

# Hazus-MH: Earthquake Event Report

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**Region Name:** Denver County Random fault 2010Census

**Earthquake Scenario:** Random Denver County

**Print Date:** April 01, 2013

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

**DOI:** <https://doi.org/10.58783/cgs.ha17.qnpf1949>

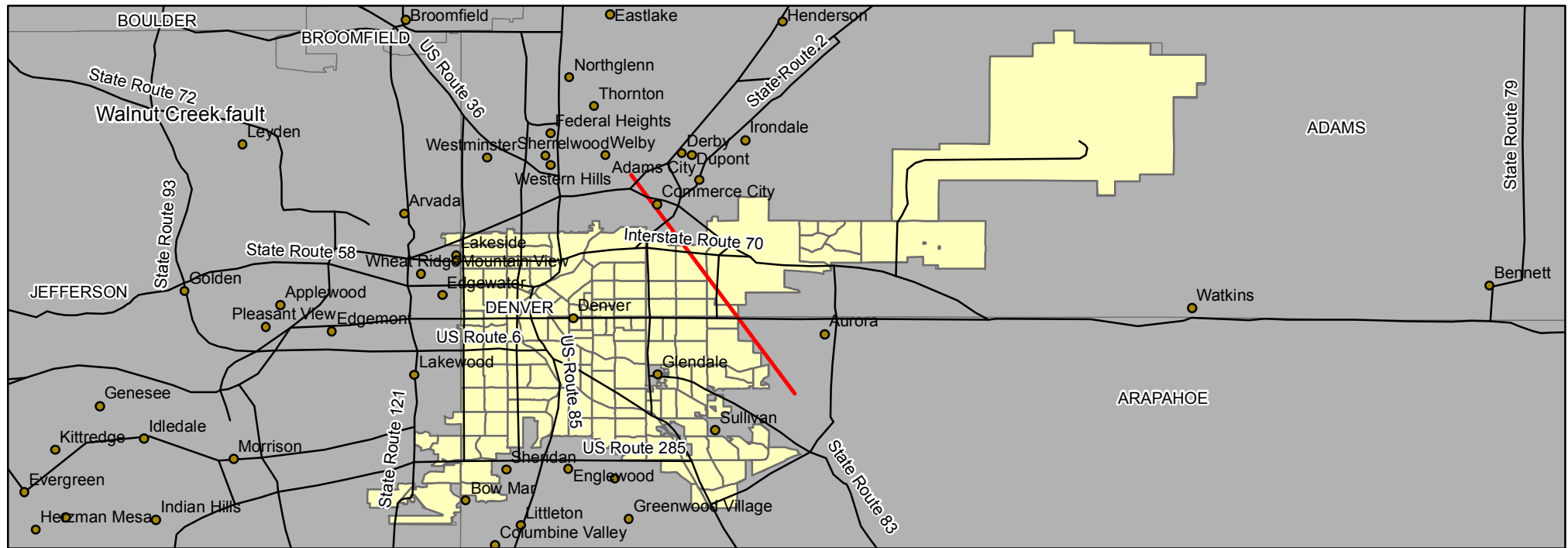
**Disclaimer:**

*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

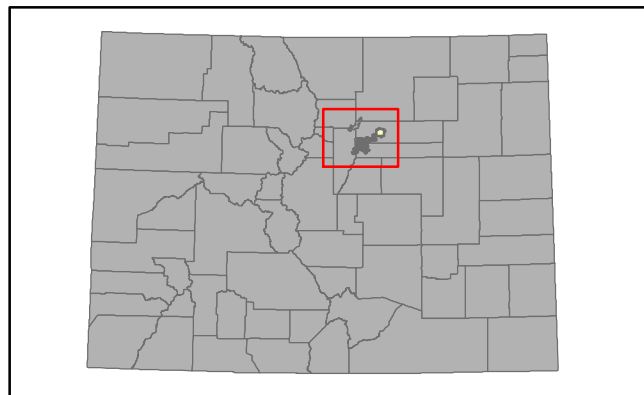
## Hazard Scenario: Random Fault 6.5

## Overview Map



### Legend

- Cities
- Roads
- Fault
- Study Region Tract



Created by: Colorado Geological Survey

Team: Matt Morgan and Scot Fitzgerald

Date Created: April 2013

Location: Denver County Colorado

Fault Parameters: arbitrary, magnitude 6.5, 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

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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**

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

**Table 2: Utility System Lifeline Inventory**

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

## Earthquake Scenario

Hazus uses the following set of information to define the earthquake parameters used for the earthquake loss estimate provided in this report.

|                                      |                               |
|--------------------------------------|-------------------------------|
| <b>Scenario Name</b>                 | Random Denver County          |
| <b>Type of Earthquake</b>            | Arbitrary                     |
| <b>Fault Name</b>                    | NA                            |
| <b>Historical Epicenter ID #</b>     | NA                            |
| <b>Probabilistic Return Period</b>   | NA                            |
| <b>Longitude of Epicenter</b>        | -104.90                       |
| <b>Latitude of Epicenter</b>         | 39.76                         |
| <b>Earthquake Magnitude</b>          | 6.50                          |
| <b>Depth (Km)</b>                    | 10.00                         |
| <b>Rupture Length (Km)</b>           | 17.18                         |
| <b>Rupture Orientation (degrees)</b> | 150.00                        |
| <b>Attenuation Function</b>          | Central & East US (CEUS 2008) |



## Building Damage

### Building Damage

Hazus estimates that about 169,670 buildings will be at least moderately damaged. This is over 56.00 % of the buildings in the region. There are an estimated 63,357 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         | (%)   |
| <b>Agriculture</b>       | 53            | 0.09  | 74            | 0.10  | 82            | 0.11  | 68            | 0.20  | 215           | 0.34  |
| <b>Commercial</b>        | 216           | 0.39  | 342           | 0.45  | 1,379         | 1.93  | 2,657         | 7.64  | 9,397         | 14.83 |
| <b>Education</b>         | 18            | 0.03  | 23            | 0.03  | 34            | 0.05  | 38            | 0.11  | 119           | 0.19  |
| <b>Government</b>        | 11            | 0.02  | 13            | 0.02  | 29            | 0.04  | 61            | 0.18  | 379           | 0.60  |
| <b>Industrial</b>        | 62            | 0.11  | 96            | 0.13  | 361           | 0.50  | 668           | 1.92  | 2,465         | 3.89  |
| <b>Other Residential</b> | 23,811        | 42.50 | 33,354        | 43.87 | 30,740        | 42.97 | 13,909        | 39.99 | 26,555        | 41.91 |
| <b>Religion</b>          | 76            | 0.14  | 108           | 0.14  | 150           | 0.21  | 172           | 0.49  | 632           | 1.00  |
| <b>Single Family</b>     | 31,778        | 56.72 | 42,015        | 55.27 | 38,759        | 54.18 | 17,206        | 49.47 | 23,595        | 37.24 |
| <b>Total</b>             | <b>56,025</b> |       | <b>76,025</b> |       | <b>71,534</b> |       | <b>34,779</b> |       | <b>63,358</b> |       |

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

|                 | None          |       | Slight        |       | Moderate      |       | Extensive     |       | Complete      |       |
|-----------------|---------------|-------|---------------|-------|---------------|-------|---------------|-------|---------------|-------|
|                 | Count         | (%)   | Count         | (%)   | Count         | (%)   | Count         | (%)   | Count         | (%)   |
| <b>Wood</b>     | 53,945        | 96.29 | 73846         | 97.13 | 63,019        | 88.10 | 18,164        | 52.23 | 4,532         | 7.15  |
| <b>Steel</b>    | 86            | 0.15  | 87            | 0.11  | 449           | 0.63  | 1,343         | 3.86  | 8,172         | 12.90 |
| <b>Concrete</b> | 186           | 0.33  | 283           | 0.37  | 1,081         | 1.51  | 2,230         | 6.41  | 8,622         | 13.61 |
| <b>Precast</b>  | 51            | 0.09  | 58            | 0.08  | 288           | 0.40  | 616           | 1.77  | 3,462         | 5.46  |
| <b>RM</b>       | 1,501         | 2.68  | 1225          | 1.61  | 5,040         | 7.05  | 9,249         | 26.60 | 27,206        | 42.94 |
| <b>URM</b>      | 187           | 0.33  | 337           | 0.44  | 899           | 1.26  | 1,472         | 4.23  | 6,214         | 9.81  |
| <b>MH</b>       | 70            | 0.13  | 189           | 0.25  | 757           | 1.06  | 1,704         | 4.90  | 5,150         | 8.13  |
| <b>Total</b>    | <b>56,025</b> |       | <b>76,025</b> |       | <b>71,534</b> |       | <b>34,779</b> |       | <b>63,358</b> |       |

\*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 (1.00%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, 3.00% of the beds will be back in service. By 30 days, 17.00% will be operational.

**Table 5: Expected Damage to Essential Facilities**

| Classification | Total | # Facilities                      |                          |                                      |
|----------------|-------|-----------------------------------|--------------------------|--------------------------------------|
|                |       | At Least Moderate<br>Damage > 50% | Complete<br>Damage > 50% | With Functionality<br>> 50% on day 1 |
| Hospitals      | 13    | 13                                | 8                        | 0                                    |
| Schools        | 215   | 215                               | 170                      | 0                                    |
| EOCs           | 1     | 1                                 | 0                        | 0                                    |
| PoliceStations | 15    | 2                                 | 0                        | 1                                    |
| FireStations   | 33    | 6                                 | 0                        | 5                                    |

## 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/<br>Segments | With at Least<br>Mod. Damage | With Complete<br>Damage | With Functionality > 50 % |             |
|            |            |                        |                              |                         | After Day 1               | After Day 7 |
| Highway    | Segments   | 357                    | 0                            | 0                       | 357                       | 357         |
|            | Bridges    | 426                    | 237                          | 37                      | 193                       | 256         |
|            | Tunnels    | 0                      | 0                            | 0                       | 0                         | 0           |
| Railways   | Segments   | 208                    | 0                            | 0                       | 208                       | 208         |
|            | Bridges    | 25                     | 17                           | 0                       | 8                         | 15          |
|            | Tunnels    | 0                      | 0                            | 0                       | 0                         | 0           |
|            | Facilities | 10                     | 9                            | 0                       | 1                         | 3           |
| Light Rail | Segments   | 28                     | 0                            | 0                       | 28                        | 28          |
|            | Bridges    | 1                      | 0                            | 0                       | 1                         | 1           |
|            | Tunnels    | 0                      | 0                            | 0                       | 0                         | 0           |
|            | Facilities | 26                     | 25                           | 0                       | 3                         | 17          |
| Bus        | Facilities | 6                      | 6                            | 0                       | 0                         | 1           |
| 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              | 1                             | 0                    | 0                         | 1           |
| Oil Systems      | 2              | 2                             | 0                    | 0                         | 0           |
| Electrical Power | 25             | 24                            | 0                    | 3                         | 21          |
| Communication    | 2              | 2                             | 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                        | 5825            | 1456             |
| Waste Water   | 1,953                        | 2926            | 732              |
| Natural Gas   | 99                           | 21              | 5                |
| Oil           | 71                           | 55              | 14               |

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               | 252,268                              | 251,271  | 248,918  | 215,390   | 0         |
| Electric Power |                       | 235,170                              | 183,860  | 106,671  | 29,324    | 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 21 ignitions that will burn about 0.62 sq. mi 0.40 % of the region's total area.) The model also estimates that the fires will displace about 5,990 people and burn about 927 (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 14.27 million tons of debris will be generated. Of the total amount, Brick/Wood comprises 25.00% 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 570,640 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 57,328 households to be displaced due to the earthquake. Of these, 33,319 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      |
|-------------|-------------------|---------------|---------------|--------------|--------------|
| <b>2 AM</b> | Commercial        | 344           | 115           | 20           | 40           |
|             | Commuting         | 1             | 1             | 1            | 0            |
|             | Educational       | 0             | 0             | 0            | 0            |
|             | Hotels            | 191           | 64            | 11           | 22           |
|             | Industrial        | 306           | 104           | 18           | 36           |
|             | Other-Residential | 3,646         | 1,137         | 181          | 355          |
|             | Single Family     | 5,951         | 1,921         | 337          | 667          |
|             | <b>Total</b>      | <b>10,439</b> | <b>3,342</b>  | <b>569</b>   | <b>1,120</b> |
| <b>2 PM</b> | Commercial        | 18,774        | 6,277         | 1,097        | 2,166        |
|             | Commuting         | 5             | 7             | 12           | 2            |
|             | Educational       | 8,544         | 2,884         | 518          | 1,014        |
|             | Hotels            | 37            | 12            | 2            | 4            |
|             | Industrial        | 2,262         | 760           | 133          | 260          |
|             | Other-Residential | 682           | 210           | 34           | 64           |
|             | Single Family     | 1,178         | 373           | 66           | 126          |
|             | <b>Total</b>      | <b>31,482</b> | <b>10,524</b> | <b>1,862</b> | <b>3,636</b> |
| <b>5 PM</b> | Commercial        | 12,192        | 4,047         | 710          | 1,380        |
|             | Commuting         | 260           | 338           | 581          | 112          |
|             | Educational       | 1,845         | 628           | 113          | 222          |
|             | Hotels            | 57            | 19            | 3            | 7            |
|             | Industrial        | 1,414         | 475           | 83           | 163          |
|             | Other-Residential | 1,402         | 433           | 70           | 132          |
|             | Single Family     | 2,321         | 738           | 130          | 249          |
|             | <b>Total</b>      | <b>19,490</b> | <b>6,678</b>  | <b>1,690</b> | <b>2,264</b> |

## Economic Loss

The total economic loss estimated for the earthquake is 41,373.38 (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 40,958.50 (millions of dollars); 18 % 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 38 % 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            |
|-----------------------------|-----------------|-----------------|-------------------|------------------|-----------------|-----------------|------------------|
| <b>Income Losses</b>        |                 |                 |                   |                  |                 |                 |                  |
|                             | Wage            | 0.00            | 68.89             | 1,426.21         | 44.32           | 214.00          | 1,753.41         |
|                             | Capital-Related | 0.00            | 29.31             | 1,315.70         | 29.72           | 74.89           | 1,449.62         |
|                             | Rental          | 198.46          | 409.69            | 608.99           | 17.29           | 115.77          | 1,350.20         |
|                             | Relocation      | 682.89          | 242.03            | 993.49           | 67.35           | 945.10          | 2,930.86         |
|                             | <b>Subtotal</b> | <b>881.35</b>   | <b>749.92</b>     | <b>4,344.39</b>  | <b>158.68</b>   | <b>1,349.76</b> | <b>7,484.10</b>  |
| <b>Capital Stock Losses</b> |                 |                 |                   |                  |                 |                 |                  |
|                             | Structural      | 1,541.03        | 663.13            | 1,747.85         | 320.19          | 638.64          | 4,910.84         |
|                             | Non_Structural  | 5,342.23        | 3,964.88          | 6,233.09         | 1,428.34        | 3,303.97        | 20,272.51        |
|                             | Content         | 1,439.05        | 930.09            | 3,009.10         | 930.57          | 1,739.60        | 8,048.40         |
|                             | Inventory       | 0.00            | 0.00              | 72.19            | 167.51          | 2.94            | 242.65           |
|                             | <b>Subtotal</b> | <b>8,322.30</b> | <b>5,558.10</b>   | <b>11,062.23</b> | <b>2,846.61</b> | <b>5,685.16</b> | <b>33,474.40</b> |
|                             | <b>Total</b>    | <b>9,203.65</b> | <b>6,308.02</b>   | <b>15,406.63</b> | <b>3,005.29</b> | <b>7,034.91</b> | <b>40,958.50</b> |



## 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        | \$304.57      | 20.85          |
|            | Tunnels      | 0.00            | \$0.00        | 0.00           |
|            | Subtotal     | <b>3726.10</b>  | <b>304.60</b> |                |
| Railways   | Segments     | 120.03          | \$0.00        | 0.00           |
|            | Bridges      | 2.03            | \$0.56        | 27.80          |
|            | Tunnels      | 0.00            | \$0.00        | 0.00           |
|            | Facilities   | 26.63           | \$16.27       | 61.09          |
|            | Subtotal     | <b>148.70</b>   | <b>16.80</b>  |                |
| Light Rail | Segments     | 14.27           | \$0.00        | 0.00           |
|            | Bridges      | 0.32            | \$0.04        | 11.89          |
|            | Tunnels      | 0.00            | \$0.00        | 0.00           |
|            | Facilities   | 69.24           | \$42.73       | 61.72          |
|            | Subtotal     | <b>83.80</b>    | <b>42.80</b>  |                |
| Bus        | Facilities   | 6.34            | \$4.27        | 67.36          |
|            | Subtotal     | <b>6.30</b>     | <b>4.30</b>   |                |
| Ferry      | Facilities   | 0.00            | \$0.00        | 0.00           |
|            | Subtotal     | <b>0.00</b>     | <b>0.00</b>   |                |
| Port       | Facilities   | 0.00            | \$0.00        | 0.00           |
|            | Subtotal     | <b>0.00</b>     | <b>0.00</b>   |                |
| Airport    | Facilities   | 10.65           | \$2.33        | 21.86          |
|            | Runways      | 227.78          | \$0.00        | 0.00           |
|            | Subtotal     | <b>238.40</b>   | <b>2.30</b>   |                |
|            | <b>Total</b> | <b>4203.40</b>  | <b>370.80</b> |                |

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           | \$26.21       | 40.28          |
|                  | Subtotal           | 65.08           | \$26.21       |                |
| Waste Water      | Pipelines          | 0.00            | \$0.00        | 0.00           |
|                  | Facilities         | 0.00            | \$0.00        | 0.00           |
|                  | Distribution Lines | 39.10           | \$13.17       | 33.72          |
|                  | Subtotal           | 39.05           | \$13.17       |                |
| Natural Gas      | Pipelines          | 33.40           | \$0.05        | 0.16           |
|                  | Facilities         | 0.00            | \$0.00        | 0.00           |
|                  | Distribution Lines | 26.00           | \$4.51        | 17.33          |
|                  | Subtotal           | 59.47           | \$4.57        |                |
| Oil Systems      | Pipelines          | 18.60           | \$0.10        | 0.55           |
|                  | Facilities         | 0.00            | \$0.00        | 0.00           |
|                  | Subtotal           | 18.64           | \$0.10        |                |
| Electrical Power | Facilities         | 0.00            | \$0.00        | 0.00           |
|                  | Subtotal           | 0.00            | \$0.00        |                |
| Communication    | Facilities         | 0.20            | \$0.06        | 28.45          |
|                  | Subtotal           | 0.19            | \$0.06        |                |
|                  | Total              | 182.44          | \$44.11       |                |

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

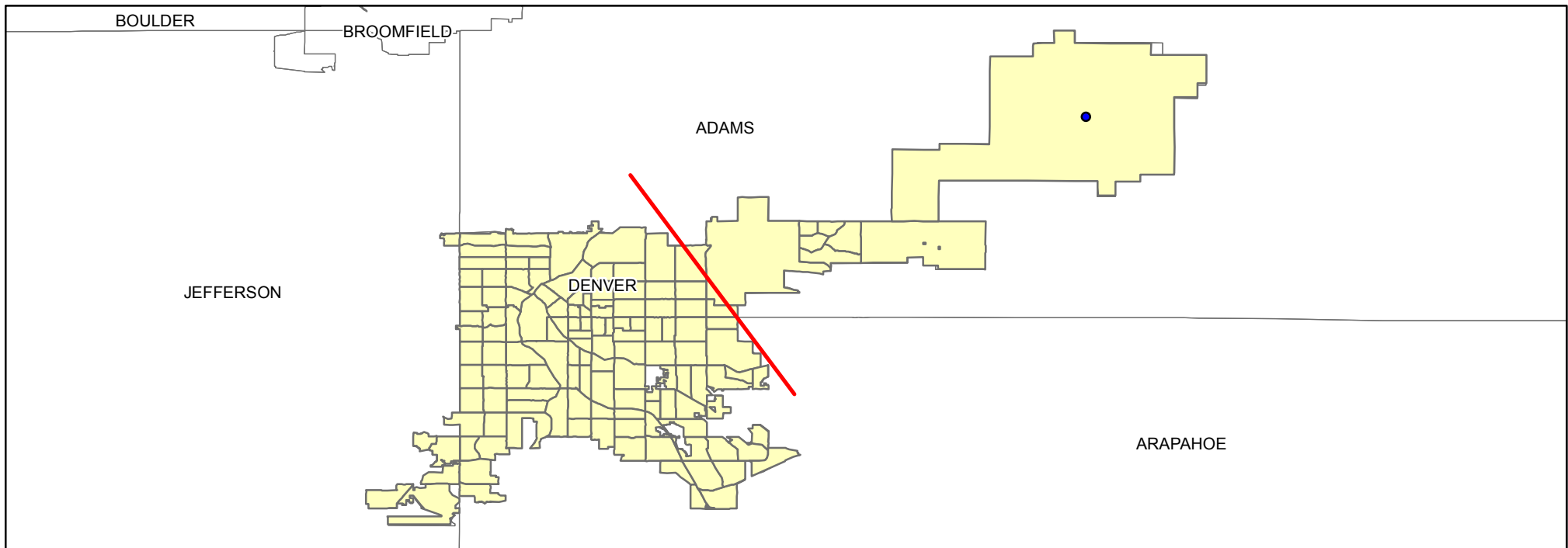
**Appendix B: Regional Population and Building Value Data**

| 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: Random Fault 6.5

### Airports Map

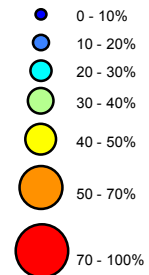


#### Legend

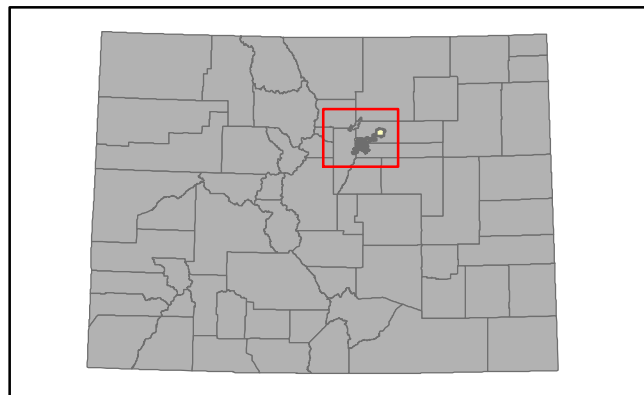
— Fault

#### Airports

##### Probability Damage > Extensive



Study Region Tract



Created by: Colorado Geological Survey

Team: Matt Morgan and Scot Fitzgerald

Date Created: April 2013

Location: Denver County Colorado

Fault Parameters: arbitrary, magnitude 6.5, depth 10km

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

Projection: GCS North American 1983

0 5 10 20 Miles

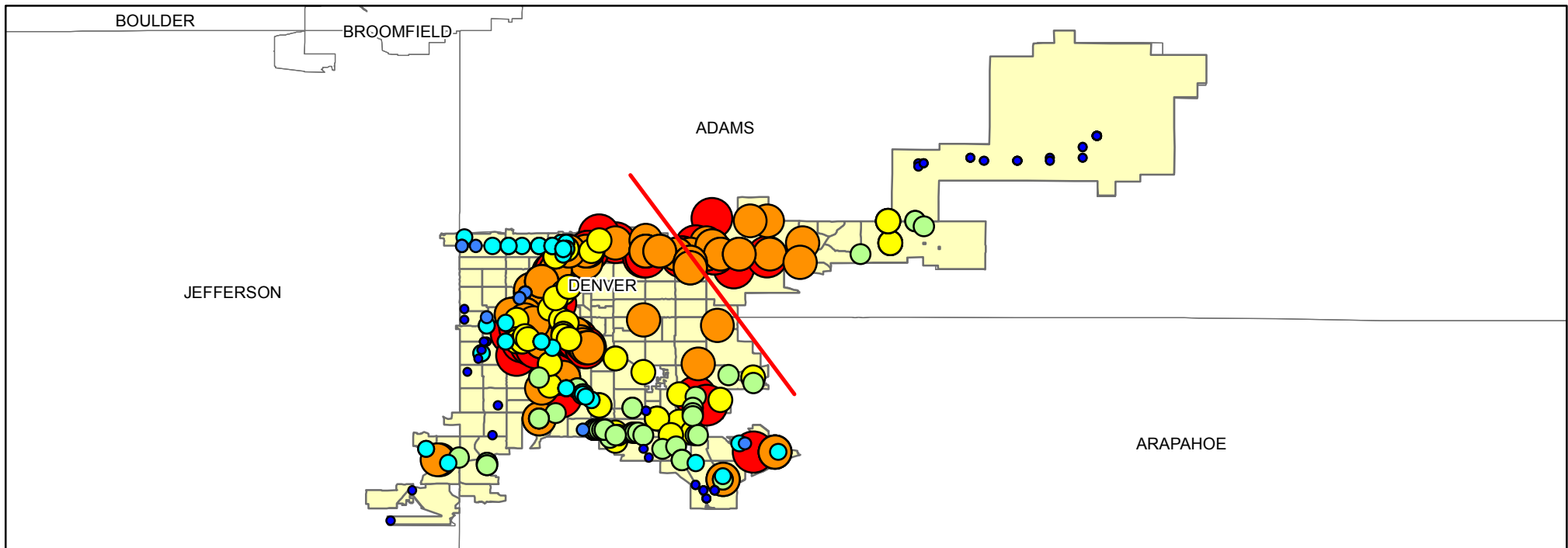


**HAZUS**  
EARTHQUAKE • WIND • FLOOD

# Study Region: Denver County

## Hazard Scenario: Random Fault 6.5

### Bridges Map



#### Legend

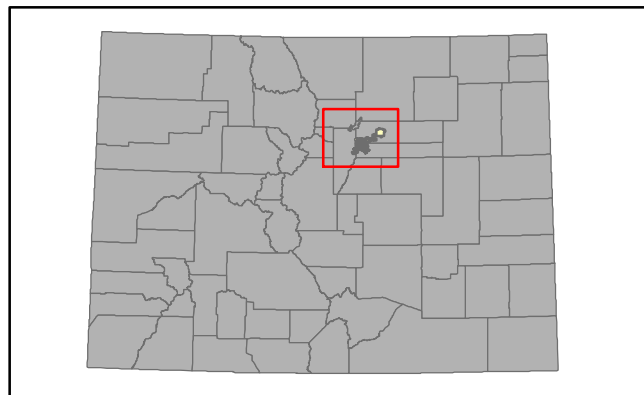
— Fault

#### 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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Date Created: April 2013

Location: Denver County Colorado

Fault Parameters: arbitrary, magnitude 6.5, depth 10km

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

Projection: GCS North American 1983

0 5 10 20 Miles

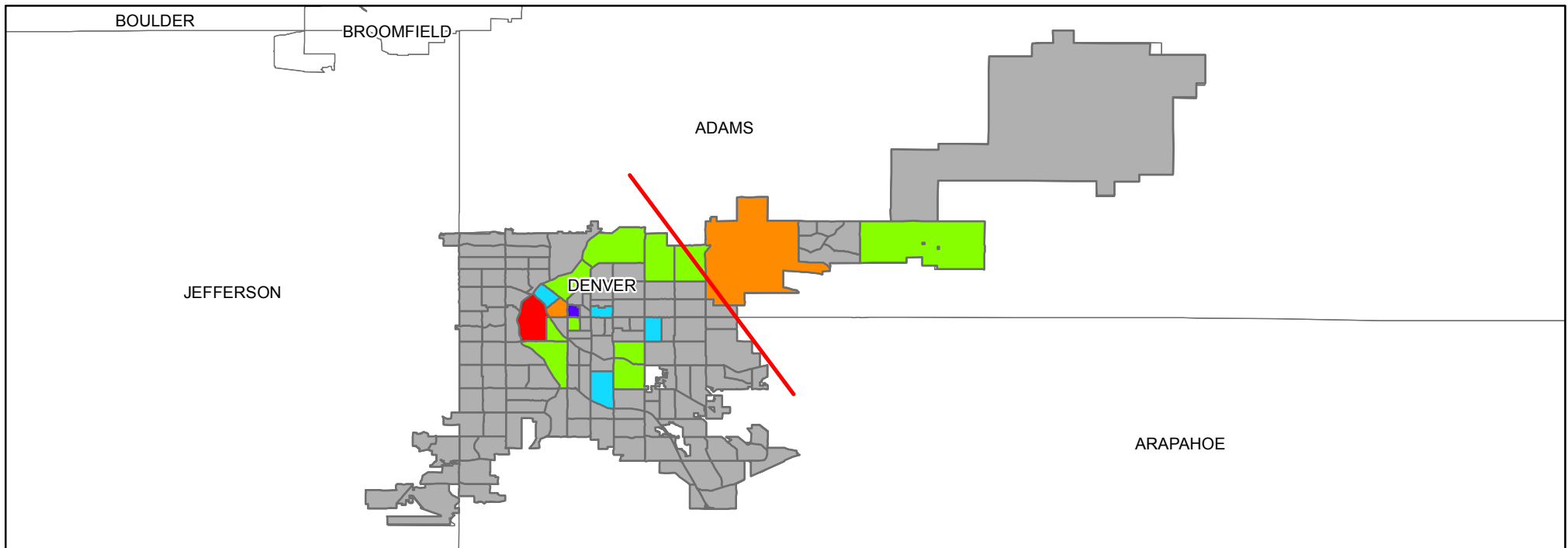


**HAZUS**  
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Study Region: Denver County

Hazard Scenario: Random Fault 6.5

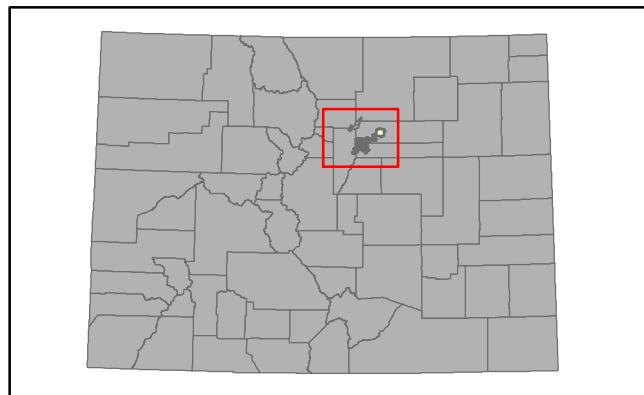
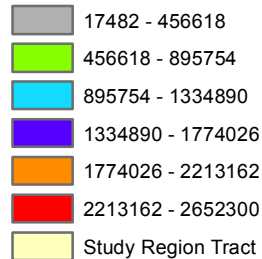
Building Economic Loss Map



### Legend

— Fault

### Building Economic Loss in Thousands of Dollars



Created by: Colorado Geological Survey

Team: Matt Morgan and Scot Fitzgerald

Date Created: April 2013

Location: Denver County Colorado

Fault Parameters: arbitrary, magnitude 6.5, depth 10km

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

Projection: GCS North American 1983

0 5 10 20 Miles

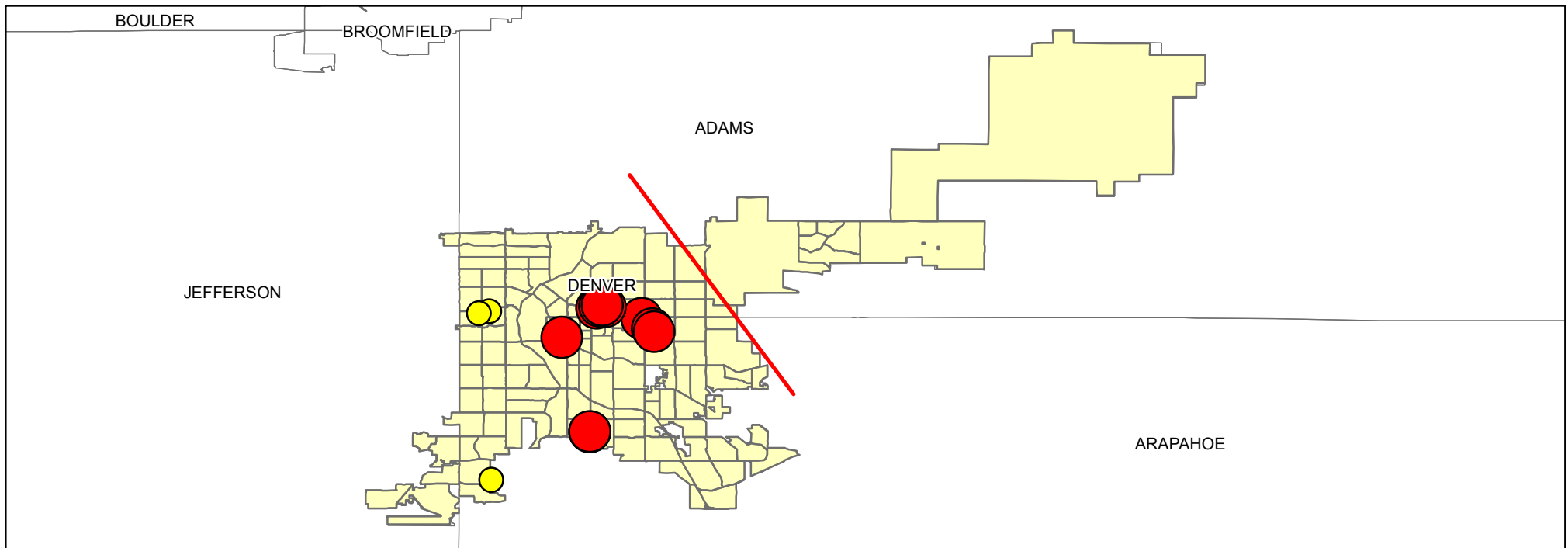


**HAZUS**  
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# Study Region: Denver County

Hazard Scenario: Random Fault 6.5

## Care Facilities Map



### Legend

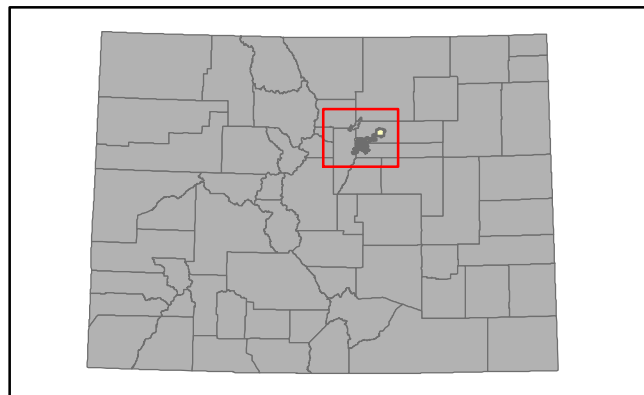
— Fault

#### 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: April 2013

Location: Denver County Colorado

Fault Parameters: arbitrary, magnitude 6.5, depth 10km

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

Projection: GCS North American 1983

0 5 10 20 Miles



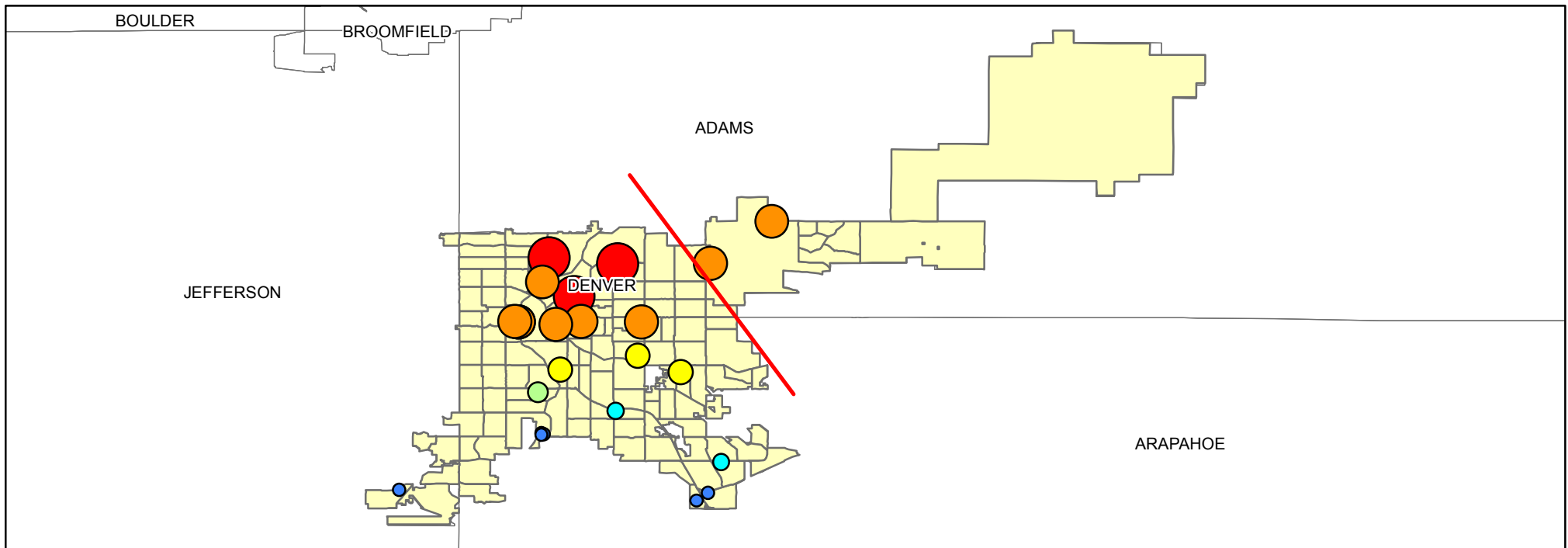
**HAZUS**  
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# Study Region: Denver County

Hazard Scenario: Random Fault 6.5

## Electrical Facilities Map



### Legend

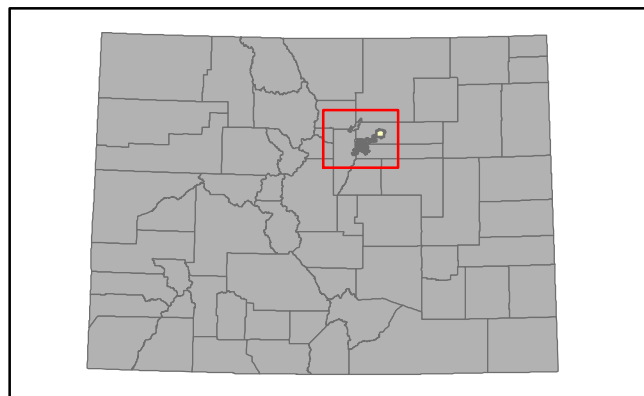
— Fault

#### Electrical Power Facilities

Probability Damage > Extensive

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

Study Region Tract



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Team: Matt Morgan and Scot Fitzgerald

Date Created: April 2013

Location: Denver County Colorado

Fault Parameters: arbitrary, magnitude 6.5, depth 10km

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

Projection: GCS North American 1983

0 5 10 20 Miles

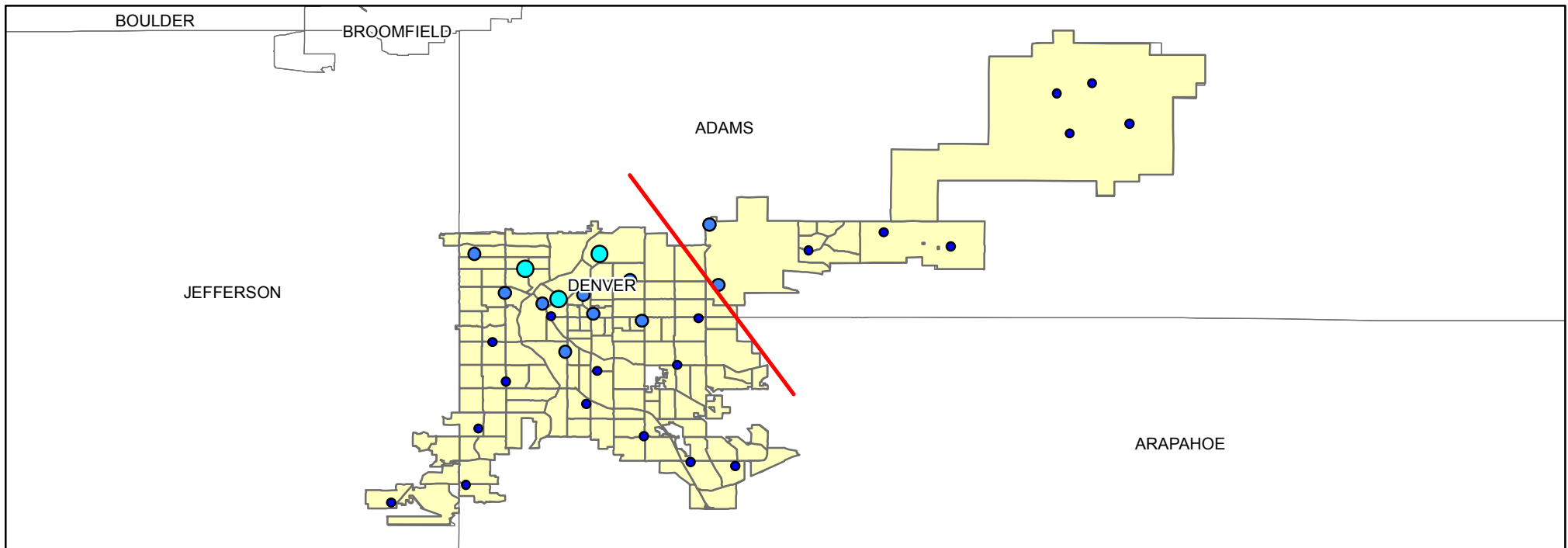


**HAZUS**  
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Study Region: Denver County

Hazard Scenario: Random Fault 6.5

Fire Stations Map



#### Legend

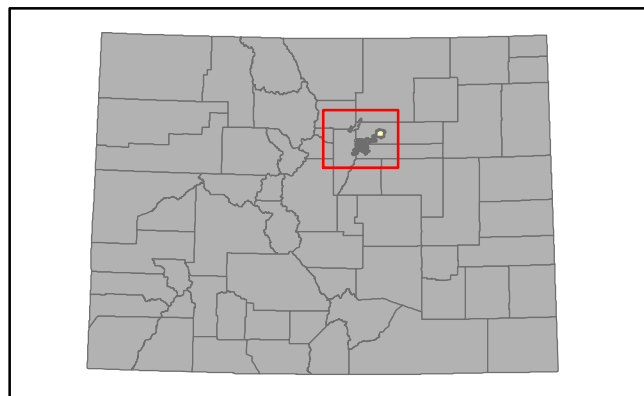
— Fault

#### Fire 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

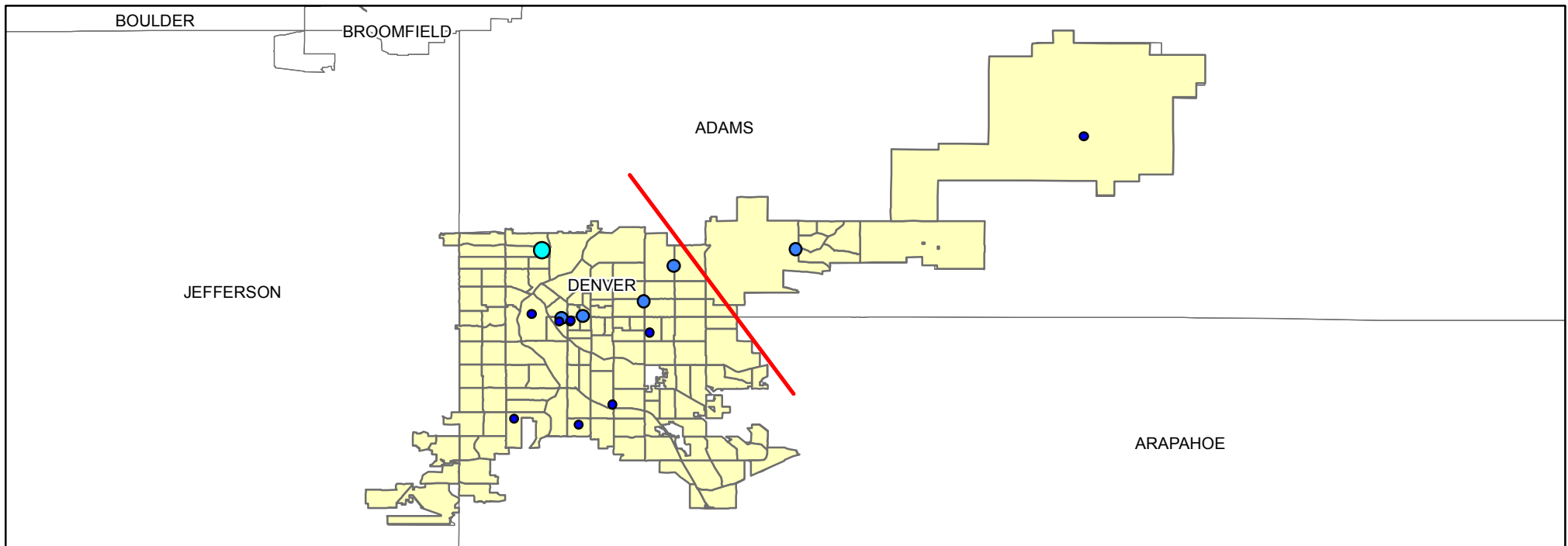


**HAZUS**  
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# Study Region: Denver County

Hazard Scenario: Random Fault 6.5

## Police Stations Map



### Legend

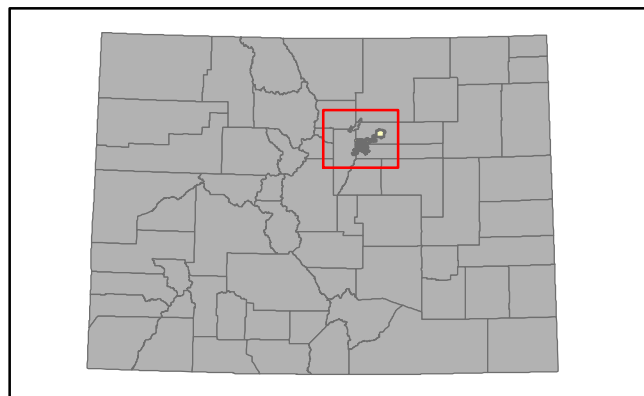
— Fault

#### Police Stations

##### 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

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Location: Denver County Colorado

Fault Parameters: arbitrary, magnitude 6.5, depth 10km

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

Projection: GCS North American 1983

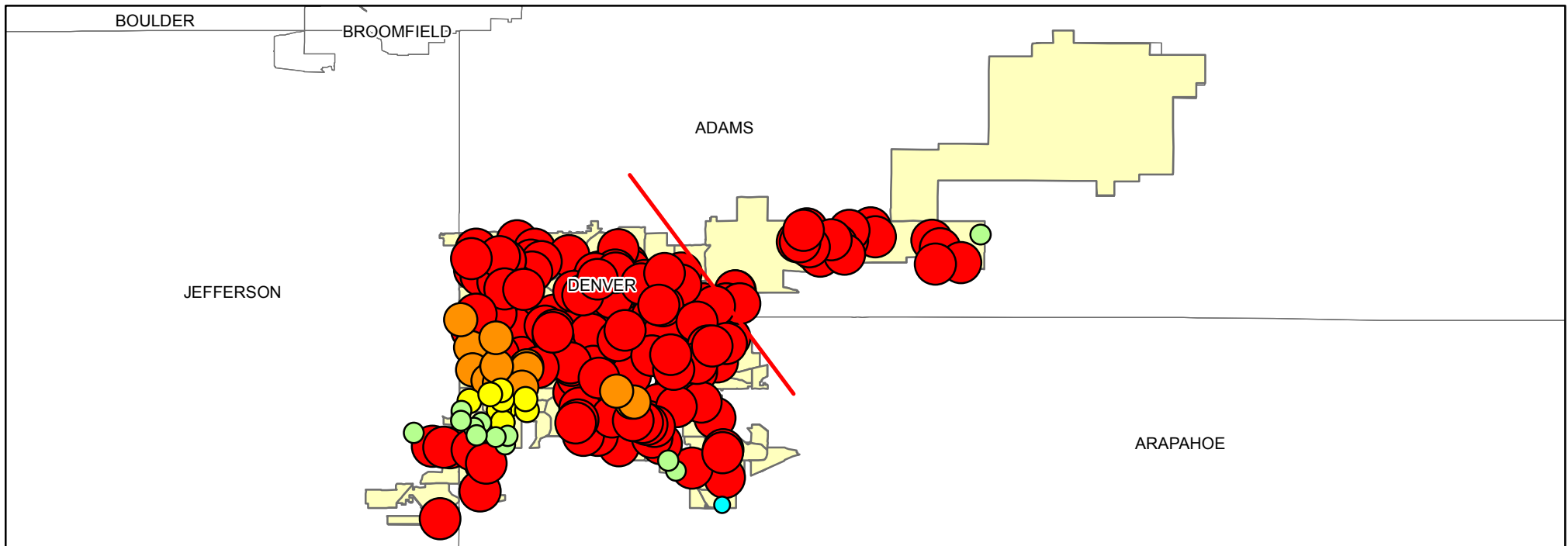
0 5 10 20 Miles



# Study Region: Denver County

Hazard Scenario: Random Fault 6.5

## Schools Map



### Legend

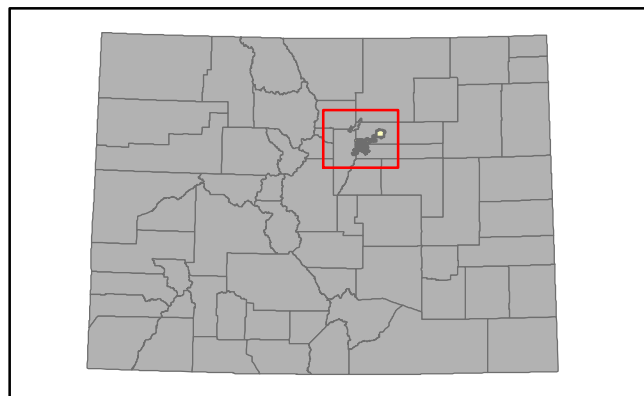
— Fault

### Schools

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: April 2013

Location: Denver County Colorado

Fault Parameters: arbitrary, magnitude 6.5, 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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