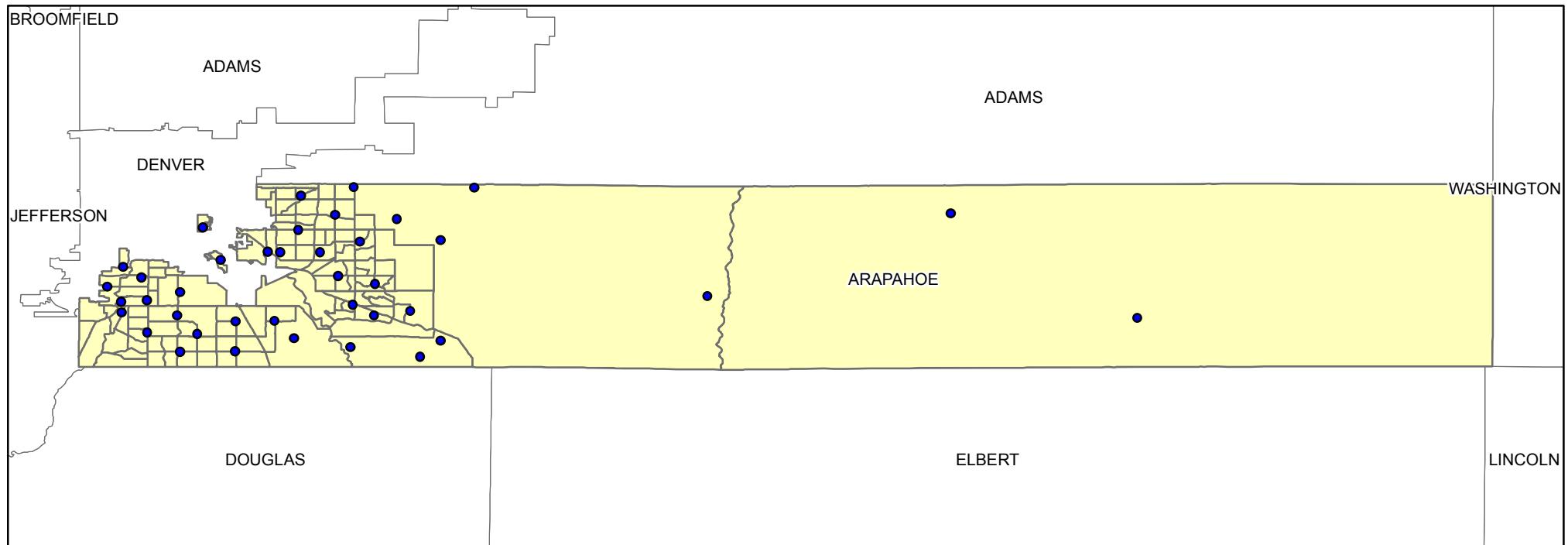


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Study Region: Arapahoe County

Fire Stations Map

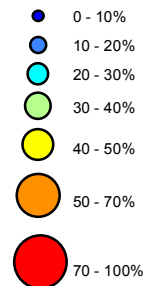
Hazard Scenario: Rampart Range Fault 7



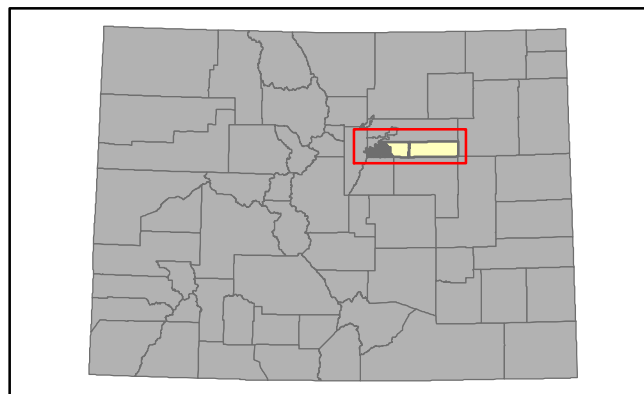
Legend

Fire Stations

Probability Damage > Extensive



Counties
Study Region Tract



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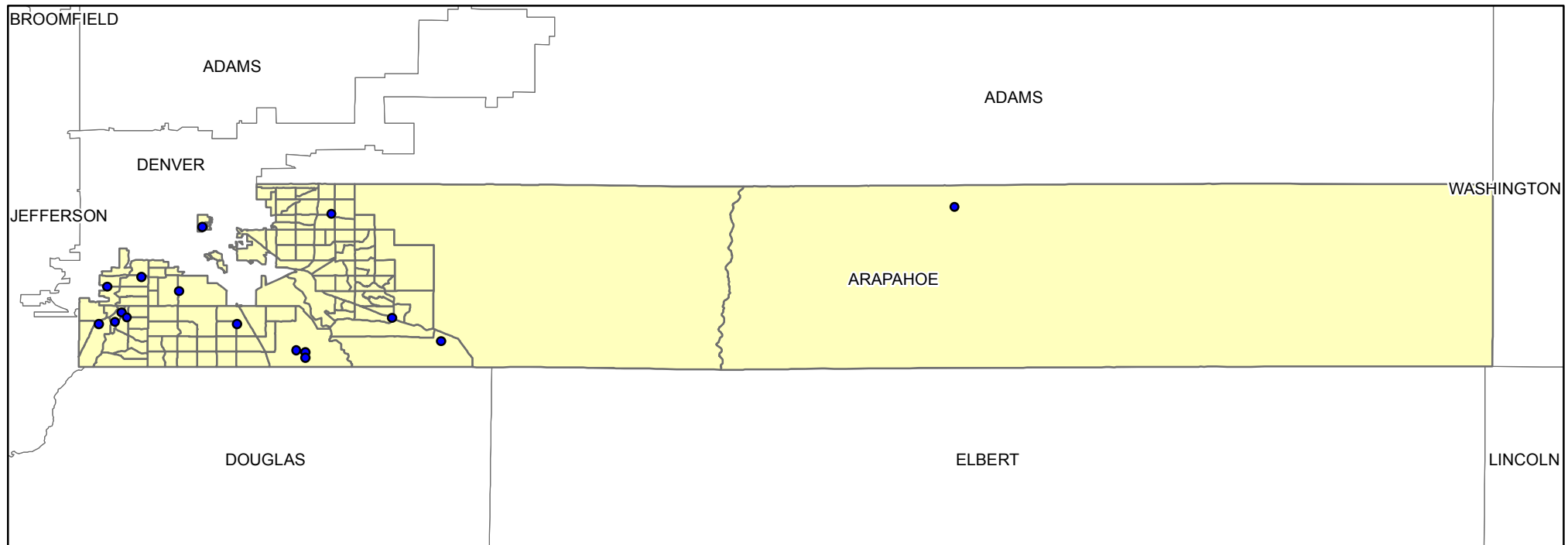


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Study Region: Arapahoe County

Police Stations Map

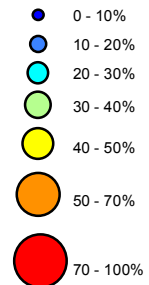
Hazard Scenario: Rampart Range Fault 7



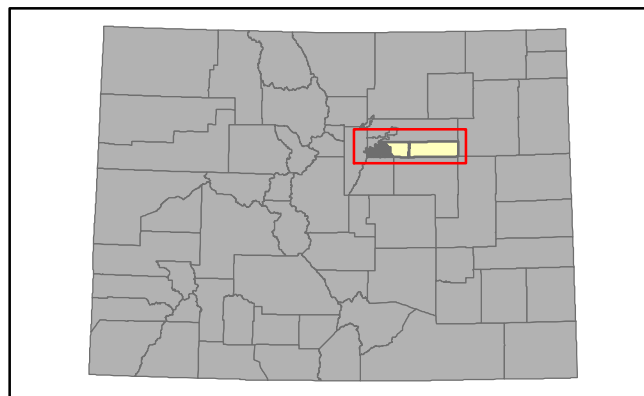
Legend

Police Stations

Probability Damage > Extensive



Counties
Study Region Tract



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Fault Parameters: arbitrary, magnitude 7, depth 10km
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0 5 10 20 Miles

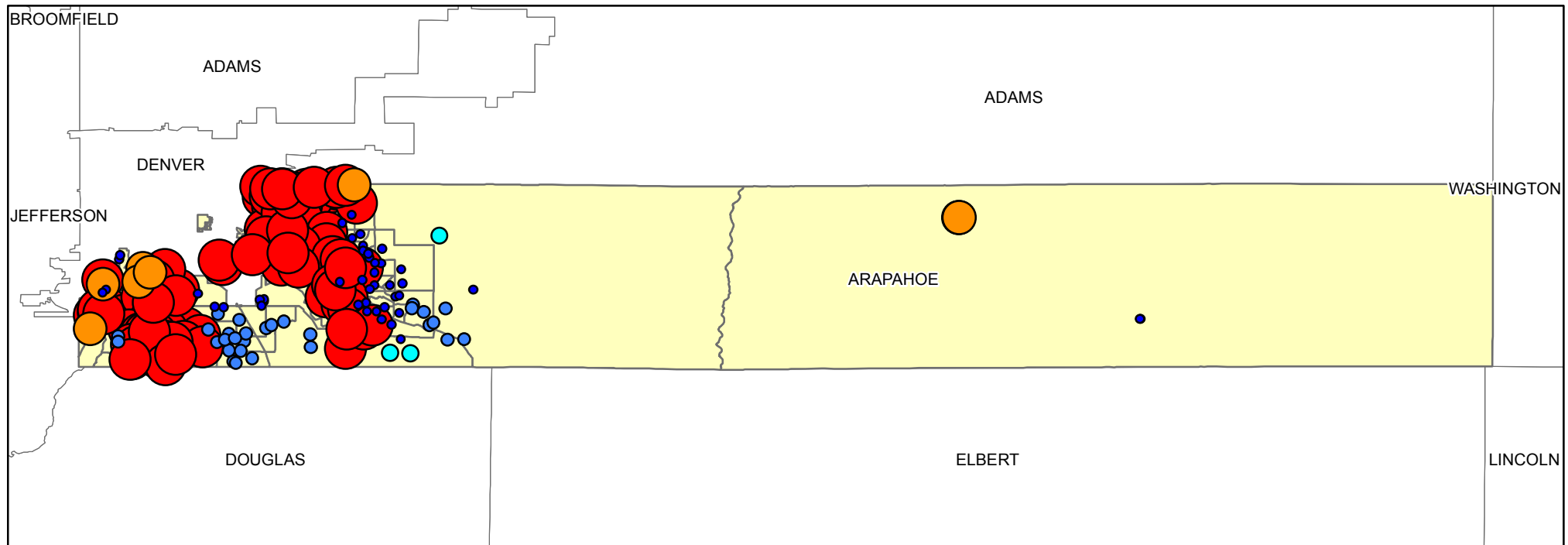


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Study Region: Arapahoe County

Schools Map

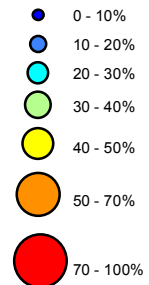
Hazard Scenario: Rampart Range Fault 7



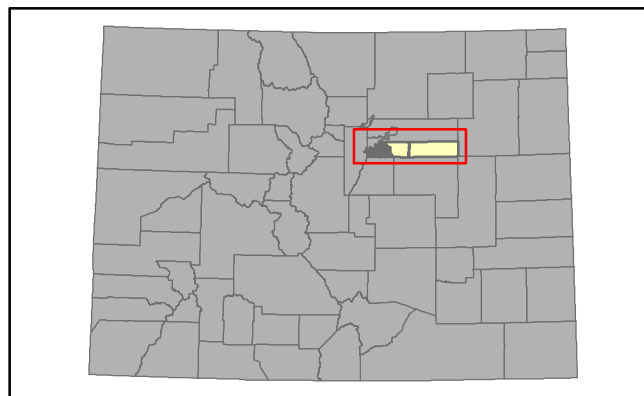
Legend

Schools

Probability Damage > Extensive



Counties
Study Region Tract



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Date Created: March 2013
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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

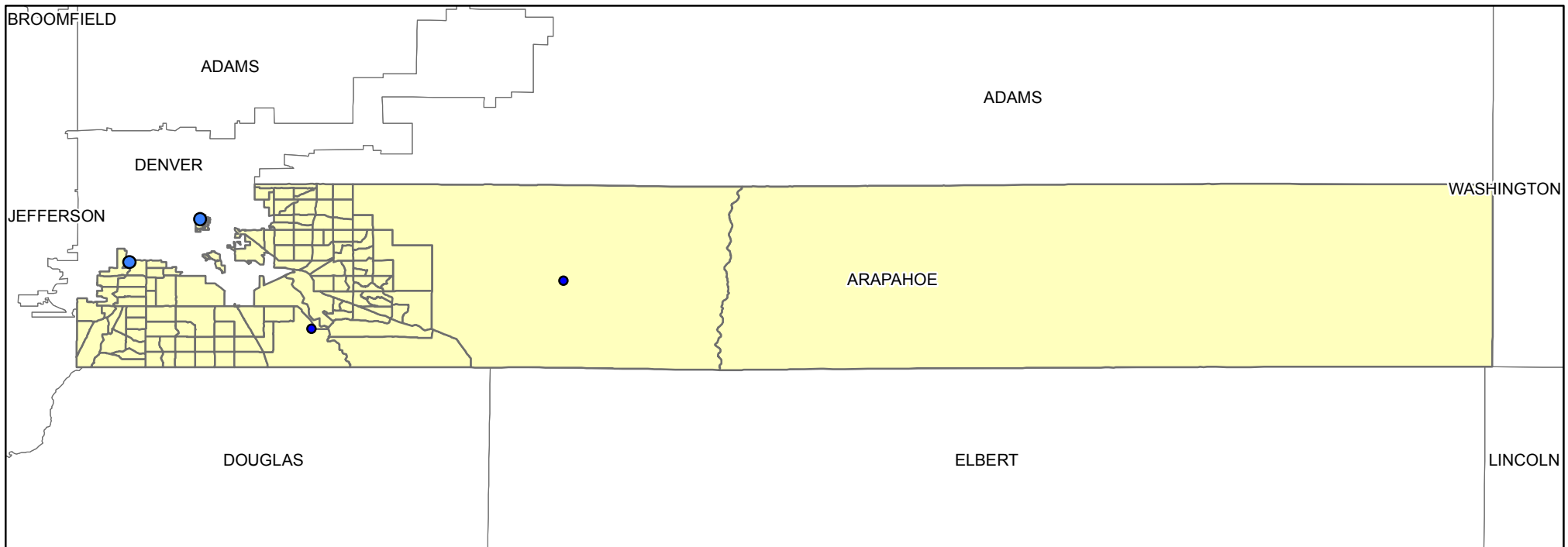


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Study Region: Arapahoe County

Hazard Scenario: Rampart Range Fault 7

Waste Water Facilities Map



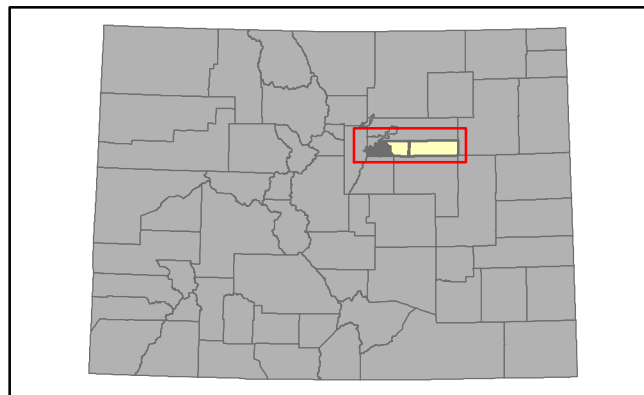
Legend

Waste Water Facilities

Probability Damage > Extensive



Counties
Study Region Tract



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Team: Matt Morgan and Scot Fitzgerald

Date Created: March 2013

Location: Arapahoe 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



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