Imagine ADAMS COUNTY

APPENDIX C: HAZARD IDENTIFICATION AND RISK ASSESSMENT

ADOPTED DECEMBER 2012

ADAMS COUNTY COLORADO

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Hazard Identification and Risk Assessment (HIRA)

The purpose of the Hazard Identification and Risk Assessment (HIRA) is to identify natural hazards and to evaluate the risk to Adams County, the health and safety of its citizens, property, and economy. A vulnerability and risk assessment is a decision support tool for determining the need for and prioritization of mitigation measures to protect assets and processes. While it is financially unfeasible to reduce risk from every natural hazard event, vulnerability and risk assessments can help ensure that the available resources and actions taken are justified and implemented based on the threat, vulnerability, and risk.[1]

This HIRA section describes the linkages to the Comprehensive Plan and then summarizes the hazard identification and ranking methodology process. Background information is then provided on the data availability for facilities, assets, land use and development, and historical hazard events. Hazard-specific profiles and vulnerability assessments are provided for all the identified hazards. The final sub-section of this HIRA concludes with a comparison of the loss estimates, which leads to the mitigation actions and project development.

An Integrated Approach

The Adams County Comprehensive Plan provides a concise statement of the County's objectives for future development within unincorporated areas of the County and in municipal growth areas. As part of this effort, other County plans including the Transportation Plan, Open Space, Parks and Trails Master Plan, and this Hazard Identification Risk Assessment (HIRA) have been incorporated. This level of integration reflects Adams County's commitment to a more resilient and sustainable future.

Hazard mitigation planning is an integral and effective component of the County's overall comprehensive planning efforts. The integration of these planning efforts has fostered a relationship between Adams County planners and emergency managers and continually enables them to work together towards a common goal. Hazard mitigation, like comprehensive planning, involves elements of land use, economic development, transportation and historic preservation. One of the goals of this effort is to raise the visibility of natural and man-made hazards in comprehensive planning and to incorporate these concerns into the planning goals for the County.

[1] Colorado Natural Hazards Mitigation Plan. Section 3: Hazard Identification and Risk Assessment. January 2011.

Hazard Identification and Ranking Methodology

Hazard Identification

During the steering committee meeting on May 21, 2012, background information on the requirements for hazard mitigation planning, and more specifically the HIRA, were presented. Steering committee members reviewed the list of natural hazards presented in the State of Colorado and the Denver Regional Council of Governments (DRCOG) hazard mitigation plans (Table 3) and discussed and rated which of these hazards could have an impact on the County. Additionally, committee members reviewed the hazardous materials facilities and the impact of such facilities within Adams County.

The natural hazards identified for Adams County and included in this risk assessment are:

- Thunderstorms
- Winter Weather
- Tornadoes
- Flood
- Drought
- Subsidence
- Earthquake
- Wildfire

Methodology

The purpose of the hazard identification and risk assessment is to provide a factual basis for developing mitigation strategies by prioritizing areas most threatened and vulnerable to natural and man-made hazards. As discussed above, the natural hazards applicable to the County were discussed in terms of frequency and historical damages. The completed prioritizations were tallied and discussed with the group. As a result of this prioritization, the hazards were broken down into three distinct categories that represent the likelihood that a hazard event will impact the County. These categories are High, Medium, and Low (Table 1). Table 2 summarizes the completed vulnerability analysis.

For the report, certain hazards have been grouped together based on similar descriptions, impacts, and severities. Flooding includes dam inundation, winter weather includes extreme cold, drought includes extreme heat, and thunderstorm includes hail, lightning and wind events. Future updates to this assessment may consider further refining the parameters to include specific return periods of probability and damage estimates for impacts.

- ***Geographic Extent:*** If the expected event does occur, what percent of the County will be impacted?
- ***Previous Occurrence:*** Based on the historical records, how often has the hazard occurred within the County?
- ***Future Probability:*** How likely is the event to occur during any given year?
- ***Magnitude/Severity:*** If the expected event does occur, how many people might be killed, injured, or contaminated, and how much property might be damaged or destroyed?

Table 1. Adams County Hazard Ranking Criteria.

Ranking	Geographic Extent	Previous Occurrence	Future Probability	Magnitude /Severity
High	>25% of County	>5 Events in last 50 years	<1 /100 or 1% annual chance	>10% of people or property impacted
Medium	5 to 25% of County	1 to 4 Events in last 50 years	1 in 1,000 to 1/100 or 0.1% to 1% annual chance	1 to 10% of people or property impacted
Low	<= 5% of County	<=1 Event in last 50 years	<=1 /1,000 or 0.1% annual chance	<1% of people or property impacted

Table 2. Adams County Hazard Ranking.

Hazard	Geographic Extent	Previous Occurrence	Future Probability	Magnitude /Severity	2012 Ranking
Thunderstorms	High	High	High	High	**High**
Winter Weather	Medium	High	High	Medium	**High**
Tornadoes	Medium	High	High	Medium	**High**
Flood	Medium	High	Medium	Medium	**Medium**
Drought	Medium	High	High	Medium	**Medium**
Subsidence	Low	Low	Low	Medium	**Low**
Earthquake	Low	Medium	High	Low	**Low**
Wildfire	Low	Low	Medium	Low	**Low**

Table 3 summarizes the results of the hazard vulnerability analysis as well as the comparison to the 2011 Colorado State Hazard Mitigation Plan and the 2011 DRCOG plan. The Colorado State Hazard Mitigation Plan included ranking hazards such as avalanche, erosion and deposition, expansive soils, and grasshopper infestation that are not included in this hazard identification and risk assessment. The ranking criteria and definitions used in the Colorado State Hazard Mitigation Plan have been included in each of the hazard profile sections of this assessment. Keypad polling completed during the June 19, 2012, meeting provided further consensus on the hazards impacting Adams County and the resultant ranking assignment.

Adams County's Emergency Operations Plan (EOP) and the County Hazard Analysis (1996) were reviewed for hazard analysis including description/frequency and impact on life/property. Natural hazards discussed include: Severe Winter Weather, Tornado, Floods, Drought, Wildfire, Thunderstorms and Lightning, and Earthquakes. When applicable; this information has been included within the hazard-specific sections.

In order to focus on the most significant hazards, only those assigned a level of High or Medium will include a Risk and Vulnerability Assessment. The discussion of all hazards identified as Low (Subsidence, Earthquake, and Wildfire) will be contained in the Hazard Identification section, but will not include a risk and vulnerability assessment.

Table 3. Hazard Mitigation Plan ranking comparison.

Hazard	Colorado State HMP 2011					DRCOG 2011			2012/2013 Adams County Ranking
	Hazards Included	Geographic Extent	Previous Occurrence	Future Probability	Magnitude/ Severity	Frequency	Severity	Significance	
Thunderstorms	Thunderstorms	Statewide	Seasonal	Expected	Extensive	High	Extensive	Medium	High
	Windstorms	Regional	Perennial	Expected	Moderate	Medium	Serious	Medium	
	Hailstorms	Regional	Seasonal	Expected	Moderate	High	Serious	Low	
	Lightning	Statewide	Perennial	Expected	Extensive	Included in Thunderstorm			
Winter Weather	Winter Weather	Statewide	Seasonal	Expected	Extensive	Medium	Serious	Medium	High
Tornadoes	Tornadoes	Regional	Seasonally	Expected	Catastrophic	High	Extensive	Medium	High
Drought	Drought	Statewide	Sporadically	Likely	Extensive	High	Extensive	High	Medium
	Extreme Heat	Regional	Seasonal	Occasional	Moderate	Medium	Extensive	Low	
Flood	Flood	Statewide	Seasonal	Likely	Extensive	High	Extensive	High	Medium
	Precipitation (heavy rain)	Statewide	Perennial	Expected	Extensive	Not Profiled			
Subsidence	Subsidence	Regional	Perennial	Expected	Extensive	Low	Medium	Medium	Low
Earthquake	Earthquake	Regional	Sporadic	Occasional	Catastrophic	Low	Extensive	Medium	Low
Wildfire	Fire	Statewide	Perennial	Expected	Extensive	Low	Serious	Low	Low
Avalanche	Avalanche	Regional	Seasonal	Expected	Extensive	N/A			Not Profiled
Erosion and Deposition	Erosion and Deposition	Statewide	Perennial	Expected	Moderate	Not Profiled			Not Profiled
Expansive Soils	Expansive Soils	Statewide	Perennial	Expected	Extensive	Not Profiled			Not Profiled
Grasshopper Infestation	Grasshopper Infestation	Regional	Cyclical	Sporadic	Moderate	Not Profiled			Not Profiled
Landslides, Mud and Debris Flows, and Rockfalls	Landslides, Mud and Debris Flows, and Rockfalls	Regional	Perennial	Expected	Moderate	Very Low	Medium	Medium	Not Profiled

Data Availability

This study includes data collected from a variety of resources including local, State, and national datasets. Whenever possible, data has been incorporated into a Geographic Information System (GIS) to aid in analysis and to develop countywide maps for depicting historical hazard events, hazard areas, and vulnerable facilities and infrastructure. Critical facility data has been collected from the Adams County GIS department. The local data provided is summarized below in Critical Facilities and Infrastructure Data and Building Data.

In accordance with Federal Emergency Management Agency (FEMA) mitigation planning guidance, the results of this study are based on best available data. In most cases, detailed data regarding the characteristics of facilities and other community-related data does not exist in a usable format. Parcel data was available for the County but did not include detailed or complete building inventories such as elevation data, year built, construction material, and values of structures and contents. This data is currently being revised by the County and should be available for future updates to this plan. This further illustrates the difficult nature of quantitatively assessing vulnerability and risk in any of the communities. Therefore, this assessment has been compiled using the best available data.

Strategies will be developed that address these data needs by recommending specific measures to increase the quality and detail of data to prepare usable and effective hazard assessments.

Critical Facilities

The Colorado Water Conservation Board (CWCB)[2] definition of "critical facility" has been used to categorize critical facilities for this hazard identification and risk assessment. For this plan, a "critical facility" means a structure or related infrastructure that, if impacted by a natural hazard event, may result in significant hazards to public health and safety or interrupt essential services and operations for the community at any time before, during, or after the event.

The CWCB includes four main types of critical facilities:

1. Essential services facilities include public safety, emergency response, emergency medical, designated emergency shelters, communications, public utility plant facilities, and transportation lifelines.
2. Hazardous materials facilities include facilities that produce or store highly volatile, flammable, explosive, toxic and/or water-reactive materials.
3. At-risk population facilities include medical care, congregate care, and schools.
4. Facilities vital to restoring normal services including government operations.

Table 4 and Figure 1 show type and locations for the four defined types of critical facilities. As shown, the majority of the facilities reside within the western portion of the County. Adams County GIS staff was actively involved in the development of the critical facilities dataset that represented facilities critical to

[2] Department of Natural Resources Colorado Water Conservation Board. Rules and Regulations for Regulatory Floodplains in Colorado. November 17, 2010. Pages 12-15.

County operations, potential targets, shelters, transportation, and tourism attractions. This data has been provided and is available through the County GIS department.

Although the majority of the critical facility information was spatially available, the attributes for the data are very limited. Without detailed, building-specific information (i.e., first floor elevation, year built), analysis options were based on the spatial location of the facility and delineated hazards. When applicable, the data provided was used and the results are included in the hazard-specific analysis sections. Future mitigation actions should address these GIS needs.

Table 4. Critical facilities as defined by Colorado Water Conservation Board (CWCB).

Facility Type	Description of Facility Types Included	Number of Facilities
1. Essential Facilities	• Public Safety • Emergency Response • Emergency Medical • Designated Emergency Shelters • Communications • Public Utility Plan Facilities • Transportation Lifelines	81
2. HazMat Materials Facilities (Tier II facilities)	• Chemical and pharmaceutical plans • Laboratories Refineries • Hazardous waste storage and disposal sites • Above-ground gasoline or propane storage or sales centers	178
3. At-Risk Populations	• Elder Care (nursing homes) • Congregate Care serving 12 or more (day care and assisted living) • Public and private schools (preK – 12), before and after school caring for 12 or more	231
4. Vital to Restoring Normal Services	• Essential Gov't operations (public records, courts, jails, permits/inspections, community admin, maintenance and equipment centers) • Public Colleges and Universities (dorms, offices, and classrooms)	28

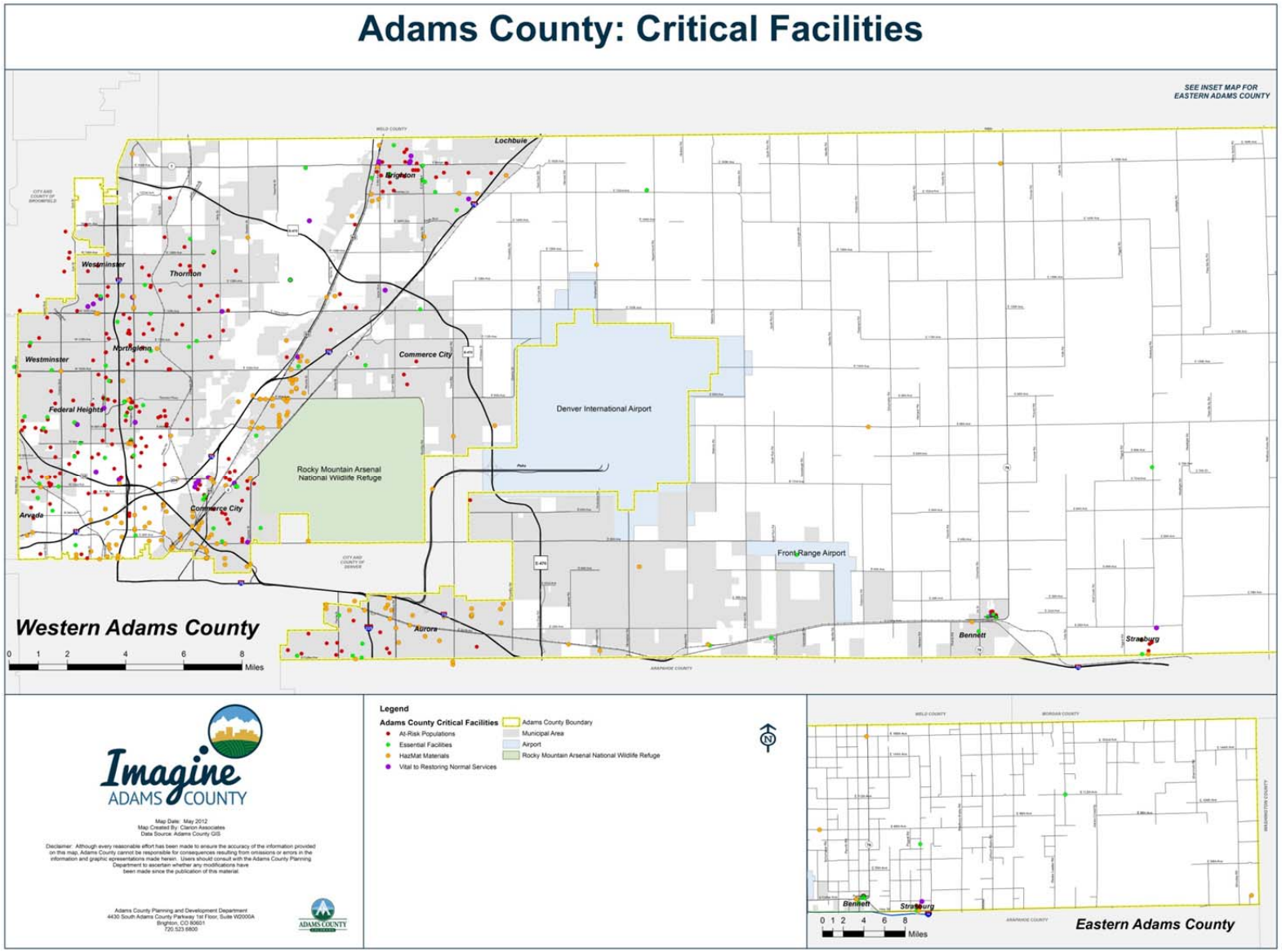

Figure 1. Critical facility locations.

ASSETS

Adams County GIS department provided parcel data with information on building value from the County Assessor. This information provides the basis of the loss estimation described in each of the hazard-specific sections. As shown in Table 5, Adams County has over 154,953 parcels located within the County, accounting for over $34.7 billion improvement value. The majority (89.3%) of the number of parcels is classified as residential, followed by commercial (3.9%). The majority of the parcels and building value is located in Western Adams County (Figure 2).

Table 5. Parcel and total improvement value by occupancy type.

Occupancy	Number of Parcels	Total Value of Improvements
Residential	138,314	$24,816,026,965
Commercial	6,101	$4,624,166,547
Agricultural	4,665	$209,461,467
Exempt	4,646	$4,445,222,863
Industrial	672	$668,976,817
State Assessed	395	$169,787
Not Classified	89	
Producing Mine	71	$7,290,486
Total	**154,953**	**$ 34,771,314,932**

Hazards-United States (Hazus) is a nationally applicable standardized methodology developed by FEMA and the National Institute of Building Sciences (NIBS) that contains models for estimating potential losses from earthquakes, floods, and hurricanes. Hazus uses GIS technology to estimate physical, economic, and social impacts of disasters. It graphically illustrates the limits of identified high-risk locations due to earthquake, hurricane, and floods. Users can then visualize the spatial relationships between populations and other more permanently fixed geographic assets or resources for the specific hazard being modeled, a crucial function in the pre-disaster planning process.

Hazus inventories have been used for loss estimation for flooding and earthquake. The analysis of these hazards is included in the hazard-specific sub-sections in this report. Hazus analysis was performed for flooding and earthquake scenarios in Adams County. General building stock information estimates 123,000 buildings in the region with a total replacement value of $22,405 million (2006 dollars). Approximately 92% of the buildings and 77% of the building value is associated with residential housing. Hazus building exposure is shown in Table 6. For assessment purposes, the Hazus building stock and parcel data provided by Adams County are comparable.

Table 6. Hazus Building Stock Exposure.

Occupancy Type	Building Exposure	
	Exposure ($1000)	% of Total
Residential	$17,266,716	77.1
Commercial	$3,322,488	14.8
Industrial	$1,011,301	4.5
Agricultural	$153,144	0.7
Religion/Nonprofit	$273,427	1.2
Government	$157,983	0.7
Education	$220,246	1
Total	$22,405,305	100

HAZARDOUS MATERIALS FACILITIES (TIER II FACILITIES)

In October 1986, the Federal Superfund and Reauthorization Act (SARA/Title III), which includes the Emergency Planning and Community Right-To-Know provisions, was enacted. This legislation was in response to several very severe hazardous materials incidents world-wide. It put in place several protection measures regarding hazardous materials incidents. The legislation required each state appoint a State Emergency Response Commission to implement the act in their state. In Colorado, the Colorado Emergency Planning Commission (CEPC) was created.

The CEPC implemented the act by designating Local Emergency Planning Districts (LEPD) and then requesting nominations from those districts for appointing Local Emergency Planning Committees (LEPC). Each LEPC has the charter of implementing the SARA/Title III requirements for their LEPD. These requirements include developing and publishing a hazardous material emergency response plan for their area, the creation of Right-To-Know procedures for their LEPD, and monitoring of specific yearly hazardous materials reporting requirements.[3]

Based on the Environmental Protection Agency (EPA) and Colorado Department of Public Health and Environment, a Hazardous Materials Facilities (Tier II facilities) report needs to be submitted for:

- Any facility that had at any time stored 10,000 pounds (lbs) of any material that is required to have a Material Safety Data Sheet (MSDS) or
- is an Extremely Hazardous Substance(EHS) of either 500 lbs or the Threshold Planning Quantity (TPQ), whichever is lower .[4]

For this analysis, Hazardous Materials Facilities (Tier II facilities) have been incorporated into the critical facilities dataset. There are 178 facilities within Adams County and of those, a seventeen (17) are part of the Risk Management Program (RMP). RMP facilities are a subset of the Hazardous Materials Facilities (Tier II facilities) and have a worst-case scenario plan developed. Table 7 and Table 8, in the Land Use and Development section, summarize the location of the facilities by current and future land use type.

[3] Colorado Tier II Reporting Requirements. http://www.epa.gov/osweroe1/content/epcra/statetier2.htm#colorado
[4] Tier II minimum thresholds CRF part 370. http://www.cdphe.state.co.us/oeis/sara/tierIIreports.html

Tri-County Health Department (TCHD) manages the local Rocky Mountain Arsenal Oversight Program which includes monitoring water, air, and activities so that workers and the community are protected.[5] TCHD staff assists in identifying environmental health hazards that would have the most potential impact on proposed adjacent land use designations including those located on or near the Rocky Mountain Arsenal. For additional information, consult the Comprehensive and Land Use plans that have been developed in tandem with this assessment.

[5] Tri-County Health Department Rocky Mountain Arsenal Oversight Program. http://www.tchd.org/arsenal.html

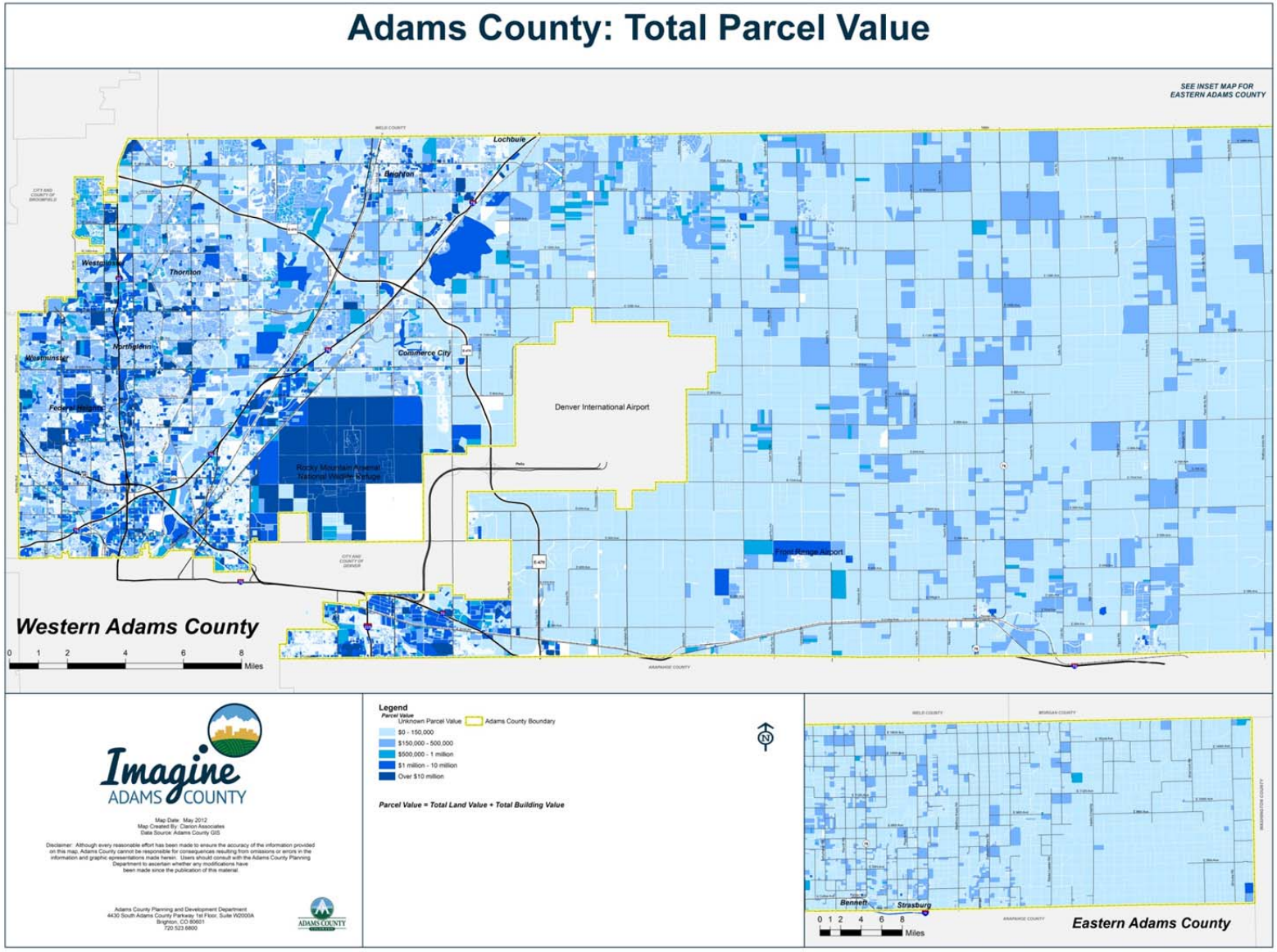

Figure 2. Total parcel value.

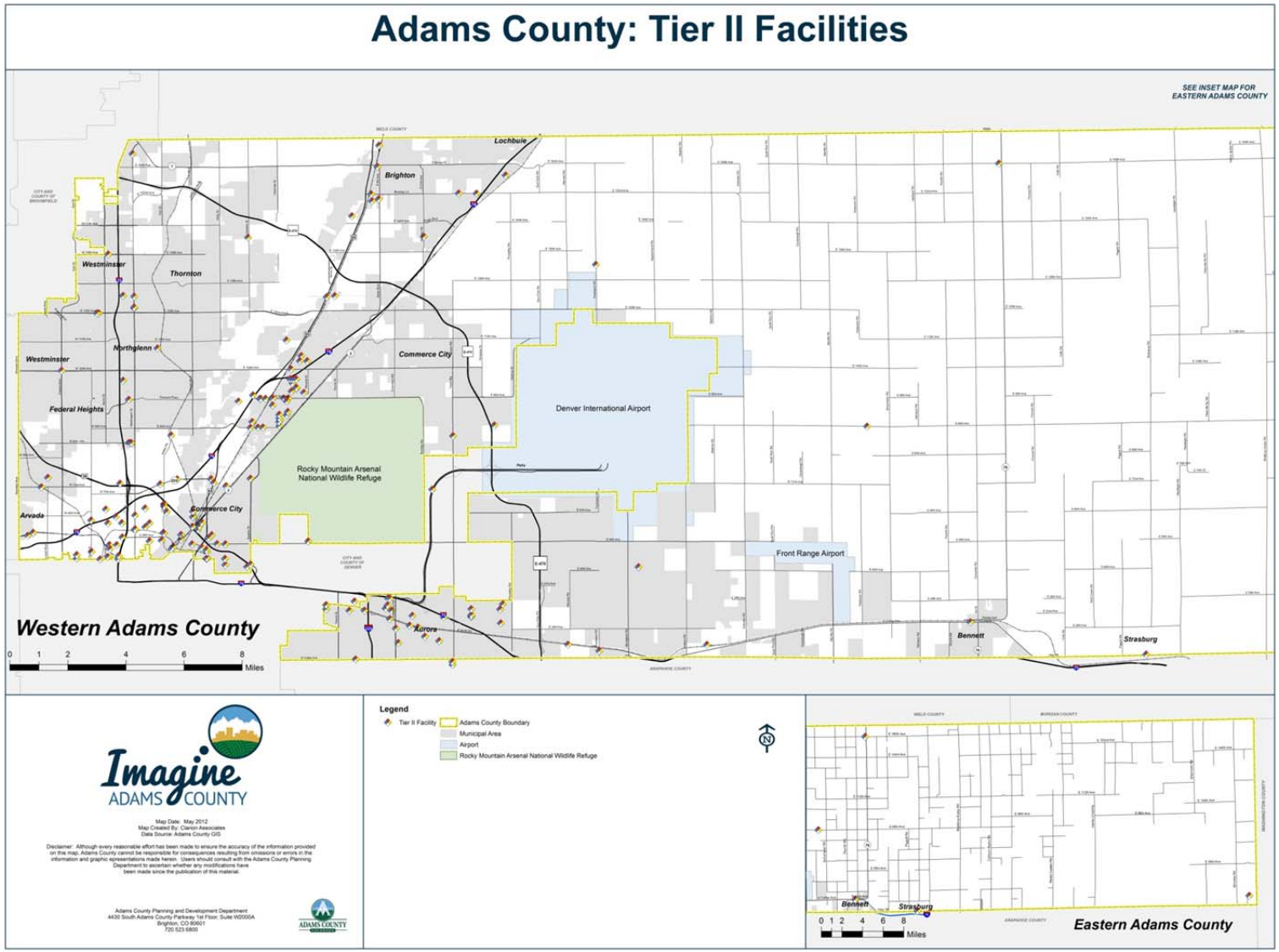

Figure 3. Hazardous Materials Facilities (Tier II facilities) locations.

Land Use and Development

This assessment is being done in tandem with the overall update to the County's Comprehensive and Transportation Plans. FEMA requires that state and local mitigation plans evaluate land use and development trends so that mitigation options can be considered in future land use decisions. Results of this are reflected in the current land use plan.

Zoning is also a critical indicator to review in considering local development trends. Current Land Use was derived from the Assessor's data and joined to the GIS parcel data provided by the County GIS department. Figure 4 shows the distribution of zoning throughout the County. Residential land use represents the majority type within the County (Figure 4). Hazardous Materials Facilities (Tier II facilities) located within the current zoning categories are summarized in Table 7; 62 Hazardous Materials Facilities (Tier II facilities), and 4 RMP facilities, are located within Commerce City. Aurora has the second largest concentration with 31 facilities.

Zone Districts were created by law in Adams County to control the use of land and buildings, regulate the location, height, bulk, and size of buildings and other structures, and to provide for minimum separation between uses and buildings.[6]

Tri-County Health Department (TCHD) works closely with the County on the development and implementation of flammable gas overlay which is used to make informed land use decisions. This information may be deemed useful in protection of critical facilities from natural hazards.

Table 7. Hazardous Materials Facilities (Tier II facilities) by current zoning type.

Current Zoning	Number of Hazardous Materials Facilities (Tier II Facilities	Number of RMP Facilities
A-1	4	1
A-3	7	
Arvada	1	1
Aurora	31	
Brighton	11	1
C-0	2	
C-4	1	
Commerce City	62	4
I-1	3	
I-2	18	
I-3	13	1
North Glenn	1	1
R-1-C	1	
Thornton	11	
Westminster	7	
Total within Zoning Categories	173	9

[6] Berkeley Neighborhood Plan, November 2008.

Land Use differs from zoning in that it focuses on the actual use of the land, rather than what it is zoned for. The future Land Use data shown below (Table 8) comes from the tax category data used by the Adams County Assessor. State Assessed property is property that is valued at the state level and not locally. The state sends the Assessor's Office the value, and then the Assessor taxes it. This is used by utility companies that have utility lines, telecommunication companies, and railroad companies that have tracks running through many counties. Exempt property is property that is exempt from property tax. Properties can be exempt in two different ways. Cities, school districts, fire districts, or any other special district that owns property in Adams County are automatically exempt. Religious and Charitable organizations can apply to become tax exempt through the State of Colorado. Once the exemption is approved, they are removed from the tax roll and become tax exempt.[7]

Table 8. Hazardous Materials Facilities (Tier II facilities) by future land use type.

Future Land Use	# of Hazardous Materials Facilities (Tier II facilities) Facilities	# of RMP Facilities
Agriculture	5	
Commercial	2	
Industrial	50	4
Low Intensity Mixed Use	3	
Mixed Use/Employment	9	
Parks and Open Space	2	1
Residential	3	
Total within Future Land Use	74	5

The 2010 US Census data cataloged 565 active building permits in Adams County. Building permits represent the number of new privately owned housing units authorized by building permits in the United States. These numbers provide a general indication of the amount of new housing stock that may have been added to the housing inventory. Since not all permits become actual housing starts, and starts lag the permit stage of construction, these numbers do not represent total new construction, but should provide a general indicator on construction activity and the local real estate market.[8] It should be noted that not all residential building permits issued in the County are for primary year round homes. Some new construction homes may be for seasonal use or second homes. Growth and development in the County is constrained based on the cost of construction, the ability to serve in a cost effective manner, land prices, and availability.

[7] Berkeley Neighborhood Plan, November 2008.
[8] US Census Housing Units Authorized by Building Permits. 7/23/2012. http://quickfacts.census.gov/qfd/meta/long_BPS030211.htm

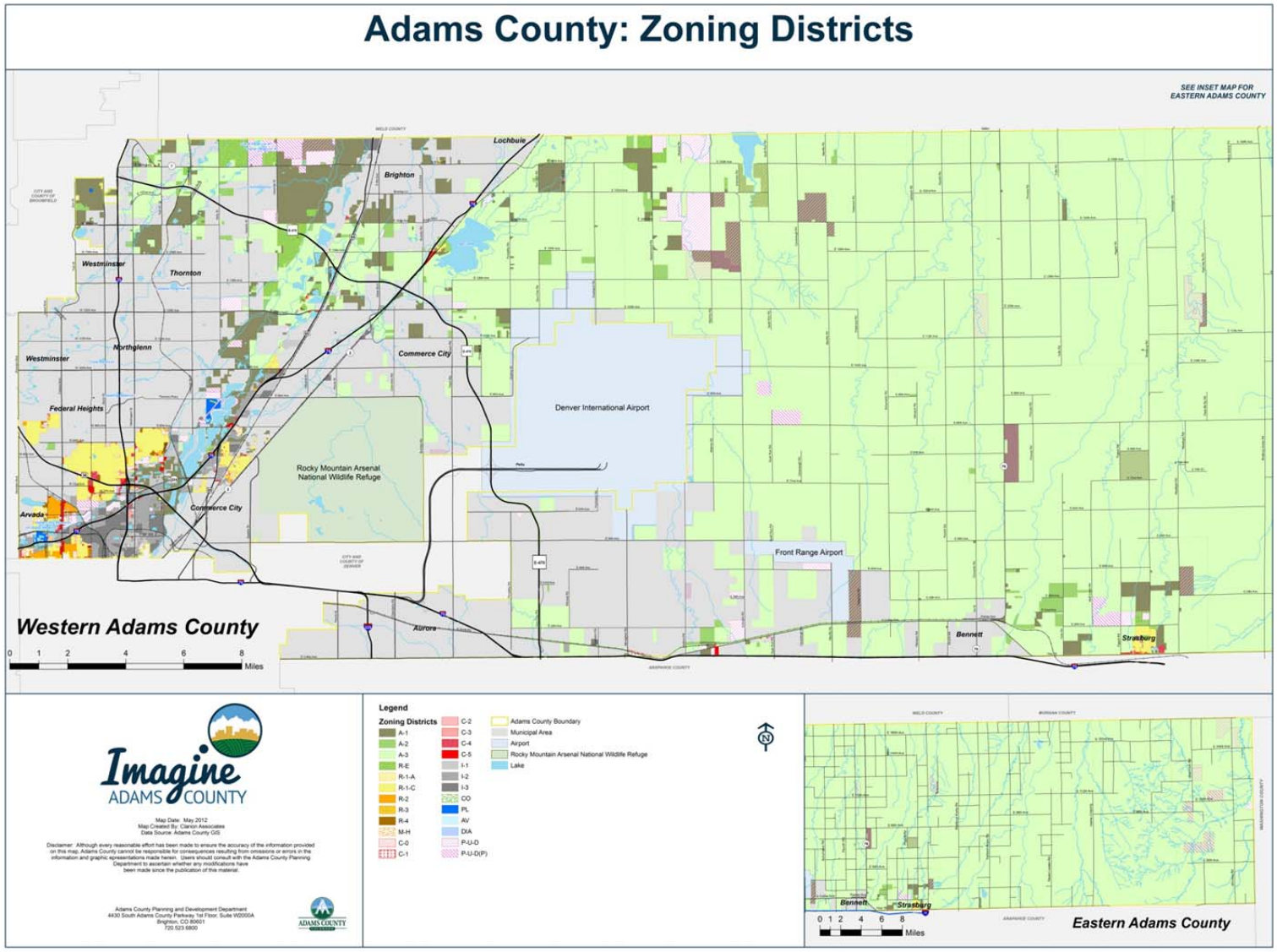

Figure 4. Zoning districts

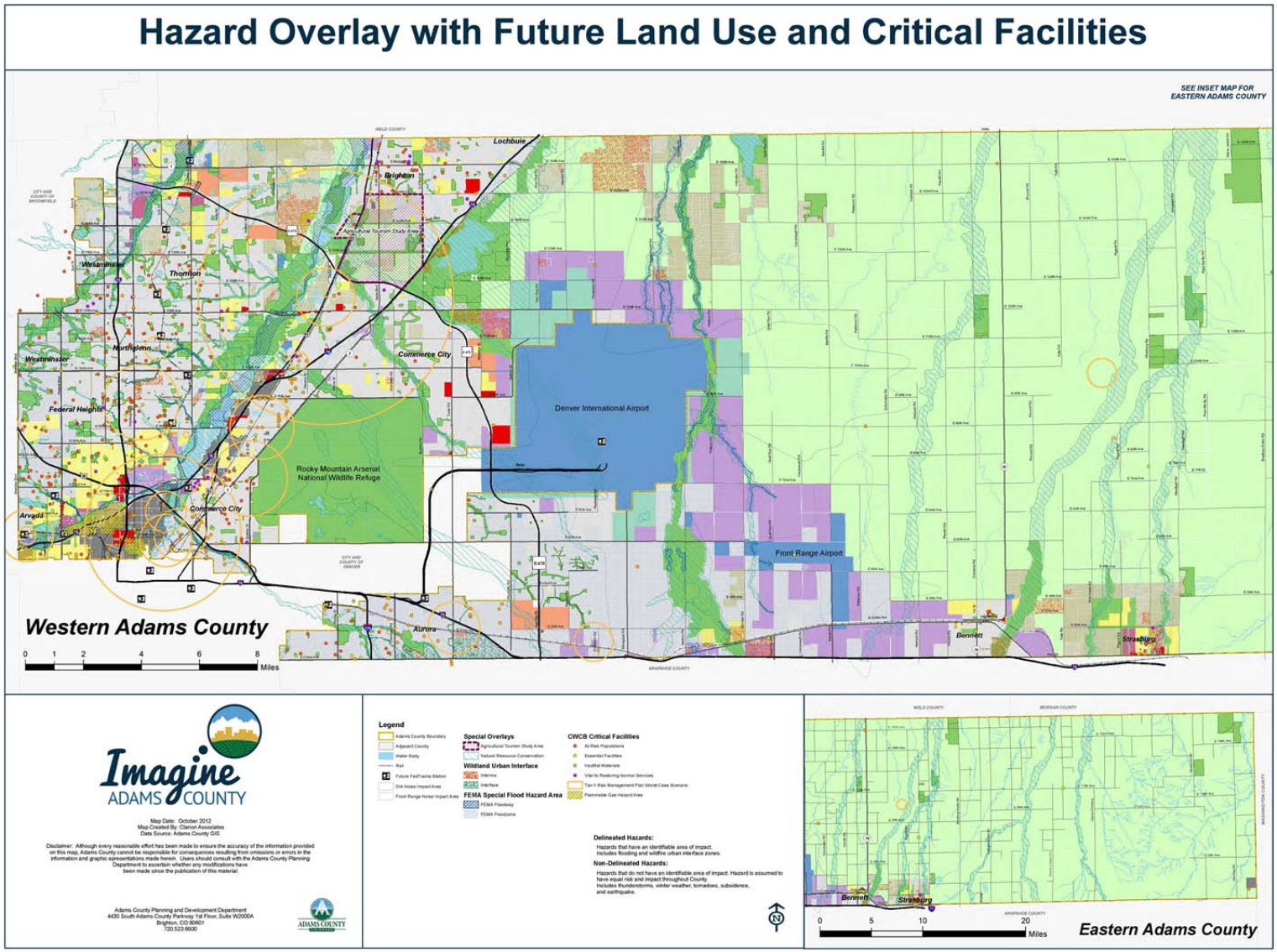

Figure 5. Future land use and critical facilities.

State and Federally Declared Disasters

Historic state and federal disaster and emergency declarations were reviewed to ensure coverage of all the events in this Assessment. State declarations have been made by the Governors from 1980 through 2012. Past emergencies and disasters have been reviewed and consolidated in Table 9. The majority of the disasters listed are statewide disasters that may not have had an impact in Adams County. A U.S. Department of Agriculture (USDA) disaster declaration certifies that the affected county has suffered at least a 30% loss in one or more crop or livestock areas. As shown, the USDA, Farm Service Agency, declarations that affected Adams County were due to drought and high winds.

Table 9. State and federally declared disasters.

Date	Hazard Type	Declaration Type
2012	Drought	USDA Disaster
2009	Severe Blizzard (Statewide)	State Declaration
2009	Severe Sprint Snowstorm	State Declaration
2006	Drought, Fire, Heat and High Winds	USDA Disaster
2006 (12/18/2006 – 12/22/2006)	Snow	Presidential Emergency (FEMA-EM-3185)
2003	Snow	Presidential Emergency (FEMA-EM-3270)
2003	Snow Emergency	State Declaration
2002 (4/23/2002 – 8/6/2002)	Wildfires	Presidential Disaster (FEMA-DR-1421)
2002	Wildfires	State Declaration
2002	Drought	USDA Disaster
2002	Drought	State Declaration
2001	Severe Winter Storms (Eastern Plains and Front Range counties)	State Declaration
2000	Drought	USDA Disaster
1982	Severe Winter Storm	State Declaration
1981	Dam Safety	State Declaration
1981	Tornadoes	State Declaration

National Climatic Data Center

The National Climatic Data Center (NCDC) Storm data is published by the National Oceanic and Atmospheric Administration (NOAA), part of the U.S. Department of Commerce. The storm events database contains information on storms and weather phenomena that have caused loss of life, injuries, significant property damage, and/or disruption to commerce. Efforts are made to collect the best available information, but because of time and resource constraints, information may be unverified by the National Weather Service (NWS). The NWS does not guarantee the accuracy or validity of the information. Although the historical records in the database often vary widely in their level of detail, the NWS does have a set of guidelines used in the preparation of event descriptions.[9] The historical

[9] National Water Service Instruction 10-1605. Operations and Services Performance: Storm Data Preparation Guide. August 17, 2007. Available at: http://www.nws.noaa.gov/directives/sym/pd01016005curr.pdf

record of the storm data used for this update includes events from February 1950 through the end of February 2012. The Storm Events database is updated as data becomes available and is usually 90-120 days behind the current month.

In order to compare the storm events data, a customized tool was utilized to process the data to account for inflation,[10] standardize hazard event types, normalize zone reported events, and annualize events and damages for Adams County. After processing the data, there were 729 storm events listed for Adams County (as shown in Table 10). Most of the records are related to thunderstorms and tornadoes. Figure 6 shows the monthly total hazard events; the months of April through September are dominated by thunderstorm and tornado events. National Climatic Data Center has recorded over $599 million in property damages, $9.5 million in crop damages, 63 injuries and 3 deaths.

Table 10. National Climatic Data Center storm events through February 2012.

Hazard Type	Number of Events	Property Damage	Crop Damage	Deaths	Injuries
Thunderstorm	430	$529,559,741	$77,075	2	20
Winter Weather	57	$7,798	$0	0	0
Tornadoes	162	$68,890,697	$9,464,149	0	43
Flood	14	$714,092	$0	1	0
Drought	64	$0	$0	0	0
Wildfire	2	$0	$0	0	0
Total	**729**	**$599,172,328**	**$9,541,224**	**3**	**63**

[10] U.S Department of Labor, Bureau of Labor Statistics. Databases, Tables & Calculators for All Urban Consumers: Consumer Price Index (CPI) http://www.bls.gov/data/#prices

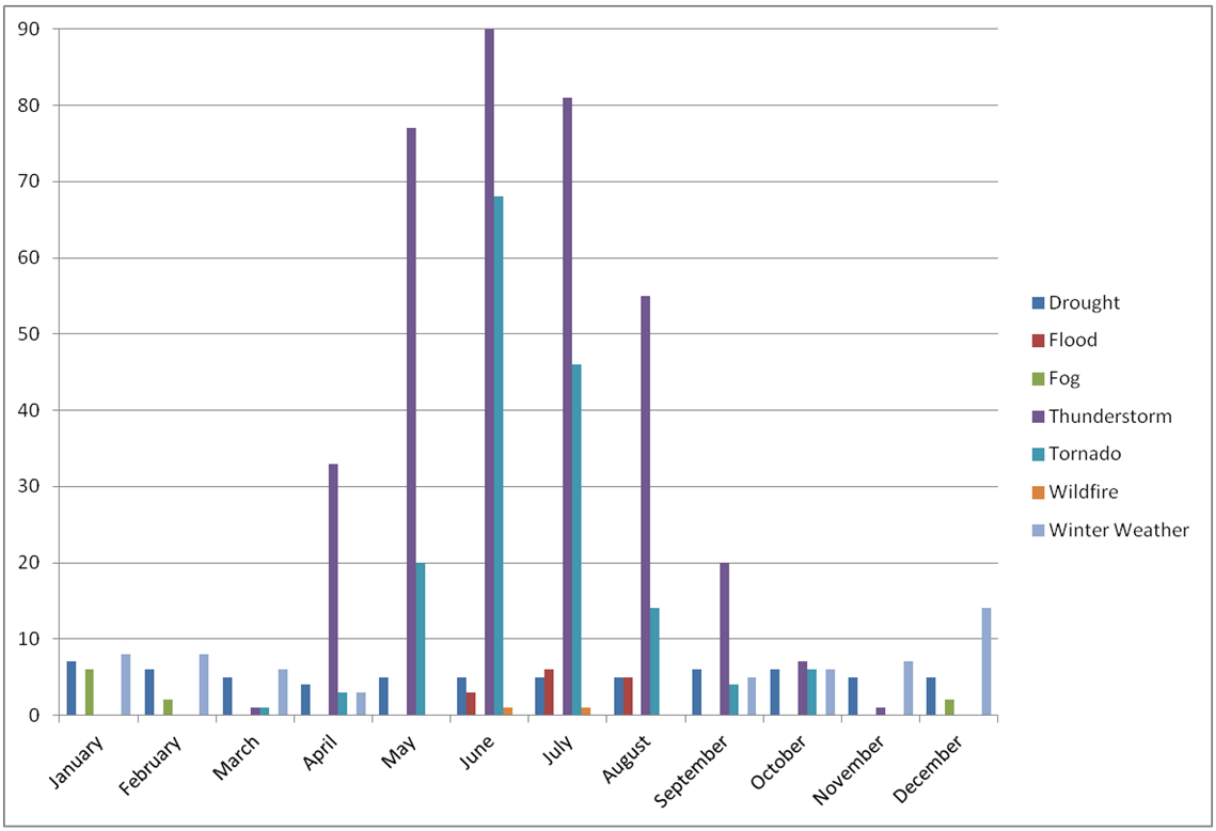

Figure 6. Monthly total of National Climatic Data Center hazard events

HAZARD-SPECIFIC DATA

Hazard-specific analysis is often the most challenging and time consuming segment of the risk assessment. The level and type of analysis that can be completed is dependent on the type of data available for analysis. Critical facility, infrastructure, and building footprint data have been described above. To determine hazard-specific risk, data needs to be available for analysis. The majority of the hazards impacting Adams County do not have definitive impact boundaries, and, as a result, past occurrences were used to try to identify probable locations where these events may happen in the future. Table 11 provides a breakdown, by hazard, of the datasets used for analysis and mapping in the hazard-specific sections that follow. The available datasets illustrate the difficult nature of quantitatively assessing vulnerability and risk within the County. This assessment has been compiled using the best available data.

It should be noted that National Climatic Data Center is well known for having limited records of geological hazards (i.e., earthquake). However, historical information for earthquakes was readily available through the Colorado Geological Survey (CGS). Most hazards do not have an identified area of impact. These hazards are assumed to have uniform risk across the County. These include thunderstorms, winter storm, tornado, drought, subsidence, and earthquake.

The 2011 Colorado Natural Hazards Mitigation Plan and the DRCOG plan were reviewed and relevant information was included in this plan. When applicable, these plans have been referenced.

Table 11. Hazard-specific data utilized for analysis and mapping.

Hazard	Dataset	Source
Thunderstorms	National Climatic Data Center Storm Events	National Climatic Data Center Storm Events Database Severe Weather GIS (SVRGIS) BCA Frequency Analysis
Winter Weather	National Climatic Data Center Storm Events	National Climatic Data Center Storm Events Database
Tornadoes	National Climatic Data Center tornado frequency statistics National Climatic Data Center Storm Events for Tornado Tornado Tracks and Touchdowns	National Climatic Data Center Storm Events Database SVRGIS Benefit Cost Analysis (BCA) Frequency Analysis
Flooding including dam failure	Digital Flood Insurance Rate Maps (DFIRMs) NFIP Policy & Claims Repetitive & Severe Repetitive Loss Properties ACOE Online database of dams Dam Inundation	FEMA FEMA NFIP National Climatic Data Center Storm Events Database FEMA Hazus US Army Corps of Engineers National Inventory of Dams Database
Drought	U.S. Drought Monitor National Climatic Data Center Storm Events for Drought	National Climatic Data Center Storm Events Database U.S. Drought Monitor
Subsidence	USGS Landslide Incidence and Susceptibility	USGS National Landslide Hazard Program via National Atlas
Earthquake	Significant US Earthquakes Peak Ground Acceleration Annualized Loss Estimates	USGS Earthquake Hazard Program via National Atlas CGS FEMA Hazus
Wildfire	Wildland Urban Interface (WUI)	Silvis Lab

Additional Sources

Existing reports were reviewed during the development of this assessment. These reports were reviewed for the natural hazards identified, historical information, and analysis methodology. These reports include:

- State of Colorado Natural Hazards Mitigation Plan (January 2011)
- DRCOG Hazard Mitigation Plan (2011)
- Adams County Hazard Analysis (1996)
- Adams County Emergency Operations Plans (2006)
- Information gathered from Adams County website
- Information on past extreme weather and climate events from NOAA's National Climatic Data Center;

- Disaster declaration history from FEMA, the Public Entity Risk Institute (PERI), and the USDA Farm Service Agency;
- Information on Natural Hazards gathered from the United States Geological Survey (USGS);
- Information on Natural Hazards gathered from the Colorado Geological Survey (CGS);
- Information on mitigation and previous events from the CWCB;
- Information on drought occurrences from the National Drought Mitigation Center (NDMC);
- GIS data and reports from Adams County

Hazard Profiles and Risk Assessment

The hazard identification and ranking documented in the previous sections of this report highlighted the types of hazards Adams County is most vulnerable to and ranked them based on specific parameters. The next step in the process is to conduct a risk assessment for each of the hazards that impact the County. A vulnerability and risk assessment is the process of measuring the potential loss of life, personal injury, economic injury, and property damage resulting from hazards. Each of the natural hazards is presented as sub-sections of this report; the primary components of the risk assessment include:

1. Hazard Identification
    a. Ranking
    b. Description
    c. Geographic Location & Severity
    d. Previous Occurrence
    e. Probability of Future Occurrence
2. Risk and Vulnerability Assessment
    a. Impacts on Critical Facilities, Infrastructure, and Population
    b. Loss Estimates

The level of analysis for the risk assessment portion varies based on the designated hazard ranking. Hazards that have been ranked as High and Medium include information in the risk assessment components.

The hazard assessment also examines the impact of hazards on existing and future land uses and development trends, within the identified hazard areas. Current conditions were evaluated in terms of what is already developed, and in terms of people and property types. Adams County has comprehensive plans, zoning ordinances, capital improvement plans, and other plans, which were used as indicators of potential future risks to undeveloped properties, services, and infrastructure. New development and areas targeted for re-development often present the best opportunities for incorporating new methods of development or retrofitting development so that it will be able to withstand the effects of hazards.

Thunderstorms (High Ranking)

Ranking

Table 12 shows the criteria used to derived a High ranking for thunderstorms in Adams County. Hazard ranking criteria from the State of Colorado Hazard Mitigation Plan and DRCOG Hazard Mitigation Plan were reviewed by the steering committee. Hazard ranking methodology is further explained in the beginning of the hazard identification section of this plan. To fully support integration, each hazard was

considered and the potential impacts are reflected in the future land use map in the body of the Comprehensive Plan.

Table 12. Thunderstorm Hazard Ranking Criteria.

Hazard	Geographic Extent	Previous Occurrence	Future Probability	Magnitude /Severity	2012 Ranking
Thunderstorms	High >25% of County	High >5 Events in last 50 years	High <1 /100 or 1% annual chance	High >10% of people or property impacted	**High**

DESCRIPTION

A severe thunderstorm includes damaging winds greater than 58 miles per hour (mph) (50 knots) or greater and hail 1 inch or larger in diameter. High winds have been further broken down into three categories by the NWS Storm Events database:

- High Wind: Sustained non-convective winds of 35 knots (40 mph) or greater lasting for 1 hour or longer or winds (sustained or gusts) of 50 knots (58 mph) for any duration (or otherwise locally/regionally defined), on a widespread or localized basis. In some mountainous areas, the above numerical values are 43 knots (50 mph) and 65 knots (75 mph), respectively.
- Strong Wind: Non-convective winds gusting less than 50 knots (58 mph), or sustained winds less than 35 knots (40 mph) resulting in a fatality, injury, or damage.
- Thunderstorm Wind: Winds, arising from convection (occurring within 30 minutes of lightning being observed or detected), with speeds of at least 50 knots (58 mph), or winds of any speed (non-severe thunderstorm winds below 50 knots) producing a fatality, injury, or damage. Events with maximum sustained winds or wind gusts less than 50 knots (58 mph) should be entered as a Storm Data event only if they result in fatalities, injuries, or serious property damage.

Hail is precipitation in the form of ice that occurs in thunderstorms between currents of rising air (updrafts) and currents of descending air (downdrafts) as shown in Figure 7. These events typically occur in late spring and early summer. One criteria for severe thunderstorms, as defined by the NWS, is hail that is 1 inch in diameter (quarter-size) or larger.

Lightning is generated by the buildup of charged ions in a thundercloud. When this buildup intersects with the best conducting object or surface on the ground, the result is a discharge of a lightning bolt. A bolt of lightning can reach temperatures approaching 50,000 degrees Fahrenheit. Lightning rapidly heats the sky as it flashes, but the surrounding air cools following the bolt. This rapid heating and cooling of the surrounding air causes thunder.

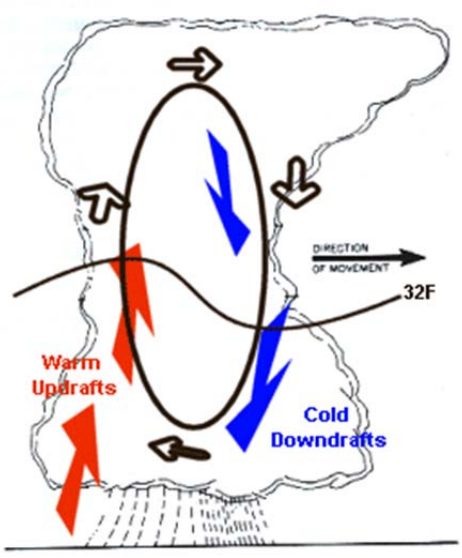

Figure 7. Formation of Hail
Source: NOAA

Geographic Location and Severity

Geographic Location = Statewide. Higher number of severe thunderstorms along Front Range and all of eastern Colorado. Thunderstorms occur statewide with varying elevation-based characteristics.[11]

All of Adams County is at risk to thunderstorm events with equal probability and magnitude. Using the NWS definition for a severe thunderstorm, Adams County would consider dime-size hail a minimum severity and quarter-sized to be a major severity for hail events. Since there is no established index for lightning, the County would consider a lightning strike with limited impacts (tree limbs) to be a minimum severity and extensive damage (utility lines or points of interest) to be a major severity.

Figure 8 shows the average number of thunderstorm events comparatively for the United States; this was created from data collected by the NWS on number and duration of thunderstorm events and lightning strike density from 1948 through 1977. As illustrated, Adams County can experience, on average, 40 to 50 thunderstorm events annually.

Magnitude/Severity = Extensive. Major or long-term property damage that threatens structural stability, isolated deaths and/or injuries, potential impact to critical services or facilities. Precursor to hazards such as flood, wind, hail, tornadoes, and lightning.[12]

Using the NWS high wind categories listed above, Adams County would consider sustained non-convective winds of 40 mph or greater lasting for 1 hour or longer or winds (sustained or gusts) of 58 mph for any duration, on a widespread or localized basis a minimum severity event. A major severity would be wind events of greater than 58 mph or wind events resulting in death, injury, or significant damage.

The potential damages resulting from lightning strikes are primarily loss of life, business interruption, fire, and minor structural damage. A false sense of security often leads people to believe that they are safe from a lightning strike because it may not appear to be near their location. However, lightning can strike 10 miles away from a rain column, which puts people that are still in clear weather at risk. Figure 9 illustrates average flash densities for cloud-to-ground lightning events. Adams County receives between 6 and 12 flashes per square kilometer per year.

The amount of cover obtained during a hail storm can greatly reduce the risk to human health during these events. Agricultural crops and structures have significant exposure and are at risk.

Quarter-sized hail can cause significant damage to agricultural crops and livestock and property, such as automobiles, aircrafts, and roofs. Damage to shingled roofs may go undetected until leaks and cracks start forming. Damage to metal roofs is more noticeable due to dents and damages to exterior finishes. Automobiles may be dented or have their windshields and windows shattered. Although rare, large hailstones may even cause injury or death.

[11] 2011 State of Colorado Natural Hazards Mitigation Plan.
[12] 2011 State of Colorado Natural Hazards Mitigation Plan.

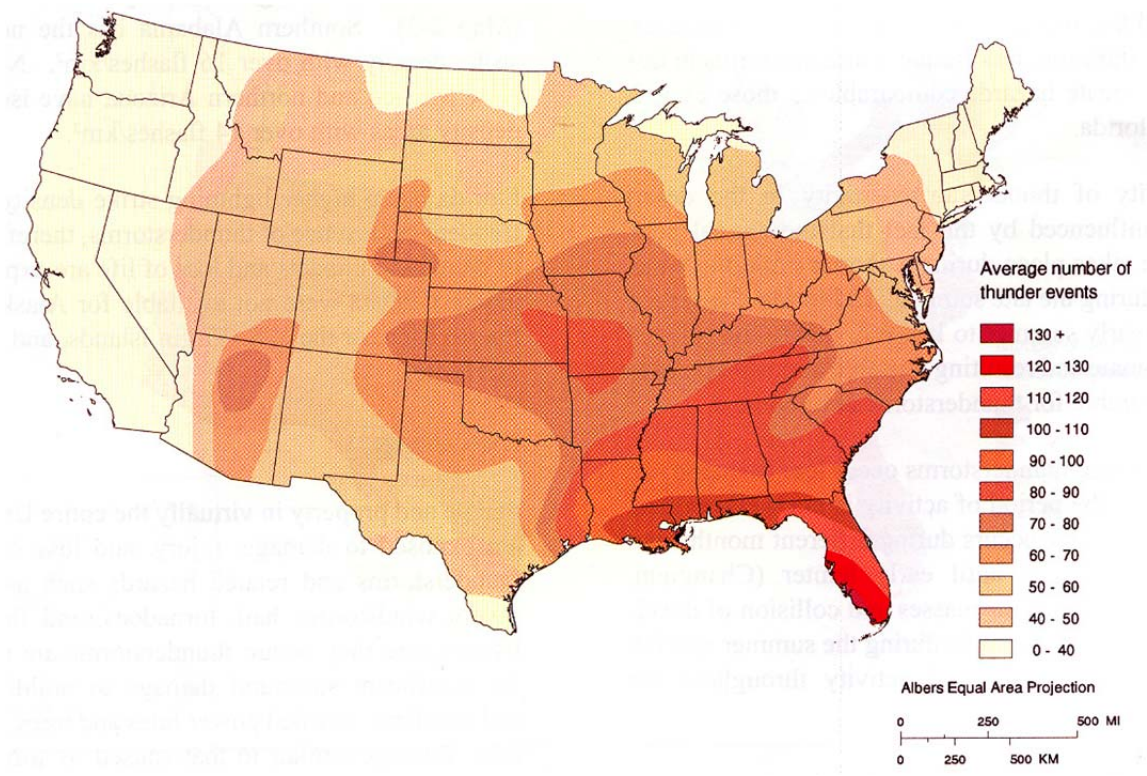

Figure 8. Annual average number of thunderstorm events 1948 through 1977. Source: FEMA

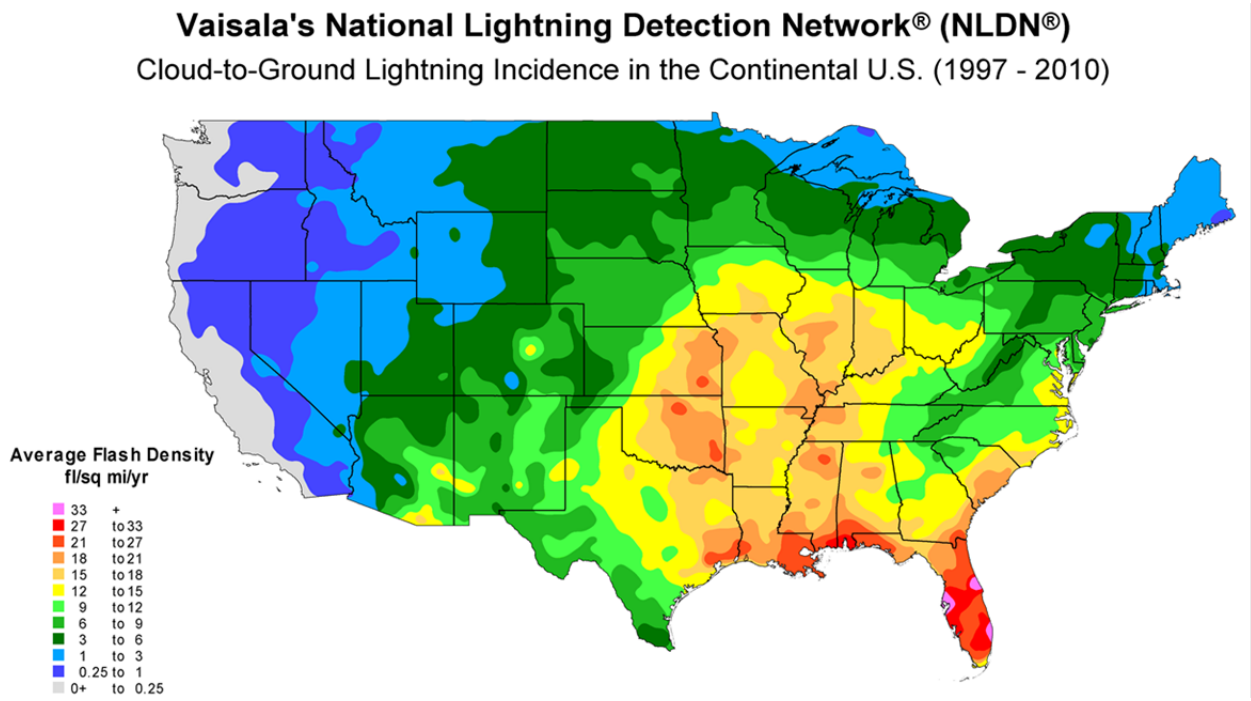

Figure 9. Cloud-to-Ground Lightning Incidents, 1997-2010. Source: NOAA

Previous Occurrences And Probability of Future Occurrence

Previous Occurrences = Seasonal. Regular occurrences from spring through late summer or early fall. Most severe storms typically occur midsummer.[13]

Based on National Climatic Data Center, since 1955, there have been 430 thunderstorm-related events in Adams County (Table 13). Twenty-two (22) lightning events that resulted in fatality, injury, and/or property and crop damage are included in the National Climatic Data Center storm events database. National Climatic Data Center events with more than $100,000 in damages (inflated to 2012):

- Hail (Figure 10)
- May 22, 1996 ($174 Million)
- July 13, 2011 ($169 Million)
- May 26, 2010 ($73 Million)
- June 20, 2001 ($63 Million)
- June 14, 1999 ($48 Million)
- Lightning
- July 11, 2001 ($257,990)
- July 27, 1997 ($106,752)
- High Wind
- April 18, 2000 ($104, 736)

Table 13. Thunderstorm National Climatic Data CenterStorm Events for Adams County, Colorado (Shown in 2012 Dollars).

Hazard Type	Number of Events	Property Damage	Crop Damage	Deaths	Injuries
Thunderstorm	430	$529,559,741	$77,075	2	20
Hail	324	$528,849,525	$77,075	0	7
Lightning	22	$498,686	$0	2	3
Microburst	12	$92,866	$0	0	2

The probability of future occurrences of thunderstorms within Adams County is high. It is extremely difficult to determine probability of future occurrence in a specific area with any degree of accuracy. All areas within Adams County are equally at risk to thunderstorms. Figure 10 was created using Version 4.5 of the FEMA Benefit-Coast Analysis Reengineering (BCAR) methodology.

It should be noted that many thunderstorms go unreported to the NWS. Therefore, data collected for the purposes of this study may not be all inclusive of all thunderstorm events experienced in Adams County.

[13] 2011 State of Colorado Natural Hazards Mitigation Plan.

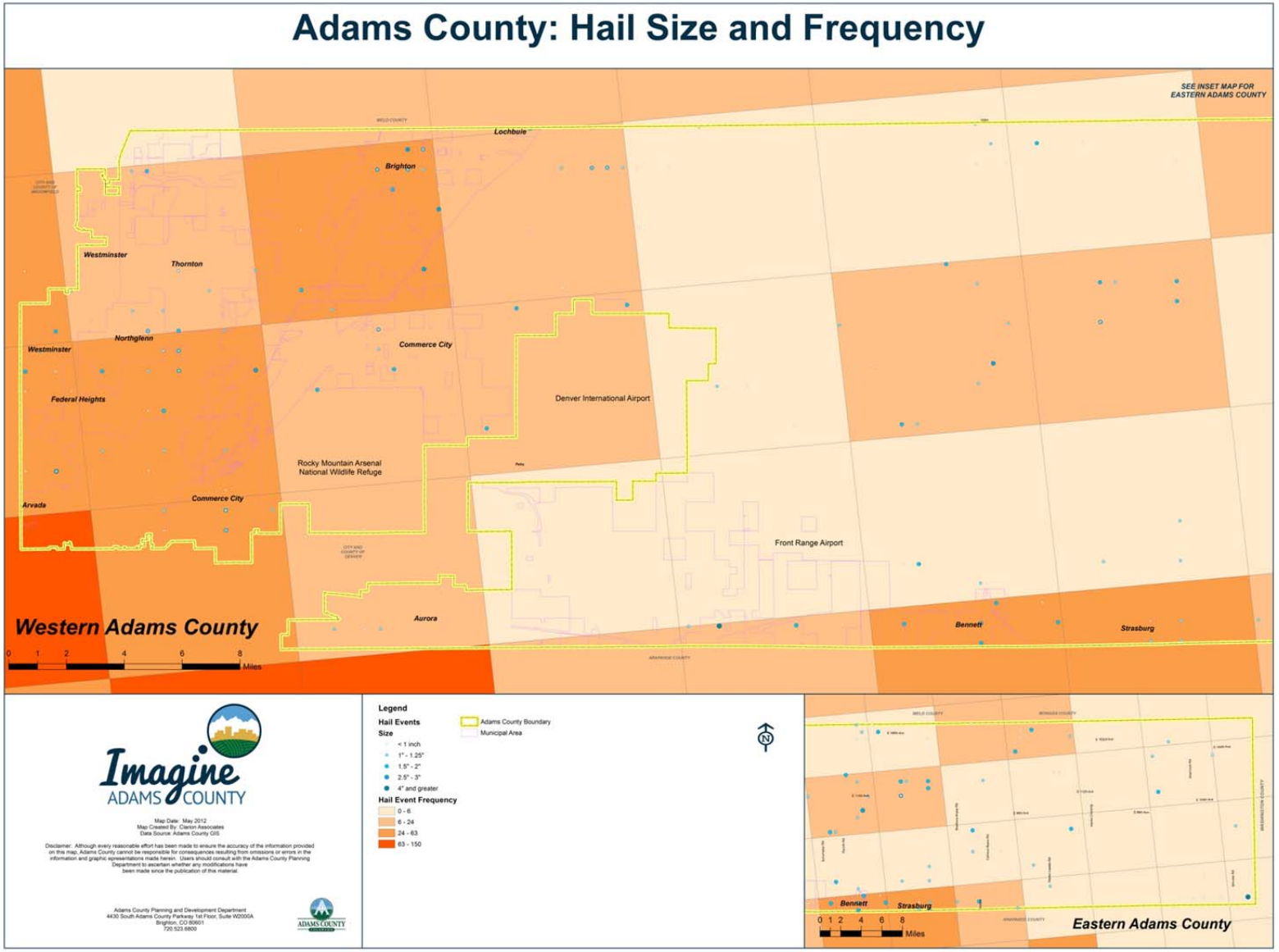

Figure 10. Hail previous occurrence and frequency.

Risk Assessment

Impacts on Critical and Hazardous Materials Facilities (Tier II facilities), Infrastructure, and Population

Severe thunderstorms can cause flash flooding, resulting in damage to property. Lightning can cause fire and loss of life in close proximity of the strike. Hail can cause damage to property and life in the event one is caught without shelter.[14]

Risk to critical facilities, infrastructure, buildings, and people cannot be quantified for severe storms as it can be for hazards such as flooding with well-defined recurrence intervals and intensity-damage models. Analysis of National Climatic Data Center data was completed to give a general indication of risk in terms of number of events and expected damages; results of this analysis are provided in the following Loss Estimates sub-section.

The damages resulting from high winds are affected by the condition of the exposed structures, their design and construction, and the quality of the building materials. The current building code (2006 International Residential Code) requires structures to be built to withstand a 90 mph (in a 3-second wind burst) wind event. However, a significant portion of structures within the County were built prior to the adoption of the current building code and current standards. As a result, older homes, certain construction materials, mobile homes, and poorly designed homes are very vulnerable to high winds and thunderstorms. Utility lines, communication towers, and transportation networks can be impacted by high winds or flying debris acting as projectiles. Deaths may result from falling trees or other debris. Mobile homes, if destroyed would result in residents having to look for alternative shelter while they rebuild or try to find a new place to reside. If high winds were to damage or destroy places of employment, employees might need to seek additional employment.

Not all critical facilities have redundant power sources and not all are wired to accept generators. Future plan updates should consider including a more comprehensive examination of critical facility vulnerability and projects related to hardening these facilities.

Existing and Future Development Trends

Building standards can offer only limited protection from thunderstorm events. Increasing population and development ultimately increase vulnerability to thunderstorms. Adams County ordinance requires a Class A roof on all new residential structures, which should effectively reduce the amount of resultant damages from thunderstorms. Fire codes in place result in fewer structure damages caused by lightning-sparked fires. Increasing population growth and development increases vulnerability to lightning. Structure damages due to thunderstorms (i.e., hail damage) are typically covered under private insurance policies.

[14] Adams County Hazard Analysis (1996)

Loss Estimates and Economic Impacts

The National Climatic Data Center Storm Events data was annualized by taking the total number of high wind, hail, lightning and thunderstorm events and dividing by the length of record. The annualized values should be utilized only as an estimate of what can be expected in a given year.

Using historical records, it can be estimated that the County will experience between five and seven high wind and thunderstorm events in any given year. Damages from these events can be expected in the magnitude of $1,574 to $9 million annually. Table 14 shows the annualized results for thunderstorms in Adams County. It should be noted that the severe storm damages reported by National Climatic Data Center drastically under represent what is expected in the County.

Table 14. National Climatic Data Center Annualized Events for Thunderstorms.

Hazard Type	Annualized Events	Annualized Property Damages	Annualized Crop Damages	Total Annualized Damages
Thunderstorm	7.29	$8,975,589	$1,306	$8,976,895
Hail	5.49	$8,963,551	$1,306	$8,964,858
Lightning	0.37	$8,452	-	$8,452
Microburst	0.20	$1,574	-	$1,574

Winter Weather (High Ranking)

Ranking

Table 15 shows the criteria used to derive a High ranking for winter weather in Adams County. Hazard ranking criteria from the State of Colorado Hazard Mitigation Plan and DRCOG Hazard Mitigation Plan were reviewed by the steering committee. Hazard ranking methodology is further explained in the beginning of the hazard identification section of this plan. To fully support integration, each hazard was considered and the potential impacts are reflected in the future land use map in the body of the Comprehensive Plan.

Table 15. Winter Weather Hazard Ranking Criteria.

Hazard	Geographic Extent	Previous Occurrence	Future Probability	Magnitude /Severity	2012 Ranking
Winter Weather	Medium to 25% of County	High >5 Events in last 50 years	High <1 /100 or 1% annual chance	Medium 1 to 10% of people or property impacted	**High**

Description

The NWS has defined winter season watches, warnings, and advisories based on specific criteria.[15]

- **Ice Storm Warning** is issued when a period of freezing rain is expected to produce ice accumulations of 1/4" or greater, or cause significant disruptions to travel or utilities.
- **Heavy Sleet Warning** is issued when a period of sleet is expected to produce ice accumulations of 1" or greater, or cause significant disruptions to travel or utilities.
- **Heavy Snow Warning** is issued when snow is expected to accumulate 4 inches or more in 12 hours, or 6 inches or more in 24 hours.
- **Winter Storm Warning** is issued for a winter weather event in which there is more than one hazard present, and one of the warning criteria listed above is expected to be met.
- **Blizzard Warning** is issued for sustained wind or frequent gusts greater than or equal to 35 mph accompanied by falling and/or blowing snow, frequently reducing visibility to less than 1/4 mile for three hours or more. Watches are issued when conditions may be met 12 to 48 hours in the future.

Winter storms may include snow, sleet, freezing rain, or a mix of these wintry forms of precipitation. Freezing rain is rain that falls onto a surface with a temperature below freezing, forming a glaze of ice.

Precipitation patterns are largely controlled by mountain ranges and elevation. Precipitation increases with elevation both in winter and summer but the elevation effect is greatest in mid-winter when winds at mountain top level are typically strongest. High peaks and mountain ranges generally receive the majority of their precipitation during the winter months. Snow accumulates without melting in both shaded and level areas at elevations above about 8,000 feet. When it melts in the spring, this snow is the primary source of water for much of the state's population and provides water for extensive irrigation. Considerable effort is made every year to measure the accumulating snowpack so that water providers and resource managers can plan ahead for the coming summer. Most of the mountain snow melts during May and June when rivers reach their peak for the year.

Geographic Location and Severity

Geographic Location = Statewide. Snowfall amounts vary with elevation, with greater amounts in the mountains and lower amounts in the plains and select southern and western regions.[16]

Adams County weather can be severe during the spring and winter months. There can be long periods of sub-degree temperatures in the winter. Wind and snow blizzards cause whiteouts and drifting snow of 2 to 3 feet and more. Blizzards can occur in late spring. Winds can be extremely strong, up to 100 mph in the spring.[17]

[15] NWS. http://w1.weather.gov/glossary
[16] State of Colorado Natural Hazards Mitigation Plan. (2011)
[17] Adams County Hazard Analysis (1996)

Adams County is uniformly exposed to severe winter storms. Winter storms occur in many forms and can vary significantly in size, strength, intensity, duration, and impact. High winds create snowdrifts, which can block roads and create dangerous wind chill factors. Storms or freezing temperatures are not needed for wind chill conditions to become dangerous. The NWS issues a wind chill advisory when wind and temperature combine to produce wind chill values of 20 degrees from zero to 35 degrees below zero. Hypothermia and frostbite are two consequences of wind chill. Hypothermia is the most common winter weather killer in Colorado. Ice accumulation becomes a hazard by creating dangerous travel conditions. When ice accumulates on roadways, the risk of losing control of a vehicle becomes much greater.

Primary concerns for winter storms are the ability to knock out heat, power, and communications services to your home or office, sometimes for days at a time. Heavy snowfall and extreme cold can immobilize an entire region. The NWS refers to winter storms as the "Deceptive Killers" because most deaths are indirectly related to the storm. Instead, people die in traffic accidents on icy roads and of hypothermia from prolonged exposure to cold. It is important to be prepared for winter weather before it strikes. Heavy snow loads have caused roofs to collapse. If combined with near freezing temperatures and early spring rains, such storms can bring down power lines.

Table 16 summarizes the monthly extremes for snowfall and precipitation from the Denver WSFO Airport weather station. As shown, Adams County receives from 58 to 112 inches of snowfall annually. Annual total mean snowfall for Adams County is 58 inches.

Table 16. Monthly Snowfall totals from National Climatic Data Center NWS Cooperative Network Denver WSFO AP, Colorado Station 052220 (8/1948-6/2012).

Time Period	Monthly Mean Precip (in)	Monthly High Precip (in)	Monthly Mean Snowfall (in)	Monthly High Snowfall (in)
January	0.50	1.33 (1962)	7.3	24.3 (1992)
February	0.57	1.66 (1960)	7.2	18.3 (1960)
March	1.21	4.81 (2003)	11.9	35.2 (2003)
April	1.76	5.35 (1999)	8.1	25.5 (1957)
May	2.40	7.31(1957)	1.6	13.7 (1950)
June	1.67	4.69 (1967)	0.0	0.8 (1951)
July	2.03	6.99 (1998)	0.0	0.0 (1949)
August	1.70	5.85 (1979)	0.0	1.3 (1951)
September	1.13	4.67 (1961)	1.4	17.2 (1971)
October	1.01	4.17(1969)	4.1	31.2 (1969)
November	0.80	2.67 (1991)	8.5	29.6 (1991)
December	0.58	2.84 (1973)	7.8	30.8 (1973)
Annual Total	**15.37**	**23.84**	**58.0**	**112.0**

Magnitude/Severity = Extensive Isolated but potentially major property damage that threatens structural stability, isolated deaths and/or injuries, potential impact to critical services or facilities.[18]

Adams County would consider winter weather advisory to be a minimum severity and a winter weather warning to be a major severity.

Previous Occurrences And Probability of Future Occurrence

Previous Occurrences = Seasonal. September through April is primary season for significant snowfalls, with December/January producing colder and dryer snow storms and March/April producing wet and heavy snowfall. Snowfall may occur at high elevations throughout the year.[19]

Since 1993, Adams County has experienced 57 winter weather events (Table 17) as recorded by National Climatic Data Center. An extreme cold event on December 4, 2005, resulted in recorded property damages of $7,798. Heavy winter storms affecting the metropolitan area occurred in 1913, 1982, 1997, 2003, and 2006. The 2006 event resulted in more than 22 inches of snowfall. Table 16 shows the monthly mean snowfall as well as the snowfall highs by month and year.

Table 17. Winter Weather National Climatic Data Center Storm Events for Adams County, Colorado (Shown in 2012 Dollars).

Hazard	Period of Record	Number of Events	Number of Deaths	Number of Injuries	Total Property Damages	Total Crop Damages	Total Damages
Winter Weather	1993-2012	57	-	-	$7,798	-	-

The probability of future occurrences of winter storms within Adams County is high. It is extremely difficult to determine probability of future occurrence in a specific area with any degree of accuracy. All areas within Adams County are equally at risk to winter weather.

Future Probability = Expected. Atmospheric activity producing conditions prone to winter weather such as ice, snow, extreme cold, and high winds are expected to occur as in the past.[20]

The entire County is equally at risk of being impacted by a winter storm. Based on National Climatic Data Center storm data, Adams County can expect three winter storm events each year. The Geographic Extent and Magnitude sub-section above provides details on the monthly averages for snowfall and freezing rain.

Risk Assessment

Risk to critical facilities, infrastructure, buildings, and people cannot be quantified for winter storms as it can be for hazards with well-defined recurrence intervals and intensity-damage models, such as for flooding. Analysis of National Climatic Data Center data was completed to give a general indication of

[18] 2011 State of Colorado Natural Hazards Mitigation Plan.
[19] 2011 State of Colorado Natural Hazards Mitigation Plan.
[20] State of Colorado Natural Hazards Mitigation Plan (2011)

risk in terms of number of events and expected damages; results of this analysis are provided in the following Loss Estimates sub-section.

Impacts on Critical and Hazardous Materials Facilities (Tier II facilities), Infrastructure, and Population

Primary impact of severe winter weather storms would be on travelers using the interstate highways (25, 76, 270, and 70), state highways (36, 85, 2, 79, and 7), and the airports. People, especially those with special needs, as well as livestock can become isolated, requiring rescue efforts.[21]

Impacts of winter storms are primarily quantified by the financial cost associated with preparing for, responding during, and recovering from them. Adams County Office of Emergency Management (OEM) provides winter weather preparedness information on their website; the majority of the preparation provided involves making sure people and properties are safe and equipped for the weather.

Even small accumulations of ice can cause a significant hazard, especially on power lines and trees. An ice storm occurs when freezing rain falls and freezes immediately upon impact. Communications and power can be disrupted for days, and even small accumulations of ice may cause extreme hazards to motorists and pedestrians. Extended power outages from ice storms would require residents to look for supplemental heat sources; improper use of these sources could result in house fires.

Injuries and death during winter storms are usually caused from transportation accidents, slipping on ice if residents, especially elderly residents, were to leave their home, and hypothermia. Secondary effects of winter storms include carbon monoxide poisoning and house fires from increased and improper use of alternative heating sources. Socially vulnerable populations and rural communities are especially at-risk to winter storms. Other issues caused by winter storms can be related to school closures, business closures, road closures, snow removal, and maintaining critical services like emergency services, food providers, and banks.

Not all critical facilities have redundant power sources and not all are wired to accept generators. Future plan updates should consider including a more comprehensive examination of critical facility vulnerability and projects related to hardening these facilities.

Existing and Future Development Trends

New structures built in Adams County should be able to withstand significant snow loads when constructed to County building codes (2006 International Building Code). Development on the fringe may be more susceptible to access issues for emergency services and road crews.

Loss Estimates and Economic Impacts

The Storm Events data was annualized to facilitate a comparison of the hazards. In general, this was accomplished by taking the parameter of interest (i.e., number of events) and dividing by the length of record for each hazard. The annualized value should only be utilized as an estimate of what can be

[21] Adams County Hazard Analysis (1996)

expected in a given year. Events and property damages were annualized in this fashion. Adams County can expect at least three winter storm events per year with an estimated loss of $410 in damages (Table 18).

Table 18. Annualized National Climatic Data CenterStorm Events for Adams County, Colorado.

Hazard Type	Annualized Events	Annualized Property Damages	Annualized Crop Damages	Total Annualized Damages
Winter Weather	3.00	$410	-	$410

Most storm damages are attributable to traffic accidents and roof or other structural collapses. It is important to note that the considerable costs associated with lost wages and business opportunities, lowered productivity, and snow and ice removal are not factored into National Climatic Data Center annualized losses due to winter storm events. Although losses to structures are typically minimal and covered by insurance, there can be other costs associated with lost time, maintenance costs, and contents within structures.

Tornadoes (High Ranking)

Ranking

Table 19 shows the criteria used to derive a High ranking for tornadoes in Adams County. Hazard ranking criteria from the State of Colorado Hazard Mitigation Plan and DRCOG Hazard Mitigation Plan were reviewed by the steering committee. Hazard ranking methodology is further explained in the beginning of the hazard identification section of this plan. To fully support integration, each hazard was considered and the potential impacts are reflected in the future land use map in the body of the Comprehensive Plan.

Table 19. Tornado Hazard Ranking Criteria.

Hazard	Geographic Extent	Previous Occurrence	Future Probability	Magnitude /Severity	2012 Ranking
Tornadoes	Medium 5 to 25% of County	High >5 Events in last 50 years	High <1 /100 or 1% annual chance	Medium 1 to 10% of people or property impacted	**High**

Description

In the Colorado Front Range, tornadoes have been reported nine months of the year, with the peak season for tornados extending from mid-May through mid-August. June is by far the month with the most recorded tornadoes. Tornadoes have occurred every time of the day, with over half of them developing between 3 p.m. and 6 p.m., and 88% occurring between 1 p.m. and 9 p.m. MDT. They also occur statewide, but by far the greatest number develops in eastern Colorado east of I-25. Since 1950, the two counties in the state with the most tornadoes have been Weld and Adams. In fact, Weld County

has one of the highest frequencies of tornadoes across the nation, due primarily to the size of the county. Weld is two to three times the size of most counties across the nation.[22]

A tornado is described as a violently rotating column of air extending from a thunderstorm to the ground. The path width of a tornado is generally less than half of a mile, but the path length can vary from a few hundred yards to dozens of miles. A tornado moves at speeds from 30 to 125 mph, but can generate winds exceeding 300 mph.

Tornado season typically is March through August; however, a tornado can occur in any month. Tremendous destruction can occur in paths over a mile wide and 50 miles long with winds reaching 300 mph. In the United States, tornadoes have been classified on the Fujita Scale, which assigns numeric scores from zero to five (or higher) based on the severity of observed damages. The traditional Fujita scale, introduced in 1971, was used to rate the intensity of tornadoes thereafter, and was also applied to previously documented tornadoes. Starting in February of 2007, an "enhanced" Fujita (EF) scale was implemented, with somewhat lower wind speeds at the higher F-numbers, and more thoroughly refined structural damage indicator definitions. Table 20 shows the differences between the old and new tornado intensity scales.

Table 20. Comparison of Enhanced Fujita Scale and Previously Used Fujita Scale.

Fujita Scale			Enhanced Fujita Scale		Typical Damage Impacts
F Number	Fastest 1/4-mile (mph)	3 Second Gust (mph)	EF Number	3 Second Gust (mph)	
0	40-72	45-78	0	65-85	Light damage: Some damage to chimneys; branches broken off trees; shallow-rooted trees pushed over; sign boards damaged.
1	73-112	79-117	1	86-110	Moderate damage: Peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos blown off roads.
2	113-157	118-161	2	111-135	Considerable damage: Roofs torn off frame houses; mobile homes demolished; boxcars overturned; large trees snapped or uprooted; light object missiles generated; cars lifted off ground.
3	158-207	162-209	3	136-165	Severe damage: Roofs and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted; heavy cars lifted off the ground and thrown.
4	208-260	210-261	4	166-200	Devastating damage: Well-constructed houses leveled; structures with weak foundations blown away some distance; cars thrown and large missiles generated
5	261-318	262-317	5	Over 200	Incredible damage: Strong frame houses leveled off foundations and swept away; automobile-sized missiles fly through the air in excess of 100 meters (109 yards); trees debarked; incredible phenomena will occur.

[22] DRCGO Natural Hazard Mitigation Plan (2011)

Geographic Location and Severity

Geographic Location = Regional. Concentrated along the central and northern Front Range east to the Kansas Border. Includes east border counties. Most counties have recorded tornado events[23]

Magnitude/Severity = Catastrophic. Destroyed or damaged property that threatens structural stability, mass fatalities and/or casualties, impact to critical lifelines, impact to government's ability to provide service. Likely to overwhelm state and local resources and require Federal assistance for full recovery.[24]

Tornadoes typically occur during May through August in Adams County (Figure 6). The tornadoes that form in this area normally move across the ground for a short duration, then rise and set down again.[25]

An EF0 tornado would be considered minimum severity and readings of EF1 and above would be considered a major severity for Adams County. Table 20 includes typical damage impacts associated with the tornado intensities.

Tornadoes can cause significant damage to structures, trees, utilities, and crops, and they have the potential to injure and kill people. Due to the erratic movement of tornadoes, destruction often appears random. There are no specific identified hazard areas as the entire County is susceptible to tornadoes. With advance warning, people can evacuate to saferooms, or to more structurally sound areas within the building. Basements are considered one of the safest places to seek shelter during a tornadic event.

Previous Occurrences And Probability of Future Occurrence

Previous Occurrences = Seasonally. Regular occurrences throughout the summer storm season, primarily from May to August, peaking in June.[26]

Since 1950, Adams County has experienced 162 tornadoes (Table 21) as recorded by National Climatic Data Center. Figure 11 shows the past tornadoes in Adams County and the associated EF Scale. Also included are National Climatic Data Center weather events that resulted in more than $500,000 in damages (inflated to 2012):

- June 3, 1981 ($62 Million & 42 Injuries)
- June 9, 1967 ($1.7 Million)
- May 30, 1976 ($1 Million)
- August 14, 1977 ($942,450 & 1 Injury)
- May 17, 1978 ($875,959)

[23] 2011 State of Colorado Natural Hazards Mitigation Plan.
[24] 2011 State of Colorado Natural Hazards Mitigation Plan.
[25] Adams County Hazard Analysis (1996)
[26] 2011 State of Colorado Natural Hazards Mitigation Plan.

Table 21. Tornado National Climatic Data CenterStorm Events for Adams County, Colorado (Shown in 2012 Dollars).

Hazard	Number of Events	Property Damage	Crop Damage	Deaths	Injuries
Tornadoes	162	$68,890,697	$9,464,149	0	43
Funnel Clouds	5	$0	$0	0	0

Future Probability = Expected. Atmospheric activity producing conditions prone to tornadoes are expected to occur as in the past.[27]

The NWS advises that tornadoes strike randomly, so all areas within Adams County are equally at risk. However, people living in valleys, which are normally the most highly developed areas, have the greatest exposure. Tornado and high-wind events could occur at any time of the year, but are more frequent in the springtime. Based on past occurrences, Adams County has a High probability of future occurrence. Figure 11 was created using Version 4.5 of the FEMA Benefit-Coast Analysis Reengineering (BCAR) methodology.

The probability of future occurrences of tornadoes within Adams County is high. It is extremely difficult to determine probability of future occurrence in a specific area with any degree of accuracy. All areas within Adams County are equally at risk to tornadoes.

[27] 2011 State of Colorado Natural Hazards Mitigation Plan.

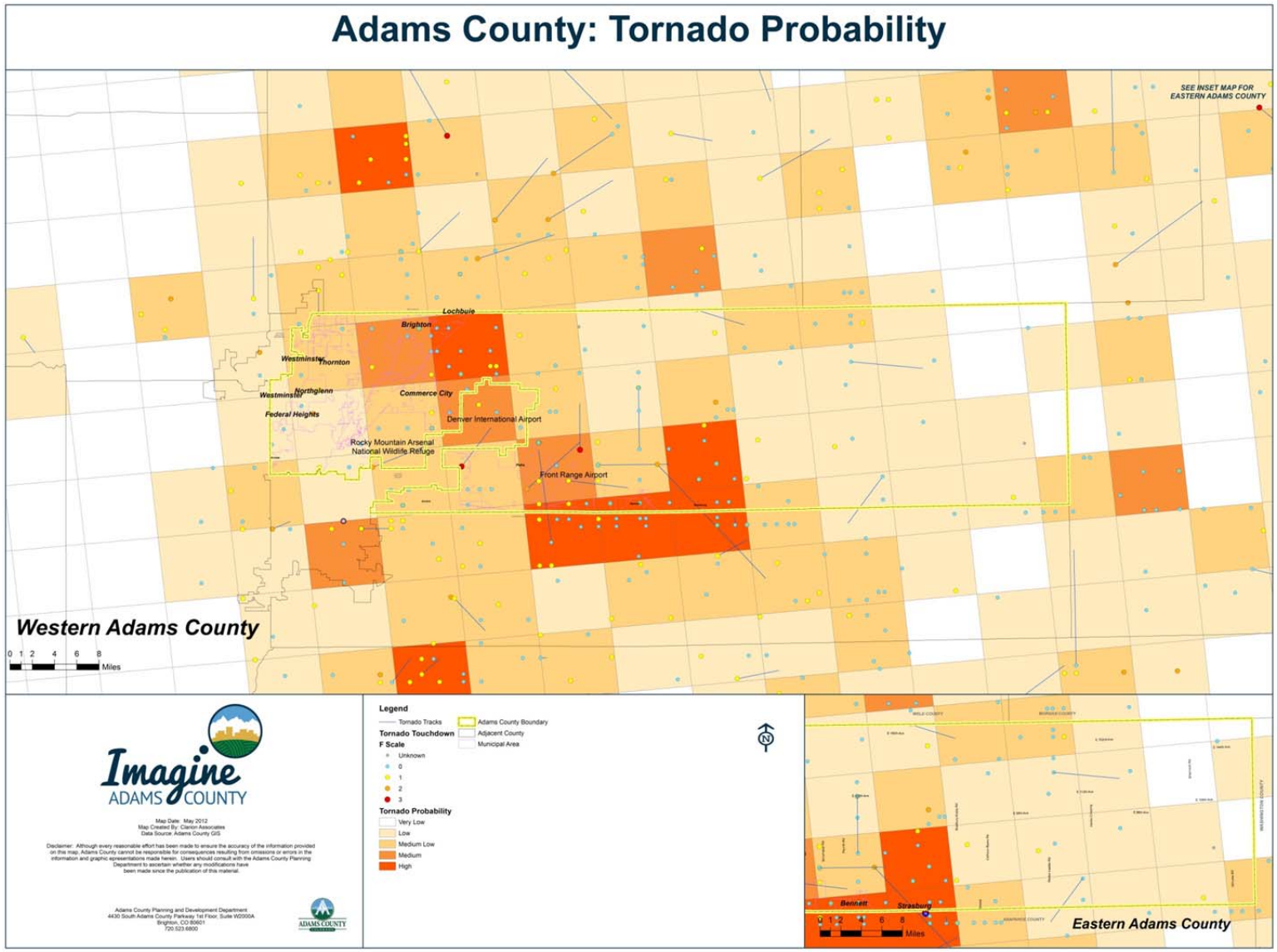

Figure 11. Tornado previous occurrence and future probability.

Several significant tornadoes have caused injuries and property damages in Adams County. In the future, tornadic events will continue to occur within the County. Predicting the location and how severe the event will be is impossible.

Risk Assessment

Impacts on Critical and Hazardous Materials Facilities (Tier II facilities), Infrastructure, and Population

In populated areas, tornadoes threaten lives and property. The Front Range Airport can be at risk. Recovery and rescue efforts will be dictated by the area of destruction.[28] Mobile home parks are extremely vulnerable to tornadoes. Towers and overhead transmission lines are extremely vulnerable to tornadoes. Damages to above-ground structures and these utilities can further decrease the County's ability to respond to emergencies.

Existing and Future Development Trends

Development pressures along the Front Range will likely increase the overall vulnerability to tornadoes. Building codes in place can reduce the overall impacts; however, significant tornadoes are unpredictable and are capable of destroying buildings with incredible structural integrity. Development to the east in Adams County will be particularly more vulnerable to tornadoes, as most of the tornadoes recorded have occurred further away from the foothills.

Loss Estimates and Economic Impacts

Tornado events are unpredictable and destruction is unsystematic. Since the entire County is equally at risk, there are no specific identified hazard areas more susceptible to tornadoes. Some of the economic impacts have been addressed under the critical and Hazardous Materials Facilities (Tier II facilities), infrastructure, and population subsection.

Committee members suggested including a hypothetical worst-case scenario for the Town of Reunion within Adams County. The hypothetical tornado path of 0.74 miles and width of 64.5 yards was derived by taking the average length and width of all tornadoes experienced in Adams County. Based on this scenario, potential damages from this event could result in 104 parcels being destroyed, accounting for $11,031,821 in total improvement value damaged. The average parcel damage would be $106,075. If three events of this magnitude were to occur within a given year, the damages could surpass $33 million.

The National Climatic Data Center Storm Events data was annualized by taking the total number of tornado events and dividing by the length of record. The annualized values should only be utilized as an estimate of what can be expected in a given year. Using historical records, it can be estimated that Adams County will experience between two and three tornado events in any given year, with an 8% chance of a funnel cloud forming. Damages from these events can be expected in the magnitude of

[28] Adams County Hazard Analysis (1996)

$1.3 million annually. Table 22 shows the annualized results for tornadoes in Adams County. It should be noted that the damages reported by National Climatic Data Center drastically under represent what is expected in the County.

Table 22. Annualized National Climatic Data Centertornado events.

Hazard Type	Annualized Events	Annualized Property Damages	Annualized Crop Damages	Total Annualized Damages
Tornadoes	2.75	$1,167,639	$160,409	$1,328,048
Funnel Clouds	0.08	-	-	-

Flood (Medium Ranking)

Ranking

Table 23 shows the criteria used to derived a Medium ranking for flooding in Adams County. Hazard ranking criteria from the State of Colorado Hazard Mitigation Plan and DRCOG Hazard Mitigation Plan were reviewed by steering committee. Hazard ranking methodology is further explained in the beginning of the hazard identification section of this plan. To fully support integration, each hazard was considered and the potential impacts are reflected in the future land use map in the body of the Comprehensive Plan.

Table 23. Flood Hazard Ranking Criteria.

Hazard	Geographic Extent	Previous Occurrence	Future Probability	Magnitude /Severity	2012 Ranking
Flood	Medium 5 to 25% of County	High >5 Events in last 50 years	Medium 1 in 1,000 to 1/100 or 0.1% to 1% annual chance	Medium 1 to 10% of people or property impacted	**Medium**

Description

Floods are generally the result of excessive precipitation, and can be classified under two categories: general floods, precipitation over a given river basin for a long period of time; and flash floods, the product of heavy, localized precipitation in a short time period over a given location. The severity of a flooding event is determined by the following: 1) a combination of stream and river basin topography and physiography; 2) precipitation and weather patterns; 3) recent soil moisture conditions; and 4) the degree of vegetative clearing.

Generally, floods are long-term events that may last for several days. The primary types of general flooding include riverine, coastal, and urban flooding. Riverine flooding is a function of excessive precipitation levels and water runoff volumes within the watershed of a stream or river. Urban flooding occurs where man-made development has obstructed the natural flow of water and decreased the ability of natural groundcover to absorb and retain surface water runoff. Sudden melting of snowpack can result in significant flooding.

Flash flooding events can occur from intense storms, a dam or levee failure within minutes or hours of heavy amounts of rainfall, or from a sudden release of water held by an ice jam or snowmelt. Most flash flooding is caused by slow-moving thunderstorms in a local area or by heavy rains associated with hurricanes and tropical storms. Although flash flooding occurs most often along mountain streams, it is also common in urbanized areas where much of the ground is covered by impervious surfaces. Flash floodwaters move at very high speeds—"walls" of water can reach heights of 10 to 20 feet. Flash floodwaters and the accompanying debris can uproot trees, roll boulders, and damage or destroy buildings, bridges, and roads.

Stormwater refers to water that collects on the ground surface or is carried in the stormwater system when it rains. In runoff events where the amount of stormwater is too great for the system, or if the channel system is disrupted by vegetation or other debris that blocks inlets or pipes, excess water remains on the surface. This water may pond in low-lying areas, often in street intersections. Stormwater ponding, also known as localized flooding, may result in deep water and pollution. Stormwater can pick up debris, chemicals, dirt, and other pollutants from impervious surfaces.[29]

Geographic Location and Severity

Geographic Location = Statewide. Flood prone areas have been identified in 267 of 270 cities and towns and in all of the 64 counties in Colorado.[30]

Three types of flooding that can occur in Adams County are: flash flooding, riverine flooding, and dam failure flooding[31].

Adams County falls within the South Platte River Basin (

Figure 12). The South Platte basin encompasses all or part of 23 counties over 27,660 square miles. Elevation in the basin ranges from 14,000 feet at the Continental Divide to 3,400 feet at the Colorado-Nebraska state line. The largest population centers in the basin are Denver and Aurora. The South Platte River is the major stream in the basin. Some of the state's most devastating floods occurred in the South Platte basin. In a 2006 report by the CWCB, historic flood damages for the basin were estimated to be $3.4 billion at the time of the study.

The floodplain on the South Platte River in the past was mostly agricultural, but today commercial, industrial, and residential development has encroached into the floodplain.[32]

[29] City of Colorado Springs Hazard Mitigation Plan. 2010.
[30] 2011 State of Colorado Natural Hazards Mitigation Plan.
[31] Adams County Hazard Analysis (1996)
[32] Flood Insurance Study for Adams County. 2007.

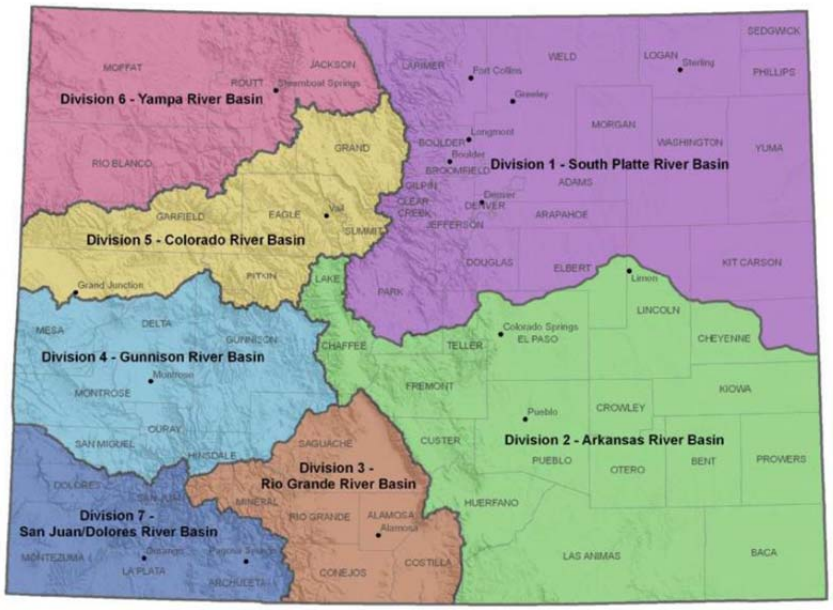

Figure 12. Major river basins in Colorado. Source: Colorado Flood Hazard Mitigation Plan 2010.

To accurately assess the risk of flooding, it is necessary to know what areas of a community may be the most susceptible to flooding. FEMA's Flood Insurance Rate Maps (FIRMs) depict these high-risk areas, referred to as Special Flood Hazard Areas (SFHAs), and their Base (1%-annual-chance) Flood Elevations (BFEs). The current FIRM for Adams County is dated March 5, 2007 (Figure 13).

Flooding sources studied in detail in the 2007 FIRM include:

- Basin 4100
- Bear Gulch & Tributaries
- Big Dry Creek
- Box Elder Creek
- Branter Creek
- Clear Creek
- Comanche Creek
- Coyote Run
- Grange Hall Creek & Tributary
- Hayesmount Creek & Tributaries
- Little Comanche Creek
- Little Dry Creek
- Niver Creek & Tributary
- North & South Fork Grange Hall Creek
- Northfield Creek
- Sand Creek
- South Platte River
- Tanglewood Creek
- Wolf Creek

In addition to the streams listed above, the following streams were studied by approximate methods:

- Bijou and West & East Bijou Creek
- Portions of Brantner Gulch and Tributaries
- FA 0054-1
- First Creek
- Portion of Grange Hall Creek
- Grange Hall Tributary Southeast
- Hidden Lake
- Kiowa Creek
- Lost Creek
- McKay Lake Drainageway
- Morris Creek

- Muddy Creey
- Niver Canal
- Portions of Niver Creek and Tributary L & M
- Portions of Northfield Creek
- Preble Creek and South Fork
- Quail Creek
- Sack Creek and South Sack
- Second Creek
- Shay Ditch
- Short Run
- Third Creek
- Todd Creek and Tributaries 2 & $
- Wadley North & South

Magnitude/Severity = Extensive. Major floods induce property damages that threaten structural integrity, result in death and injuries, and impact critical services, facilities, and infrastructure. Between 20 and 30 large magnitude floods occur somewhere in Colorado every year with varying impact depending on location.[33]

Flooding impacts a community only to the degree that it affects the lives of its citizens and the community functions overall. Therefore, the most vulnerable areas of a community will be those most affected by floodwaters in terms of potential loss of life, damages to homes and businesses, and disruption of community services and utilities. For example, an area with a highly developed floodplain is significantly more vulnerable to the impacts of flooding than a rural or undeveloped floodplain where potential floodwaters would have little impact on the community.

The severity of a flood on a community can be magnified to the degree floodwaters affect special needs populations and critical facilities. Special needs populations are those that may require special assistance during a flood event, may not be able to protect themselves prior to an event, or may not be able to understand potential risks.

The impacts of floodwater on critical facilities, such as police and fire stations, hospitals, and water or wastewater treatment facilities, can greatly increase the overall effect of a flood event on a community. In general, relatively few of these facilities are located in areas with a high risk to flooding.

A number of factors contribute to the relative vulnerabilities of certain areas in the floodplain. Development, or the presence of people and property in the hazardous areas, is a critical factor in determining vulnerability to flooding. Additional factors that contribute to flood vulnerability range from specific characteristics of the floodplain to characteristics of the structures located within the floodplain. The following is a brief discussion of some of these factors and how they may relate to Adams County.

- **Flood depth:** The greater the depth of flooding, the higher the potential for significant damages.
- **Flood duration:** The longer duration of time that floodwaters are in contact with building components, such as structural members, interior finishes, and mechanical equipment, the greater the potential for damage.

[33] 2011 State of Colorado Natural Hazards Mitigation Plan.

- **Velocity:** Flowing water exerts forces on the structural members of a building, increasing the likelihood of significant damage.
- **Elevation:** The lowest possible point where floodwaters may enter a structure is the most significant factor contributing to its vulnerability to damage due to flooding.
- **Construction Type:** Certain types of construction are more resistant to the effects of floodwaters than others. Typically masonry buildings, constructed of brick or concrete blocks, are the most resistant to damages simply because masonry materials can be in contact with limited depths of flooding without sustaining significant damage. Wood frame structures are more susceptible to damage because the construction materials used are easily damaged when inundated with water.

Floods may also be caused by structural or hydrologic failures of dams or levees. A hydrologic failure occurs when the volume of water behind the dam or levee exceeds the structure‘s capacity resulting in overtopping. Structural failure arises when the physical stability of the dam or levee is compromised due to age, poor construction and maintenance, seismic activity, rodent tunneling, or myriad other causes. Each of these causes results in floods that have distinct characteristics relative to flow rate, rate of rise, volume, duration, and flood season.

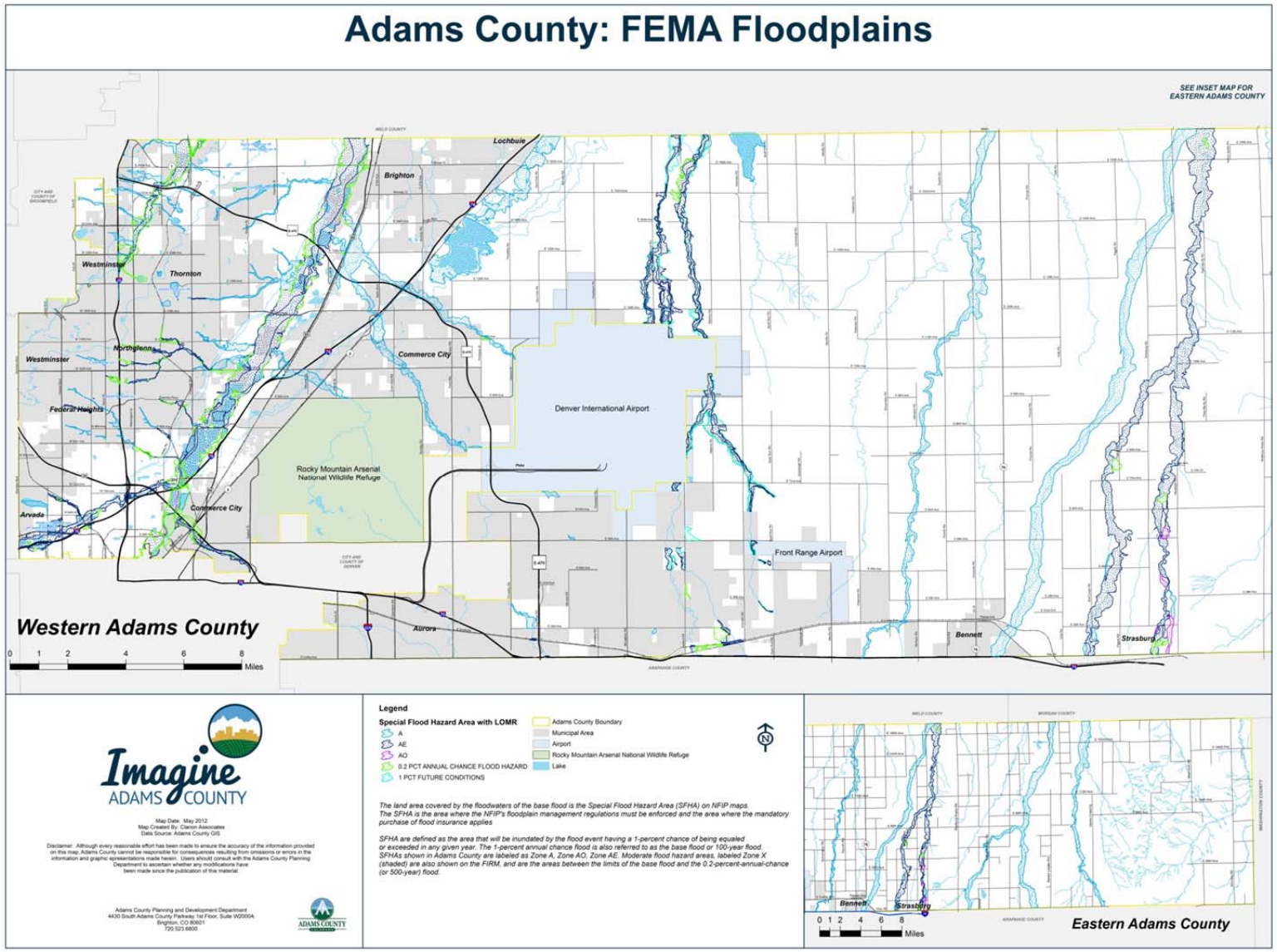

Figure 13. FEMA Digital Flood Insurance Rate Map (DFIRM).

In addition to floodplains, the location of Colorado's most significant dams allows for point of origin analysis related to downstream impacts of release. The Colorado Division of Water Resources runs the Dam Safety Program. Adams County has 36 dams located within the County; six are federal, 12 are local governments, and 18 are privately owned. The majority are used for irrigation (16) and water supply (9). Figure 14 shows the National Inventory of Dams (NID) general locations of the dams in and around Adams County.

Of the non-federal dams in Colorado, approximately 677 are classified as dams that are classified as Class I (High) or Class II (Significant).[34] Class I dams, if failure was to occur, could cause loss of human life. Class II dams, if failure was to occur, will cause significant damage, but not loss of human life. Significant damage refers to structural damage where humans live, work, or recreate, or public or private facilities exclusive of unpaved roads and picnic areas. Damage refers to making the structures uninhabitable or inoperable. There are eight Class I and 12 Class II dams in Adams County.

The State of Colorado requires Emergency Action Plans (EAPs) for all High and Significant Hazard dams due to the increased potential for loss of life and/or property damage in the event of a dam failure. The EAP is a formal document that outlines possible emergency conditions at a dam, sets forth actions to minimize damages and danger, and includes a plan for the dam owner to moderate or alleviate the problems at the dam. The EAP contains inundation map exhibits to help emergency management authorities identify the critical areas for action in case of an emergency.

Based on previous occurrences, dam failure is unlikely to occur in Adams County. However, it should be noted that the conditions of all private dams are unknown and poor structural conditions may contribute to the likelihood of failure.

Dam failure floods are primarily a result of hydrologic or structural deficiencies. The operation of a reservoir can also influence the safety of the structure. Dam failure by hydrologic deficiency is a result of inadequate spillway capacity, which can cause a dam to be overtopped during large flows into the reservoir. Dam failure by hydrologic deficiency occurs from excessive runoff after unusually heavy precipitation in the basin. Dam failure can also occur when the dam is overtopped as a result of large waves generated from landslides into a reservoir or the sudden inflow from upstream dam failures. Overtopping is especially dangerous for an earth dam because the down-rush of water over the crest will erode the dam face and, if continued long enough, breach the dam embankment and release all the stored water suddenly into the downstream floodplain.

Examples of structural deficiencies include seepage through the embankment, piping along internal conduits, erosion, cracking, sliding, overturning, rodent tunneling, or other weakness in the structure. Old age is often at the root of structural deficiencies. Seismic activity in Colorado has recently been recognized as a potential source of structural problems due to liquefaction of sand layers in the embankment of a dam.

[34] 2011 State of Colorado Hazard Mitigation Plan

The mechanics of a structural failure depend on the type of dam and the mode of failure. Floods that result from dam failure caused by structural deficiencies are characterized by a sudden rise in stream level and relatively short duration similar to a thunderstorm flood. Such flooding can occur at any time, but earthen dams appear to be most susceptible to structural failure during the fall and spring freezing and thawing cycles.

Dam failures typically occur with little warning. Depending on the size of the dam and the inundation area, the loss of life and amount of damage can be catastrophic. Inundation maps are required for each dam with an EAP. An inundation map illustrates which properties may be affected by floodwaters and show the extent of flooding expected spatially within a geographic area. These maps will not be included in this plan for security reasons, but remain on file with the owners of the dam associated with the EAP.

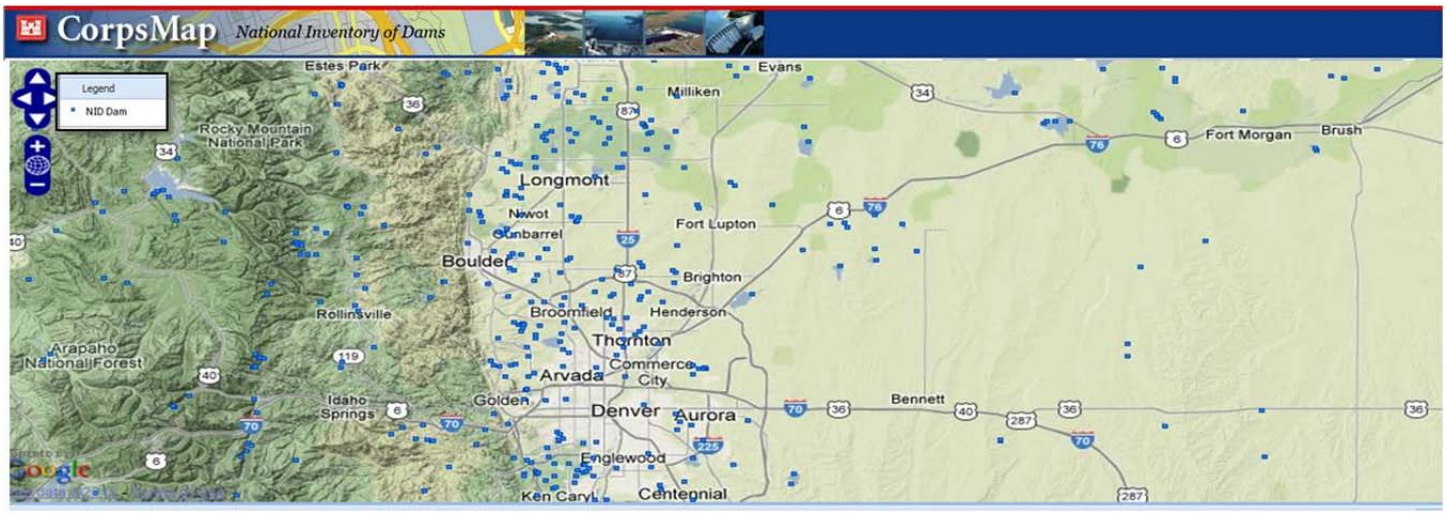

Figure 14 . National Inventory of Dams (NID) Adams County dam locations.

Previous Occurrences And Probability of Future Occurrence

Previous Occurrence = Season. Notable flood events from 1864 to 2010 include dozens of events. These events total significant deaths and damage.[35]

Future Probability = Likely. In addition to annual minor flood events, Colorado experienced major floods every 5 years on average.[36]

The major cause of flooding in Adams County is cloudbursts of intensive rainstorms, which normally occur during the period of May through August. The South Platte River flooding is also aggravated by snowiest runoff on the tributary streams during the rainstorm period.[37]

[35] 2011 State of Colorado Natural Hazards Mitigation Plan.
[36] 2011 State of Colorado Natural Hazards Mitigation Plan.
[37] Adams County FIS. 2007.

There have been a number of past flooding events throughout the County, ranging widely in terms of location, magnitude, and impact. The most frequent flooding events are quite localized in nature, resulting from heavy rains in a short period of time over urbanized areas that are not able to appropriately handle storm water runoff. These events typically do not threaten lives or property and will not result in emergency or disaster declarations; thus, historical data is difficult to obtain.

Table 24 summarizes the number of flood events recorded in the National Climatic Data Center database for Adams County. Of the 14 flood events, 11 have been categorized as flash flood events. Two events resulted in property damage:

- August 4, 1999 ($685,624) Flash Flood
- July 29, 1997 ($28,467) Urban/Small Stream Flood

Table 24. Flood National Climatic Data Center Storm Events for Adams County, Colorado (Shown in 2012 Dollars).

Hazard Type	Number of Events	Property Damage	Crop Damage	Deaths	Injuries
Flood	14	$714,092	-	1	0
Flash Flood	11	$685,624	$0	1	0

Almost all record floods on the South Platte River have been generated near the river's headwaters on the slopes of Monument Divide. Past floods have resulted from snowmelt and intensive rain storms over the mountain and eastern tributaries. The following flood events and principle flood problems have been taken from the March 5, 2007, Flood Insurance Study for Adams County:

- Major floods have occurred on the South Platte River and tributaries since 1844; specifically on Clear Creek, Box Elder, Comanche, and Bijou Creeks in 1905, 1933, 1935, and 1965.
- Significant floods on the South Platte River have occurred in 1912, 1921, 1933, 1935, 1942, 1965, and 1973.
- June 16, 1965: Severe thunderstorms over the headwater of Plum and Creek Creeks moved northeasterly resulting in 14 inches of rain at Palmer Creek. Westerly winds caused the storm front to reposition over Kiowa and Bijou Creeks resulting in 5.25 inches of rain in 45 minutes. This storm system and resultant flooding led to 8 deaths and over $500 million in damages in the South Platte River Basin.
- August 1933: Castlewood Dam burst under pressure of water from severe thunderstorms in the upper Cherry Creek Basin.
- Levees along the South Platte River are ineffective against the 100-year frequency floods.

Urban and stormwater drainage within the County has largely been associated with flooding of roadways during storm events. Adams County currently monitors these areas and has noted that they are proactive in clearing the areas and closing the roads. This Appendix includes the maps of the areas within the County that are noted to have reoccurring flooding issues.

Periodic flooding of lands adjacent to rivers and streams is a natural occurrence that can be expected to take place based upon established recurrence intervals. The recurrence interval of a flood is defined as the average time interval, in years, expected between a flood event of a particular magnitude and an

equal or larger flood. Flood magnitude increases with increasing recurrence interval. Based on historical records from National Climatic Data Center and the FEMA National Flood Insurance Program (NFIP), the County will experience one significant flooding event in any given year.

A 100-year flood is not a flood that occurs every 100 years. This recurrence interval is an average; it does not mean that a flood of such a magnitude will happen exactly every 100 years. In fact, the 100-year flood has a 26% chance of occurring during a 30-year period, the typical length of many mortgages. The 100-year flood is a regulatory standard used by federal agencies, states, and NFIP-participating communities to administer and enforce floodplain management programs. The 100-year flood is also used by the NFIP as the basis for insurance requirements nationwide[38]. The 500-year flood event, which has a 0.2% chance (or 1 in 500) chance of occurring in a given year, may also be shown on the FIRM.[39] The main recurrence intervals shown in Table 25; the 100- and 500-year events are shown on the FIRM.

Flooding remains a highly likely occurrence throughout the identified flood hazard areas. Smaller floods caused by heavy rains and inadequate drainage capacity in urbanized areas will be more frequent, but not as costly as the large-scale floods, which may occur at much less frequent intervals.

Table 25. Annual Probability Based on Flood Recurrence Intervals.

Flood Recurrence Interval	Annual Chance of Occurrence
10-year	10.0%
50-year	2.0%
100-year	1.0%
500-year	0.2%

The probability of future occurrences of flooding within Adams County is a medium risk. FEMA-mapped floodplain areas, as well as problem spot areas noted above are at risk to flooding.

National Flood Insurance Program (NFIP)

Requirement §201.6(c)(2)(ii): [The risk assessment] must also address National Flood Insurance Program (NFIP) insured structures that have been repetitively damaged by floods.

In 1968, the U.S. Congress established the NFIP making flood insurance available to residents of communities that adopt and enforce floodplain management ordinances. The NFIP is a part of FEMA.[40] The Risk Insurance Division of the Flood Insurance and Mitigation Administration (FIMA) manages the NFIP. The three components of the NFIP are:

- Flood Insurance
- Floodplain Management
- Flood Hazard Mapping

[38] National Flood Insurance Program (www.fema.gov)
[39] http://pubs.usgs.gov/gip/106/pdf/100-year-flood_041210web.pdf
[40] http://www.fema.gov/cis/cis31release.shtm

Nearly 20,000 communities across the United States and its territories participate in the NFIP by adopting and enforcing floodplain management ordinances to reduce future flood damage. In exchange, the NFIP makes federally backed flood insurance available to homeowners, renters, and business owners in these communities. Community participation in the NFIP is voluntary.

Flood insurance is designed to provide an alternative to disaster assistance to reduce the escalating costs of repairing damage to buildings and their contents caused by floods. Flood damage is reduced by nearly $1 billion a year through communities implementing sound floodplain management requirements and property owners purchasing flood insurance. Additionally, buildings constructed in compliance with NFIP building standards suffer approximately 80% less damage annually than those not built in compliance.

In addition to providing flood insurance and reducing flood damages through floodplain management regulations, the NFIP identifies and maps the nation's floodplains. Mapping flood hazards creates broad-based awareness of the flood hazards and provides the data needed for floodplain management programs and to actuarially rate new construction for flood insurance.

Table 26 shows the dates Adams County, and the communities within Adams County, were identified with Flood Hazard Boundary Maps (FHBM), when the first FIRMs became effective, the date of the current FIRM used for insurance purposes, and the date the community entered into the NFIP. The Town of Bennett has not been included.

Table 26. NFIP participation.

Community Name	Init FHBM Identified	Init FIRM Identified	Curr Eff Map Date	Reg-Emer Date
Adams County	-	02/01/1979	03/05/2007	02/01/1979
City of Arvada	07/01/1972	12/31/1974	06/17/2003	06/23/1972
City of Aurora	07/26/1974	06/01/1978	12/17/2010	06/01/1978
City of Brighton	02/22/1974	11/16/1977	03/05/2007	11/16/1977
City of Commerce City	06/28/1974	02/15/1978	03/05/2007	02/15/1978
City of Federal Heights	07/11/1975	04/15/1986	03/05/2007	04/15/1986
City of Northglenn	08/22/1975	09/15/1978	03/05/2007	09/15/1978
City of Thorton	11/01/1974	06/15/1978	03/05/2007	06/15/1978
City of Westminster	06/07/1974	09/30/1988	06/17/2003	09/30/1988

Source: http://www.fema.gov/cis/CO.html 5/29/2012

Adams County has 175 flood insurance policies in-force within the County, and 1,216 policies in-force including all of the communities that reside within the County. As of February 29, 2012, the County had 25 NFIP claims and $79,074 in total payments.[41] The 168 claims within the County resulted in $415.775 in claim payment. Table 27 summarizes the NFIP policy and claim statistics for the County with Colorado totals for comparison.

[41] NFIP BureauNet http://bsa.nfipstat.com/ 5/29/2012

Table 27. NFIP policy and claim information.

Community Name	Policy Statistics (as of 02/29/2012)		Claim Statistics (01/01/1978 – 02/29/2012)	
	Policies In-Force	Insurance In-Force	Total Claims	Total Payment
Adams County	175	$50,249,500	25	$79,074
City of Arvada	527	$111,282,800	53	$40,611
City of Aurora	284	$58,608,800	37	$1,852
City of Brighton	16	$4,398,400	3	$3,292
City of Commerce City	15	$5,605,000	1	$0
City of Federal Heights	5	$518,000	6	$21,217
City of Northglenn	26	$6,932,900	2	$2,785
City of Thornton	67	$16,716,300	6	$7,452
City of Westminster	101	$25,735,100	35	$259,492
Total for County	**1,216**	**$280,046,800**	**168**	**$415,775**
Colorado Total	**20,208**	**$4,498,497,200**	**2,213**	**$10,400,415.47**

Source: http://bsa.nfipstat.com 5/29/2012

Floodplain management regulations are the cornerstone of NFIP participation. Communities that participate in the NFIP are required to adopt and enforce the minimum federal NFIP floodplain management regulations. These regulations apply to all types of floodplain development and ensure that development activities will not cause an increase in future flood damages. Buildings are required to be reasonably safe from flooding, which usually requires the finished floor elevation to be elevated at or above the corresponding Base Flood Elevation (BFE). If the finished grade elevation for a structure is below the corresponding BFE, and there is a federally insured loan on the structure, then there is a mandatory requirement to purchase a flood insurance policy. The requirement for high risk structures to carry a flood insurance policy is one method used by the NFIP to offset the escalating costs of flood disasters.

FEMA Repetitive Flood Claims Program

The Repetitive Flood Claims (RFC) grant program was authorized by the Bunning-Bereuter-Blumenauer Flood Insurance Reform Act of 2004 (P.L. 108–264), which amended the National Flood Insurance Act of 1968 (42 U.S.C. 4001, et al). Currently, up to $10 million is available annually for FEMA to provide RFC funds to help states and communities reduce flood damages to insured properties that have had one or more claims to the NFIP.[42]

A Repetitive Loss Property is a property that is insured under the NFIP and has filed two or more claims in excess of $1,000 each, within a 10-year period. Nationwide, repetitive loss properties constitute 2% of all NFIP insured properties, but are responsible for 40% of all NFIP claims. Mitigation for repetitive

42 FEMA Severe Repetitive Loss Guidance for Severe Repetitive Loss Properties http://www.fema.gov/pdf/nfip/manual200610/20srl.pdf 10/2006

loss properties is a high priority for FEMA, and the areas in which these properties are located typically represent the most flood prone areas of a community.

The identification of repetitive loss properties is an important element to conducting a local flood risk assessment, as the inherent characteristics of properties with multiple flood losses strongly suggest that they will be threatened by continual losses. Repetitive loss properties are also important to the NFIP, since structures that flood frequently put a strain on the National Flood Insurance Fund. Under the NFIP, FEMA defines a severe repetitive loss property as "any NFIP-insured property that, since 1978 and regardless of any change(s) of ownership during that period, has experienced: a) at least four or more paid flood losses over $5000 each and the cumulative amount of such claims payments exceeds $20,000; or b) two paid flood losses within a 10-year period that equal or exceed the current value of the insured property." A primary goal of FEMA is to reduce the number of structures that meet these criteria, whether through elevation, acquisition, relocation, or a flood-control project that lessens the potential for continual losses.

According to FEMA, there are currently no repetitive loss properties within Adams County.

Community Rating System

The NFIP Community Rating System (CRS) is a voluntary incentive program that recognizes and encourages community floodplain management activities that exceed the minimum NFIP requirements. The three main goals of the CRS are to (1) reduce flood damage to insurable property, (2) strengthen and support the insurance aspects of the NFIP, and (3) encourage a comprehensive approach to floodplain management.[43]

All communities start out with a Class 10 rating, which provides no discount. There are 10 CRS classes: Class 1 requires the most credit points and gives the greatest premium discount; Class 10 identifies a community that does not apply for the CRS, or does not obtain a minimum number of credit points and receives no discount. There are 18 activities recognized as measures for eliminating exposure to floods. Credit points are assigned to each activity. The activities are organized under 4 main categories:

- Public Information
- Mapping and Regulation
- Flood Damage Reduction
- Flood Preparedness

Class number determines the premium discount for policyholders. Premium discounts ranging from 5% to a maximum of 45% are applied to eligible policies written in a community as recognition of the floodplain management activities instituted. Adams County is currently a Class 10 rating as of May 1, 2011, and receives no discount for policyholders.

[43] FEMA Community Rating System http://www.fema.gov/business/nfip/crs.shtm 9/7/2012.

Risk Assessment

A number of factors contribute to the relative vulnerabilities of certain areas in the floodplain. Development, or the presence of people and property in the hazardous areas, is a critical factor in determining vulnerability to flooding. Additional factors that contribute to flood vulnerability range from specific characteristics of the floodplain to characteristics of the structures located within the floodplain.

Hazus is a regional multi-hazard loss estimation model that was developed by the FEMA and the National Institute of Building Sciences (NIBS). The primary purpose of Hazus is to provide methodology and software application to develop multi-hazard losses at a regional scale. The loss estimates are used primarily by local, state, and regional officials to plan and stimulate efforts to reduce risk from multi-hazards and prepare for emergency response and recovery.

Potential loss estimates analyzed in Hazus include:

- Physical damage to residential and commercial buildings, schools, essential facilities, and infrastructure
- Economic loss including lost jobs, business interruptions, repair and reconstruction costs.

Flood hazard is defined by a relationship between depth of flooding and the annual chance of inundation to that depth. Probabilistic events were modeled to be able to determine annualized losses for Adams County. Probabilistic events are modeled by looking at the damage caused by an event that is likely to occur over a given period of time, known as a return period or recurrence interval. Hazard analysis of the 10, 25, 50, 100, and 500-year return interval were also performed in order to assess risk to provide a comparative look at vulnerability as well as risk to essential facilities.

Depth, duration, and velocity of water in the floodplain are the primary factors contributing to flood losses. Other hazards associated with flooding that contribute to flood losses include channel erosion and migration, sediment deposition, bridge scour, and the impact of flood-borne debris. The Hazus Flood Model allows users to estimate flood losses due to flood velocity to the general building stock (GBS). The agricultural component allows the user to estimate a range of losses to account for flood duration. The flood model does not estimate the losses due to high velocity flash floods at this time.

Hazus MR-2 runs were completed in January 2009 and were researched to determine their usability in this assessment. Correspondence with the state and FEMA Region VIII determined that the files used in the analysis were no longer available, but the table outputs were available in the Colorado Flood HMP. For this assessment, a new Hazus 2.1 Level 1 analysis was completed using 10-meter Digital Elevation Models (DEMs) and 10 square mile drainage. Data for this analysis has been provided at the census block level. The values from the 2009 Hazus runs have been compared against the runs completed for this assessment. The complete Hazus geodatabase has been provided to the County and are available through the Adams County GIS department.

Impacts on Critical and Hazardous Materials Facilities (Tier II facilities), Infrastructure, and Population

The greatest population is in the western portion of the County. Life and property would be at risk in the event of flash flooding or dam failure in a populated area. Industry located in the 100-year floodplain may handle and store hazardous materials. Flooding or flash flooding could cause damage to industry located in floodplains, thus contaminating the waterways.[44]

Essential facilities, including medical care facilities, emergency response facilities, and schools, are vital to emergency response and recovery following a disaster. School buildings are included in this category because of the key role they often play in sheltering people displaced from damaged homes. Generally there are very few of each type of essential facility in a census tract, making it easier to obtain site-specific information. Thus, damage and loss-of-function are evaluated on a building-by-building basis for this class of structures, even though the uncertainty in each such estimate is large.[45]

Hazus analysis shows 8 schools in the vicinity of the defined floodplains; 5 are estimated to experience at least moderate damage and 3 to experience complete loss of use due to a 100-year flood event. As the result of a 500-year flood event, 6 schools are estimated to experience moderate damage and 5 loss of use. The actual level of risk for each facility may only be determined by further on-site assessments.

Schools impacted by the 100- and 500-year return intervals include:

- Northeast Elementary School
- North Elementary School
- Brighton High School
- Vikan Middle School
- Brighton Heritage Academy
- South Elementary
- Brighton Adventist Academy

Hazus also estimates the number of persons and households that are expected to be displaced from their homes based on the flood return-period and the number of displaced people that will require accommodations in temporary public shelters. Table 28 shows the household displacement and shelter estimates for each return period.

Table 28. Hazus social vulnerability results

Return Period	Shelter Requirements	
	Number of Displaced Households	Number of People needing Short Term Shelter
100-Year	3,885	9,825
500-Year	6,291	16,689

[44] Adams County Hazard Analysis (1996)
[45] Multi-hazard Loss Estimation Methodology HAZUS-MH MR4, Chapter 1: Introduction, 1-6

To supplement the Hazus analysis, the critical facilities dataset was intersected with the FIRM to determine if any additional facilities were located within the mapped floodplains. Table 29 shows the results of this analysis. Stuart Middle School and Elmwood Baptist Academy are the two At-Risk Population facilities, and they are shown to be located within Zone A. Studio School, Byers High School, Fire Station #63 are the facilities located within the 500-year floodplain. Six HazMat facilities are located within the SFHA and should be further investigated in the Mitigation Strategies. Several facilities are located within the 500-year floodplain.

Table 29. Critical facilities located within mapped FEMA floodplains.

Facility Type	Number within 100-Year SFHA	Number within 500-Year SFHA
1. Essential Facilities	0	2
2. HazMat Materials	6	3
3. At-Risk Populations	2	1
4. Vital to Restoring Normal Services	0	0

Existing and Future Development Trends

The South Platte basin is expected to experience major strains on water use from population growth. Population growth could also potentially mean that more people will be at risk to flood.

No new structures can be built in the floodway portion of a flood zone. For NFIP purposes, the floodway is defined as the channel of a river or other watercourse and adjacent land areas that must be reserved
in order to discharge the base flood without cumulatively increasing the water surface elevation more than one foot. Future development is controlled by existing regulations but existing structures will continue to be at risk unless they are removed from the flood area.

Current GIS zoning data was intersected with the FEMA FIRM. As shown in Table 33, 80% of the producing mines and 16% of agricultural and state assessed parcels are located within the 100-year floodplain.

With the population expected to increase, there is a high probability the percentage of structures located within the SFHA will increase unless appropriate floodplain management regulations are adopted and enforced. Use of floodplain development permits and review of plans for all future development will help to ensure there is no increase in flood risk and, where possible, can assist in implementing activities to reduce the flood risk to the existing population and buildings.

Land use changes have the potential to change and increase the risk to flooding. A change in environment can create localized flooding problems inside and outside of natural floodplains by altering or confining watersheds or natural drainage channels. The Mitigation Strategy section of this report summarizes ongoing and potential projects that would reduce this risk. Areas of concern are included above in the probability of future occurrence section.

Existing floodplain regulations are designed to decrease future losses from events such as dam or levee failure. However, upstream locations with deficient or unenforced floodplain regulations may lead to structures being built in the floodplain. This situation may create more potential debris flow during

major flood events or dam failures and could damage or destroy downstream dams. Any additional development downstream of a dam and within the inundation area could elevate the dam hazard ranking and the level of risk.

Loss Estimates and Economic Impacts

The Hazus flood model analyzes both riverine and coastal flood hazards. Flood hazard is defined by a relationship between depth of flooding and the annual chance of inundation to that depth. Probabilistic events are modeled by looking at the damage caused by an event that is likely to occur over a given period of time, known as a return period or recurrence interval. As discussed above, analysis for the 10, 25, 50, 100, and 500-year return intervals were also performed in order to assess risk to essential facilities.

A threshold of 10 square mile minimum drainage area, using 10-meter (1 arc second) DEMs was used for this study. Hydrology and hydraulic processes utilize the DEMs, along with flows from USGS regional regression equations and stream gauge data, to determine reach discharges and to model the floodplain. Losses are then calculated using national baseline inventories (buildings and population) at the census block level.

In rural Colorado, census blocks are large (as in the eastern part of Adams County) and often sparsely populated or developed; this may create inaccurate loss estimates. Hazus assumes population and building inventory to be evenly distributed over a census block; flooding may occur in a small section of the census block where there are not actually any buildings or people, but the model assumes that there is damage to that block.

Loss estimation for this Hazus module is based on specific input data. The first type of data includes square footage of buildings for specified types or population. The second type of data includes information on the local economy that is used in estimating losses. Table 30 displays the economic loss categories used to calculate annualized losses by Hazus. Data for this analysis has been provided at the census block level.

Table 30. Hazus direct economic loss categories and descriptions.

Category Name	Description of Data Input into Model	Hazus Output
Building	Cost per sq ft to repair damage by structural type and occupancy for each level of damage	Cost of building repair or replacement of damaged and destroyed buildings
Contents	Replacement value by occupancy	Cost of damage to building contents
Inventory	Annual gross sales in $ per sq ft	Loss of building inventory as contents related to business activities
Relocation	Rental costs per month per sq ft by occupancy	Relocation expenses (for businesses and institutions)
Income	Income in $ per sq ft per month by occupancy	Capital-related incomes losses as a measure of the loss of productivity, services, or sales
Rental	Rental costs per month per sq ft by occupancy	Loss of rental income to building owners
Wage	Wages in $ per sq ft per month by occupancy	Employee wage loss as described in income loss

Table 31 summarizes and compares the total building exposure for the County and the exposure to the 100- and 500-year return periods. Agricultural building occupancy has over 62% building exposure in

the 100-year return interval and 59% within the 500-year return period for agricultural occupancy. More than 22% of all industrial building exposure is within the 100-year return period. Approximately 10% of Adams County building value is located within the 100 year return period and 12% within the 500-year return period.

Table 31. Building exposure by Occupancy type.

Occupancy Type	Total County Building Exposure	100-year Scenario Building Exposure	500-year Scenario Building Exposure
Residential	$17,266,716	$1,378,354	$1,587,346
Commercial	$3,322,488	$538,383	$707,116
Industrial	$1,011,301	$230,573	$261,429
Agricultural	$153,144	$95,584	$90,111
Religion/Nonprofit	$273,427	$21,819	$28,693
Government	$157,983	$11,218	$13,215
Education	$220,246	$35,787	$40,211
Total	**$22,405,305**	**$2,311,718**	**$2,728,121**

Building and contents loss make up the majority of expected damages for all of the return periods analyzed. Residential occupancy accounts for over 42% of the total damages for the 100- and 500-year return periods. As shown in Table 32, Adams County can expect over $205 million in damages from the 100-year scenario (Figure 15) and $420 million from the 500-year scenario.

Table 32. General Occupancy Economic Loss by return period. Shown in thousands of dollars.

Occupancy Type	Building Loss	Contents Loss	Inventory Loss	Relocation	Income Loss	Rental Income	Wage Loss	Total Loss
100-year Scenario								
Agriculture	$1,395	$2,841	$480	$1	$7	$0	$1	$4,725
Commercial	$18,001	$49,361	$1,689	$67	$245	$47	$333	$69,743
Education	$827	$5,062	$0	$9	$33	$0	$89	$6,020
Government	$363	$2,151	$0	$10	$4	$3	$232	$2,763
Industrial	$7,167	$15,136	$2,835	$1	$1	$0	$1	$25,141
Religious/Non-Profit	$531	$3,190	$0	$1	$3	$0	$19	$3,744
Residential	$58,501	$34,256	$0	$143	$0	$11	$1	$92,912
Total	**$86,785**	**$111,997**	**$5,004**	**$232**	**$293**	**$61**	**$676**	**$205,048**
500-year Scenario								
Agriculture	$3,121	$7,817	$1,477	$5	$19	$0	$6	$12,445
Commercial	$34,809	$92,935	$3,896	$109	$372	$76	$542	$132,739
Education	$1,474	$4,872	$0	$6	$26	$0	$73	$6,451
Government	$408	$2,541	$0	$11	$4	$2	$300	$3,266
Industrial	$19,354	$51,173	$9,558	$10	$7	$2	$13	$80,117
Religious/Non-Profit	$1,197	$6,949	$0	$3	$8	$0	$36	$8,193
Residential	$110,406	$65,825	$0	$220	$0	$29	$4	$176,484
Total	**$170,769**	**$232,112**	**$14,931**	**$364**	**$436**	**$109**	**$974**	**$419,695**

To supplement the Hazus analysis, the digital FIRM data was overlaid with parcel and assessor's data in order to perform a GIS-based risk assessment for critical facilities (summarized previously in this section). Additionally, the information was used to determine the exposure (number and value) of potentially at-risk parcels as shown in Table 33. Approximately 4% of the parcels in Adams County are located near or within a SFHA accounting for 0.15% of the total building value for the County.

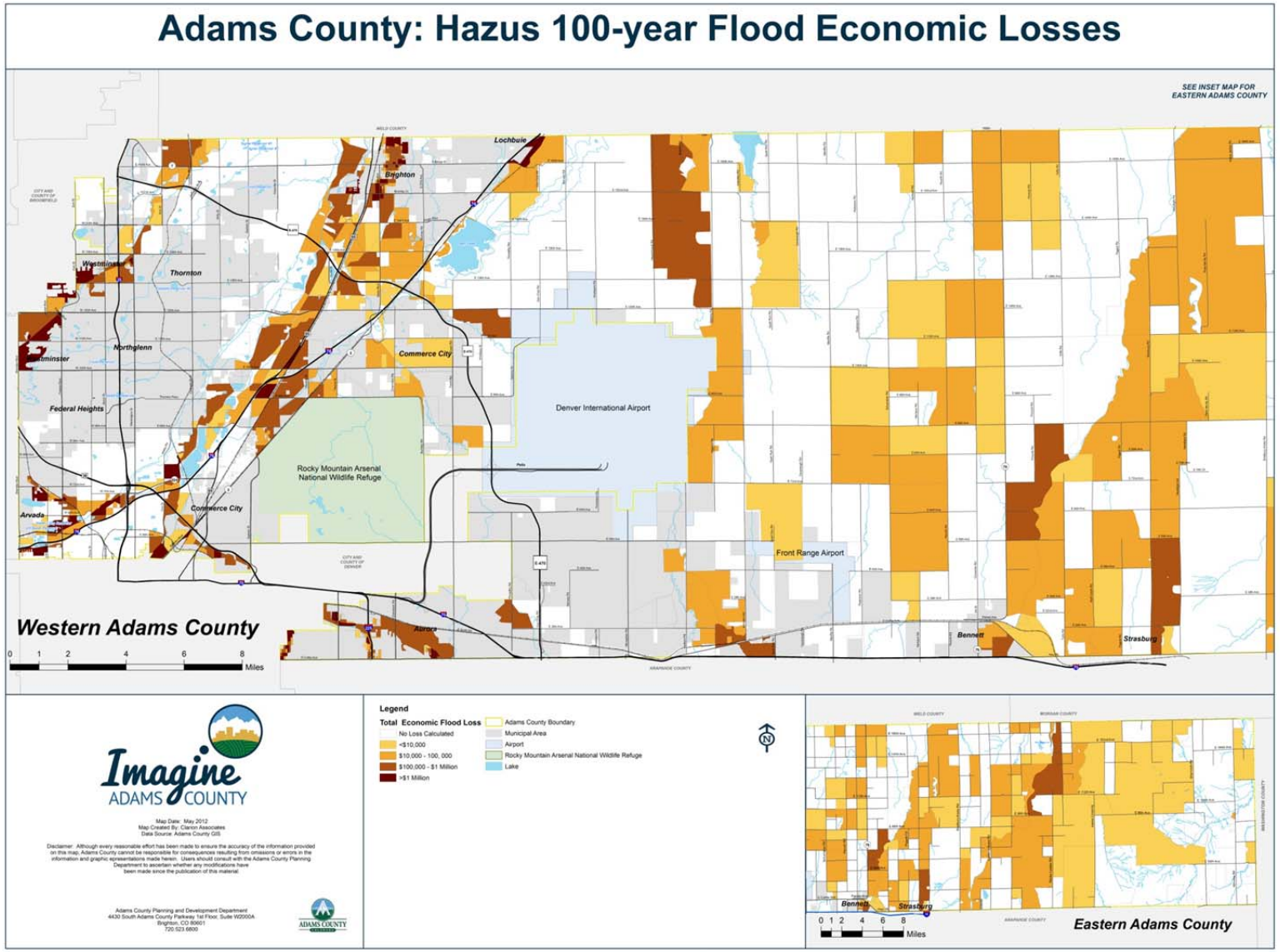

Figure 15. Economic Flood loss for the 100-year Hazus scenario.

Table 33. Exposure and flood risk of County-provided parcel data.

Parcel Type	100-year Floodplain		Floodway		500-year Floodplain		Future 1%	
	Number of Parcels	Bldg Value	Number of Parcels	Bldg Value	Number of Parcels	Bldg Value	Number of Parcels	Bldg Value
Residential	1,655	$390,834,169	365	$147,605,646	1,088	$199,275,053	85	$13,146,529
Commercial	325	$182,338,346	107	$54,030,770	150	$65,436,668	4	$166,139
Agricultural	754	$30,321,848	115	$3,769,102	77	$5,353,922	70	$1,236,206
Exempt	588	$1,062,696,535	267	$50,493,993	202	$930,108,577	16	$321,305
Industrial	60	$38,399,630	24	$10,175,218	28	$9,958,826	0	$0
Producing Mine	57	$213,500	37	$130,655	22	$22,869	0	$0
State Assessed	62	$0	43	$0	25	$0	0	$0
Other	2	$0	0	$0	0	$0	0	$0
Total	**3,503**	**$ 1,704,804,028**	**958**	**$ 266,205,384.00**	**1,592**	**$ 1,210,155,915**	**175**	**$14,870,100**

Comparison of the Hazus results completed for this HIRA with the Colorado State Hazard Mitigation Plan Hazus results (Table 34) highlight the influence the input parameters have on the loss estimates. The Hazus MR2 analysis used a 10-square mile drainage threshold and 30-meter DEM, while the Hazus 2.1 analysis used a 10-square-mile drainage threshold and 10-meter DEM.

Table 34. Hazus results from 2011 Colorado HMP.

Return Period	Building Damage Loss	Building Exposure	Contents Damage Loss	Contents Exposure	Total Direct Economic Building Loss
Hazus MR2 100-year	$131,458,000	$20,685,685,000	$169,831,000	$13,596,898,000	$315,824,000

The National Climatic Data Center Storm Events data was annualized by taking the total number of flood events and dividing by the length of record. The annualized values should be utilized only as an estimate of what can be expected in a given year. Using historical records, it can be estimated that the County has a 74% chance of experiencing a flood event in any given year. Damages from these events can be expected in the magnitude of $37,584. Table 35 shows the annualized results for flooding in Adams County. It should be noted that the severe storm damages reported by National Climatic Data Center drastically under represent what is expected in the County.

Table 35. Flood National Climatic Data Center Annualized events.

Hazard Type	Annualized Events	Annualized Property Damages	Annualized Crop Damages	Total Annualized Damages
Flood	0.74	$37,584	-	$37,584
Flash Flood	0.58	$36,085	-	$36,085

The 2009 Hazus Flood Average Annualized Loss (AAL) study, which concluded in June 2010, was performed for the entire continental United States using the MR4 release of Hazus. The analysis was performed at the County level using Level 1 methodology with national datasets, and each Production and Technical Services (PTS) contractor performed the work for its FEMA Regions. The analysis was performed using USGS 30-meter DEMs, 10-square mile drainage area for stream delineation, and default Hazus inventory data. The purpose was to develop an initial identification of flood loss for the entire nation based on nationally available datasets and to avoid bias to areas with more detailed data related to flooding and/or infrastructure. The AAL study completed for Adams County shows that the County could experience over $18 million in annualized damages from flood; this includes $7.4 million in building losses and $10.7 million in contents losses.[46]

Dam Failure Vulnerability

Dams are classified based on the potential loss of life and property to the downstream area resulting from failure of the dam or facilities, and not from the condition or probability of the dam failing. There are 36 dams within Adams County, of these 8 of them are rated as high hazard potential and 12 as significant hazard potential by the State Department of Natural Resources Dam Safety Branch.

[46] FEMA Hazus AAL Usability Analysis. April 13, 2011.

Independent of the dam classification, the following dams, because of their proximity to populated areas, have been identified as a high or moderate hazard for the County.[47]

High

- Badding (aka Croke Adams)
- Barr Adams
- Niver Creek Detention
- East Adams #3
- Kalcevic

Moderate

- East Adams #1
- East Adams #2
- Northglenn terminal
- Ohio Adams
- Todd
- Webster Adams East
- Copeland
- Dewey #1
- Boot Leg
- Croke Reservoir

Adams County has digital dam inundation mapping for Clear Lake Dam and Lower Cabin Creek Dam and has the EAPs for Kalcevic, Bear Creek, Chatfield Dam 1, 2 and 3, and Spring Gulch Dam. Spatial dam inundation mapping was not made available for this study due to security and privacy. If these files were made available, analysis similar to the floodplain analysis would be completed. This would include intersecting the parcel and assessor data with the dam inundation zones to determine the number and building value exposure for parcels located within the failure zones. Critical facilities could also be intersected with the dam inundation zones.

Drought (Medium Ranking)

Ranking

Table 36 shows the criteria used to derived a Medium ranking for drought in Adams County. Hazard ranking criteria from the State of Colorado Hazard Mitigation Plan and DRCOG Hazard Mitigation Plan were reviewed by the steering committee. Hazard ranking methodology is further explained in the beginning of the hazard identification section of this assessment. To fully support integration, each hazard was considered and the potential impacts are reflected in the future land use map in the body of the Comprehensive Plan.

[47] Adams County Hazard Analysis (1996)

Table 36. Drought Hazard Ranking Criteria.

Hazard	Geographic Extent	Previous Occurrence	Future Probability	Magnitude /Severity	2012 Ranking
Drought	Medium 5 to 25% of County	High >5 Events in last 50 years	High <1 /100 or 1% annual chance	Medium 1 to 10% of people or property impacted	**Medium**

DESCRIPTION

A drought is a period in which an unusual scarcity of rain causes a serious hydrological imbalance in which water supply reservoirs empty, water wells dry up, and crop damage ensues. A prolonged period of drought may or may not accompany the periods of extreme heat.

There are four main classifications of droughts. They include (1) Meteorological, (2) Agricultural, (3) Hydrological, and (4) Socio-economic. Meteorological droughts are typically defined by the level of "dryness" when compared to an average, or normal, amount of precipitation over a given period of time. Agricultural droughts relate common characteristics of drought to their specific agricultural-related impacts. Emphasis tends to be placed on factors such as soil/water deficits, water needs based on differing stages of crop development, and water reservoir levels. Hydrological drought is directly related to the effect of precipitation shortfalls on surface and groundwater supplies. Human factors, particularly changes in land use, can alter the hydrologic characteristics of a basin. Socio-economic drought is the result of water shortages that limit the ability to supply water-dependent products in the marketplace.

Extreme heat is a summer phenomenon that usually involves temperatures over 100° Fahrenheit for a period of several days. The NWS can issue heat-related messages to inform citizens of forecasted extreme heat conditions. These messages are based on projected or observed heat index values and include:

- Excessive Heat Outlook: When there is a potential for an excessive heat event within three to seven days;
- Excessive Heat Watch: When conditions are favorable for an excessive heat event within 12 to 48 hours but some uncertainty exists in regards to occurrence and timing; and
- Excessive Heat Warning / Advisory: When an excessive heat event is expected within 36 hours. These messages are usually issued when confidence is high that the event will occur. A warning implies that conditions could pose a threat to life or property, while an advisory is issued for less serious conditions that may cause discomfort or inconvenience, but could still lead to threat to life and property if caution is not taken.

Several indices are available to determine drought stages, two of which are the Palmer Drought Severity Index and the Keetch-Bryam Drought Index. The Palmer Drought Severity Index (PDSI) uses precipitation, air temperature, soil moisture, evapotranspiration, and pervious indices to produce a number indicating current conditions. The Keetch-Byram Drought Index (KBDI) monitors fire danger and severity using maximum daily temperature, daily, antecedent, and annual precipitation.

Geographic Location and Severity

Geographic Location = Statewide. Mountains and plains both experience drought. Changes geographically from year to year and decade to decade. Drought in one area of the state may affect other regions.[48]

Magnitude/Severity = Extensive. Limited property damage that does not threaten structural integrity; deaths (3-4 per year); and injuries; little or no impact to critical services or facilities. May result in significant economic and water resource impacts.[49]

Drought has been an all too familiar part of Colorado's history. It is one of the most destructive, but least understood of all natural hazards. Its onset is slow and silent and its effects can last for years. Geographically, drought can occur locally, regionally, or statewide. The impacts from drought are non-structural and generally affect the economy and environment of the host area. Drought and extreme heat are regional phenomena and affect the entire County. Using the KBDI, Adams County would consider an index reading of 400 to be a minimum severity and an index reading of 600 to be a major severity for drought. The heat index is often used to measure how hot the air "feels" based on temperature and humidity. The index can be used as an indicator of potential health effects (Figure 16).

Droughts can last a few months to several years. Longer droughts can increase wildfire risk and impact municipal water use. The severity of a drought may be gauged by the size of the area affected, the duration, and the degree of moisture deficiency. Droughts may also result in a reduction of electric power generation and water quality deterioration. Drought conditions can also cause soil to compact, decreasing its ability to absorb water, making an area more susceptible to flash flooding and erosion. A drought may also increase the speed at which dead and fallen trees dry out and become more potent fuel sources for wildfires. Drought may also weaken trees in areas already affected by mountain pine beetle infestations, causing more extensive damage to trees and increasing wildfire risk, at least temporarily.

Risks from exposure to extreme heat include sunburn, heat cramps, heat exhaustion, heat stroke, and death. Overexposure to sunlight can also increase the risk for skin cancer, macular degeneration, and cataracts. Extreme heat is also hazardous to livestock, agriculture, and structures such as roads and bridges, and may diminish water and energy supplies, which may increase the risk to human health.

[48] 2011 State of Colorado Natural Hazards Mitigation Plan.
[49] 2011 State of Colorado Natural Hazards Mitigation Plan.

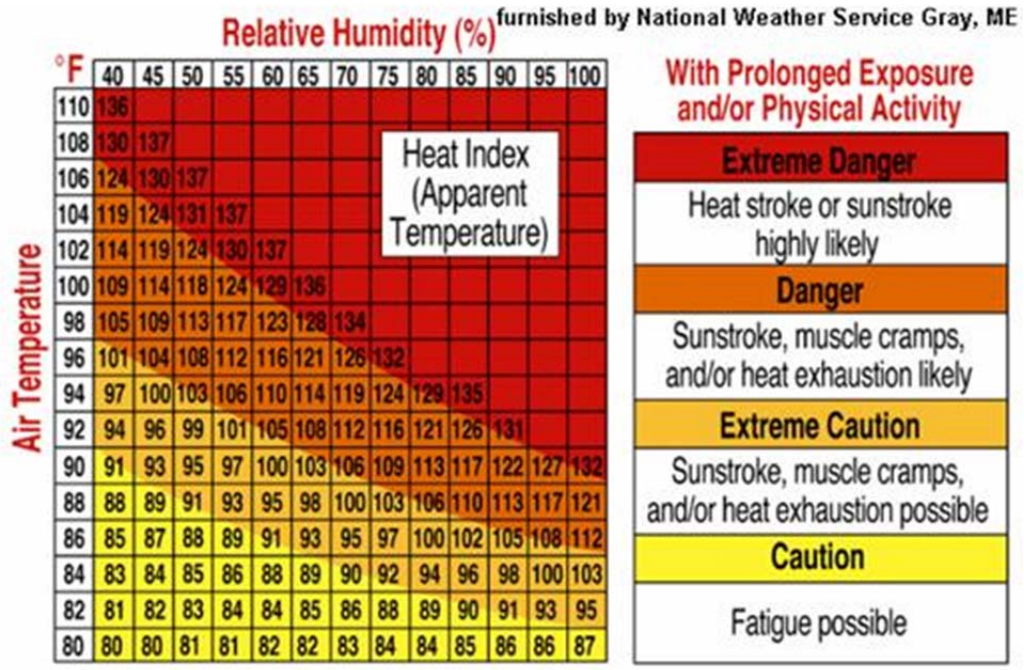

Figure 16. NWS Heat Index.

Previous Occurrences And Probability of Future Occurrence

Previous Occurrences = Sporadically. Drought may occur at any time of the year and be short or long-term in development, duration, and ending.[50]

A drought event can be short-term or it can be a multi-year event much like the current drought affecting Colorado. From a historical perspective, scientific studies have shown that Colorado has experienced drought periods lasting ten years and longer. The Colorado Drought Mitigation and Response Plan from 2001 identified several multi-year dry periods in the state, with the longest one spanning 12 years from 1893 through 1905, followed by a period of 10 years during 1931 to 1941.

Colorado has experienced multiple widespread droughts since the late 1800s. Table 37 highlights more recent droughts, recorded by USDA, in Adams County. On a statewide basis, 2002 was the most intense single year of drought in Colorado's history. In April 2002, statewide snow pack was 52% of average and general precipitation was well below the 70% average that is commonly used to define a severe drought. This was an extremely dry year embedded in a longer dry period (2000-2006). These conditions were rated exceptional by the U.S. Drought Monitor and were the most severe drought experienced in the region since the Dust Bowl. Based on studies of tree rings and archaeological evidence from aboriginal cultures, the 2002 drought was the most severe in the recorded history of the state.[51]

Figure 17 shows the current (July 2012) U.S. Drought Monitor for the West. As shown, Adams County is listed as extreme drought conditions.

[50] 2011 State of Colorado Natural Hazards Mitigation Plan.
[51] Colorado Drought Mitigation and Response Plan. 2010.

Table 37. USDA Secretarial Disasters (2003 – 2009) and State Disasters for Adams County. Source: Colorado Hazard Mitigation Plan.

Date	Hazard Type	Declaration Type
2012	Drought	USDA Disaster
2006	Drought, Fire, Heat and High Winds	USDA Disaster
2002	Drought	USDA Disaster
2002	Drought	State Declaration
2000	Drought	USDA Disaster

Since 1950, Adams County has been a part of 64 county and statewide droughts (Table 38) as recorded by National Climatic Data Center. None of the events have recorded damages. These events can be grouped by the time periods recorded in the database; it appears that there are four drought periods in which the 64 events took place. These include:

- May 2002 through September 2006
- January 2007
- September 2007 through February 2008
- January 2010 through March 2010

Table 38. Drought National Climatic Data CenterStorm Events for Adams County, Colorado (Shown in 2012 Dollars).

Hazard	Number of Events	Property Damage	Crop Damage	Deaths	Injuries
Drought	64	-	-	-	-

The probability of future occurrences of droughts within Adams County is high. It is extremely difficult to determine probability of future occurrence in a specific area with any degree of accuracy. All areas within Adams County are equally at risk to drought.

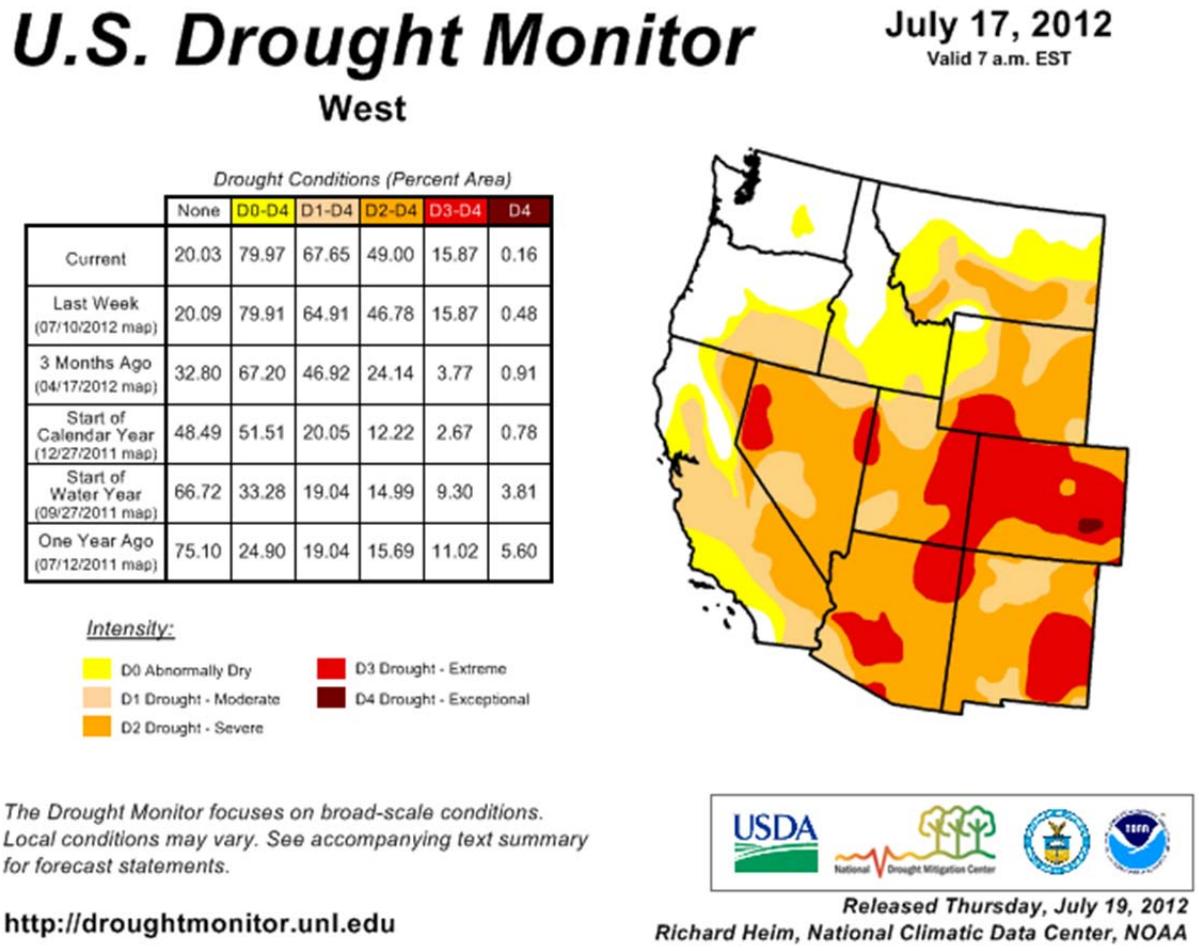

Figure 17. U.S. Drought Monitor conditions up to July 2012.

Future Probability = Likely. Atmospheric conditions resulting in severe drought conditions are expected to occur as frequently in the future as in the past. The Colorado Drought Mitigation and Response Plan also notes that "Short duration drought as defined by the three-month Standardized Precipitation Index (SPI) occurs somewhere in Colorado in nearly nine out of every ten years."[52]

Drought and extreme heat are often unpredictable and may be localized, which makes it difficult to assess the probability. Historical analysis of precipitation shows that drought is a frequent occurrence in Colorado. Short duration droughts as defined by the three-month Standardized Precipitation Index (SPI) occur somewhere in Colorado in nearly nine out of every ten years. However, severe, widespread multiyear droughts are much less common.

Risk Assessment

Impacts from drought are often related to water-intensive activities such as municipal usage, agriculture, wildfire protection, business, and recreation.

[52] 2011 State of Colorado Natural Hazards Mitigation Plan.

Risk to critical facilities, infrastructure, buildings and people cannot be quantified for drought or extreme heat as it can be for hazards with well-defined recurrence intervals and intensity-damage models, such as flooding.

Impacts on Critical and Hazardous Materials Facilities (Tier II facilities), Infrastructure, and Population

Adams County relies on the runoff from the mountains for its domestic and irrigation water. A drought can have serious impacts on the county.[53]

Critical facilities and infrastructure are typically not directly affected by drought; as a drought persists, the supplies for municipal and agricultural water sources are diminished. Several areas within the County rely on individual ground wells and man-made water retention structures for their water resources. These individual ground water wells are also at risk to reduced water supplies due to extended periods of drought.

Existing and Future Development Trends

Vulnerability, in terms of decreased water supply, will increase with development. The Comprehensive and Land Use plans are being developed concurrent to this effort and include strategies for preparing a Drought Mitigation and Response Plan.

Loss Estimates and Economic Impacts

Significant property damage is not typically attributed to extreme heat; however, these events claim several lives each year throughout Colorado. The majority of the injuries and deaths attributed to extreme heat are a result of heat exhaustion or improperly functioning heat/air conditioning units.

The National Climatic Data Center Storm Events data was annualized by taking the total number of drought events and dividing by the length of record. The annualized values should only be utilized as an estimate of what can be expected in a given year. Using historical records, it can be estimated that the County will experience a drought or series of events in any given year; all months appear to have the same number of droughts attributed with them (Figure 6). No historical damages have been recorded due to drought, and therefore no estimated annualized damages could be derived. Table 39 shows the annualized results for drought in Adams County. It should be noted that the damages reported by National Climatic Data Center drastically under represent what is expected in the County.

Table 39. Drought Annualized events.

Hazard Type	Annualized Events	Annualized Property Damages	Annualized Crop Damages	Total Annualized Damages
Drought	3.37	-	-	-

[53] Adams County Hazard Analysis (1996)

Subsidence (Low Ranking)

Ranking

Table 40 shows the criteria used to derive a low ranking for subsidence in Adams County. Hazard ranking criteria from the State of Colorado Hazard Mitigation Plan and DRCOG Hazard Mitigation Plan were reviewed by steering committee. Hazard ranking methodology is further explained in the beginning of the hazard identification section of this plan. To fully support integration, each hazard was considered and the potential impacts are reflected in the future land use map in the body of the Comprehensive Plan.

Table 40. Subsidence Hazard Ranking Criteria.

Hazard	Geographic Extent	Previous Occurrence	Future Probability	Magnitude /Severity	2012 Ranking
Subsidence	Low <= 5% of County	Low <=1 Event in last 50 years	Low <=1 /1,000 or 0.1% annual chance	Medium 1 to 10% of people or property impacted	**Low**

Description

The term land subsidence refers to any failures in the ground that cause collapses in the earth's surface. Land subsidence can be caused by natural processes, such as the dissolving of limestone underground, the collapse of certain soil types, an earthquake, or volcanic activity. Subsidence can also be the result of human actions such as withdrawal of groundwater, oil and gas or underground mining. In the Front Range of Colorado, the types of subsidence that are generally seen are either a result of mining activities (coal or mineral mines) or collapsible soils.[54]

Ground subsidence is the sinking of the land over man-made or natural underground voids. In Colorado, the type of subsidence of greatest concern is the settling of the ground over abandoned mine workings. Collapsing and settling soils are relatively low density materials that shrink in volume when they become wet, and/or are subjected to great weight such as from a building or road fill. The process of collapse with the addition of water is also known as hydrocompaction.

Land subsidence is the loss of surface elevation due to a lack or loss of subsurface support; it can include a gradual lowering of the ground-surface elevation over a vast area, and sudden, localized collapses of the ground surface. Land subsidence can be caused by natural and man-made sources. In areas of karst topography, groundwater can erode limestone, dolomite, and other soluble minerals to cause sinkhole formation. Land subsidence can also be generated by a controlled lowering of the groundwater table, which results in settlement. Underground mining and petroleum withdrawal can induce a lack of ground support, resulting in subsidence.[55]

Natural and human activities cause subsidence. Activities that lead to subsidence include underground mining, pumping groundwater or petroleum out of the ground, hydrocompaction, and draining organic soils.

[54] DRCOG Natural Hazard Mitigation Plan (2011)

[55] Mitigating Losses from Land Subsidence in the United States. Panel on Land Subsidence, Committee on Ground Failure Hazards Mitigation Research, Division of Natural Hazard Mitigation, National Research Council. 1991.

Natural causes of subsidence include the development of sinkholes, rock sliding downward along faults, natural sediment compaction, and melting of permafrost.

Subsidence may occur abruptly—virtually instantly—or gradually over many years. It may occur uniformly over a wide area as local depressions or pits separated by areas with abandoned coal and clay mines. The crystalline rocks in which most metals are mined have greater strength and are less likely to settle or collapse. Subsidence can also occur where underground water has dissolved subsurface materials or has been withdrawn by wells. Although serious in other western states, these latter types of subsidence are less common in Colorado than sinking caused by the caving in of underground mine workings.

Collapsing and settling soils have considerable strength when dry and generally are not a problem to structures and improvements. When they become wet, they are subject to rapid collapse and can be reduced in volume as much as 10 to 15%. Surface ground displacement of several feet can result. Similar processes frequently affect old landfills or poorly placed earth fills. Subsidence is likely to occur on the surface directly above abandoned coal mining operations.

Geographic Location and Severity

Geographic Location = Regional. South-central, southwest, and northwest are impacted by this hazard. (It is) distributed across the state with areas of denser concentration in heavily mined areas.[56]

Subsidence can result in serious structural damage to buildings, roads, irrigation ditches, underground utilities, and pipelines. It can disrupt and alter the flow of surface or underground water. Surface depressions created by subsidence may be filled in, only to sink further because the underground void has not been completely closed. Areas may appear to be free of subsidence for many years and then undergo renewed gradual or even drastic subsidence. Weight, including surface developments such as roads, reservoirs, and buildings, and man-made vibrations from such activities as blasting, and heavy truck or train traffic can accelerate the natural processes of subsidence. Natural fluctuation of groundwater levels or burning coal seams can also accelerate the process.[57]

Adams County Mineral Conservation Overlay District regulations are to establish limitations and controls for conservation and utilization of natural resources and for rehabilitation of excavated land. Land within this classification is designated as containing commercial mineral deposits in sufficient size parcels and in areas where extraction and rehabilitation can be undertaken while still protecting the health, safety, and welfare of the inhabitants of the area and the County. In cases where the location of the district or use abuts other zoning or use of land, structures, excavation, and rehabilitation may be restricted to be compatible with and protect the adjoining area.[58]

Subsidence and collapsible soils tends to be problematic along the Front Range. Adams County does not have any case histories of collapsible soil. The largest concern for subsidence generally occurs where land with sedimentary rock is undermined around historic coal and clay mines.

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[56] 2011 State of Colorado Natural Hazards Mitigation Plan.
[57] DRCOG Natural Hazard Mitigation Plan (2011).
[58] The Southwest Adams County Framework Plan

Magnitude/Severity = Extensive. Major or long-term property damage with potential to threaten structural integrity; Limited or no loss of life or injury; one of the Colorado's most prevalent causes of damage to buildings and construction.[59]

Adams County considers small subsidence formations near the soil surface not impacting property to be a minimum severity and large subsidence formations causing damage to people or property to be a major severity.

Subsidence can result in serious structural damage to buildings, roads, irrigation ditches, underground utilities, and pipelines. It can disrupt and alter the flow of surface or underground water. Surface depressions created by subsidence may be filled in, only to sink further because the underground void has not been completely closed. Areas may appear to be free of subsidence for many years and then undergo renewed gradual or even drastic subsidence.

The large ground displacements caused by collapsing soils can totally destroy roads and structures and alter surface drainage. Minor cracking and distress may result as the improvements respond to small adjustments in the ground beneath them. Geologic conditions conducive to subsidence are extensive throughout Colorado. Known serious problems of mining-related subsidence, hydro-compaction, and dissolution subsidence are known to occur in the state. With increased demand for mineral fuels, other mining activities, and pressures for intensive urban and recreational development throughout much of the state, these problems will intensify unless recognized and wisely dealt with.

Previous Occurrences And Probability of Future Occurrence

Previous Occurrences = Perennial. Ongoing event resulting from natural causes such as drought and precipitation and human-caused development activities.[60]

Future Probability = Expected. Conditions related to natural causes such as precipitation and drought cycles in addition to development and land use prevalent in the past are expected to continue.[61]

Recurrence intervals or probability of occurrence due to land subsidence cannot be predicted accurately without historical data; subsidence can occur suddenly without warning or over an extended period of several years. However, some factors that can cause a decrease in strength are wet conditions, vibrations, and increased surface loading. Land subsidence that occurs as a result of a drawdown of the groundwater table is likely to take place over a number of years.

The probability of future occurrences of subsidence within Adams County is low. It is extremely difficult to determine probability of future occurrence in a specific area with any degree of accuracy. All areas within Adams County are equally at risk to subsidence.

Risk Assessment

Risk and vulnerability assessment has not been completed for hazards ranked Low.

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[59] 2011 State of Colorado Natural Hazards Mitigation Plan.
[60] 2011 State of Colorado Natural Hazards Mitigation Plan.
[61] 2011 State of 2010 State of Colorado Natural Hazards Mitigation Plan.

The potential impacts of land subsidence depend on the type of subsidence that occurs (regional or localized, gradual or sudden) and the location where the subsidence occurs. The impacts of subsidence occurring in nonurban areas are likely to be less damaging than subsidence that occurs in heavily populated locations. The amount of structural damage depends on the type of construction, the structure location and orientation with respect to the subsidence location, and the characteristics of the subsidence event.

Structures and critical facilities as well as infrastructure such as roadway, pipelines, and utility lines are vulnerable to sinkholes. If a sinkhole were to take out a major roadway, this would result in loss of access and the need to look for alternative routes, which would impact critical service response. Damage to structures and infrastructure (such as power lines) would require people to seek alternative shelter with the potential to be cut off from utilities or critical facilities while reconstruction and mitigation take place.

Vulnerability to land subsidence could include residential, commercial, and industrial structures, underground and above-ground utilities, transportation infrastructure, as well as agricultural products.

Countywide policies and strategies within the Comprehensive Plan have been developed to provide for the extraction of subsurface resources. Strategies include restoring and enhancing unreclaimed land, requiring existing and future mining operations to reclaim land, strengthen resource extraction regulations, and compliance with the Mineral Extraction Master Plan.

Earthquake (Low Ranking)

Ranking

Table 41 shows the criteria used to derive a low ranking for earthquake in Adams County. Hazard ranking criteria from the State of Colorado Hazard Mitigation Plan and DRCOG Hazard Mitigation Plan were reviewed by the steering committee. Hazard ranking methodology is further explained in the beginning of the hazard identification section of this assessment. To fully support integration, each hazard was considered and the potential impacts are reflected in the future land use map in the body of the Comprehensive Plan.

Table 41. Earthquake Hazard Ranking Criteria.

Hazard	Geographic Extent	Previous Occurrence	Future Probability	Magnitude /Severity	2012 Ranking
Earthquake	Low <= 5% of County	Medium 1 to 4 Events in last 50 years	High <1 /100 or 1% annual chance	Low <1% of people or property impacted	**Low**

Description

An earthquake is the motion or trembling of the ground produced by sudden displacement of rock in the Earth's crust. Earthquakes result from crustal strain, volcanism, landslides, or the collapse of caverns. Earthquakes can affect hundreds of thousands of square miles; cause damage to property measured in the tens of billions of dollars; result in loss of life and injury to hundreds of thousands of persons; and disrupt the social and economic functioning of the affected area.

Most earthquakes are caused by the release of stresses accumulated as a result of the rupture of rocks along opposing fault planes in the Earth's outer crust. These fault planes are typically found along borders of the

Earth's 10 tectonic plates. These plate borders generally follow the outlines of the continents, with the North American plate following the continental border with the Pacific Ocean in the west, but following the mid-Atlantic trench in the east. As earthquakes occurring in the mid-Atlantic trench usually pose little danger to humans, the greatest earthquake threat in North America is along the Pacific Coast.

The areas of greatest tectonic instability occur at the perimeters of the slowly moving plates because these locations are subjected to the greatest strains from plates traveling in opposite directions and at different speeds. Deformation along plate boundaries causes strain in the rock and the consequent buildup of stored energy. When the built-up stress exceeds the rocks' strength, a rupture occurs. The rock on both sides of the fracture is snapped, releasing the stored energy and producing seismic waves, generating an earthquake.

Earthquakes are measured in terms of their magnitude and intensity. Magnitude is measured using the Richter Scale, an open-ended logarithmic scale that describes the energy release of an earthquake through a measure of shock wave amplitude (Table 42). Each unit increase in magnitude on the Richter Scale corresponds to a 10-fold increase in wave amplitude, or a 32-fold increase in energy. Intensity is most commonly measured using the Modified Mercalli Intensity (MMI) Scale based on direct and indirect measurements of seismic effects. The scale levels are typically described using Roman numerals, with a I corresponding to imperceptible (instrumental) events, IV corresponding to moderate (felt by people awake), to XII for catastrophic (total destruction). A detailed description of the MMI Scale of earthquake intensity and its correspondence to the Richter Scale is given in Table 43.

Table 42. Richer Scale.

Richter Magnitudes	Earthquake Effects
Less than 3.5	Generally not felt, but recorded.
3.5-5.4	Often felt, but rarely causes damage.
Under 6.0	At most, slight damage to well-designed buildings. Can cause major damage to poorly constructed buildings over small regions.
6.1-6.9	Can be destructive in areas up to about 100 kilometers across where people live.
7.0-7.9	Major earthquake. Can cause serious damage over larger areas.
8 or greater	Great earthquake. Can cause serious damage in areas several hundred kilometers across.

Table 43. Modified Mercalli Intensity scale for earthquakes.

Scale	Intensity	Description of Effects	Corresponding Richter Scale Magnitude
I	Instrumental	Detected only on seismographs	
II	Feeble	Some people feel it	<4.2
III	Slight	Felt by people resting; like a truck rumbling by	
IV	Moderate	Felt by people walking	
V	Slightly Strong	Sleepers awake; church bells ring	<4.8
VI	Strong	Trees sway; suspended objects swing, objects fall off shelves	<5.4
VII	Very Strong	Mild Alarm; walls crack; plaster falls	<6.1
VIII	Destructive	Moving cars uncontrollable; masonry fractures, poorly constructed buildings damaged	
IX	Ruinous	Some houses collapse; ground cracks; pipes break open	<6.9

Scale	Intensity	Description of Effects	Corresponding Richter Scale Magnitude
X	Disastrous	Ground cracks profusely; many buildings destroyed; liquefaction and landslides widespread	<7.3
XI	Very Disastrous	Most buildings and bridges collapse; roads, railways, pipes and cables destroyed; general triggering of other hazards	<8.1
XII	Catastrophic	Total destruction; trees fall; ground rises and falls in waves	>8.1

Geographic Location and Severity

Geographic Location = Regional. Recorded earthquakes are located over a large area of the state. However, faults with capacity for larger magnitude events are in central and western Colorado. [62]

Colorado's earthquakes have occurred throughout the state with the northeastern portion largely void of earthquakes. Thousands of faults have been mapped in Colorado, but scientists think only about 90 of these were active in the past 1.6 million years.[63]

Magnitude/Severity = Catastrophic. Destroyed or damaged property that threatens structural stability, mass fatalities and/or casualties, impact to critical lifelines, impact to government's ability to provide service. Likely to overwhelm state and local recourses and require federal assistance for full recovery.[64]

The destructiveness of an earthquake depends on a number of factors, including the magnitude of the tremor, direction of the fault, distance from the epicenter, regional geology, and the design characteristics of buildings and infrastructure. Earthquakes are a regional hazard that would affect all of Adams County with similar magnitude and severity. Based on discussion with CGS, a magnitude 6 ½ through 7 ½ earthquake could occur anywhere in the state. Adams County considers a Modified Mercalli Intensity Scale of III to be a minimum severity and a Modified Mercalli Intensity Scale of VI to be a major severity.

Ground shaking can lead to the collapse of buildings and bridges and disrupt gas lines, electricity, and phone service. Most property damage and earthquake-related deaths are caused by the failure and collapse of structures due to ground shaking. The level of damage depends upon the amplitude and duration of the shaking, which are directly related to the earthquake size, distance from the fault, site, and regional geology. Death, injuries, and extensive property damage are possible vulnerabilities from this hazard. Some secondary hazards caused by earthquakes may include fire, hazardous material release, landslides, flash flooding, avalanches, tsunamis, and dam failure.

The age of many downtown buildings, infrastructure, and many older homes would probably make damages in an earthquake above Richter level 5.5 devastating in terms of the economy and the structures of the area. Earthquakes of a magnitude above 5.5 Richter might threaten dams, with severe results in communities downstream. It would also cause some dislocation for Front Range communities through the loss of water

[62] 2011 State of Colorado Natural Hazards Mitigation Plan.
[63] Widmann, B.L., compiler, 1997, Fault number 2308a, Sawatch fault, northern section, in Quaternary fault and fold database of the United States: U.S. Geological Survey website, http://earthquakes.usgs.gov/regional/qfaults, accessed 07/24/2012 12:38 PM.
[64] 2011 State of Colorado Natural Hazards Mitigation Plan.

(principal owners of the stored water). The costs of engineering studies on each of the buildings in the area would probably overwhelm building owners who are beset by tightening economies and increasing costs.

Previous Occurrences And Probability of Future Occurrence

Previous Occurrences = Sporadic. More than 500 earthquake tremors of magnitude 2 ½ or higher have been recorded in Colorado since 1867. High magnitude earthquake have only occurred a few times in the last 150 years.[65]

Table 44 provides a list of Colorado's larger earthquakes. The largest known earthquake in Colorado occurred on November 7, 1882. The first ever to cause damage in Denver, probably centered in the Front Range near Rocky Mountain National Park, is the largest historical earthquake in the state. The magnitude is estimated to be about 6.6 on the Richter scale. In Boulder County, the walls of the depot cracked, and plaster fell from walls at the University at Boulder. The quake was felt as far away as Salina, Kansas, and Salt Adams City, Utah.[66] Additional earthquakes of magnitude 2.5 to 3 probably occurred during that time, but were not recorded because of the sparse distribution of population and limited instrumental coverage in much of the state.

Table 44. Notable Earthquake Events in Colorado: 1870 Through 2000

Date	Location	Magnitude	Intensity
12/04/1870	Pueblo-Ft. Reynolds		VI
10/1871	Lily Park, Moffat Co.		VI
09/17/1880	Aspen		VI
11/07/1882	**North Central Colorado**	**6.5***	**VII**
12/1891	Maybell		VI
11/15/1901	Buena Vista		VI
11/11/1913	Ridgway Area		VI
09/09/1944	Montrose-Basalt		VI
08/03/1955	Adams City		VI
10/11/1960	Montrose/Ridgway	5.5	V
01/04/1966	Northeast of Denver	5.0	V
01/23/1966	Southern Colorado	5.5	VII
08/09/1967	Northeast of Denver	5.3	VII
11/27/1967	Northeast of Denver	5.2	VI

**Estimated, based on historical felt reports.*
Sources: Colorado Natural Hazards Mitigation Plan, Colorado Division of Emergency Management, 2011

Historical earthquake activity for Adams County is above the average occurrence in Colorado. Figure 18 shows earthquake epicenter locations available from the CGS in and around Adams County. The lines show the locations of faults and the circles show the locations of epicenters. The figure shows a few faults to the west of Adams County; however, there have been numerous earthquakes in Adams County with magnitudes ranging from 1.6 to 3.4 (176 earthquakes) and several from 3.5 to 5.3 (36 earthquakes). There have been 212

[65] 2011 State of Colorado Natural Hazards Mitigation Plan.
[66] *2011 State of Colorado Natural Hazards Mitigation Plan*, Colorado Division of Emergency Management, 2011

earthquake epicenters located within 25 kilometers of Adams County since 1870, with the majority located northeast of Denver. Five of the earthquakes were greater than magnitude 4.8. These include:

- 8/9/1967 (Magnitude 5.3)
- 11/27/1967 (Magnitude 5.2)
- 1/5/1966 (Magnitude 5.0)
- 2/16/1965 (Magnitude 4.9)
- 4/10/1967 (Magnitude 4.9)

The most recent earthquakes in or around Adams County were on November 8, 1989, and February 25, 1984, and were registered as 2.5 magnitude events.

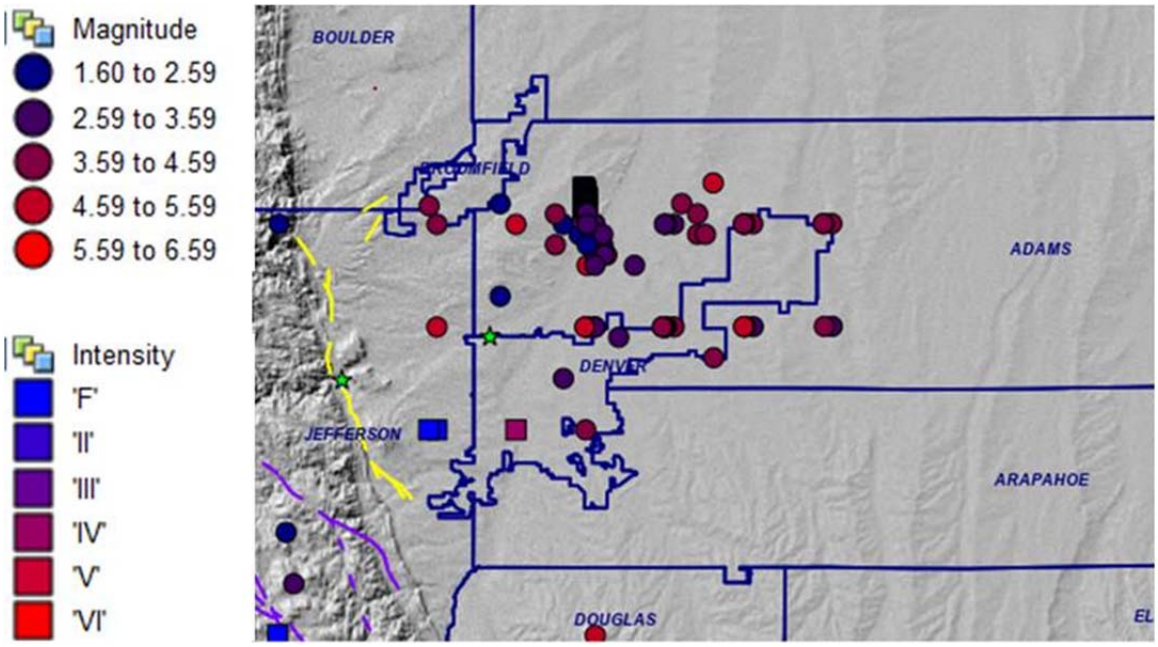


Figure 18. Faults and Earthquake epicenters in and around Adams County. Source: Colorado Geological Survey.

Future Probability = Occasional. Although on average, several earthquakes are expected to occur in the state, they are likely to be of smaller magnitude. A 5+ magnitude is expected once or twice per decade based on historic trend.[67]

Probabilistic ground motion maps are typically used to assess the magnitude and frequency of seismic events. These maps measure the probability of exceeding a certain ground motion, expressed as percent peak ground acceleration (%PGA), over a specified period of years. The severity of earthquakes is site specific and influenced by proximity to the earthquake epicenter and soil type, among other factors. Figure 19 shows levels of horizontal shaking that have a 2-in-100 chance of being exceeded in a 50-year period. The areas of

[67] 2011 State of Colorado Natural Hazards Mitigation Plan.

Red indicate a higher risk of shaking from an earthquake while white indicates the lowest. Adams County falls in the lower to middle range of this indicator. [68]

Occurrence of earthquakes is relatively infrequent in Colorado and the historical earthquake record is short; it is challenging if not impossible to accurately estimate the timing or location of future dangerous earthquakes in Colorado. Although limited, available seismic hazard information can provide a basis for a reasoned and prudent approach to seismic safety. Scientists are constantly studying faults in Colorado to determine future earthquake potential. Based on the historical earthquake record and geologic studies in Colorado, an event of magnitude 6.5 to 7.5 could occur somewhere in the state.

Based on all documented events for the past 143 years, 212 earthquakes have had their epicenter locations in or near Adams County, equating to approximately a 1.48 annual chance of occurrence for an earthquake less than 5.4 magnitude. The probability of future occurrences of small magnitude earthquakes within Adams County is high. It is extremely difficult to determine probability of future occurrence in a specific area with any degree of accuracy. All areas within Adams County are equally at risk to earthquakes.

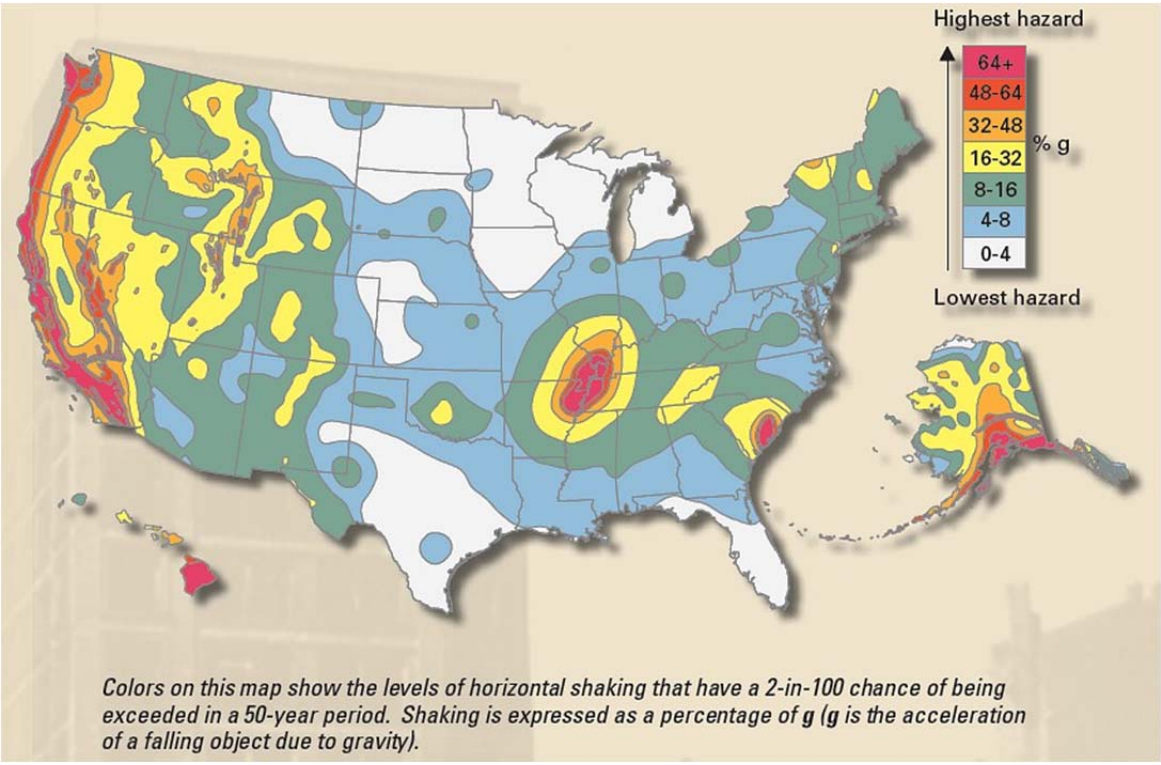


Figure 19. National Seismic Hazard Map, 2008.
Source: Colorado State Hazard Mitigation Plan, 2011.

Risk Assessment

An in-depth risk and vulnerability assessment has not been completed for hazards ranked Low.

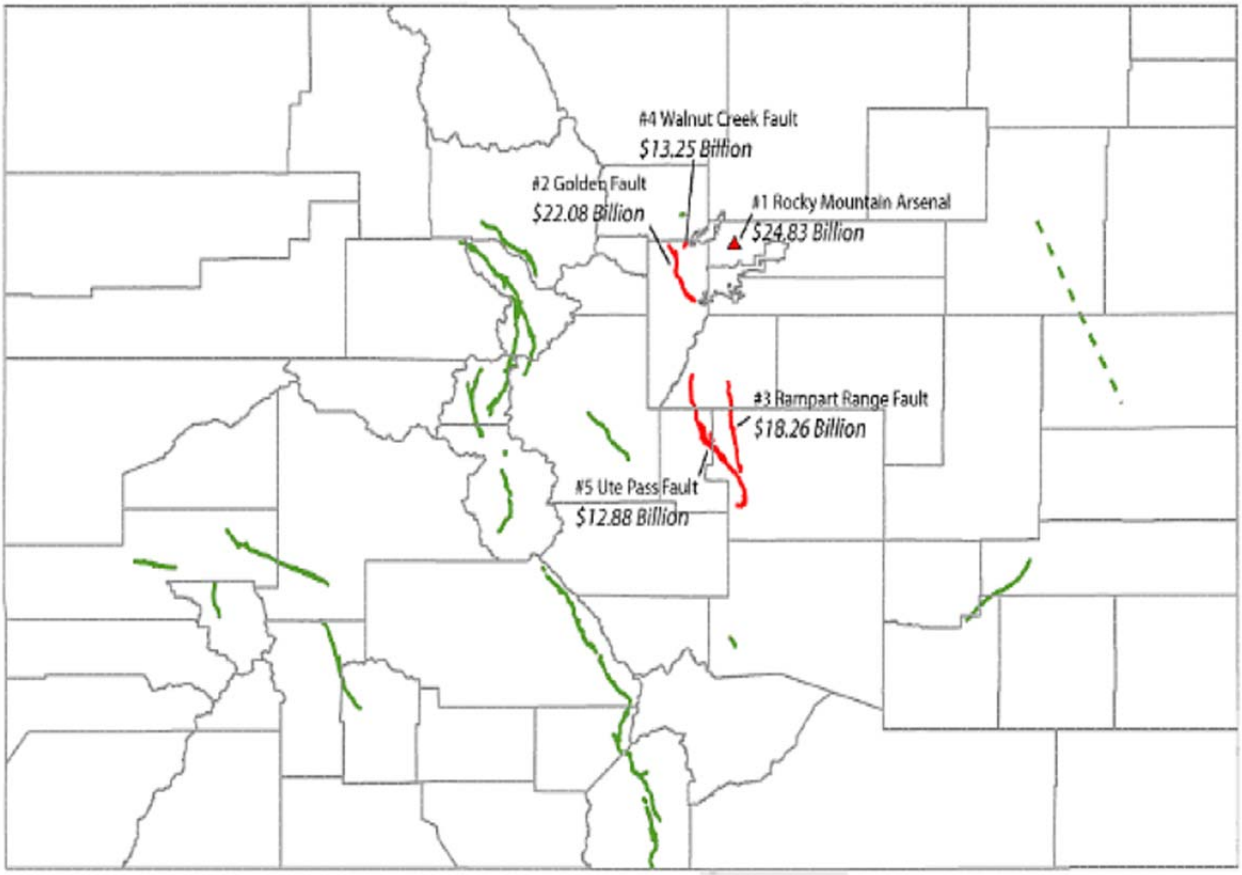
[68] 2010 State of 2010 State of Colorado Natural Hazards Mitigation Plan, Colorado Division of Emergency Management, 2011

Earthquakes are low probability, high consequence events. Although they may only occur once in the lifetime of an asset, they can have devastating impacts. A moderate earthquake can cause serious damage to unreinforced buildings, building contents, non-structural systems, and can cause serious disruption in building operations. Moderate and even very large earthquakes are inevitable, although very infrequent, in areas of normally low seismic activity. Consequently, in these regions, buildings are seldom designed to deal with an earthquake threat; therefore, they are extremely vulnerable.

The CGS ran a series of deterministic scenarios for selected faults (Figure 20) around the state using Hazus. The earthquake magnitudes used for each fault were the "Maximum Credible Earthquake" taken from the USGS Quaternary Fault and Fold Database or from the USGS National Earthquake Hazard Map. The Hazus model is able to estimate expected damages for earthquakes at various locations and magnitudes within proximity to inflict damage to Adams County.

The scenarios include one random event, six worst case scenarios with earthquake magnitudes ranging from 6.75 to 7.0, and the historic 1882 Rocky Mountain National Park magnitude 6.6 event. Highlights of the results of this analysis are provided below and include losses to buildings, transportation, and utility systems, and loss of life. The locations of the worst case scenario earthquakes that are shown include Rocky Mountain Arsenal (RMA) (6.25 magnitude), Rampart Range Fault (7.0 magnitude), Golden Fault (6.5 magnitude), Ute Pass (7.0 magnitude), Valmont (5.0 magnitude), Walnut Creek (6.0 magnitude) and 1882 Rocky Mountain National Park (RMNP) (6.6 magnitude).

This risk assessment includes Hazus analysis completed by the Colorado Geological Survey and supplemented with annualized loss completed specifically for this assessment.



Source: Colorado Geological Survey, Earthquake Evaluation Report

Figure 20.Top five earthquake potential for direct economic loss.

Impacts on Critical and Hazardous Materials Facilities (Tier II facilities), Infrastructure, and Population

The main threat from an earthquake would be from damage to buildings, and other structures, including dams, bridges, storage tanks, and rupture of gas lines..[69] All structures in Adams County are potentially vulnerable to seismic ground shaking. The most vulnerable are historic buildings constructed of unreinforced masonry. Some buildings may be more susceptible to damages due to buildings deteriorating over time as well as changes in building codes.

Hazus provides estimates for the number of available hospital beds, or functionality, on the day of the earthquake, after one week, and after 30 days. Table 45 summarizes the percent of hospital beds available for these timeframes for each Hazus scenario. After reviewing all of the data for each scenario, the RMA M6.25 earthquake produced the greatest amount of damage.

The RMA M6.25 scenario resulted in the most damage to hospitals with only 38% of hospital beds available the day of the earthquake. On average, 90% of the hospitals beds were available after one week and 98% were available after 30 days.

[69] Adams County Hazard Analysis (1996)

Table 45. Expected damage to hospitals.

Hazus Scenario	Available Hospital Beds, Percent*		
	Day of Earthquake	After One Week	After 30 days
Adams County Random	72	87	98
RMA M6.25	38	67	92
Rampart M7	70	90	99
Golden M6.5	55	84	99
Ute Pass M7	77	93	99
Valmont M5.0	99	100	100
Walnut Creek M6.0	67	91	99
1882 M6.6 RMNP	88	97	100
Average of all scenarios	71	89	98
**The Hazus report states that before the earthquake, the region had 390 hospital beds available for use.*			

Impacts to critical facilities including hospitals, schools, police stations, and fire stations for the RMA magnitude 6.25 earthquake shows all are expected to receive at least moderate damage and none will be completely destroyed.

The data shows that at least 96% of the transportation system will have at least 50% functionality on the day of the earthquake. No transportation systems will be completely destroyed.

With the exception of natural gas systems, all utility systems will receive moderate damage. None of the utility systems will be completely destroyed and most will have at least 50% functionality after seven days.

Potable water system will remain intact. The electric system will receive enough damage to provide service to less than 40% of the households with electric power. More than 50% of the households will have power by the third day after the earthquake and nearly all households will have power by 90 days after the earthquake.

The HAZUS model also estimates the number of people that will be injured or killed by the earthquake. The injuries presented in this section include the total for the three severity levels listed below:

- Severity level 1: Injuries will require medical attention but not hospitalization
- 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 treated promptly.

The casualty estimates are provided for three times of the day: 2:00 a.m., 2:00 p.m., and 5:00 p.m. These times represent the periods of the day that different sectors of the community are at the peak occupancy loads. The 2:00 a.m. estimate considers that the residential occupancy load is maximum, the 2:00 p.m. estimate considers that the educational, commercial, and industrial sector loads are maximum, and the 5:00 p.m. estimate represents peak commute time.[70]

Table 46 summarizes the injuries and fatalities for each HAZUS scenario. The 2:00 a.m. and 5:00 p.m. scenarios resulted in the greatest numbers of casualties, followed closely by the 2:00 a.m. scenario. Injuries

[70] Earthquake Event Report, FEMA, 2006

ranged from a low of three for the 5:00 pm Valmont scenario to a high of 2,045 for the 2:00 p.m. RMA earthquake. Fatalities ranged from zero to 130 for these same scenarios. The 2:00 p.m. scenarios resulted in the greatest number of casualties, followed by the 5:00 pm scenario. This may be due to the highly industrialized nature of Adams County.

Table 46. Injury and Fatality Estimates.

Hazus Scenario	2 AM		2PM		5PM	
	Injuries	Fatalities	Injuries	Fatalities	Injuries	Fatalities
Adams County Random	377	12	428	20	402	18
RMA M6.25	1,659	70	2,045	130	1,902	113
Rampart M7	393	12	527	26	457	21
Golden M6.5	747	24	944	51	846	42
Ute Pass M7	226	6	302	12	261	10
Valmont M5.0	4	0	4	0	3	0
Walnut Creek M6.0	418	10	465	20	430	17
1882 M6.6 RMNP	55	1	61	1	55	1
Average of all Scenarios	485	17	597	33	545	28
Note: The Hazus report states that the total population of Adams County for the timeframe of the scenario is 363,857.						

Existing and Future Development Trends

Adopted building codes reduce the potential cost of damages to future structures.

Loss Estimates and Economic Impacts

An earthquake risk assessment is difficult because it is challenging to monetize the potential damages accurately. The Hazus earthquake model was utilized to estimate damages and losses to buildings, lifelines, and essential facilities from deterministic (scenario-based) and probabilistic earthquakes.

Loss data from the Hazus reports for the seven scenarios has been provided by CGS. The loss estimates include capital stock and income losses. Capital stock includes structural, nonstructural, content, and inventory. Income losses include wage, capital-related, rental, and relocation losses. Table 47 shows the total building-related losses for each Hazus scenario.

Total losses ranged from a low of $35.4 million for the Valmont earthquake to a high of $2.8 million for the RMA earthquake. The average for all scenarios is estimated to be just less than $891 million. Single family residential received the greatest losses.

Table 47. Earthquake Building Loss Estimate by scenario and occupancy (shown in millions of dollars).

Hazus Scenario	Single Family	Other Residential	Commercial	Industrial	Other	Total
Adams County Random	$335,620	$108,500	$162,970	$37,250	$10,490	$654,830
RMA M6.25	$1,482,460	$474,570	$623,810	$158,540	$40,270	$2,779,650
Rampart M7	$277,340	$123,510	$192,040	$46,730	$10,840	$650,460
Golden M6.5	$673,120	$255,210	$347,870	$91,710	$20,830	$1,388,740
Ute Pass M7	$171,000	$77,400	$126,890	$30,580	$7,090	$412,960

Hazus Scenario	Single Family	Other Residential	Commercial	Industrial	Other	Total
Valmont M5.0	$17,310	$6,080	$8,090	$3,300	$620	$35,400
Walnut Creek M6.0	$576,390	$196,360	$236,680	$60,580	$15,420	$1,085,430
1882 M6.6 RMNP	$52,420	$21,670	$35,410	$8,550	$2,050	$120,100
Average of all scenarios	**$448,208**	**$157,913**	**$216,720**	**$54,655**	**$13,451**	**$890,946**

Utility system total losses range from $1.2 million for the Valmont earthquake to $1.49 million for the Adams County Random earthquake. The average of all scenarios is just over $1.3 million. The electric power system is expected to suffer the greatest losses followed by wastewater systems.

Table 48 and Table 49 provide summaries of expected lifeline losses for the transportation and utility systems. The inventory value includes the estimated direct repair cost for each component. 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.71

The total loss for all scenarios was relatively constant with an average of all estimated transportation system losses just less than $3.0 million. The RMA M6.25 earthquake, located in Commerce City within Adams County, resulted in the greatest losses. The highway system is expected to suffer the most damage with an average of 2$.15 million in losses, followed by the airport with an average of $681 million. Utility system total losses range from $1.2 million for the Valmont earthquake to $1.49 million for the Adams County Random earthquake. The average of all scenarios is just over $1.3 million. The electric power system is expected to suffer the greatest losses followed by wastewater systems.

Table 48. Transportation System Total Losses (Millions)

Hazus Scenario	Highway	Railways	Airport	Total
Adams County Random	$2,145,200	$162,000	$1,200	**$707,000**
RMA M6.25	$2,172,200	$166,300	$1,500	**$689,500**
Rampart M7	$2,144,300	$161,800	$1,300	**$679,700**
Golden M6.5	$2,153,600	$164,100	$1,500	**$678,900**
Ute Pass M7	$2,140,300	161,100	$1,200	**$676,600**
Valmont M5.0	$2,135,900	$160,300	$1,200	**$669,900**
Walnut Creek M6.0	$2,142,300	$163,900	$1,400	**$677,100**
1882 M6.6 RMNP	$2,136,300	$160,200	$1,200	**$671,600**
Average of all scenarios	**$2,146,263**	**$162,463**	**$1,313**	**$681,288**

Table 49. Utility System Total Losses (Millions)

Hazus Scenario	Potable Water	Waste water	Natural Gas	Oil Systems	Electric Power	Communication	Total
Adams County	$142,880	$502,870	$74,590	$1,080	$617,060	$880	**$1,339,360**
RMA M6.25	$150,690	$586,970	$70,200	$1,240	$684,820	$1,030	**$1,494,950**
Rampart M7	$142,100	$493,750	$67,910	$1,080	$586,660	$870	**$1,292,370**
Golden M6.5	$146,520	$526,500	$67,980	$1,170	$615,430	$930	**$1,358,530**

[71] *Earthquake Event Report*, FEMA, 2006

Hazus Scenario	Potable Water	Waste water	Natural Gas	Oil Systems	Electric Power	Communication	Total
Ute Pass M7	$140,830	$481,130	$67,210	$1,050	$568,500	$840	**$1,259,560**
Valmont M5.0	$139,330	$467,230	$66,030	$1,000	$543,200	$810	**$1,217,600**
Walnut Creek M6.0	$145,270	$538,190	$67,420	$1,160	$609,790	$940	**$1,362,770**
1882 M6.6 RMNP	$139,340	$463,360	$66,220	$1,000	$545,790	$800	**$1,216,510**
Average for all scenarios	**$143,370**	**$507,500**	**$68,445**	**$1,098**	**$596,406**	**$888**	**$1,317,706**

In addition to the CGS scenarios described above, Hazus 2.1 was used to simulate annualized damages. Probabilistic annualized loss for the County was estimated by Hazus to be $650,025 annually with 24% related to business interruption. All damages are in the Western portion of the county with the highest losses in Commerce City.

Wildfire (Low Ranking)

Ranking

Table 50 shows the criteria used to derive a low ranking for wildfire in Adams County. Hazard ranking criteria from the State of Colorado Hazard Mitigation Plan and DRCOG Hazard Mitigation Plan were reviewed by the steering committee. Hazard ranking methodology is further explained in the beginning of the hazard identification section of this assessment. To fully support integration, each hazard was considered and the potential impacts are reflected in the future land use map in the body of the Comprehensive Plan.

Table 50. Wildfire Hazard Ranking Criteria.

Hazard	Geographic Extent	Previous Occurrence	Future Probability	Magnitude /Severity	2012 Ranking
Wildfire	Low <= 5% of County	Low <=1 Event in last 50 years	Medium 1 in 1,000 to 1/100 or 0.1% to 1% annual chance	Low <1% of people or property impacted	**Low**

Description

A wildfire is an undesirable fire occurring in the natural environment; it is a serious and growing hazard over much of the United States. Wildfires pose a great threat to life and property, particularly when they move from forest or rangeland into developed areas. An average of 5 million acres burn every year in the United States as a result of wildfires; causing millions of dollars in damage. Each year more than 100,000 wildfires occur in the United States, almost 90% of which are started by humans; the rest are caused by lightning. Weather is one of the most significant factors in determining the severity of wildfires.[72]

[72] HAZUS-MH Risk Assessment and User Group Series How-to-Guide: Using HAZUS-MH for Risk Assessment (FEMA 433/August 2004)

Wildfires can be classified as uncontrolled fire spreading through vegetative fuels, exposing and possibly consuming structures for areas greater than one acre. Wildfires may create additional environmental concerns well after they are extinguished, such as increased erosion and water quality concerns resulting from storm water runoff.

The Colorado Natural Hazards Mitigation Plan states that wildfires are divided into four categories:

- **Wildland Fire** – fuel consists mainly of natural vegetation
- **Interface or Intermix Fire** – urban/wildland fires that consist of vegetation and manmade fuel
- **Catastrophic Fire** – a very intense event that makes suppression very difficult and negatively impacts human values
- **Prescribed Fire** – Any fire ignited by management actions to meet specific objectives. A written, approved prescribed fire plan must exist, and National Environmental Policy Act programmatic agreement requirements (where applicable) must be met, prior to ignition.

Three main factors influence wildfire behavior – topography, fuel, and weather. Other hazards can contribute to the potential for wildfires or can influence wildfire behavior. High winds can down power lines, earthquakes can crack gas lines, and lightning can spark fires. Lightning is a major cause of structural fires and wildfires. In 1997, a lightning-caused warehouse fire in Denver resulted in a $70 million loss. Drought conditions increase wildfire potential by decreasing moisture in the fuel feeding the fire. Warm winters; hot, dry summers; severe drought; insect and disease infestations; years of fire suppression; and growth in the wildland-urban interface (WUI) continue to increase wildfire risk and the potential for catastrophic wildland fires in Colorado.

Forest insect epidemics and forest parasites contribute to wildfire potential by increasing fuel loading. Over the past two decades, Colorado has experienced an increase in insect infestations that have left vast areas of forest vulnerable to wildfire. These infestations, coupled with the increasing number of people who live in the WUI, where humans and human-made structures abut vegetation, make Colorado increasingly susceptible to large-scale fires that threaten human lives, communities, power lines, roads, domestic water supplies, wildlife habitat, and other important resources.

Protecting the WUI is the nation's fastest-growing firefighting expense. In 2007, suppressing wildfires in the WUI accounted for 85% of firefighting costs in the United States. Protecting life and property in these areas is costly because fire managers must take an aggressive stand on the ground and from the air.

Geographic Location and Severity

Geographic Location = Statewide. Grassland and forest fires occur throughout the state. Eastern plains, Front Range foothills, and the West Slope all have high to moderate wildfire risk. Every county has some area determined at least a moderate risk.[73]

The WUI is where houses meet or intermingle with wildland vegetation. The WUI poses the biggest risk to human lives and structures.[74] Intermix WUI are areas where housing and vegetation intermingle; interface

[73] 2011 State of Colorado Natural Hazards Mitigation Plan.

WUI are areas with housing in the vicinity of contiguous wildland vegetation. Figure 21 shows the WUI zones within Adams County. There are several locations of interface and intermix within Adams County. In general, the plains of Eastern Adams County are at risk to wildfire.[75]

The 2011 State of Colorado Natural Hazards Mitigation Plan reports that the threat of wildfires is statewide in Colorado with the forests, grasslands, and WUIs all at risk. The CGS website reports that wildfires can have disastrous consequences causing damage to residences, commercial buildings, and to timber, grasslands, and natural resources. Economic consequences include the cost of suppression, reduced property values, lost sales and business revenues, reduced tourism, and increased water treatment costs. Resources threatened include communities, homes, gas transmission lines, electrical facilities and lines, timber, watershed and recreation areas, and wildlife.

[74] Radeloff, V. C., R. B. Hammer, S. I Stewart, J. S. Fried, S. S. Holcomb, and J. F. McKeefry. 2005. The Wildland Urban Interface in the United States. Ecological Applications 15:799-805.
[75] Adams County Hazard Analysis (1996)

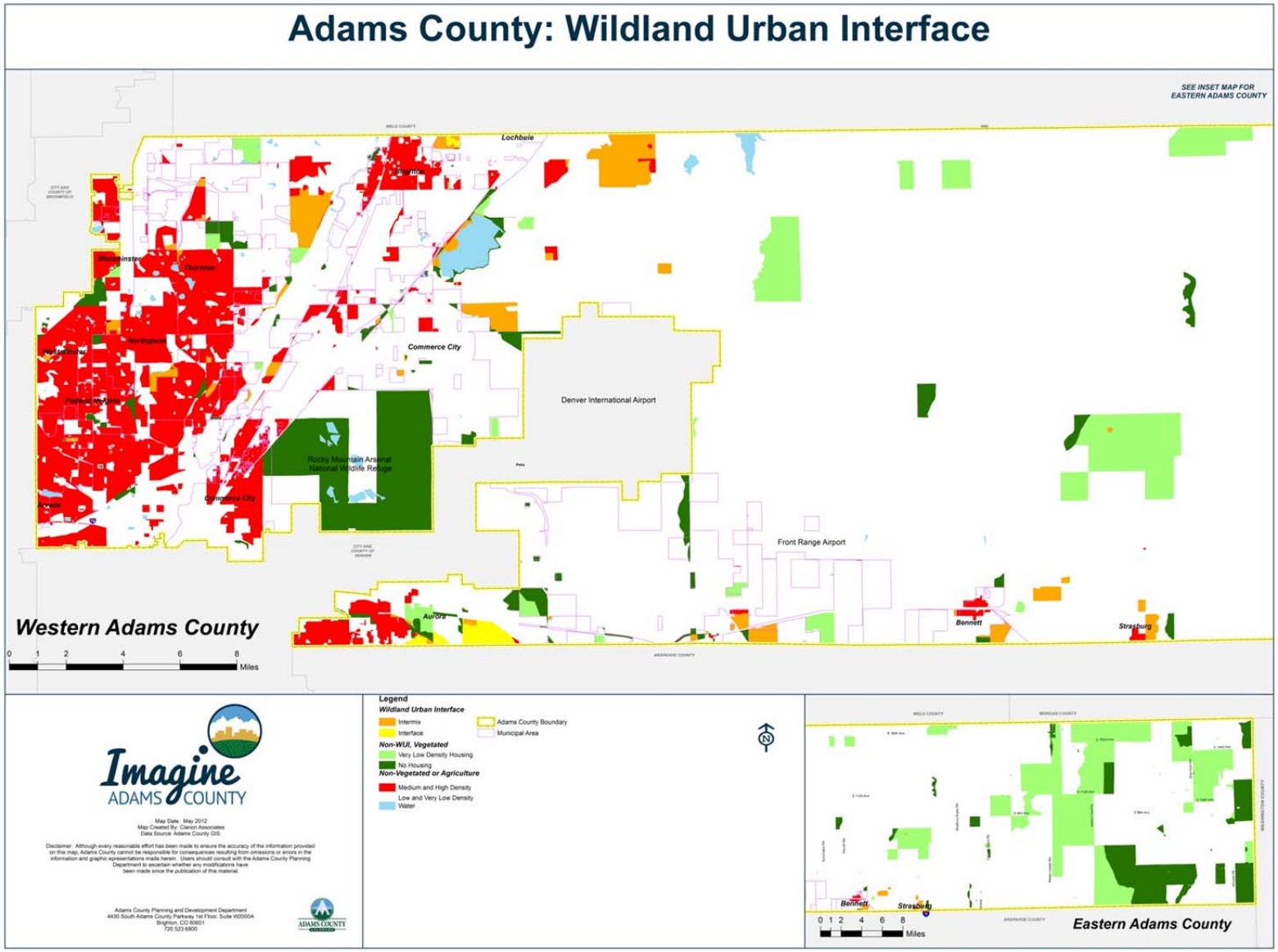


Figure 21. Wildland Urban Interface (WUI) in Adams County.

Magnitude/Severity = Extensive. Major or long-term property damage that threatens structural stability, isolated deaths (average 1 every 2 years) and injuries, impact to critical lifelines, potential impact to government's ability to provide service.[76]

Keetch-Byram Drought Index (KBDI) monitors fire danger and severity using maximum daily temperature, and daily, antecedent, and annual precipitation. The index ranges from 0 (no drought) to 800 (extreme drought) and is based on the soil capacity in 8 inches of water. Ranges in the index are as follows:

- KBDI 0 - 200: Soil moisture and large class fuel moistures are high and do not contribute much to fire intensity. Typical of spring dormant season following winter precipitation.
- KBDI200 - 400: Typical of late spring, early growing season. Lower litter and duff layers are drying and beginning to contribute to fire intensity.
- KBDI 400 - 600: Typical of late summer, early fall. Lower litter and duff layers actively contribute to fire intensity and will burn actively.
- KBDI 600 - 800: Often associated with more severe drought with increased wildfire occurrence. Intense, deep burning fires with significant downwind spotting can be expected. Live fuels can also be expected to burn actively at these levels.

Using the KBDI, Adams County would consider an index reading of 400 to be a minimum severity and an index reading of 600 to be a major severity for wildfire.

Timber loss and environmental damage frequently result from wildfires. Wildfire poses a significant threat to nearby buildings and populations. Forest damage from thunderstorms may have blocked interior access roads and fire breaks, pulled down overhead power lines, or damaged pavement and underground utilities, thereby creating heavy fire load and making suppression and response more difficult.

Previous Occurrences And Probability of Future Occurrence

Previous Occurrences = Perennial. Regular occurrences throughout the fire season from March to August, but forest and grass fires are a year-round occurrence. Human-caused or natural in origin. An annual average of 2,164 wildfires occurs on state and private lands.[77]

Colorado experiences many wildfires on an annual basis. With its steep terrain, dense forests, and dry climate, it is expected that wildfires will always be part of Colorado's natural processes. In 2012, Colorado is suffering from severe drought conditions that rival the drought of 2002. These drought conditions contributed to severe fire danger. Up until the summer of 2012, Adams County had not experienced many wildfires of significance over the last 100 years

The Colorado Natural Hazards Mitigation Plan provided information on the following notable past fires in Colorado:

The Fourmile Canyon fire started in Boulder County on Labor Day 2010. The resulting event burned nearly 6,280 acres, 169 homes, and many other structures and quickly became Colorado's most costly wildland fire

[76] 2011 State of Colorado Natural Hazards Mitigation Plan.
[77] 2011 State of Colorado Natural Hazards Mitigation Plan.

relative to home and property value lost. Early estimates on insured property losses for this fire are around $200 million. In addition to property losses, many residents in the area were displaced for a week. Those who did not evacuate lacked access to water and electric service.

In 2002, much of the Front Range of the Rocky Mountains in Colorado was rich in dry vegetation as a result of fire exclusion and the drought conditions that prevailed in previous years. The dry and heavy fuel loadings were continuous along the South Platte River corridor located between Denver and Colorado Springs on the Front Range. These topographic and fuel conditions combined with a dry and windy weather system centered over eastern Washington to produce ideal burning conditions. The Hayman Fire had a wildfire run in 1 day of over 60,000 acres and finally impacted over 138,000 acres. This represents Colorado's largest wildland fire in terms of acres burned.

While these fires were located outside of Adams County, they do provide significant insight into the fire conditions found across Colorado and much of the West. Mature forests combined with heavy beetle kill and drought conditions have resulted in tinder dry conditions in forests across the State including Adams County.

Preceding the fire season of 2012, the 2002 Wildland Fire season was the worst in United States history, with 2.3 million acres burned. There were 4,612 Wildland Fires in Colorado during 2002 that burned over 619,000 acres, and resulted in approximately $152 million in Wildland Fire suppression costs, 81,435 people evacuated, and approximately 1,000 structures burned. Unfortunately, there were also 9 lives lost. Based on a 10-year average, Colorado typically experiences 3,119 Wildland Fires with a loss of 70,000 acres per year.

Future Probability = Expected. Events producing conditions prone to wildfires are expected to occur as in the past. These conditions are variable based on precipitation, drought, fuel loading, lightning strikes, and other human activities.[78]

Drought conditions and other natural disasters increase the probability of wildfires by producing fuel in both urban and rural settings. Since 1993, Adams County has been a part of 2 county and statewide wildfires (Table 51) as recorded by National Climatic Data Center. Two National Climatic Data Center events:

- June 13, 2006
- July 29, 2006

Table 51. Wildfire National Climatic Data Center Storm Events for Adams County, Colorado (Shown in 2012 Dollars).

Hazard	Number of Events	Property Damage	Crop Damage	Deaths	Injuries
Wildfire	2	$0	$0	0	0

The probability of future occurrences of wildfires within Adams County is medium. It is extremely difficult to determine probability of future occurrence in a specific area with any degree of accuracy.

[78] 2011 State of Colorado Natural Hazards Mitigation Plan.

Risk Assessment

An in-depth risk and vulnerability assessment has not been completed for hazards ranked Low.

Traditional metropolitan area residents and development patterns are moving into rural areas that offer attractive recreational and aesthetic amenities, especially forests. In the past two decades, a quarter million people have moved into Colorado's red zones – the parts of the state at risk for the most dangerous wildfires. Today, one of every four Colorado homes is in a red zone. This demographic change is increasing the size of the WUI, defined as the area where structures and other human development meet or intermingle with undeveloped wildland. The expansion of the WUI in recent decades has significant implications for wildfire management and impact. The WUI creates an environment in which fire can move readily between structural and vegetation fuels. Its expansion has increased the likelihood that wildfires will threaten structures and people.[79] Figure 21 shows the WUI Interface for Adams County, Colorado. Adams County is dominated by Non-WUI vegetated areas.

Impacts on Critical and Hazardous Materials Facilities (Tier II facilities), Infrastructure, and Population

The areas susceptible to wildfires are lightly populated. In the event of a wildfire, buildings crops, and livestock could be at risk.[80] Buildings without fire suppression (i.e., sprinkler systems) are more vulnerable to building fires. If a residence or commercial property were to burn to the ground, the community would experience significant upheaval.

Information on land use occupancy and critical facilities were compiled and analyzed to determine the risk of being impacted by a wildfire based on their proximity to the WUI Zones. This analysis was done by intersecting the land use and critical facilities data with the WUI Zones. Approximately 3.7% of Adams County parcels are located with WUI zone, accounting for 0.05% of total building value exposure.

Table 52 shows the current parcel types and associated building values for each parcel that falls within either the Interface or Intermix WUI Zone. The total building values within the WUI Zones is estimated at just over $810 million with residential development accounting for 83% of the total exposure to wildfire and 2.3% of total improvement values in the County.

Of the 138,314 total parcels designated as residential, 1.4% (1,876) are within the Interface and 2.4% (3,374) are within the Intermix WUI Zone. This shows that most residential developments could be impacted by a wildfire and the resources potentially required to save lives and preserve property could be significant. Approximately 3.7% of Adams County parcels are located with WUI zone, accounting for 0.05% of total building value exposure.

[79] University of Wisconsin-Madison Forest & Wildlife Ecology SILVIS Lab. The Wildland-Urban Interface. http://silvis.forest.wisc.edu/projects/WUI_Main.asp 6/20/2010
[80] Adams County Hazard Analysis (1996)

Table 52. Current land use types within WUI Zones.

Parcel Type	Number within Interface WUI Zone	Bldg Value	Number within Intermix WUI Zone	Bldg Value
Residential	1,876	$183,976,956	3,374	$626,082,885
Commercial	91	$55,113,466	54	$20,812,339
Agricultural	19	$125,740	102	$6,881,170
Exempt	34	$5,072,134	174	$49,539,352
Industrial	2	$2,067,600	5	$29,138,924
Producing Mine	0	$0	6	$40,138
State Assessed	3	$0	2	$0
Total	**2,025**	**$246,355,896**	**3,717**	**$732,494,808**

Analysis intersected the locations of the critical facilities with WUI to determine which critical facilities could be at risk in the event of a wildfire. Table 53 summarizes which of these facilities are located within a WUI Zone. Seven critical facilities are located within both WUI Zones, three are within the Interface WUI Zone, and four within the Intermix WUI Zone. The majority of the facilities located within WUI are Hazardous Materials Facilities (Tier II facilities).

Table 53. Critical Facilities within WUI zones.

Facility Type	Number within Interface WUI Zone	Number within Intermix WUI Zone
1. Essential Facilities	0	1
2. HazMat Materials	2	1
3. At-Risk Populations	1	0
4. Vital to Restoring Normal Services	0	2
Not Classified	0	0
Total	**3**	**4**

Existing and Future Development Trends

Building standards can offer only limited protection from fire damage. Increasing population growth and development increases vulnerability to fires.

Loss Estimates and Economic Impacts

Using available mapping for WUI zones and parcel data, it is estimated that Adams County has $973 million in total improvement value exposed to WUI intermix and $246 million exposed to WUI interface zones; this accounts for less than 3% of the total value of improvements in Adams County.

The National Climatic Data Center Storm Events data was annualized by taking the total number of wildfire events and dividing by the length of record. The annualized values should be utilized only as an estimate of what can be expected in a given year. Using historical records, it can be estimated that the County has an 11% chance of experiencing high wind and thunderstorm events in any given year. No damages have been recorded for wildfire in National Climatic Data Center for Adams County. Table 54 shows the annualized

results for wildfire. It should be noted that the wildfire events and damages reported by National Climatic Data Center drastically under represent what is expected in the County.

Table 54. Wildifre Annualized National Climatic Data Center Storm Events for Adams County, Colorado (Shown in 2012 Dollars).

Hazard Type	Annualized Events	Annualized Property Damages	Annualized Crop Damages	Total Annualized Damages
Wildfire	0.11	-	-	-

Overall HIRA Conclusions

The preceding hazard sections discussed the probability, impacts, and vulnerabilities, and risk for each of the natural hazards that have been determined to have a significant impact on the population and infrastructure in Adams County. This final sub-section to the HIRA provides an overall assessment and summary of the individual hazard analyses.

It should be noted that while the National Climatic Data Center storm events data is the most comprehensive database available for comparing most natural hazards, its considerable limitations include spotty property and crop damage data that are considered to significantly under-estimate actual losses. Much of the National Climatic Data Center data is gathered from damage reports and insurance records.

Hazus provides another method for estimating annualized loss that uses science and engineering principals and building stock values along with historical hazard occurrences to analyze potential damage and economic loss. Annualized loss statistics for flood and earthquake are from Hazus 2.1.

Hazard Composite

To fully support integration, each hazard was considered and the potential impacts are reflected in the future land use map in the body of the Comprehensive Plan. Figure 22 is a natural hazard susceptibility overlay map for hazards with a defined geographic extent. This map illustrates the areas in the County that may be prone to multiple hazards that affect specific geographic locations. These geographic-specific hazards include floodplains and the WUI. The remaining hazards are those that can occur anywhere in the County and therefore are not mapped. The overlay shows that the western half of the County is particularly susceptible to natural hazards.

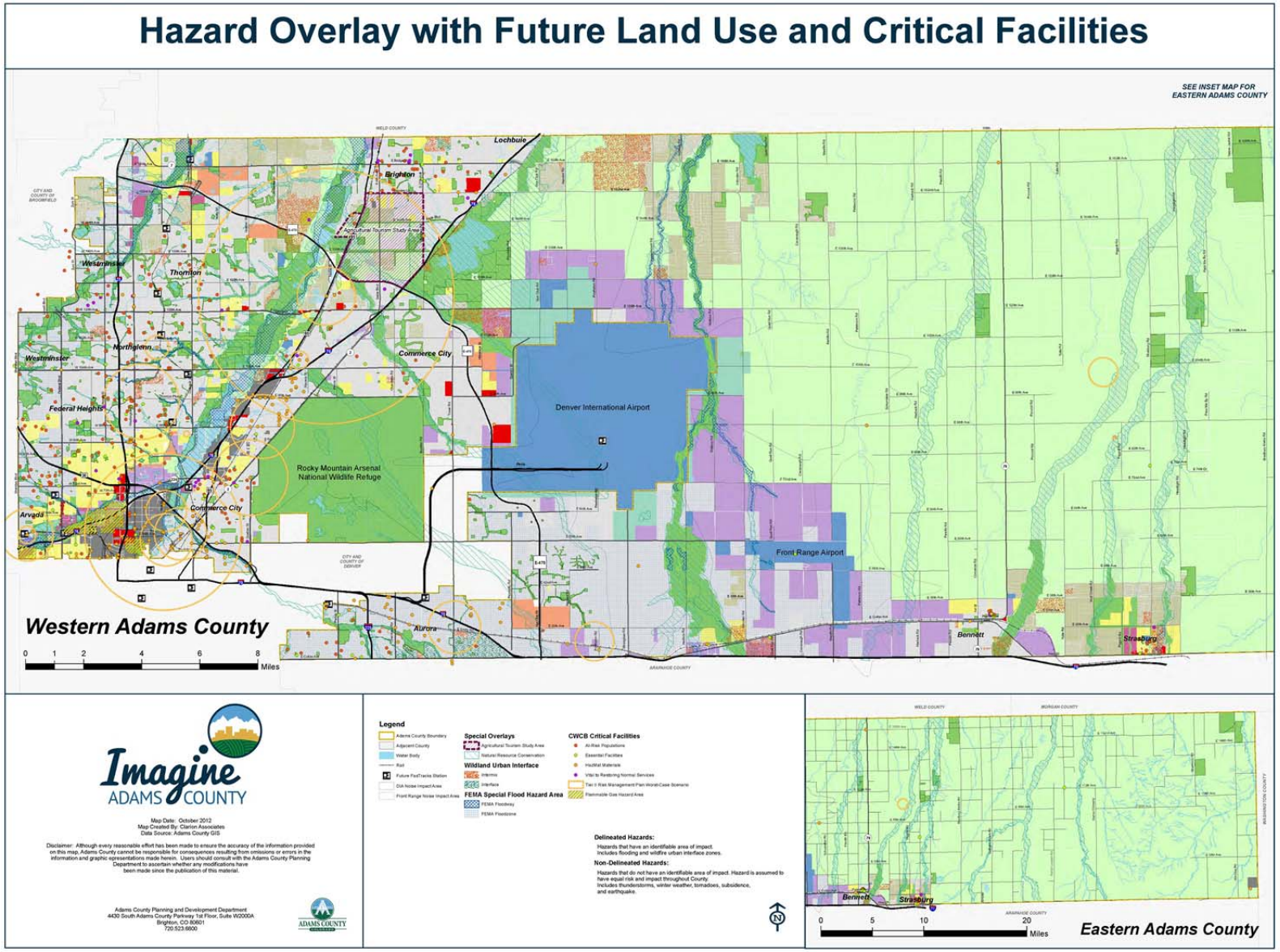


Figure 22. Hazard susceptibility overlay for delineated hazards.

Loss Estimates

Requirement §201.6(c) (2) (ii) (B): *[The plan should describe vulnerability in terms of an] estimate of the potential dollar losses to vulnerable structures identified in paragraph (c) (2) (ii)(A) of this section and a description of the methodology used to prepare the estimate ….*

Coarse estimates of annualized losses can be generated based on the National Climatic Data Center Storm Events database, which documents the damage costs associated with the various hazards. Supplemental annualized loss values for flooding and earthquake have been derived from the other sources as described in each of the individual hazard sections.

Based on information from the National Climatic Data Center database, Adams County can expect approximately $10 million in annualized damages due to all the hazards that impact the area. As previously discussed, this data has limitations due to the amount of historical data available, and reporting of significant events. To supplement the National Climatic Data Center loss estimates with Hazus analysis, the County can expect $18 million in annualized flood damages and $650,025 in earthquake damages. Table 55 illustrates the estimated number of events per year, total damages reported in 2012 dollars, and annualized loss values.

As noted in the hazard-specific sections, the total and annualized losses drastically underestimate expected damages as a result of reporting discrepancies.

It should also be noted that the Hazus module considers the total direct economic losses including damage to structural, non-structural, building contents, inventory loss, relocation, income loss, rental, and wage loss. The National Climatic Data Center loss estimates provided in this report are solely based on the reported property damage of past events.

Data Limitations

It should be noted that the data sources used in this HIRA are varied in their degree of completeness, accuracy, precision, etcetera, and the ability to accurately prioritize some of the hazards would be greatly improved with better information about them (e.g., stormwater/urban drainage, land subsidence, etc.).

2017 Hazard Mitigation Plan Update

An attempt was made to include the best available data for this revision of the hazard mitigation plan. Spatial data is constantly changing and efforts are being made to increase the accuracy of this data by Adams County. As this data is made available, it will be used in revisions of this plan. During the update period, the GIS department within the County should have updated spatial data including, but not limited to, critical facility, parcel and assessor's data attributes, etc., that will increase the ability to complete more comprehensive analysis for some of the hazards.

Table 55. Potential loss estimates from National Climatic Data Centerand Hazus analysis.

Hazard	2012 Ranking	Annualized Events	Annualized Property Damages	Annualized Crop Damages	Total Annualized Damages	Source
Thunderstorm	HIGH	7.29	$8,975,589	$1,306	$8,976,895	National Climatic Data Center Storm Event Database
Hail		5.49	$8,963,551	$1,306	$8,964,858	National Climatic Data Center Storm Event Database
Lightning		0.37	$8,452	None Recorded	$8,452	
Microburst		0.20	$1,574	None Recorded	$1,574	
Winter Weather	HIGH	3.00	$410	None Recorded	$410	National Climatic Data Center Storm Event Database
Extreme Cold		0.05	$410	None Recorded	$410	National Climatic Data Center Storm Event Database
Tornadoes	HIGH	2.75	$1,167,639	$160,409	$1,328,048	National Climatic Data Center Storm Event Database
Funnel Clouds		0.08	None Recorded	None Recorded	None Recorded	National Climatic Data Center Storm Event Database
Flood	MEDIUM	0.74	$37,584	None Recorded	$37,584 $18,098,000	National Climatic Data Center Hazus AAL Study
Flash Flood		0.58	$36,085	None Recorded	$36,085	National Climatic Data Center Storm Event Database
Drought	MEDIUM	3.37	None Recorded	None Recorded	None Recorded	National Climatic Data Center
Earthquake	LOW	1.48 (<5.3 Magnitude)			$650,025	Hazus
Subsidence	LOW	No Delineated Risk				
Wildfire	LOW	0.11	None Recorded	None Recorded	None Recorded	National Climatic Data Center Storm Event Database

Mitigation Strategies

The mitigation strategy section of a hazard mitigation plan can be thought of as the culmination of the plan. The previous sections of this plan build the informational foundation on which the County develops the mitigation strategies. This section describes the process of integrating hazard related mitigation strategies into the Comprehensive Plan and establishes a framework to implement and accomplish over the next 5 years.

Mitigation Planning should be both comprehensive and strategic. In order to be comprehensive, the plan must address all hazards pertinent to the County. This is achieved by building upon the information developed in the Vulnerability Assessment. The plan should be strategic ensuring that each goal, objective, and action work together in order to form an effective mitigation strategy. This can be accomplished through a thorough understanding of the information developed in the Capability Assessment (Appendix B), the susceptible elements in the County, and how effective and practical mitigation planning can benefit the County.

Comprehensive Plan

This Comprehensive Plan paints a picture or "vision" of the type of place the citizens, business people, landowners, and elected and appointed officials want Adams County to be over the next 10 to 20 years. Prior to defining specific policies and strategies for the future, it is important to understand the context for this vision.

Developing Goals

The Key Goals for a More Sustainable and Resilient Adams County, taken from the Comprehensive Plan that is being developed in tandem with this hazard mitigation plan, define the broad directions that will need to be taken to achieve our vision over time. Additional information on each of these goals is provided in the Comprehensive Plan. Key Goals include:

1. Promote Coordinated and Connected Growth;
2. Protect the Health, Safety, and Welfare of Adams County's Inhabitants;
3. Foster Regional Collaboration and Partnerships;
4. Reduce the Fiscal Impact of Growth;
5. Promote Economic Vitality; and
6. Preserve the County's Natural Resources.

Each of these goals is intrinsically linked to the others. These goals represent the need for a more integrated approach to day-to-day decision making—the need for a clear understanding of how actions in one area of focus affect another and a desire to seek and implement shared solutions. In the implementation of this Plan, each goal should be regarded with equal focus and commitment.

Developing Policies

Twelve countywide policies have been created as part of the Comprehensive Plan; of which Hazard Mitigation is included. Hazard mitigation planning is a key component of a sustainable and resilient community. The County should lead by example in this are through the implementation of policies, strategies, and programs that reduce injuries and loss of life; trauma; damage to property, equipment and infrastructure; community disruption; and economic, environmental, and other losses caused by natural hazards that are likely to impact the County resulting in a more resilient and sustainable Adams County.

Three main policies are included in the Comprehensive Plan for Hazard Mitigation. These include:

Policy 12.1: Reduce Risk and Effects of Natural Hazards

Policy 12.2: Increase Public Awareness of Hazard Risks

Policy 12.3: Limit Building in High-Risk Areas and Improve Disaster Prevention.

Table 56 shows the connection key goals have with the hazard mitigation policies in the Comprehensive Plan.

Table 56. Excerpt from Comprehensive Plan: Relationship between Key Goals and Countywide Policies.

Countywide Policies	Key Goals for a More Sustainable and Resilient Adams County					
	Coordinated and Connected Growth	Protect Health, Safety, and Welfare	Regional Collaboration and Partnerships	Reduce Fiscal Impact of Growth	Economic Vitality	Preserve Natural Resources
12. Hazard Mitigation						
Policy 12.1: Reduce Risk and Effects of Natural Hazards	X	X	X			X
Policy 12.2: Increase Public Awareness of Hazard Risks	X	X	X			X
Policy 12.3: Limit Building in High-Risk Areas and Improve Disaster Prevention	X	X	X			X

Identifying Countywide Strategies

Countywide strategies have been developed in the Comprehensive Plan and include strategies for hazard mitigation. These are broad categories of mitigation techniques that are narrower than the key Goals and Policies and are measurable. The hazard mitigation countywide strategies include:

1. **Strategy 12.1.a. Natural Resource Protection—**Protect and enhance Adams County natural resources by adopting and implementing sustainable policies that have few or no negative impacts and have positive environmental effects whenever possible.
2. **Strategy 12.1.b. Preventive Measures—**Expand mapping, regulations, and loss prevention programs in areas with high risks and catastrophic potential where additional safety considerations are warranted.

3. **Strategy 12.1.c Protect Public Health and Safety –** Take proactive steps to protect Adams County inhabitants through the development of improved Safe Rooms, warning and communication systems
4. **Strategy 12.2.a. Public Information and Education—**Improve public awareness of natural hazards in general and at specific high-risk locations; and give people knowledge about measures they can use to protect themselves, their property, and their community.
5. **Strategy 12.3.a. Structural Projects—**Obtain funding for and implement projects that can reduce the impacts of natural hazards and hazardous materials facilities with consideration for comprehensive solutions in accord with resilient and sustainable implementation and management plans.
6. **Strategy 12.3.b. Property Protection—**Identify and protect people, structures, critical facilities, and critical infrastructure that are vulnerable to natural hazards and the potential impacts of hazardous materials facilities.
7. **Strategy 12.2.b. Emergency Services—**Identify the needs and implement additional emergency operation plans and services for areas at high risk including additional prediction forecasting capability, emergency alerts, and education and outreach activities.

Area Specific Mitigation Strategy Actions

The specific actions to be taken in order to achieve these goals and policies are called strategy actions. They need to be targeted actions that are easily translatable to every-day activities. Lack of specificity is a common source of failure in plan implementation. This tier of mitigation planning is where conceptual targets are translated into measurable action and implementation.

During plan development, the mitigation strategy actions from the 2011 DRCOG Hazard Mitigation Plan were reviewed. They were assessed for current status of completion, as well as relevancy for the updated plan. Table 6.1 in the Comprehensive Plan contains a detailed spreadsheet identifying actions taken towards completion, or reasons for not completing. Those strategy actions that were determined to be ongoing or incomplete were considered for inclusion in the plan.

In formulating the mitigation strategy actions, a wide range of activities was considered to help achieve the regional goals while addressing each specific hazard. This included the results of the HIRA, in addition to considering critical facilities, repetitive loss properties, and other critical datasets.

During the development of the mitigation strategy actions, the Steering Committee considered the mitigation goals of the State, and the 2011 DRCOG HMP.

Prioritizing Strategy Actions

In order to determine those strategy actions that would make the best use of current resources, the Steering Committee considered numerous alternative mitigation strategy actions, and used the STAPLEE criteria to determine priorities. The STAPLEE criteria come from FEMA publication 386-3, Developing the Mitigation Plan: identifying mitigation actions and implementation strategies. Table 57 summarizes the criteria and provides a series of questions for ranking each strategy action.

Ranking was completed based on order of priority according to the STAPLEE criteria, as well as the strategy action's potential to reduce vulnerability and cost-effectiveness as was completed by the Steering Committee at the HIRA Results and Mitigation Strategy Action meetings. Based upon Committee input, actions were then given a ranking of High, Medium, or Low.

Those rankings are defined as:

- High (H) – implement in the short-term;
- Medium (M) – implement in the long-term; and
- Low (L) – implement only as funding becomes available.

Table 57. Review and selection criteria for considering and prioritizing mitigation actions.

Acronym	Criteria
S **Social**	• Is the proposed action socially acceptable to the community(s)? • Are there equity issues involved that would mean that one segment of a community is treated unfairly? • Will the action cause social disruption?
T **Technical**	• Will the proposed action work? • Will it create more problems than it solves? • Does it solve a problem or only a symptom? • Is it the most useful action in light of other community(s) goals?
A **Administrative**	• Can the community(ies) implement the action? • Is there someone to coordinate and lead the effort? • Are sufficient funding, staff, and technical support available? • Are there ongoing administrative requirements that need to be met?
P **Political**	• Is the action politically acceptable? • Is there public support both to implement and to maintain the project?
L **Legal**	• Is the community(ies) authorized to implement the proposed action? Is there a clear legal basis or precedent for this activity? • Are there legal side effects? Could the activity be construed as a taking? • Is the proposed action allowed by a comprehensive plan, or must a comprehensive plan be amended to allow the proposed action? • Will the community(ies) be liable for action or lack of action? • Will the activity be challenged?
E **Economic**	• What are the costs and benefits of this action? • Do the benefits exceed the costs? • Are initial, maintenance, and administrative costs taken into account? • Has funding been secured for the proposed action? If not, what are the potential funding sources (public, non-profit, and private)? • How will this action affect the fiscal capability of the community(ies)? • What burden will this action place on the tax base or local economy? • What are the budget and revenue effects of this activity? • Does the action contribute to other community goals, such as capital improvements or economic development? • What benefits will the action provide?
E **Environmental**	• How will the action affect the environment? • Will the action need environmental regulatory approvals? • Will it meet local and State regulatory requirements? • Are endangered or threatened species likely to be affected?

Mitigation Strategy Actions

The steering committee developed eighteen new strategy actions and included several actions from the DRCOG HMP. Area Specific Mitigation Strategy Actions are provided in the Comprehensive Plan. An Action Plan has been developed for eighteen strategies including the following information:

- The mitigation strategies – the actions or projects that the City would like to accomplish in the next planning cycle
- The parties responsible for implementation – agencies or organizations that are responsible for ensuring that progress is made towards accomplishing that action
- Funding sources – potential funding mechanisms to accomplish the action
- Interim measures of success – specific intermediate steps towards accomplishing the action that can be measured
- Strategy's priority level – the Steering Committee's ranking of the action in terms of High, Medium, or Low

More detailed Strategy Action Worksheets have been developed for each of the top ten prioritized strategies. Information documented in these worksheets includes:

- Project Name
- Schedule/Targeted Completion Date
- Hazards Impacted
- Action Supported By Goal #
- Location
- Issue
- Recommendation
- Action
- Lead Agency
- Support Agency
- Funding Cost
- Funding Source
- Interim Measure of Success

To fully integrate this Hazard Mitigation Plan, the specific mitigation strategy actions are located in the Comprehensive Plan and can be found on pages 153-166 of the Plan.