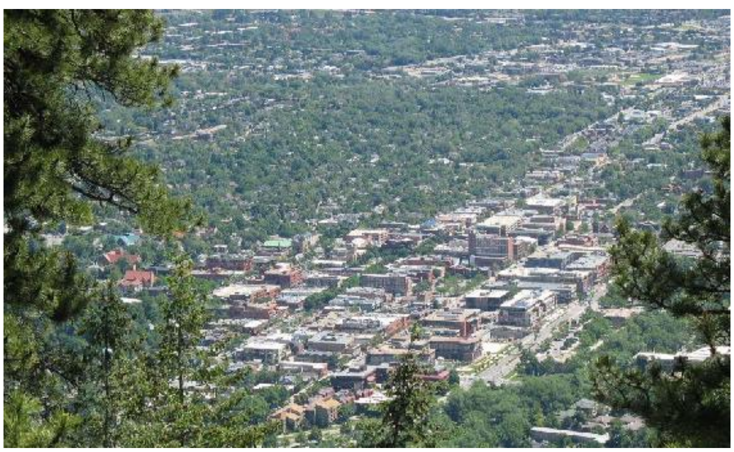
City of Boulder
Multi-Hazard Mitigation Plan

Comprehensive Update
March 2018






City of Boulder

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City of Boulder, Colorado
Multi-Hazard Mitigation Plan

Comprehensive Update
2018

Developed in compliance with the Disaster Mitigation Act of 2000
by the City of Boulder Department of Public Works

with professional planning services provided by:

Amec Foster Wheeler Environment and Infrastructure, Inc.
Boulder, Colorado

EXECUTIVE SUMMARY

The purpose of hazard mitigation and this plan is to reduce or eliminate long-term risk to people and property from natural hazards and their effects in the City of Boulder, Colorado. This plan has been prepared to meet the Disaster Mitigation Act of 2000 (DMA 2000) requirements in order to maintain the city's eligibility for FEMA Pre-Disaster Mitigation (PDM) and Hazard Mitigation Grant Programs (HMGP). More importantly, this plan update and planning process lays out the strategy that will enable the city to become less vulnerable to future disaster losses.

The process followed a methodology prescribed by FEMA. It began with the formation of a Hazard Mitigation Planning Committee (HMPC) comprised of key city departments and stakeholder representatives. The planning process examined the recorded history of losses resulting from natural hazards, and analyzed the future risks posed to the city by these hazards. The City of Boulder is vulnerable to several natural hazards that are identified, profiled, and analyzed in the plan. Floods, wildfires, and severe weather are some of the hazards that can have a significant impact on the city.

The plan identifies several mitigation goals and objectives that are based on the results of the risk assessment. The plan includes specific actions that the city can implement over time to reduce future losses from hazards. The plan also includes a review of the city's current capabilities to reduce hazard impacts. This plan has been formally adopted by the Boulder City Council and is required to be updated a minimum of every five years. The plan was originally prepared between 2005 and 2007 and approved by FEMA in 2008. In accordance with the DMA 2000 requirements the plan underwent its first major update in 2012. This plan was again updated in 2017-2018 through a collaborative planning process.

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1 INTRODUCTION

1.1 Purpose

The City of Boulder Colorado has prepared this multi-hazard mitigation plan to guide hazard mitigation planning to better protect the people and property of the City of Boulder from the effects of hazard events. The plan was originally prepared in 2007-2008, updated in 2012, and was updated again in 2017-2018. It demonstrates the city's commitment to reducing risks from hazards and serves as a tool to help decision makers direct mitigation activities and resources. Other purposes include making the City of Boulder eligible for certain federal disaster assistance, specifically, the Federal Emergency Management Agency's (FEMA) Hazard Mitigation Assistance (HMA) grant programs including the Hazard Mitigation Grant Program (HMGP), Flood Mitigation Assistance (FMA), the and Pre-Disaster Mitigation (PDM) program, as well as earning points for the National Flood Insurance Program's (NFIP) Community Rating System (CRS) to lower flood insurance premiums communitywide.

1.2 Background and Scope

Each year in the United States, natural disasters take the lives of hundreds of people and injure thousands more. Nationwide, taxpayers pay billions of dollars annually to help communities, organizations, businesses, and individuals recover from disasters. These monies only partially reflect the true cost of disasters, because additional expenses to insurance companies and nongovernmental organizations are not reimbursed by tax dollars. Many natural disasters are predictable, and much of the damage caused by these events can be alleviated or even eliminated.

Hazard mitigation is defined by FEMA as "any sustained action taken to reduce or eliminate long-term risk to human life and property from a hazard event." The results of a three-year, congressionally mandated independent study to assess future savings from mitigation activities provides evidence that mitigation activities are highly cost-effective. On average, each dollar spent on mitigation saves society an average of $4 in avoided future losses in addition to saving lives and preventing injuries (National Institute of Building Science Multi-Hazard Mitigation Council 2005). An update to this report in 2017 (Natural Hazard Mitigation Saves: 2017 Interim Report) indicates that mitigation grants funded through select federal government agencies, on average, can save the nation $6 in future disaster costs, for every $1 spent on hazard mitigation.

Hazard mitigation planning is the process through which natural hazards that threaten communities are identified, likely impacts of those hazards are determined, mitigation goals are set, and appropriate strategies to lessen impacts are determined, prioritized, and implemented. This plan documents the City of Boulder's natural hazards mitigation planning process, identifies relevant natural hazards and risks, and identifies the strategy the city will use to decrease its vulnerability and increase its resiliency and sustainability.

The City of Boulder Multi-Hazard Mitigation Plan Update is a single-jurisdiction plan that covers the incorporated community of the City of Boulder. It documents the city's natural hazards mitigation planning process, identifies natural hazards and associated risks to the city, and develops a hazards mitigation strategy to lessen vulnerability and improve resiliency to natural disasters, thereby enhancing the city's long-term sustainability.

The city prepared this multi-hazard mitigation plan update pursuant to the requirements of the Disaster Mitigation Act of 2000 (Public Law 106-390) and the implementing regulations set forth by the Interim Final Rule published in the Federal Register on February 26, 2002 (44 CFR §201.6), finalized on October 31, 2007, and updated in 2012. Hereafter, these requirements and regulations will be referred to collectively as the DMA. While the act emphasized the need for mitigation plans and more coordinated mitigation planning and implementation efforts, the regulations established the requirements that local hazard mitigation plans must meet in order for a local jurisdiction to be eligible for certain federal disaster assistance and hazard mitigation funding under the Robert T. Stafford Disaster Relief and Emergency Act (Public Law 93-288). Because the City of Boulder is subject to many kinds of natural hazards, access to these programs is vital.

This plan addresses natural hazards only. Although the hazard mitigation planning committee (HMPC) recognizes that FEMA encourages communities to address manmade and technological as well as natural hazards, the scope of this effort was limited to natural hazards for two reasons: 1) many of the planning activities for manmade and technological hazards are either underway or complete and were developed by a different set of organizations and 2) the DMA requires extensive public information and input, which is in direct conflict with the confidentiality necessary in planning for the fight against chemical, biological, and radiological terrorism. The HMPC determined it was not in the community's best interest to publicly share specific information about the area's vulnerability to manmade hazards.

Information in this plan will be used to help guide and coordinate mitigation activities and decisions for local land use policy in the future. Proactive mitigation planning will help reduce the cost of disaster response and recovery to the city and its property owners by protecting critical community facilities, reducing liability exposure, and minimizing overall community impacts and disruption. Boulder has been affected by natural hazards in the past and is thus committed to reducing future disaster impacts and maintaining eligibility for federal funding.

1.3 Plan Organization

The City of Boulder's Multi-Hazard Mitigation Plan is organized as follows:

- Chapter 1: Introduction
- Chapter 2: Community Profile
- Chapter 3: Planning Process
- Chapter 4: Risk Assessment
- Chapter 5: Mitigation Strategy

- Chapter 6: Plan Adoption
- Chapter 7: Plan Implementation and Maintenance
- Appendix A – Adoption Resolution
- Appendix B – HMPC Member List
- Appendix C – Mitigation Categories
- Appendix D – References
- Appendix E – Planning Process Documentation
- Appendix F – Public Participation Plan
- Appendix G – Critical Facilities

2 COMMUNITY PROFILE

The City of Boulder, surrounded by a greenbelt of trails and open space, is known for its natural beauty, outdoor recreation, natural product retailers, restaurants, alternate transportation options, diverse businesses, and technological and academic resources. It is a home-rule municipality with a council-manager form of government. The elected City Council, which consists of the mayor, the deputy mayor, and seven council members, sets the policies for the operation of the city government and appoints the city manager, who is tasked with the administrative responsibilities of the city.

2.1 Geography and Climate

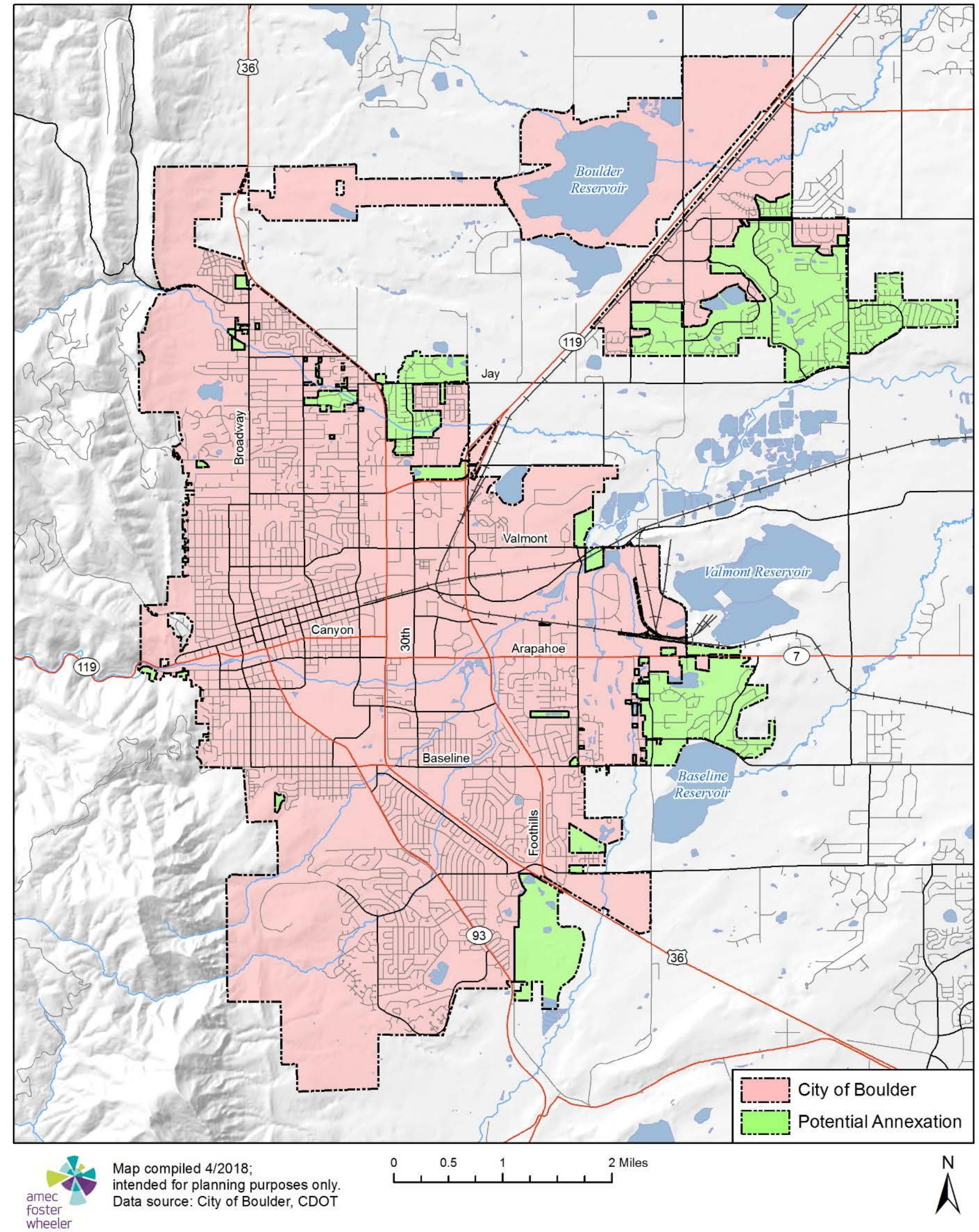
At an elevation of 5,340 feet above sea level, the city is located along Boulder Creek at the base of the foothills of the Rocky Mountains, roughly 30 miles east of the Continental Divide and about 35 miles northwest of Denver. The Boulder foothills are home to the Flatirons, slabs of sedimentary rock tilted up on the foothills, which are unique to Boulder and provides a dramatic backdrop to the city. Boulder covers approximately 25.4 square miles and is characterized by gently rolling terrain, interrupted by small ridges. Fifteen major drainageways or creeks pass through Boulder, including Boulder Creek, which flows through the center of the city. A map of the City of Boulder boundaries and areas of potential annexation is represented in Figure 2.1.

The climate is generally semiarid with a series of extremes occurring throughout the winter and summer seasons. Most precipitation occurs during the winter and spring months with an average annual precipitation of 18.7 inches of rain and 79.4 inches of snow. In winter, temperatures can plunge to minus 30°F and hover below 0°F for days on end. These cold spells are often followed by periods of unseasonably warm weather. Temperatures often climb into the 60s in January and February.

Winter also brings snowstorms that regularly result in a foot or more of snow. Some of the most powerful winds recorded in the continental United States have occurred in or near the City of Boulder in December and January; gusts of more than 120 mph are not uncommon.

In summer, temperatures can be in the upper 90s for days. These hot temperatures are moderated by low humidity that can drop into the single digits at times. With the semiarid climate that produces moderate average annual rainfall, most days have some sunshine.

Figure 2.1. City of Boulder Municipal Boundaries and Planning Area



2.2 History

The Boulder Valley was first home to Native Americans, primarily the Southern Arapaho Tribe that maintained a village near Haystack Mountain. Utes, Cheyennes, Comanches, and Sioux were occasional visitors to the area. The first European settlers came to Boulder during the Pikes Peak Gold rush in 1858. These settlers established a permanent settlement at the head of Boulder Canyon, and in 1859, gold was discovered in Boulder in Gold Run Creek (Gold Hill). That same year, the Boulder City Town Company was formed.

Originally part of the Nebraska Territory, Boulder became part of the Colorado Territory when the territory was established by Congress in 1861. Boulder incorporated as a town in November of 1871 following its designation as the Boulder County seat in 1867. By 1882, Boulder City's population exceeded 3,000 and the town became a second class city.

In 1874, the University of Colorado opened its doors after residents contributed $15,000 to the territorial government. That year also saw the building of the railroad that connected Boulder to Denver. In the early years of the following decade, rail service was extended to the mountain communities west of Boulder.

At the turn of the century, Boulder relied on tourism to strengthen its economy. The Chautauqua auditorium was built in 1897 and the Hotel Boulderado opened to the public in 1909. Tourism continued to dominate the Boulder economy for the next 40 years.

Boulder's population did not increase much between1920 and 1940, but the city saw an influx of people following World War II. The population rose from 12,958 in 1940 to 20,000 in 1950. By 1950, Boulder leaders were actively recruiting new "clean" industries and improved transportation, and they secured a new highway, the Boulder-Denver Turnpike, and the National Bureau of Standards in 1952. Other research and development industries soon followed. With the turnpike to downtown Denver, Boulder continued to expand. From 1950–1972, the population grew from 20,000 to 72,000.

With the purchase of thousands of acres of open space beginning in 1967, the adoption of the Boulder Valley Comprehensive Plan in 1970, passage of the building height restriction ordinance in 1972, and the residential growth management ordinance in 1977, Boulder began a period of infill and reuse of its past architectural development that continues to the present day. The Historic Preservation Code was passed in September 1974 and has been instrumental in preserving significant portions of Boulder's past while encouraging the rehabilitation of historic buildings.

2.3 Economy

Boulder has a diverse economy that is supported by a prominence of entrepreneurship, global business, and research institutions. Data from the 2012 Economic Census indicates that the largest percent of employers in Boulder (26%) are in the professional, scientific, and technical services industry (2.37 times the national average), followed by retail trade (9%) and health care and social assistance (9%). The largest percent of employees (20%) work for government entities including the University of Colorado and Federal labs. After government, the city's highest employment sectors are professional, scientific, and technical services (15%) and manufacturing (10%).

The city is home to numerous start-ups and small businesses and a number of major corporations, including Amgen, Ball, Cisco, Emerson, GE, Google, IBM, Lockheed Martin, Merck, Microsoft, and Northrop Grumman, have a presence in Boulder. Research institutions include the University of Colorado Boulder and more than a dozen federal research laboratories including the University Corporation for Atmospheric Research (UCAR), National Oceanic and Atmospheric Administration (NOAA), and National Institute of Standards and Technology (NIST). Education, healthcare, and government are also important sectors of the Boulder economy. This diversity has buffered the effects of the 2008 recession and contributed to the area's economic vitality. The 2016 American Community Survey reports that Boulder has 58,362 employed individuals 16 years and over. Roughly 26.8% of the City's residents work "outside place of residents".

2.4 Demographics and Growth Trends

According to the U.S. Census Bureau, the City of Boulder's 2015 population was estimated at 103,919, a 6.7 percent increase from 97,385 in 2010. This population is exclusive of the student population at the University of Colorado, which includes a total enrollment of 31,600.

Table 2.1. American Community Survey 2015 Demographic Characteristics for the City of Boulder

Demographic	
Gender/Age	
Male	51.3%
Female	48.7%
Under 5 years	3.5%
65 years and over	10.0%
Race	
White	88.5%
Black or African American	1.0%
American Indian and Alaska native	0.3%
Asian	5.0%
Native Hawaiian or Pacific Islander	0.1%
Other	1.9%
Two or more races	3.2%
Other	
Average household size (owner-occupied)	2.29
Population with a disability, 2010	9.8%

Demographic	
Median family income, 2015	$105,034
Median household income, 2015	$58,484
Per capita income, 2015	$37,639
Families below poverty level, 2015	6.0%
Individuals below poverty level, 2015	23.1%
Median home value, 2015	$512,600

Source: U.S. Census Bureau

According to population projections by the City of Boulder Department of Community Planning and Sustainability Boulder's population is anticipated to grow to 114,025 by 2035. As of January 2015, the City of boulder had approximately 44,725 housing units, 104,800 residents, and 98,500 jobs. According to the 2017 BVCP, over the next 25 years, the city is projected to add 6,500 housing units, 19,000 residents and 19,000 jobs. CU student enrollment could increase by a range of 5,000 to 15,000 additional students, or 45,000 students total by 2030. Since there is little vacant land remaining within Boulder's Urban Growth Boundary, new housing units are primarily being added through redevelopment. Slightly more than half (52%) of housing in Boulder is multi-family housing, compared to 33% in the region.

3 PLANNING PROCESS

Requirements §201.6(b) and §201.6(c)(1):
An open public involvement process is essential to the development of an effective plan. In order to develop a more comprehensive approach to reducing the effects of natural disasters, the planning process shall include:

1) **An opportunity for the public to comment on the plan during the drafting stage and prior to plan approval;**
2) **An opportunity for neighboring communities, local and regional agencies involved in hazard mitigation activities, and agencies that have the authority to regulate development, as well as businesses, academia, and other private and nonprofit interests to be involved in the planning process; and**
3) **Review and incorporation, if appropriate, of existing plans, studies, reports, and technical information.**

[The plan shall document] the planning process used to develop the plan, including how it was prepared, who was involved in the process, and how the public was involved.

3.1 Background on Mitigation Planning in the City of Boulder

The planning process and development of the City of Boulder Multi-Hazard Mitigation Plan has its roots in meetings and activities that began in September 2005. The first version of this plan was approved by FEMA in 2008. The plan underwent comprehensive updates in 2012 and 2017-2018 to comply with the five-year update cycle required by the DMA 2000. The city has worked with a consultant, Amec Foster Wheeler Environment and Infrastructure (Amec Foster Wheeler) to facilitate and develop the plan. Amec Foster Wheeler's role was to:

- Assist in establishing a hazard mitigation planning committee (HMPC) as defined by regulations in the Disaster Mitigation Act of 2000 (DMA),
- Meet the DMA requirements as established by federal regulations and following the Federal Emergency Management Agency's (FEMA) planning guidance,
- Support objectives under the National Flood Insurance Program's Community Rating System and the Flood Mitigation Assistance program,
- Facilitate the entire planning process under the guidance of a professional planner
- Identify the data requirements that HMPC participants could provide and conduct the research and documentation necessary to augment that data,
- Assist in facilitating the public input process,
- Produce the draft and final plan documents, and
- Coordinate the Colorado Division of Homeland Security and Emergency Management (DHSEM) and FEMA Region VIII plan reviews.

3.2 Plan Section Review and Analysis – 2018 Update

This multi-hazard mitigation plan update involves a comprehensive review and update of each section of the 2012 plan and includes an assessment of the success of the city in evaluating, monitoring and implementing the mitigation strategy outlined in the initial plan. Since the original development of the plan, FEMA guidance for local hazard mitigation plans has been refined and updated. The process followed to review and revise the chapters of the plan during the 2018 update is detailed in Table 3.1 As part of this plan update, all sections of the plan were reviewed and updated to reflect new data on hazards and risk, risk analysis processes, capabilities, participating stakeholders, and mitigation strategies. Only the information and data still valid from the 2012 plan was carried forward as applicable into this LHMP update.

Table 3.1. 2018 Plan Update Summary of Changes by Chapter

Plan Section	Update Review and Analysis
1.0 Introduction	Updated language to describe purpose and requirements of the City of Boulder Local Hazard Mitigation Plan update process.
2.0 Community Profile	Updated with 2010 Census data, American Community Survey 2015 estimates, information from the 2015 Boulder Valley Comprehensive Plan, and current economy description.
3.0 Planning Process	Described and documented the planning process for the 2017-2018 update, including coordination among agencies and integration with other planning efforts. Described any changes in participation in detail. Described 2017-2018 public participation process.
4.1 Identifying Hazards and 4.2 Profiling Hazards	Revisited former hazards list for possible modifications. Reviewed hazards from the 2013 Colorado State Hazard Mitigation Plan (CSHMP) for consistency. Updated list of disaster declarations to include 2012-2018 data. Updated NCDC tables to include 2012-2018 data. Updated past occurrences for each hazard to include 2008-2011 data. Incorporated new hazard studies since 2012, including the Bear Canyon Creek and Gregory Canyon Flood Mitigation Master Plan studies, and 2013 flood impacts. Considered consequences of climate change on hazard frequency and severity

Plan Section	Update Review and Analysis
4.3 Assessing Vulnerability and Estimating Potential Losses	Updated critical facilities definition and locations from the 2012 plan using definition in the proposed Critical Facilities Ordinance. Updated growth and development trends to include Census 2010, American Community Survey 2015 estimates, and local data sources. Updated historic and cultural resources using Colorado State Historic Preservation Office and other local/state/national sources. Using 2017 County Assessor's parcel data, updated current property values. Estimated flood losses using the latest flood hazard mapping and building counts and values. Updated NFIP data and Repetitive Loss structure data from the previous plan. Incorporate new hazard loss estimates since 2012, as applicable. Changes in growth and development were examined; especially changes in the context of hazard-prone areas and how the changes may affect loss estimates and vulnerability. A HAZUS-MH Level I earthquake vulnerability analysis data was developed with HAZUS 4.0 and incorporated. Updated information regarding specific vulnerabilities to hazards, including maps and tables of specific assets at risk, specific critical facilities at risk, and specific populations at risk Updated maps in plan where appropriate.
4.4 Assessing Capabilities	Reviewed city mitigation capabilities and updated to reflect current capabilities. Indicated what projects have been implemented that may reduce previously identified vulnerabilities Incorporated100 Resilient City participation and resiliency planning and related initiatives
5.0 Mitigation Strategy	Updated Chapter 5 based on the results of the updated risk assessment, completed mitigation actions, and implementation obstacles and opportunities since the completion of the previous plan.
5.1 Goals and Objectives	Reviewed goals and objectives to determine if they are still representative of the city's mitigation strategy. Revised the goals and objectives based on HMPC input.
5.2 Identified Mitigation Measures and Alternatives	Revised to include more information on the categories of mitigation measures (structural projects, natural resource protection, emergency services, etc.) and how they are reviewed when considering the options for mitigation. Included more information on how actions are prioritized.
5.3 Mitigation Actions	Reviewed mitigation actions from the 2012 plan and developed a status report for each; identified if action has been completed, deleted, or deferred. Identified "Mitigation Success Stories" to highlight positive movement on actions identified in 2012 plan. Identified and detailed new mitigation actions proposed by the HMPC. Identified projects that will be likely candidates for pre-vs. post disaster mitigation funding
6.0 Plan Adoption	No changes to section but updated with resolution in Appendix A.
7.0 Plan Implementation and Maintenance	Reviewed and updated procedures for monitoring, evaluating, and updating the plan. Revised to reflect current methods. Updated the system for monitoring progress of mitigation activities by identifying additional criteria for plan monitoring and maintenance.
Appendices	Appendix A – Update adoption resolution Appendix B – Update HMPC member list Appendix C – Updated Mitigation Categories Appendix D – Updated references as appropriate Appendix E – Updated planning process documentation Appendix F – Updated Public Participation Plan Appendix G - Updated Critical Facilities details

3.3 Local Government Participation

The DMA planning regulations and guidance stress that each local government seeking FEMA approval of their mitigation plan must participate in the planning effort in the following ways:

- Participate in the process,
- Detail areas within the planning area where the risk differs from that facing the entire area,
- Identify specific projects to be eligible for funding, and
- Have the governing board formally adopt the plan.

For the City of Boulder's HMPC members, "participation" meant:

- Attending and participating in the HMPC meetings,
- Providing available data requested of the HMPC,
- Reviewing and providing comments on the plan drafts,
- Advertising, coordinating, and participating in the public input process.

The city's Utilities Division within the Department of Public Works took the lead on the plan's initial development in 2005, the update in 2012, as well as in 2017-2018.

3.4 The 10-Step Planning Process

Amec Foster Wheeler established the planning process for updating the City of Boulder's plan using the DMA planning requirements and FEMA's associated guidance. The original FEMA planning guidance is structured around a four-phase process:

1. Organize Resources
2. Assess Risks
3. Develop the Mitigation Plan
4. Implement the Plan and Monitor Progress

FEMA's March 2013 Local Mitigation Planning Handbook recommends a nine-step process within the original four phase process. Into this four-phase process, Amec Foster Wheeler integrated a more detailed 10-step planning process used for FEMA's Community Rating System (CRS) and the Flood Mitigation Assistance program. Thus, the modified 10-step process used for this plan meets the funding eligibility requirements of the Hazard Mitigation Assistance grants (including Hazard Mitigation Grant Program, Pre-Disaster Mitigation program, Flood Mitigation Assistance), Community Rating System, and the flood control projects authorized by the U.S. Army Corps of Engineers (USACE). Table 3.2 summarizes the four-phase DMA process, the detailed CRS planning steps and work plan used to develop the plan, the nine handbook planning tasks from FEMA's 2013 Local Mitigation Planning Handbook, and where the results are captured in the Plan.

Table 3.2. Mitigation Planning Process Used to Update the Plan

FEMA 4 Phase Guidance	Community Rating System (CRS) Planning Steps (Activity 510) and Amec Foster Wheeler Work Plan Tasks	FEMA Local Mitigation Planning Handbook Tasks (44 CFR Part 201)	Location in Plan
Phase I: Organize Resources	Task 1. Organize Resources	1: Determine the Planning Area and Resources	Chapters 1, 2 and 3
		2: Build the Planning Team 44 CFR 201.6(c)(1)	Chapter 3, Section 3.1
	Task 2. Involve the public	3: Create an Outreach Strategy y 44 CFR 201.6(b)(1)	Chapter 3, Section 3.1, 3.3.1
	Task 3. Coordinate with Other Agencies	4: Review Community Capabilities 44 CFR 201.6(b)(2) & (3)	Chapter 3, Section 3.1, 3.3.1 Chapter 4, Section 4.4
Phase II: Assess Risks	Task 4. Assess the hazard	5: Conduct a Risk Assessment 44 CFR 201.6(c)(2)(i) 44 CFR 201.6(c)(2)(ii) & (iii)	Chapter 4, Sections 4.1-4.3
	Task 5. Assess the problem		Chapter 4, Sections 4.3
Phase III: Develop the Mitigation Strategy	Task 6. Set goals	6: Develop a Mitigation Strategy 44 CFR 201.6(c)(3)(i); 44 CFR 201.6(c)(3)(ii); and 44 CFR 201.6(c)(3)(iii)	Chapter 5, Sections 5.1 and 5.2
	Task 7. Review possible activities		Chapter 5, Section 5.3
	Task 8. Draft an action plan		Chapter 5, Section 5.4
Phase IV: Adopt and Implement the Plan	Task 9. Adopt the plan	8: Review and Adopt the Plan 44 CFR 201.6(c)(3)	Chapter 6, Appendix A
	Task 10. Implement, evaluate, revise	7: Keep the Plan Current	Chapter 7
		9: Create a Safe and Resilient Community 44 CFR 201.6(c)(4)	Chapter 7

This planning process is similar to the planning process used in the creation of the original City of Boulder Multi-Hazard Mitigation Plan. The planning process that follows describes the process which Amec Foster Wheeler and the city used in the 2017-2018 plan update.

3.4.1 Phase 1: Organize Resources

Planning Step 1: Organize the Planning Effort

With the City of Boulder's commitment to participate in the DMA planning process, Amec Foster Wheeler worked with the city Department of Public Works Utilities Division Engineering Project Manager to establish the framework and organization for development of the plan. The HMPC, which was comprised of key city, county, and other local government and stakeholder representatives, developed the plan with leadership from the city's Engineering Project Manager and facilitation by Amec Foster Wheeler. The list of city departments that participated on the HMPC organizations is provided below; additional details are available in Appendix B.

City of Boulder

- City Manager's Office - Resilient Boulder
- Communications/Webmaster
- Education and Outreach
- Emergency Management
- Environmental Affairs
- Facilities and Asset Management
- Finance
- Fire Rescue
- Housing and Human Services
- Information Technology/Geographic Information Systems
- Office of Emergency Management
- Open Space and Mountain Parks
- Parks and Recreation
- Planning - Engineering
- Planning-Historic Preservation
- Planning-Long Range
- Police Department
- Public Works
- Risk Management
- Transportation
- Urban Forestry
- Wildland Fire Mitigation

The City of Boulder's HMPC members have varying degrees of experience related to natural hazards mitigation projects and planning. The table below outlines staff expertise and overall capability within the hazard mitigation categories promoted by the FEMA/National Flood Insurance Program's Community Rating System.

Table 3.3. City of Boulder Staff Expertise with Mitigation Categories

Community Department/Office	Prevention	Property Protection	Natural Resource Protection	Emergency Services	Structural Flood Control Projects	Public Information
City Manager's Office- Resilient Boulder	✓	✓			✓	✓
Communications/ Webmaster						✓
Environmental Affairs			✓			
Facilities and Asset Management		✓				
Finance					✓	
Fire Rescue	✓	✓	✓	✓		✓
Housing and Human Services	✓	✓				✓
Information Technology/Geographic Information Systems	✓					✓
Office of Emergency Management	✓	✓		✓		✓
Open Space and Mountain Parks	✓		✓		✓	✓
Parks and Recreation	✓		✓		✓	✓
Planning- Engineering	✓	✓	✓		✓	
Planning- Historic Preservation	✓	✓				
Planning- Long Range	✓	✓	✓			✓
Police Department				✓		✓
Public Works	✓	✓	✓	✓	✓	✓
Risk Management		✓				
Transportation	✓	✓			✓	
Urban Forestry			✓			

Community Department/Office	Prevention	Property Protection	Natural Resource Protection	Emergency Services	Structural Flood Control Projects	Public Information
Wildland Fire Mitigation	✓	✓	✓	✓		

During the planning process, the HMPC communicated through face-to-face meetings, e-mail, and a website site hosted by Resilient Together (www.resilienttogether.org), a joint city-county website to communicate resiliency building initiatives. The HMPC formally met three times during the planning period (June 8, 2017 to November 2, 2017). The purpose of these meetings is described in Table 3.4. Agendas for each of the meetings and lists of attendees are included in Appendix E.

Table 3.4. Schedule of Meetings

HMPC Meeting	Meeting Topic	Meeting Date	Associated CRS Planning Steps*
1	Kick-off Meeting	June 8, 2017	1,2,3
2	Risk Assessment and Goals Update Meeting	September 18, 2017	2,3,4,5,6
3	Mitigation Strategy Development Meeting	November 2, 2017	5,6,7,8,9,10

* All 10 FEMA Planning Steps were covered during the planning process. The text in this chapter provides more information on the fulfillment of the requirements for each step

During the kickoff meeting, Amec Foster Wheeler presented information on the scope and purpose of the plan update, participation requirements of HMPC members, and the proposed project work plan and schedule. A plan for public involvement (Step 2) and coordination with other agencies and departments (Step 3) were discussed. Amec Foster Wheeler also reviewed the list of identified hazards with HMPC members. Participants were provided a handout indicating a review of each plan's sections and proceeded to analyze information needed to support the plan update, such as data on historic hazard events, progress on mitigation strategies, and new capabilities.

Planning Step 2: Involve the Public

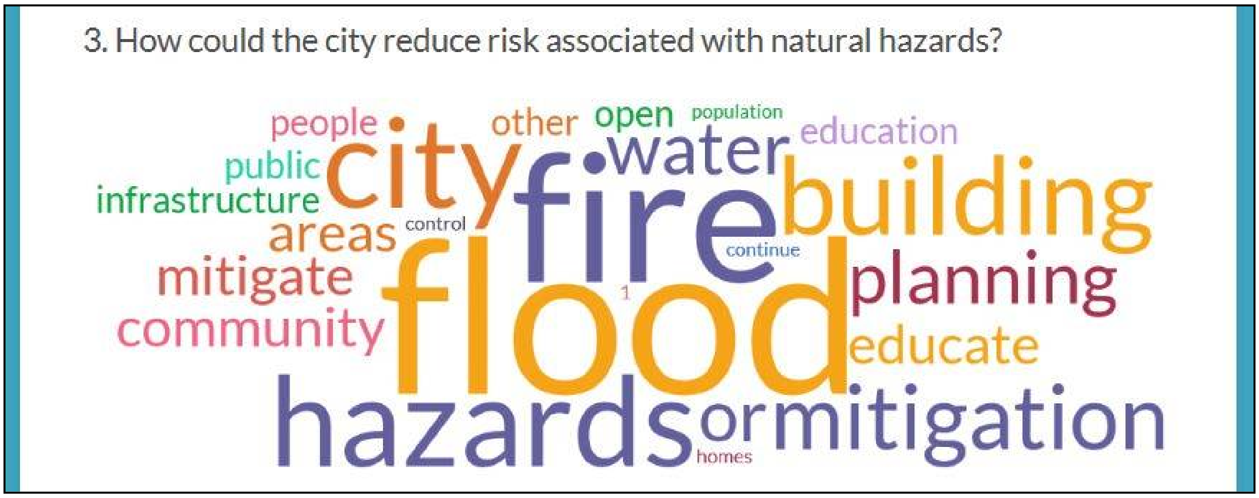
Planning for involvement of the public began early in the plan update process. At the kick-off meeting, the HMPC discussed options for public involvement and agreed to an approach using established public information mechanisms and resources within the community and guidance from public involvement used on the initial development and 2012 update of this plan captured in the Public Participation Plan (PPP) in Appendix F. The PPP outlines the public participation requirements of the DMA and CRS program and identify potential options to best engage the public. The PPP also served to document public outreach/involvement activities utilized during the 2017-18 process.

In the 2017-18 update of the plan, Boulder's Resilient Together group was responsible for the public outreach component. Resilient Together is collaboration between Resilient Boulder and BoCo strong. Resilient Boulder represents the local participation in the 100 Resilient Cities initiative, aimed at helping the community become more resilient to physical, social, and economic challenges. BoCo Strong is a result of the 2013 floods, focusing on fortifying cross sector relationships and integrated collaboration throughout Boulder county. The organization is comprised of an extensive network of community leaders, organizations, and government departments who are interested in participating in actions to increase the resilience of Boulder.

Public Survey and Website

The Resilient Together representatives helped coordinate a range of public involvement activities, including press releases, Channel 8 News video clip, website postings, and the collection of public comments from a survey developed specifically for the plan update. There were 108 responses to the survey. The public survey queried the public on hazards of concern, the role of the community and the responsibility of the government, and effective actions for reducing risk. The majority of survey participants live in North Boulder (31% of responses). When asked what is the greatest natural threat to Boulder, most participants answered hail, followed by flood, wind, lightning, dam failure, climate change, and drought. People agree that the most effective ways the city could reduce risk associated with natural hazards is to utilize educational programs and spread awareness, as well as planning/growth management practices, and communication and warning systems. When asked to use a scale of 1 to 10 to quantify the government's responsibility for reducing risk to natural disasters, the average response was 5.67. This result reflects a varied range of opinions regarding government involvement, however, most people believe that the responsibility is shared by both the city and community. Input received from this survey will help guide future outreach and notification efforts. Detailed information from the public survey is summarized in Appendix E.

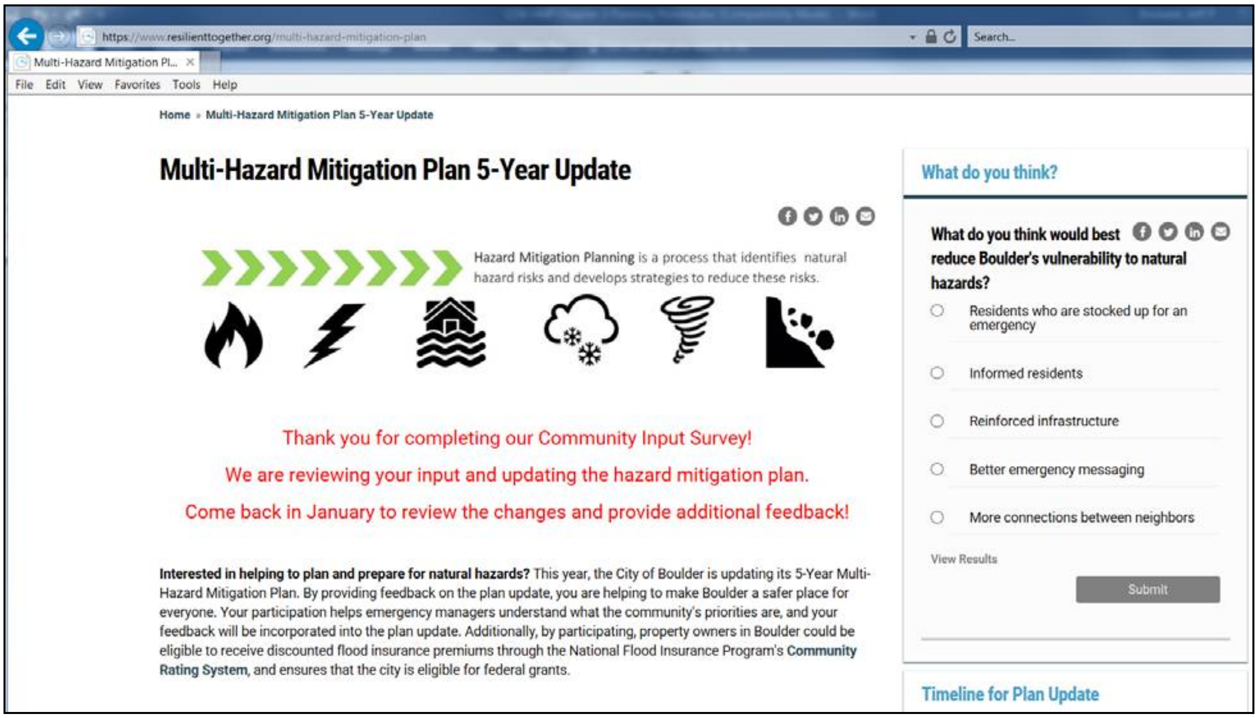
Figure 3.1. Excerpt of Mitigation Plan Survey – Word Cloud based on Question 3 Responses



In addition to the survey, early in the process, prior to the kickoff meeting, a public workshop was held on April 12, 2017 by the Utilities Flood Department that showcased all flood projects together in one open house. It was also a good opportunity to educate the public on the MHMP. The workshop was an open house format where citizens could ask questions of staff from various city departments including Public Works-Utilities. The open house included an informational board letting folks know about the HMP update, what the HMP does, and how they can participate. A feedback form/public survey was developed to collect public comments, of which six were completed.

The Resilient Together web page was used to describe the plan update and provide updates on the process. The plan was made available to the public on the city Public Works-Utilities website for a three-week period during January-February 2018, along with the on-line comment form. The plan was advertised by social media posts including Facebook and Twitter. A few public comments were received that resulted in minor, mostly editorial, changes to the plan. All public process documentation is included in Appendix E and is on file with the City of Boulder Utilities Division.

Figure 3.2. Excerpt of Mitigation Plan Update Web Page - Resilient Together Website



Planning Step 3: Coordinate with Other Departments and Agencies

Early in the planning process, the HMPC determined that data collection, mitigation strategy development, and plan approval would be greatly enhanced by inviting other local, state and federal agencies and organizations to participate in the process. Based on their involvement in hazard mitigation projects or planning, and/or their interest as a neighboring jurisdiction, representatives from the following agencies were invited to participate on the HMPC. Some of these participated at HMPC meetings while others stayed in the loop by email and reviewed drafts of the plan.

Other Government and Stakeholder Representatives:

- Boulder Community Hospital*
- Boulder County/City of Boulder Office of Emergency Management*
- Boulder County Transportation*
- Boulder Valley School District*
- Colorado Division of Homeland Security and Emergency Management*
- Colorado Water Conservation Board*
- FEMA Region VIII*
- Urban Drainage and Flood Control District

*Participated at HMPC meetings.

All the entities listed above participated on the HMPC. A full list of HMPC participants is available in Appendix B.

In addition to those listed above, the HMPC used technical data, reports, and studies from the following agencies and groups. The HMPC obtained this information either through the web or directly from the organization.

- Boulder Daily Camera
- City of Boulder IT/GIS Department
- City of Boulder Open Space and Mountain Parks
- City of Boulder Parks and Recreation
- City of Boulder Planning Department
- City of Boulder Public Works
- National Oceanic and Atmospheric Administration National Center for Environmental Information
- State and Federal Historic Preservation Offices
- Natural Resource Conservation Service
- U.S. Geological Survey
- Western Regional Climate Center

Other Community Planning Efforts and Hazard Mitigation Activities

Hazard mitigation planning involves identifying existing policies, tools, and actions that will reduce a community's risk and vulnerability from natural hazards. As such, this plan was coordinated with, and builds from, other related planning efforts that help reduce hazard losses. The City of Boulder uses a variety of comprehensive planning mechanisms, such as a master plan, an emergency response plan, and city policies, to guide growth and development. Integrating existing planning efforts and mitigation policies and action strategies into this multi-hazard mitigation plan establishes a credible and comprehensive plan that ties into and supports other community programs. The development of this plan incorporated information from the following existing plans, studies, reports, and initiatives as well as other relevant data from Boulder County and the State of Colorado. These and other related plans are discussed further in Section 4.4 Capability Assessment.

- Boulder Valley Comprehensive Plan
- Boulder Climate Preparedness Plan
- FEMA Flood Insurance Study
- Various Flood Studies and Flood Mitigation Master Plans
- Comprehensive Flood and Stormwater Utility Master Plan
- Greenways Master Plan
- City of Boulder Drought Plan
- City of Boulder Community Wildfire Protection Plan

- City of Boulder Resilience Strategy
- St. Vrain Wildfire Watershed Assessment
- 2011 Barker Dam Overtopping Study
- Urban Open Lands Master Plan
- 2013 State of Colorado Hazard Mitigation Plan

Other documents were reviewed and considered, as appropriate, during the collection of data to support Planning Steps 4 and 5, which include the hazard identification, vulnerability assessment, and capability assessment.

3.4.2 Phase 2: Assess Risks

Planning Steps 4 and 5: Identify the Hazards and Assess the Risks

Amec Foster Wheeler led the HMPC in a comprehensive research effort to identify and document all the natural hazards that have, or could, impact the city. Where data permitted, geographic information systems (GIS) were used to display, analyze, and quantify hazards and vulnerabilities. The HMPC also updated a mitigation capability assessment to review and document the city's current capabilities to mitigate risk and reduce vulnerability from natural hazards. By collecting information about existing government programs, policies, regulations, ordinances, and emergency plans, the HMPC can assess those activities and measures already in place that contribute to mitigating some of the risks and vulnerabilities previously identified. A more detailed description of the risk assessment process and the results are included in Chapter 4: Risk Assessment; the Capability Assessment is described in Section 4.4.

3.4.3 Phase 3: Develop the Mitigation Plan

Planning Steps 6 and 7: Set Goals and Review Possible Activities

Amec Foster Wheeler facilitated brainstorming and discussion sessions with the HMPC that described the purpose and the process of developing planning goals and objectives, a comprehensive range of mitigation alternatives, and a method of selecting and defending recommended mitigation actions using a series of selection criteria. This information is included in Chapter 5: Mitigation Strategy. Additional documentation on the process the HMPC used to develop the goals and strategy is in Appendix C.

Planning Step 8: Draft an Action Plan

Based on input from the HMPC regarding the draft risk assessment and the goals and activities identified in Planning Steps 6 and 7, Amec Foster Wheeler produced a complete draft of the updated plan. Other agencies were invited to comment on this draft as well. HMPC and agency comments were integrated into the second updated draft, which was advertised and posted for review and comment on the city's website. Amec Foster Wheeler integrated comments and issues from the public, as appropriate, along with additional internal review comments and produced a final draft for the Colorado Division of Homeland Security and Emergency Management and FEMA Region VIII to review and approve, contingent on final adoption by the City Council.

3.4.4 Phase 4: Implement the Plan and Monitor Progress

Planning Step 9: Adopt the Plan

In order to secure buy-in and officially implement the plan, the plan was adopted by the City of Boulder City Council on the dates included in the adoption resolution in Appendix A: Adoption Resolution. Once the adoption is complete, final approval by FEMA occurs.

Planning Step 10: Implement, Evaluate, and Revise the Plan

The HMPC developed and agreed upon an overall strategy for plan implementation and for monitoring and maintaining the plan over time. Since its initial development the City of Boulder has been proactive in implementing the mitigation actions identified in the plan. A discussion on the progress with implementation is included in Chapter 5. Each recommended mitigation action includes key descriptors, such as a lead manager and possible funding sources, to help initiate implementation. An overall implementation strategy is described in Chapter 7: Plan Implementation and Maintenance.

Finally, there are numerous organizations within the city whose goals and interests interface with hazard mitigation. Coordination with these other planning efforts, as addressed in Planning Step 3, is paramount to the ongoing success of this plan and mitigation in the City of Boulder and is addressed further in Chapter 7. An updated overall implementation strategy and maintenance and a strategy for continued public involvement are also included in Chapter 7.

4 RISK ASSESSMENT

Requirement §201.6(c)(2): [The risk assessment shall provide the] factual basis for activities proposed in the strategy to reduce losses from identified hazards. Local risk assessments must provide sufficient information to enable the jurisdiction to identify and prioritize appropriate mitigation actions to reduce losses from identified hazards.

Risk, as defined by the Federal Emergency Management Agency (FEMA), is a combination of hazard, vulnerability, and exposure. “It is the impact that a hazard would have on people, services, facilities, and structures in a community and refers to the likelihood of a hazard event resulting in an adverse condition that causes injury or damage.”

The risk assessment process identifies and profiles relevant hazards and assesses the exposure of lives, property, and infrastructure to these hazards. The process allows for a better understanding of a jurisdiction’s potential risk to natural hazards and provides a framework for developing and prioritizing mitigation actions to reduce risk from future hazard events.

This risk assessment followed the methodology described in the FEMA publication *Local Mitigation Planning Handbook (March 2013*), which breaks the assessment down to a four-step process:

1) Describe Hazards
2) Identify Community Assets
3) Analyze Risks
4) Summarize Vulnerability

Data collected through this process has been incorporated into the following sections of this chapter:

- **Section 4.1:** Identifying Hazards identifies the hazards that threaten the planning area and describes why some hazards have been omitted from further consideration.
- **Section 4.2:** Profiling Hazards discusses the threat to the planning area, the extent/magnitude of the threat, and describes previous occurrences of hazard events and the likelihood of future occurrences.
- **Section 4.3: Assessing Vulnerability** assesses the city’s total exposure to natural hazards, considering assets at risk, critical facilities, and future development trends.

While not required by FEMA, the Hazard Mitigation Planning Committee (HMPC) also conducted and updated a mitigation capability assessment, which inventoried existing mitigation activities and existing policies, regulations, and plans that pertain to mitigation and can affect net vulnerability. The findings from this undertaking are in **Section 4.4: Mitigation Capabilities Assessment**.

4.1 Identifying Hazards

Requirement §201.6(c)(2)(i): [The risk assessment shall include a] description of the type…of all natural hazards that can affect the jurisdiction.

The HMPC conducted a hazard identification study to determine the hazards that threaten the planning area.

Methodology

Using existing natural hazards data and input gained through planning meetings, the HMPC agreed upon a list of natural hazards that could affect the City of Boulder. Hazards data from the Colorado Division of Homeland Security and Emergency Management, the Natural Hazards Center at the University of Colorado at Boulder, the National Oceanic and Atmospheric Administration, and many other sources were examined to assess the significance of these hazards to the planning area. Significance was measured in general terms and focused on key criteria such as frequency and resulting damage, which includes deaths and injuries and property and economic damage. The natural hazards evaluated as part of this plan include those that have occurred historically or have the potential to cause significant human and/or monetary losses in the future.

Certain natural hazards were identified and investigated for the City of Boulder Multi-Hazard Mitigation Plan. Table 4.1 was completed by the HMPC to identify, profile, and rate the significance of identified hazards.

Table 4.1. City of Boulder Hazard Identification Table

Hazard	Geographic Extent	Probability of Future Occurrences	Magnitude/Severity	Significance
Avalanche	Limited	Unlikely	Negligible	Low
Dam Failure	Significant	Unlikely	Catastrophic	High
Drought	Extensive	Likely	Critical	High
Earthquakes	Significant	Occasional	Limited	Medium
Floods	Significant	Occasional	Catastrophic	High
Human Health Hazards:				
Pandemic Flu	Extensive	Occasional	Critical	High
West Nile Virus	Extensive	Likely	Negligible	Low
Landslides & Rockfalls	Limited	Occasional	Negligible	Low
Severe Weather:				
Extreme Temperatures	Extensive	Highly Likely	Negligible	Low
Fog	Significant	Unlikely	Negligible	Low
Hailstorms	Extensive	Likely	Limited	Medium
Thunderstorms	Extensive	Highly Likely	Limited	Low
Lightning	Extensive	Highly Likely	Limited	Medium
Tornadoes	Limited	Occasional	Negligible	Low
Windstorms	Extensive	Highly Likely	Limited	Medium
Soil Hazards:				
Expansive Soils	Negligible	Occasional	Limited	Low
Land Subsidence	Negligible	Unlikely	Limited	Low
Volcanoes	Limited	Unlikely	Negligible	Low
Wildfire	Significant	Likely	Critical	High
Winter Storms	Extensive	Highly Likely	Critical	Medium

Geographic Extent
Limited: Less than 10% of planning area
Significant: 10-50% of planning area
Extensive: 50-100% of planning area

Probability of Future Occurrences
Highly Likely: Near 100% chance of occurrence in next year, or happens every year.
Likely: Between 10 and 100% chance of occurrence in next year, or has a recurrence interval of 10 years or less.
Occasional: Between 1 and 10% chance of occurrence in the next year, or has a recurrence interval of 11 to 100 years.
Unlikely: Less than 1% chance of occurrence in next 100 years, or has a recurrence interval of greater than every 100 years.

Magnitude/Severity
Catastrophic—More than 50 percent of property severely damaged; shutdown of facilities for more than 30 days; and/or multiple deaths
Critical—25-50 percent of property severely damaged; shutdown of facilities for at least two weeks; and/or injuries and/or illnesses result in permanent disability
Limited—10-25 percent of property severely damaged; shutdown of facilities for more than a week; and/or injuries/illnesses treatable do not result in permanent disability
Negligible—Less than 10 percent of property severely damaged, shutdown of facilities and services for less than 24 hours; and/or injuries/illnesses treatable with first aid

Significance
Low: minimal potential impact
Medium: moderate potential impact
High: widespread potential impact

During the 2018 update the HMPC reviewed the list of hazards from the previous plan. The HMPC decided that the current list of hazards is complete and acceptable. Priority levels for each hazard were revisited and discussed by the HMPC, but ultimately, they remained unchanged. During the 2018 update a number of improvements were made to the hazard profiles and the vulnerability assessment. This included summaries of disasters and hazard impacts between 2012 and 2017, improvements in the vulnerability assessments for flood, and earthquakes, as well as updates and refinements in maps and tables that portray the risk. An emphasis was placed on improving the information on the higher significance hazard data, or where new data was available.

One method the HMPC used to identify hazards was the researching of past events that triggered federal, state, and/or local disaster declarations within the planning area. Federal and state disaster declarations may be granted when the severity and magnitude of an event surpasses the ability of the local government to respond and recover. Boulder County received 3 presidential major disaster declarations between 1955 and 2017 and 3 emergency declarations (including one related to assistance for evacuees following Hurricane Katrina). Boulder County's disaster declaration history is summarized in Table 4.2.

Table 4.2. Boulder County Disaster Declaration History, 1969-2012

Year	Declaring Jurisdiction	Disaster Type
1969	Federal/Major Disaster Declaration	Severe Storms and Flooding
1973	Federal/Major Disaster Declaration	Heavy Rains, Snowmelt, and Flooding
1989	Local	Wildfire
1990	Local	Wildfire
1994	Local	Flooding
1995	State	Flooding
1998	Local	Wildfire
2000	U.S. Department of Agriculture	Drought
2001	State	Severe Weather
2002	FEMA/Major Disaster Declaration	Wildfire
2002	U.S. Department of Agriculture	Drought
2003	FEMA/Emergency Declaration	Snow
2006	U.S. Department of Agriculture	Heat, High Winds, and Ongoing Drought (contiguous county)
2006	FEMA/Emergency Declaration	Snow
2007	FEMA Emergency Declaration	Snow
2009	FEMA Fire Mitigation Assistance Declaration	Wildfire (Olde Stage)
2010	FEMA Fire Mitigation Assistance Declaration	Wildfire (Four Mile Canyon).
2013	FEMA Major Disaster Declaration	Severe Storms, Flooding, Landslides, and Mudslides

Source: State of Colorado Natural Hazard Mitigation Plan, 2004; Federal Emergency Management Agency, PERI Presidential Disaster Declaration Site. U.S. Department of Agriculture

Previous occurrences are discussed in more detail by hazard in **Section 4.2: Profiling Hazards**.

4.2 Profiling Hazards

Requirement §201.6(c)(2)(i): [The risk assessment shall include a] description of the…location and extent of all natural hazards that can affect the jurisdiction. The plan shall include information on previous occurrences of hazard events and on the probability of future hazard events.

For each hazard, a generic description of the hazard and associated problems is provided along with details specific to Boulder County and the City of Boulder. Information on past occurrences and the extent or location of the hazard within or near the city and impacts, where known, are also discussed here. To assess the history of natural hazard events in Boulder, the HMPC evaluated the hazards history for both the city and county. Much of the existing data and statistics are maintained on a countywide basis; therefore, the HMPC relied heavily on Boulder County data. The HMPC and other local resources, such as newspaper articles, were used to refine the county data to more accurately indicate how hazards affected the city in the past. In general, information provided by planning team members is integrated into this section with information from other data sources, such as National Weather Service databases.

The frequency of past events was used to gauge the likelihood of future occurrences. Based on historical data, the frequency of occurrence is categorized into the following classifications:

- **Highly Likely**—Near 100 percent chance of occurrence in next year or happens every year.
- **Likely**—Between 10 and 100 percent chance of occurrence in next year or has a recurrence interval of 10 years or less.
- **Occasional**—Between 1 and 10 percent chance of occurrence in the next year or has a recurrence interval of 11 to 100 years.
- **Unlikely**—Less than 1 percent chance of occurrence in next 100 years or has a recurrence interval of greater than every 100 years.

Where possible, frequency was calculated based on existing data. It was determined by dividing the number of events observed by the number of years and multiplying by 100. This gives the percent chance of the event happening in any given year (e.g., three droughts over a 30-year period equates to a 10 percent chance of an experiencing a drought in any given year).

The following sections provide profiles (in alphabetical order) of the natural hazards that the HMPC identified in **Section 4.1: Identifying Hazards**.

4.2.1 Avalanche

Hazard/Problem Description

Avalanche hazards occur predominantly in the mountainous regions of Colorado above 8,000 feet. The vast majority of avalanches occur during and shortly after winter storms. Avalanches occur when loading of new snow increases stress at a rate faster than strength develops, and the slope fails. Critical stresses develop more quickly on steeper slopes and where deposition of wind-transported snow is common.

The combination of steep slopes, abundant snow, weather, snowpack, and an impetus to cause movement create an avalanche episode. According to the Colorado Avalanche Information Center (CAIC), about 90 percent of all avalanches start on slopes of 30-45 degrees; about 98 percent of all avalanches occur on slopes of 25-50 degrees. Avalanches release most often on slopes above timberline that face away from prevailing winds (leeward slopes collect snow blowing from the windward sides of ridges). Avalanches can run, however, on small slopes well below timberline, such as gullies, road cuts, and small openings in the trees. Very dense trees can anchor the snow to steep slopes and prevent avalanches from starting; however, avalanches can release and travel through a moderately dense forest. An average-sized avalanche travels around 80 mph; the typical range of impact pressure from an avalanche is from 0.5 to 5.0 tons per foot.

Historically in Colorado, avalanches have occurred during the winter and spring months between November and April. The avalanche danger increases with major snowstorms and periods of thaw. About 2,300 avalanches are reported to the CAIC in an average winter. More than 80 percent of these fall during or just after large snowstorms. The most avalanche-prone months are, in order, February, March, and January. Avalanches caused by thaw occur most often in April.

This hazard generally affects a small number of people, such as snowboarders, backcountry skiers, and climbers who venture into backcountry areas during or after winter storms. Motorists along highways are also at risk of injury and death due to avalanches. Road and highway closures, damaged structures, and destruction of forests are also a direct result of avalanches. Recognizing areas prone to avalanches is critical in determining the nature and type of development allowed in each area.

Avalanche hazards exist in western Boulder County and in the City of Boulder’s watershed, where combinations of the above avalanche conditions occur. The avalanche hazard extent within city limits is considered negligible.

Extent

Avalanches typically occur above 8,000 feet and on slopes ranging between 25 and 50 degrees incline. The CAIC website provides backcountry forecasts for avalanche conditions for various forecast zones within the state. The City of Boulder falls outside of the zone boundaries. Only a small portion of the west side of Boulder County falls into the Front Range forecast zone. The

Front Range zone extends from the Wyoming border south, west to Loveland Pass, and includes the Pikes Peak Area. Overall, this equates to far less than 10% of the planning area.

Based on this information, the geographic extent rating for avalanches in the City of Boulder is **negligible** or, at most, **limited**.

Past Occurrences

Avalanches following significant snowstorms have resulted in fatalities in Boulder County. According to the CAIC, between the winters of 1950/51 and 2011/2012, four avalanche fatalities and eleven avalanche events occurred in Boulder County. There is no history of avalanche fatalities in the City of Boulder.

Likelihood of Future Occurrences

Unlikely: There is no recorded history of avalanches occurring within Boulder city limits. Except within limited areas, the topography of the city is well below the slopes of 25-50 degrees on which the CAIC data indicate that 98 percent of all avalanches occur.

Climate Change Considerations

An increase in precipitation and temperature may have an effect on avalanches. Warmer weather can weaken a mountain's snow pack and make it more difficult for the layers of snow to stick together. As winter is taking longer to descend, weaker snow accumulates at the very bottom of the snow pack. As more snow piles on top of the weak layer, and temperatures remain warm, the upper, moisture-laden layers became vulnerable to sliding, and create a delicate situation.

4.2.2 Dam Failure

Hazard/Problem Description

Dams are manmade structures built for a variety of uses, including flood protection, power, agriculture, water supply, and recreation. Dams typically are constructed of earth, rock, concrete, or mine tailings. Factors that influence the potential severity of a full or partial dam failure are the amount of water impounded and the density, type, and value of development and infrastructure located downstream.

Dam failures can result from any one or a combination of the following causes:

- Prolonged periods of rainfall and flooding, which result in overtopping
- Earthquake
- Inadequate spillway capacity resulting in excess overtopping flows
- Internal erosion caused by embankment or foundation leakage or piping or rodent activity
- Improper design

- Improper maintenance
- Negligent operation
- Failure of upstream dams on the same waterway

Overtopping is the primary cause of earthen dam failure.

Water released by a failed dam generates tremendous energy and can cause a flood that is catastrophic to life and property. A catastrophic dam failure could challenge local response capabilities and require evacuations to save lives. Impacts to life safety will depend on the warning time and the resources available to notify and evacuate the public. Major loss of life could result as well as potentially catastrophic effects to roads, bridges, and homes. Associated water quality and health concerns could also be an issue.

In general, there are three types of dams: concrete arch or hydraulic fill, earth-rockfill, and concrete gravity. Each type of dam has different failure characteristics. A concrete arch or hydraulic fill dam can fail almost instantaneously: the flood wave builds up rapidly to a peak then gradually declines. An earth-rockfill dam fails gradually due to erosion of the breach: a flood wave will build gradually to a peak and then decline until the reservoir is empty. And, a concrete gravity dam can fail instantaneously or gradually with a corresponding buildup and decline of the flood wave.

Extent

The Colorado Division of Water Resources Dam Safety Branch assigns hazard ratings to large dams within the State. Two factors are considered when assigning hazard ratings: existing land use and land use controls (zoning) downstream of the dam. Dams are classified in three categories that identify the potential hazard to life and property:

- High hazard indicates that a failure would most probably result in the loss of life
- Significant hazard indicates a failure could result in appreciable property damage
- Low hazard exists where failure would result in only minimal property damage and loss of life is unlikely.

Privately owned high and significant hazard dams are required by Colorado regulations to have Emergency Action Plans (EAPs) in place. Federally-owned high hazard dams are also required to have EAPs by federal regulations. According to the 2013 State Hazard Mitigation Plan, all high-hazard dams in Colorado have EAPs in place, which provide for the emergency response procedures in the event of a dam emergency event. According to the National Inventory of Dams (NID) database, housed in the Homeland Security Infrastructure Program (HSIP), there are 28 high hazard and 21 significant hazard dams located in Boulder County (see Table 4.3). Figure 4.1 displays the location of high and significant hazard dams that could affect the city.

Table 4.3. High and Significant Hazard Dams Affecting the City of Boulder

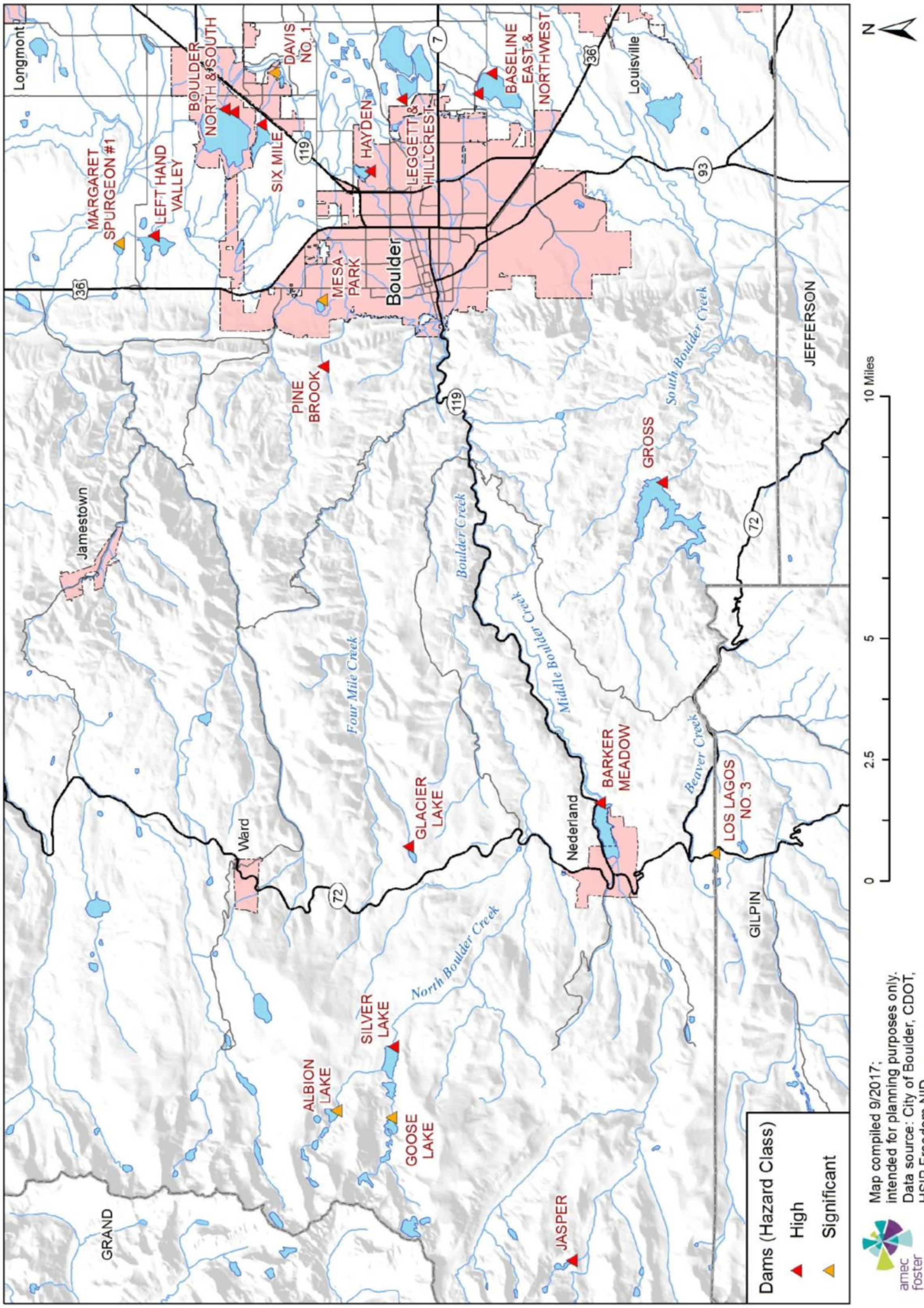
Name	Type of Dam	Year Built	River	Near City	Distance to City (miles)	Dam Height (ft.)	Max Storage (acre-feet*)	Normal Storage (acre-feet*)	Hazard Class	EAP
Valmont 'A'	Earth	1962	Boulder Creek-Tr	Boulder	0	67	15950	11234	H	Y
Gross	Concrete Gravity Arch	1955	South Boulder Creek	Eldorado Springs	7	340	46200	41000	H	Y
Jasper	Rockfill	1988	Jasper Creek	Eldora	5	18	426	325	H	Y
Hayden	Earth	1905	Boulder Creek-Os	Boulder	0	27	765	502	H	Y
Foothills	Earth	1911	St. Vrain Creek-Tr	Longmont	3	52	4983	4139	H	Y
Six Mile - Main	Earth	1892	Little Dry Creek-Tr	Boulder	1	35	2186	1367	H	Y
Baseline - East	Earth	1905	Dry Creek	Boulder	0	40	6592	5300	H	Y
Pleasant Valley	Earth	1868	St. Vrain Creek-Os	Longmont	2	19	4562	3076	H	Y
Silver Lake	Earth	1887	North Boulder Creek	Boulder	17	71	4819	3987	H	Y
Button Rock	Earth	1969	North St. Vrain Creek	Lyons	9	210	20400	16080	H	Y
Barker	Concrete Gravity	1911	Middle Boulder Creek	Boulder	14	175	12400	11700	H	Y
Beaver Park	Earth	1892	Beaver Creek	Lyons	18	33	2731	2161	H	Y
Lagerman	Earth	1878	Dry Creek-Tr	Longmont	3	34	1832	923	H	Y
Glacier Lake	Earth	1905	Pennsylvania Gulch	Boulder	13	25	329	229	H	N
Waneka	Earth	1865	Coal Creek-Os	Lafayette	0	31	838	604	H	Y
Clover Basin	Earth	1910	Dry Creek-Tr	Longmont	3	34	984	584	H	Y
Marshall Lake	Earth	1908	South Boulder Creek-Tr	Marshall	4	80	12878	11545	H	Y
Superior	Earth	1994	Coal Creek-Os	Superior	0	59	500	400	H	Y
Baseline - Northwest	Earth	1905	South Boulder Creek-Os	Boulder	0	20	6592	5300	H	Y
Boulder - South	Earth	1955	Little Dry Creek	Boulder	1	45	17700	13300	H	Y
Harper Lake	Earth	1985	Coal Creek-Tr	Louisville	1	11	843	715	H	Y
Left Hand Valley	Earth	1952	Dry Creek	Boulder	3	54	2814	1624	H	Y
Boulder - North	Earth	1955	Dry Creek	Boulder	1	44	17700	13300	H	Y
Longmont Wtp Forebay Embankment	Earth	2005	St. Vrain Creek-Os	Hygiene	4	20	129	102	H	Y
Pine Brook	Earth	2006	Two Mile Creek	Boulder	1	84	140	120	H	Y
Mccall	Earth	1909	St. Vrain Creek-Os	Longmont	5	14	722	510	H	Y
Leggett & Hillcrest	Earth	1917	South Boulder Creek-Tr	Boulder	0	28	15950	11234	H	Y
Left Hand Park	Earth	1966	Left Hand Creek	Longmont	28	50	2075	1429	H	Y
Panama No. 1 - East	Earth	1904	Boulder Creek-Os	Frederick	3	46	6979	4691	S	Y

Name	Type of Dam	Year Built	River	Near City	Distance to City (miles)	Dam Height (ft.)	Max Storage (acre-feet*)	Normal Storage (acre-feet*)	Hazard Class	EAP
Mesa Park	Earth	1907	Fourmile Canyon Creek-Tr	Boulder	0	31	260	140	S	Y
Louisville No. 1	Earth	1888	Bullhead Gulch-Tr	Louisville	1	13	250	206	S	Y
Allen Lake	Earth	1928	Left Hand Creek-Os	Longmont	9	24	865	700	S	Y
Davis No. 1	Earth	1910	Dry Creek-Os	Boulder	0	13	189	138	S	Y
Mcintosh	Earth	1902	St. Vrain Creek-Os	Longmont	0	17	3352	2460	S	Y
Erie	Earth	1935	Boulder Creek-Os	Erie	2	12	421	306	S	Y
Gaynor	Earth	0	Boulder Creek-Os	Longmont	1	10	840	384	S	Y
Goose Lake	Timber Crib	1908	North Boulder Creek-Tr	Boulder	18	32	1170	940	S	Y
Los Lagos No. 3	Earth	1894	Beaver Creek-Tr	Pinecliffe	5	10	60	35	S	Y
Highland #2 (South)	Earth	1881	Little Thompson River-Os	Longmont	4	37	4613	3713	S	Y
Margaret Spurgeon #1	Earth	1963	Dry Creek-Tr	Boulder	3	32	350	254	S	Y
Gold Lake #1	Earth	1879	Bell Gulch	Longmont	21	24	587	435	S	Y
Albion Lake	Concrete Gravity	1913	North Boulder Creek	Boulder	19	36	700	560	S	Y
Brainard Lake	Other	1943	South St Vrain Creek	Lyons	28	15	160	85	S	NR
Gold Lake #3	Earth	1879	Bell Gulch	Longmont	21	9	587	435	S	Y
Gold Lake #2	Earth	1879	Bell Gulch	Longmont	21	19	587	435	S	Y
Oligarchy #1	Earth	1889	St. Vrain Creek-Os	Longmont	3	18	2161	1737	S	Y
Highland #2 (North)	Earth	1881	Little Thompson River-Os	Berthoud	5	37	4613	3713	S	Y
Panama No. 1 - South	Earth	1904	Boulder Creek-Os	Frederick	3	16	6979	4691	S	Y
Ish #3 (East Dam)	Earth		Little Thompson River-Os	Milliken	13	12	9065	7128	S	Y

Source: HSIP Freedom, 2015

* One acre foot of water is equivalent to 325,000 gallons

Figure 4.1. Locations of Dams that Could Affect the City of Boulder



In 2017, Colorado DWR Dam Safety set out to systematically evaluate all high hazard dams related to operational and flood releases. The analysis produced the "Colorado High Hazard Dam Release-Downstream Floodplain Impacts Database and Ranking Tool", containing information for both private and publicly owned high hazard dams across the state. The ranking of the dams identifies the dams with the highest threat of downstream flooding associated with releases of excess water during high runoff or heavy rain. DWR Dam Safety screened the state's dam database using information from USGS (Streamstats), FEMA Flood Insurance Studies (FIS), and the National Flood Hazard Layer (NFHL). The data was used to compare natural flows versus natural flows in combination with dam release flows. The resulting ranks were developed based on the severity of the conditions, estimated safe channel capacity of the downstream channel, and maximum controlled discharge. The report assesses 415 dams in the State of Colorado and provides a ranking for 366 dams where there is either a high, moderate, or low likelihood of dangerous conditions created by dam and reservoir release operations simultaneously with naturally occurring flood conditions. The high, moderate, or low designations were assigned by DWR by dividing the total number of ranked dams into thirds. Boulder County has 31 dams evaluated by the study, of which five dams went through the hydraulic analysis process. All of Boulder's dams were ranked, and 11 were determined to be high hazard (listed in top 1/3rd of overall ranks) based on release flow characteristics.

Barker Reservoir has the potential to have the worst impacts on the city if a dam failure occurred. The structural integrity of the dam during a Peak Maximum Flood (PMF) event was evaluated in a 2011 overtopping study by GEI consultants. The results of the study indicate that the stability of Barker Dam is not expected to be adversely affected due to overtopping in a PMF event. The dam failure hazard extent within city limits is considered significant, potentially impacting 10-50% of the planning area.

Past Occurrences

According to historical data, there have been no dam failures in Boulder. Two dams in Boulder County were listed as unsafe in the past but have since been fixed and the unsafe rating removed. However, on July 15, 1982, the nearby Lawn Lake Dam in Rocky Mountain National Park near Estes Park, Colorado, failed causing a flood through downtown Estes Park. Three people were killed in this flood.

Likelihood of Future Occurrences

Unlikely: There are no official recurrence intervals calculated for dam failures, so estimating the frequency of occurrence of dam failure is extremely difficult. Based on historical data indicating that there have been no dam failures in the past that adversely impacted the City of Boulder, the risk of future occurrences is unlikely. The structural integrity of dams can decrease with age and other factors, thus regular inspections and maintenance should remain a priority.

Climate Change Considerations

The potential for climate change to affect the likelihood of dam failure is not fully understood at this point in time. With a potential for more extreme precipitation events a result of climate change, this could result in large inflows to reservoirs. However this could be offset by generally lower reservoir levels if storage water resources become more limited or stretched in the future due to climate change, drought and/or population growth.

4.2.3 Drought

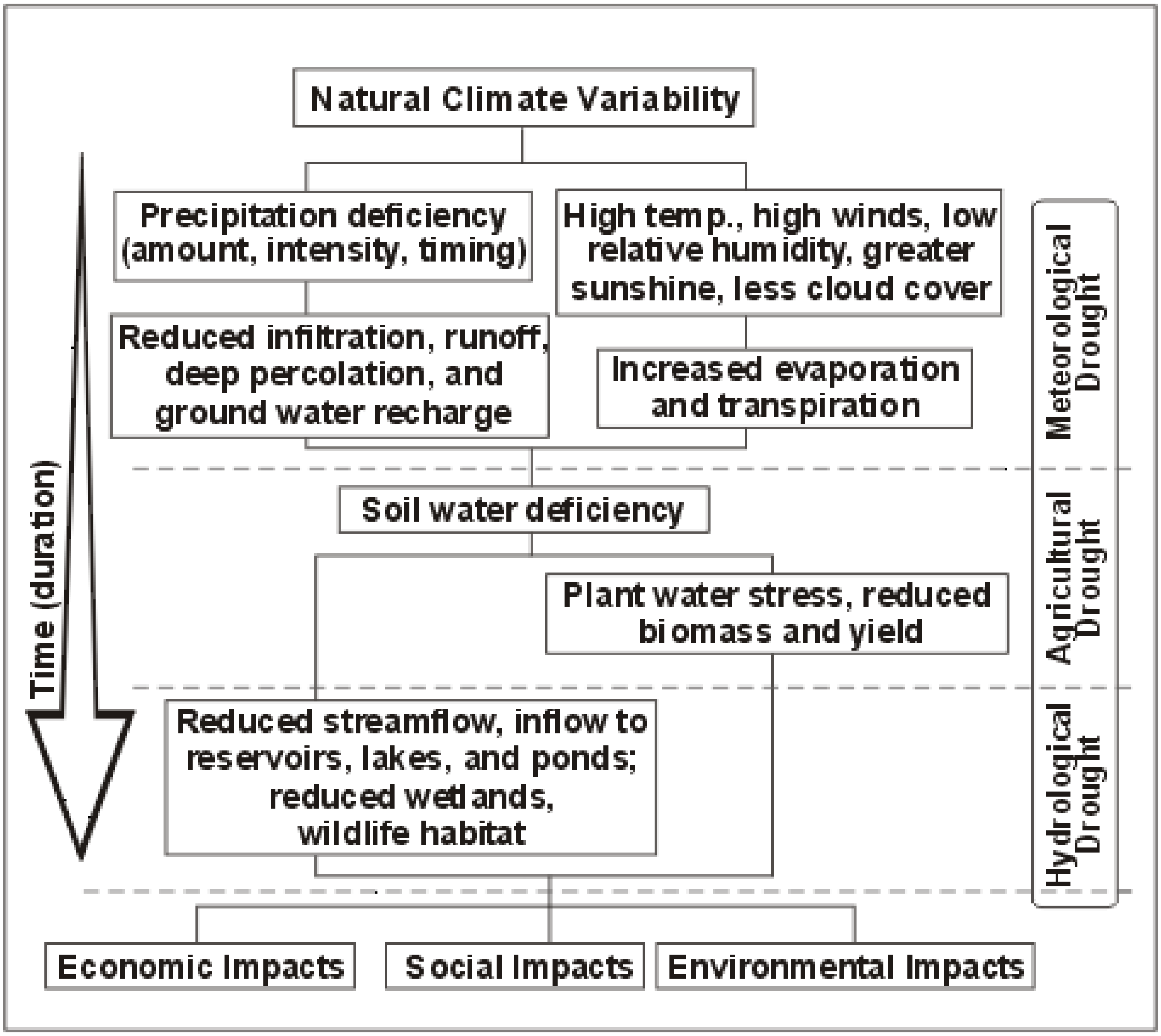
Hazard/Problem Description

Drought is a gradual phenomenon. Although droughts are sometimes characterized as emergencies, they differ from typical emergency events. Most natural disasters, such as floods or forest fires, occur relatively rapidly and afford little time for preparing for disaster response. Droughts occur slowly, over a multi-year period, and it is often not obvious or easy to quantify when a drought begins and ends.

Drought is a complex issue involving many factors (see Figure 4.2)—it occurs when a normal amount of moisture is not available to satisfy an area’s usual water-consuming activities. Drought can often be defined regionally based on its effects:

- **Meteorological** drought is usually an expression of precipitation’s departure from normal over some period of time. Meteorological measurements are the first indicators of drought.
- **Agricultural** drought occurs when there is an inadequate water supply to meet the needs of the state’s crops and other agricultural operations such as livestock.
- **Hydrological** drought is defined as deficiencies in surface and subsurface water supplies. It is generally measured as streamflow, snowpack, and as lake, reservoir, and groundwater levels.
- **Socioeconomic** drought occurs when a drought impacts health, well-being, and quality of life, or when a drought starts to have an adverse economic impact on a region.

Figure 4.2. Causes and Impacts of Drought



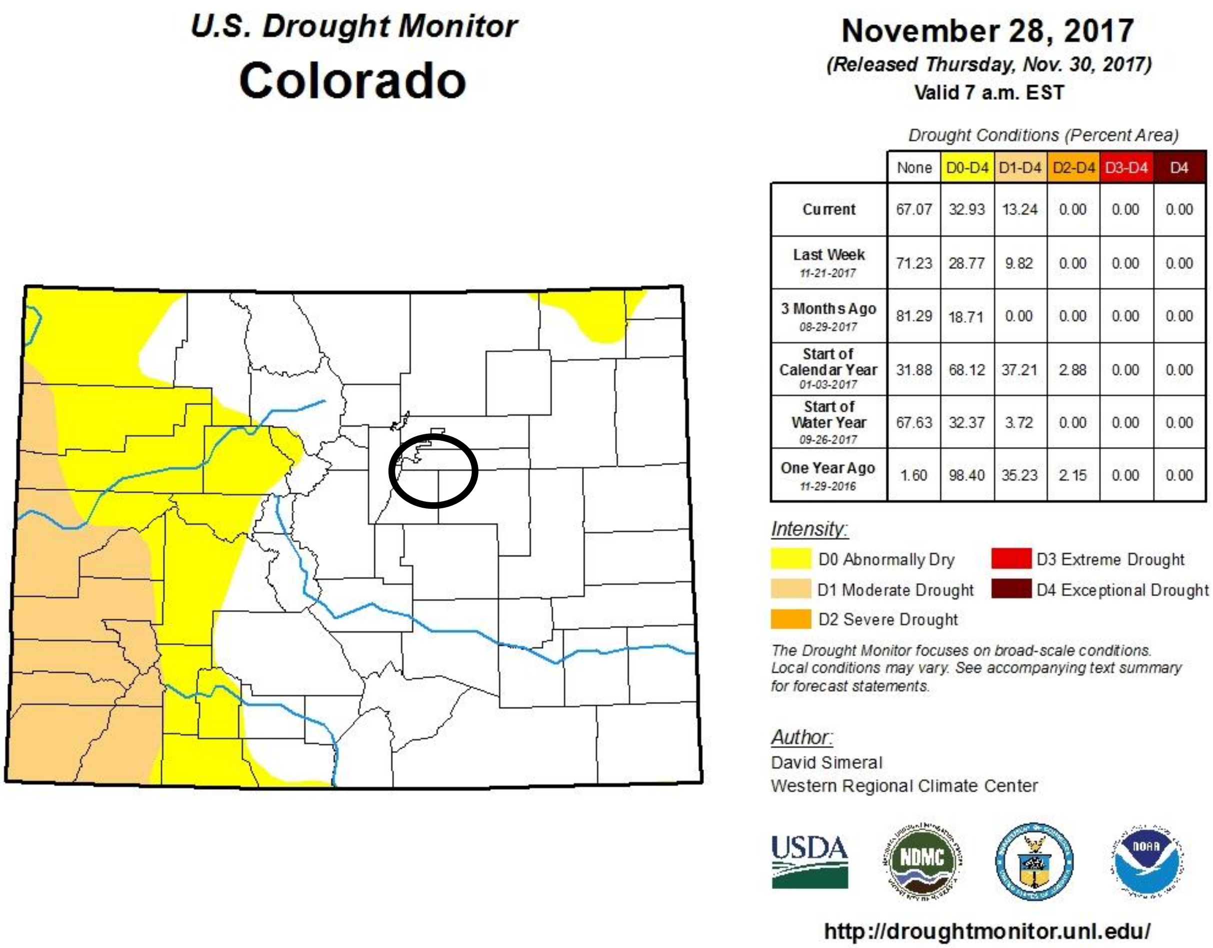
Source: National Drought Mitigation Center

Extent

The United States Drought Monitor measures drought in five categories, from "abnormally dry" to "exceptional drought." Boulder is vulnerable to all levels of drought. Droughts are subject to global climate and precipitation trends, and wet and dry periods can persist for years.

Drought in the United States is monitored by the National Integrated Drought Information System (NIDIS). A major component of this portal is the U.S. Drought Monitor. The Drought Monitor concept was developed jointly by the NOAA's Climate Prediction Center, the National Drought Mitigation Center (NDMC), and the USDA's Joint Agricultural Weather Facility in the late 1990s as a process that synthesizes multiple indices, outlooks and local impacts, into an assessment that best represents current drought conditions. The outcome of each Drought Monitor is a consensus of federal, state, and academic scientists who are intimately familiar with the conditions in their respective regions. A snapshot of the drought conditions in Colorado and the planning area can be found in Figure 4.3. The map indicates that the majority of the State has no drought conditions. The western region of Colorado, especially the south-west displays moderate to abnormally dry drought conditions, as indicted by the beige and yellow shading in the figure below. Boulder County, emphasized by the black oval, does not exhibit any drought conditions as of November 28, 2017.

Figure 4.3. Current Drought Status in Colorado and the City of Boulder



Source: US Drought Monitor; White oval indicates approximate location of Boulder

With its semiarid conditions, drought is a natural but unpredictable occurrence in Colorado. Due to natural variations in climate and precipitation sources, it is rare for all of Colorado to be deficient in moisture at the same time. However, single season droughts over some portion of the state are quite common. Defining when a drought begins is a function of drought impacts to water users.

Hydrologic conditions constituting a drought for water users in one location may not constitute a drought for water users elsewhere, or for water users that have a different water supply. Individual water suppliers may use criteria, such as rainfall/runoff, amount of water in storage, or expected supply from a water wholesaler, to define their water supply conditions. The drought issue is further compounded by water rights specific to a state or region. Water is a commodity possessed under a variety of legal doctrines.

Drought impacts are wide-reaching and may be economic, environmental, and/or societal. The most significant impacts associated with drought in Colorado are those related to water intensive activities such as agriculture, wildfire protection, municipal usage, commerce, tourism, recreation, and wildlife preservation. A reduction of electric power generation and water quality deterioration are also potential problems. Drought conditions can also cause soil to compact and not absorb water well, potentially making an area more susceptible to flooding. An ongoing drought may also leave an area more prone to beetle kill and associated wildfires. Drought impacts increase with the length of a drought, as carry-over supplies in reservoirs are depleted and water levels in groundwater basins decline. The drought hazard extent within city limits is considered extensive, potentially impacting 50-100% of the planning area.

Past Occurrences

Several times since the late 1800's, Colorado has experienced conditions of drought. The most dramatic occurred in the 1930s and 1950s when many states, Colorado included, were affected for several years at a time. Table 4.4, drawn from a study done by McKee, Pielke, and Doesken, shows six multi-year droughts experienced in Colorado since 1893.

Table 4.4. Historical Dry and Wet Periods in Colorado

Date	Dry	Wet	Duration (years)
1893-1905	X		12
1905-1931		X	26
1931-1941	X		10
1941-1951		X	10
1951-1957	X		6
1957-1959		X	2
1963-1965	X		2
1965-1975		X	10
1975-1978	X		3
1979-1999		X	20
2000-2006	X		6
2011-2012	X		1

Source: McKee, et al. *modified for the Colorado State Drought Plan in 2010 based on input from the Colorado Climate Center

The HMPC identified the following as drought events of significance to the city and Boulder County. Some of these droughts may not appear in Table 4.4, as they affected the city and county, but not the entirety of the State.

- **1930-1937**—The drought of the 1930s had the greatest impact on the agricultural industry. Poor farming techniques, low market prices, and a depressed economy compounded the problem.
- **1951-1957**—Like the drought of the 1930s, the drought of the 1950s once again impacted the agricultural industry. Improvements in irrigation and farming techniques mitigated the effects.
- **1976-1977**—This drought was characterized as a winter event, limited in duration. It was the driest winter in recorded history for much of Colorado's high country and western slope, severely impacting the ski industry.
- **1980-1981**—This drought, beginning in the fall of 1980 and lasting until the summer of 1981, also had costly impacts to the ski industry.
- **1994**—This growing season drought that impacted northeast Colorado was one of the driest years on record. Significant impacts included increased wildfires statewide, winter wheat crop losses, difficulties with livestock feeding, and declines in the state's fisheries.
- **2000**—Strong La Niña conditions created below average precipitation and above average temperatures for most months in 2000. Statewide, snowpack started out well below average but recovered to near average in March. However, an early snowmelt resulted in low stream flows, and by June, drought conditions began to affect most of the state. Conditions were most severe in the northeastern plains and the Rio Grande and San Juan/Dolores basins in the southwest. Wildfire conditions were extreme and several fires were reported statewide. Agriculture also suffered. Dryland farming and ranching was affected the most. As of October 2000, 17 Colorado counties and 29 contiguous counties were eligible for assistance because of a USDA secretarial disaster designation. Boulder County was eligible for aid as a contiguous county. By fall, weather patterns returned to near normal with average precipitation and below average temperatures.
- **May 2002**—The Colorado governor, for the first time in state history, asked the federal government to declare all of Colorado a drought disaster area. With an average temperature of 52.4 degrees, 2001 was the warmest year since 1986. The drought started in late 1999 and was compounded by scarce snowfall in 2001. 2002 was the driest year on record for the Denver region and much of the state. Total precipitation for 2002 was 7.48 inches.
- **2002-2006**—Damage to trees because of early twenty-first century drought conditions resulted in pruning and removal costs for both parks and streets estimated at approximately $122,660 in the City of Boulder.
- **2011-2012** – Even though 2011 was very wet across northern Colorado, the extreme drought during this time in Texas, New Mexico and Oklahoma was also felt in the Rio Grande and Arkansas Basins in Colorado. This trend continued in those basins as 2012 began, but also increased in breadth across the rest of Colorado. Based on the U.S. Drought Monitor, approximately 50% of Colorado was already under drought conditions at the beginning of 2012. Drought conditions and a period of extremely hot temperatures in June 2012 contributed

to very dry forests, contributing to the conditions that led to the High Park fire in northern Colorado and the Waldo Canyon fire near Colorado Springs, two of Colorado's most destructive wildfires. Drought conditions also exacerbated the Lower North Fork fire in Jefferson County in March of 2012. Reservoir levels in many portions of the State helped abate some of the drought impacts seen in 2011-2013. Had the reservoir levels not been at levels sufficient for carryover storage into 2012 (due to record breaking high snowpack in 2011) in many river basins, many of the impacts discussed above may have been worse.

In the past 10 years, Boulder County suffered 23 impacts related to drought. Those impacts were felt in the following categories: agriculture (5), business & industry (1), fire (7), plants & wildlife (6), relief, response, & restrictions (11), society & public health (2), tourism & recreation (1), water supply & quality (8).

Likelihood of Future Occurrences

Likely: According to historical data, Boulder has experienced seven periods of drought since 1900. Based on the seven historical droughts, this is an average of one drought every 16.7 years. Given the geographic location of the planning area, its semiarid conditions, and historical drought cycles, drought is likely to affect the City of Boulder in the future.

Climate Change Considerations

According to the Boulder County Climate Change Preparedness Plan, the nature and frequency of drought could be altered from climate change. A future of reduced overall precipitation, warmer summers, and greater demand downstream of the county will cause much more stress to water supplies. The City of Boulder relies primarily on snowpack in the watersheds feeding Middle and North Boulder creeks for its water supply. Higher temperatures can lead to declining snowpacks and earlier snowmelt and runoff. If Boulder County's future climate warms as expected, snowpack could become a less reliable mechanism for water storage, even without any changes in total precipitation. Future extended droughts that impact snowpack in the high mountains – especially if such droughts reduce the frequency or size of spring upslope storms – could push the city into more severe drought restrictions.

Warmer temperatures can lead to more severe drought impacts, even if the precipitation deficit is the same. In addition, the projected seasonal shift in precipitation and earlier runoff could see additional stress on natural and human systems in the summers of drought years. What is less certain, but probable, is the possibility for more frequent, longer-term or more severe droughts.

The need for water use limitations due to drought is not expected to happen often to Boulder's municipal water system given the city's diversified water rights portfolio that has a high degree of reliability. However, Boulder is in a semiarid climate, and drought is and will continue to be an expected part of the natural hydrologic cycle in the region.

4.2.4 Earthquakes

Hazard/Profile Description

An earthquake is caused by a sudden slip on a fault. Stresses in the earth's outer layer push the sides of the fault together. Stress builds up, and the rocks slip suddenly, releasing energy in waves that travel through the earth's crust and cause the shaking that is felt during an earthquake.

The actual movement of the ground in an earthquake is seldom the direct cause of injury or death. Casualties typically result from falling objects and debris, or from forces that damage or demolish buildings and other structures. Disruption of communications, electrical power supplies, and gas, sewer, and water lines should be expected in a large earthquake. Earthquakes can trigger widespread fires, dam failures, landslides, or releases of hazardous material, compounding their hazards.

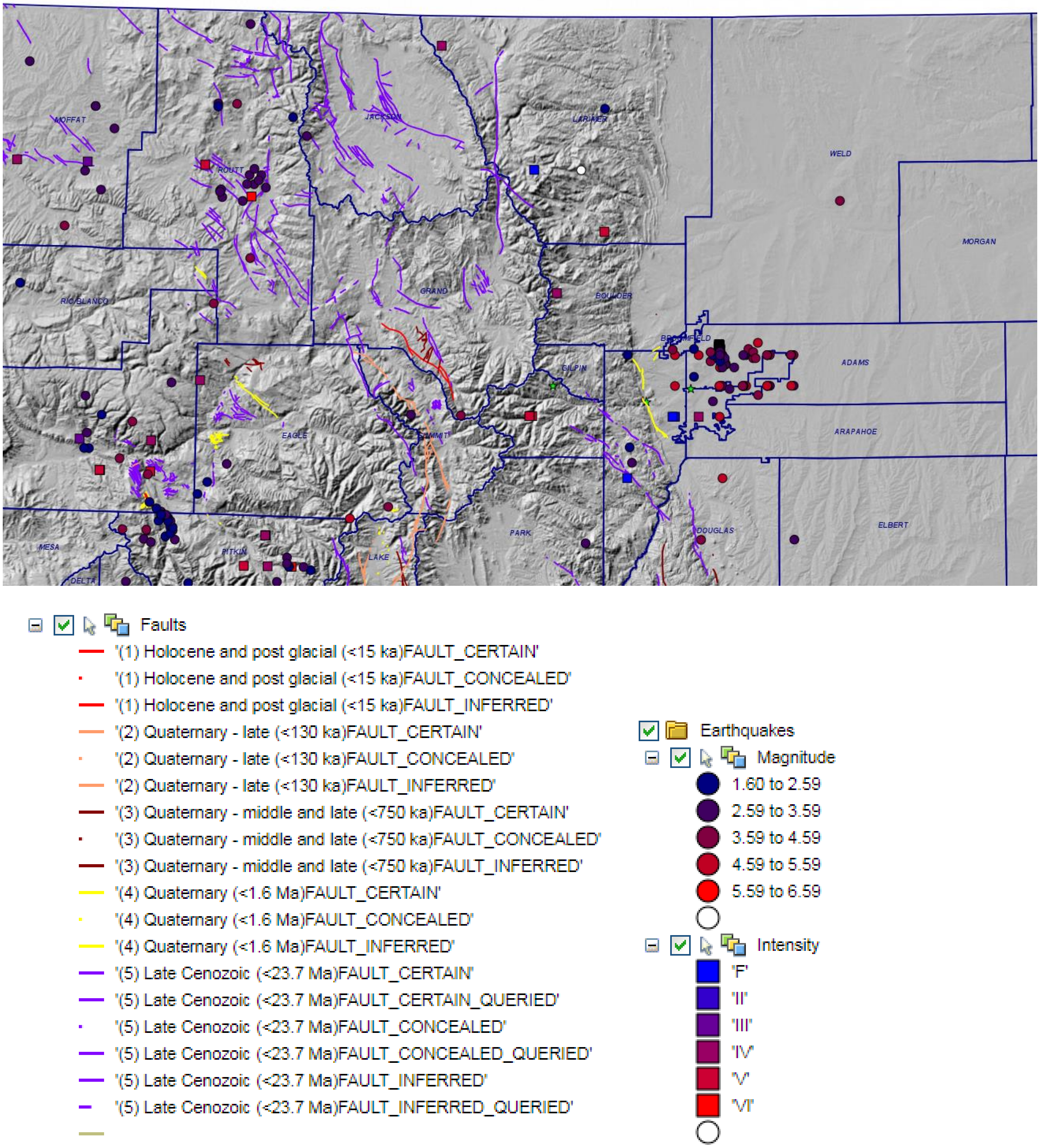
Earthquakes can cause structural damage, injury, and loss of life, as well as damage to infrastructure networks, such as water, power, communication, and transportation lines. Other damage-causing effects of earthquakes include surface rupture, fissuring, settlement, and permanent horizontal and vertical shifting of the ground. Secondary impacts can include landslides, seiches, liquefaction, fires, and dam failure.

Faults

A fault is defined as "a fracture or fracture zone in the earth's crust along which there has been displacement of the sides relative to one another." For the purpose of planning there are two types of faults, active and inactive. Active faults have experienced displacement in historic time, suggesting that future displacement may be expected. Inactive faults show no evidence of movement in recent geologic time, suggesting that these faults are dormant.

Colorado is considered a region of minor earthquake activity. Geologic studies indicate there are about 90 potentially active faults in Colorado with documented movement within the last 1.6 million years. Faults with evidence of movement during the past 130,000 years are often considered active faults. Faults that last moved between 130,000 and 2 million years ago may be considered potentially active. Locations of these faults are depicted on the map by the dark red-brown lines. Thousands of other faults exist in Colorado, but few have been studied in sufficient detail to determine their activity during the recent geologic past. Some of these faults also may be a potential concern. Figure 4.4 shows the location of faults and past earthquake epicenters in Colorado. Since earthquakes affect large areas the earthquake hazard extent within city limits is considered significant, potentially impacting 50-100% of the planning area.

Figure 4.4. Colorado Earthquake and Fault Map

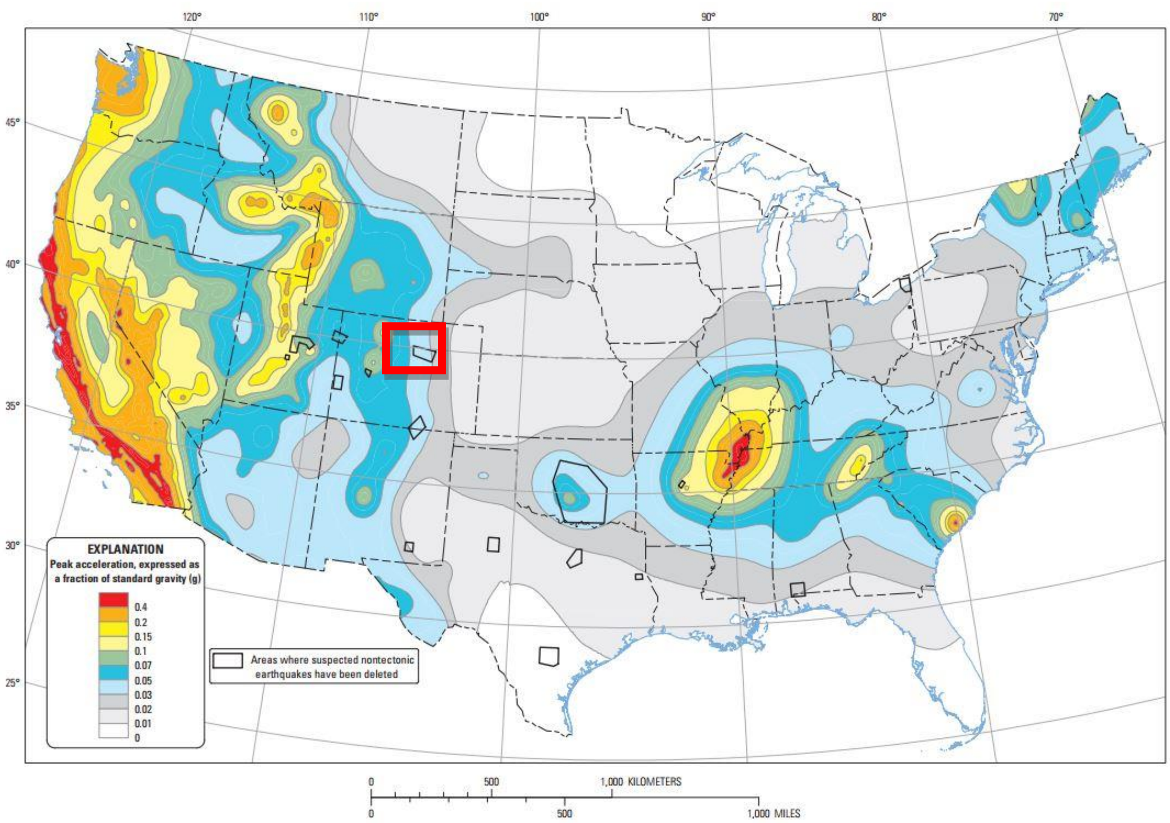


Source: Colorado's Earthquake and Fault Map, CGS 2017

The U.S. Geological Survey (USGS) issues National Seismic Hazard Maps as reports every few years. These maps provide various acceleration and probabilities for time periods. Figure 4.5

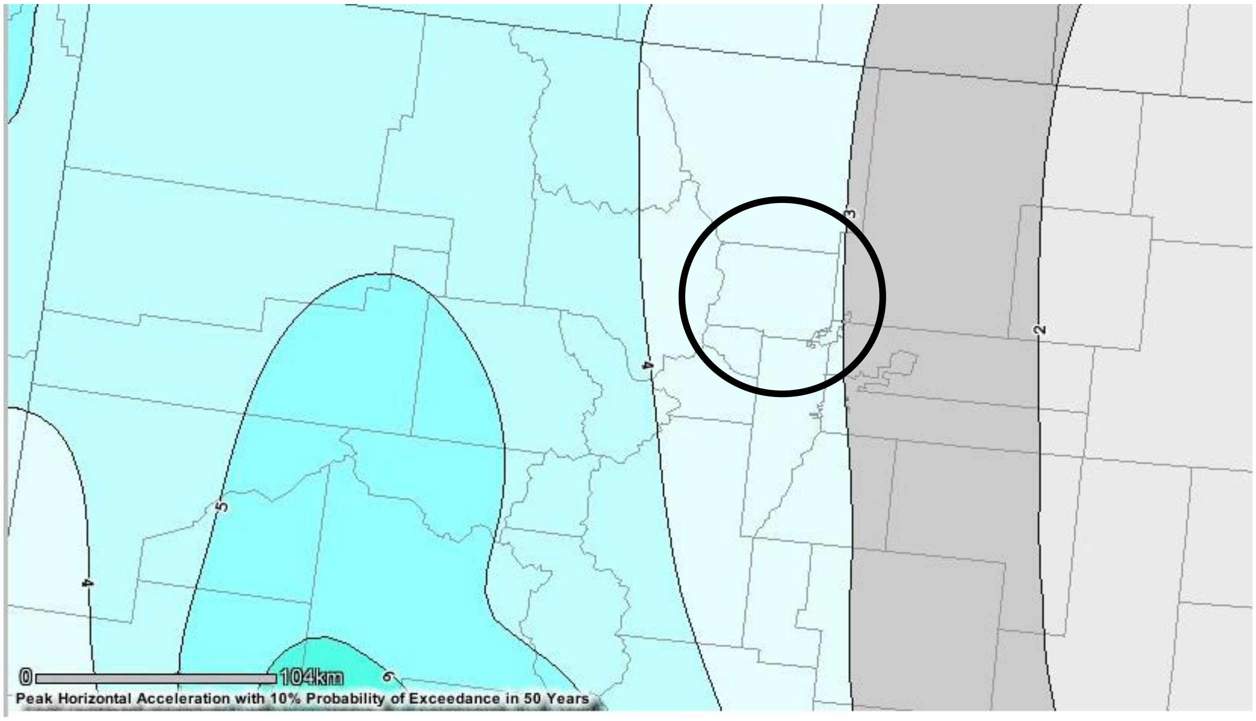
depicts the peak horizontal acceleration (%g) with 10% probability of exceedance in 50 years for the planning region. The figure demonstrates that the city falls in the 3%g area. This data indicates that the expected severity of earthquakes in the region is fairly limited, as damage from earthquakes typically occurs at peak accelerations of 30%g or greater. However, as demonstrated by the HAZUS modeling documented earlier, the potential, though remote, does exist for damaging earthquakes.

Figure 4.5. Peak Horizontal Acceleration with 10% Probability of Occurrence in 50 Years



Source: USGS National Seismic Hazard Maps – 2014 Long-term Model.

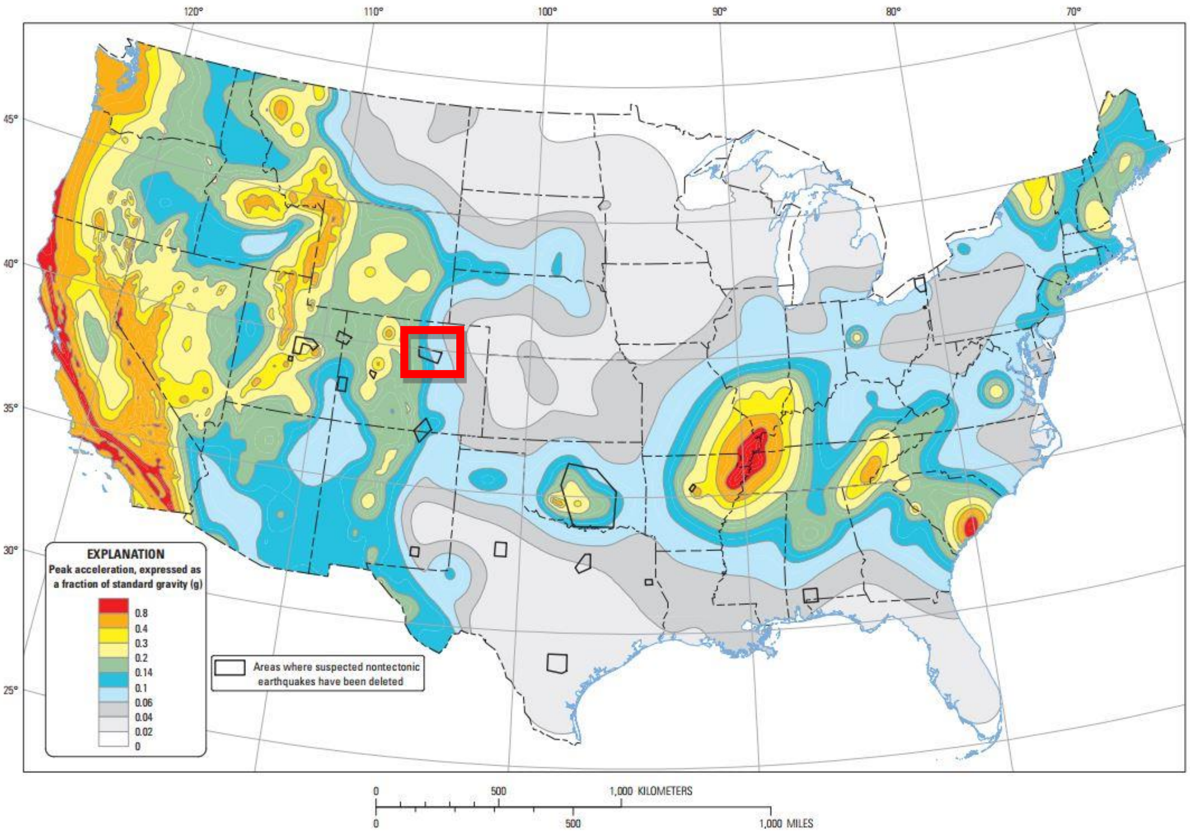
Figure 4.6. Peak Horizontal Acceleration with 10% Probability of Occurrence in 50 Years



Source: USGS National Seismic Hazard Maps – 2008 Interactive Tool.

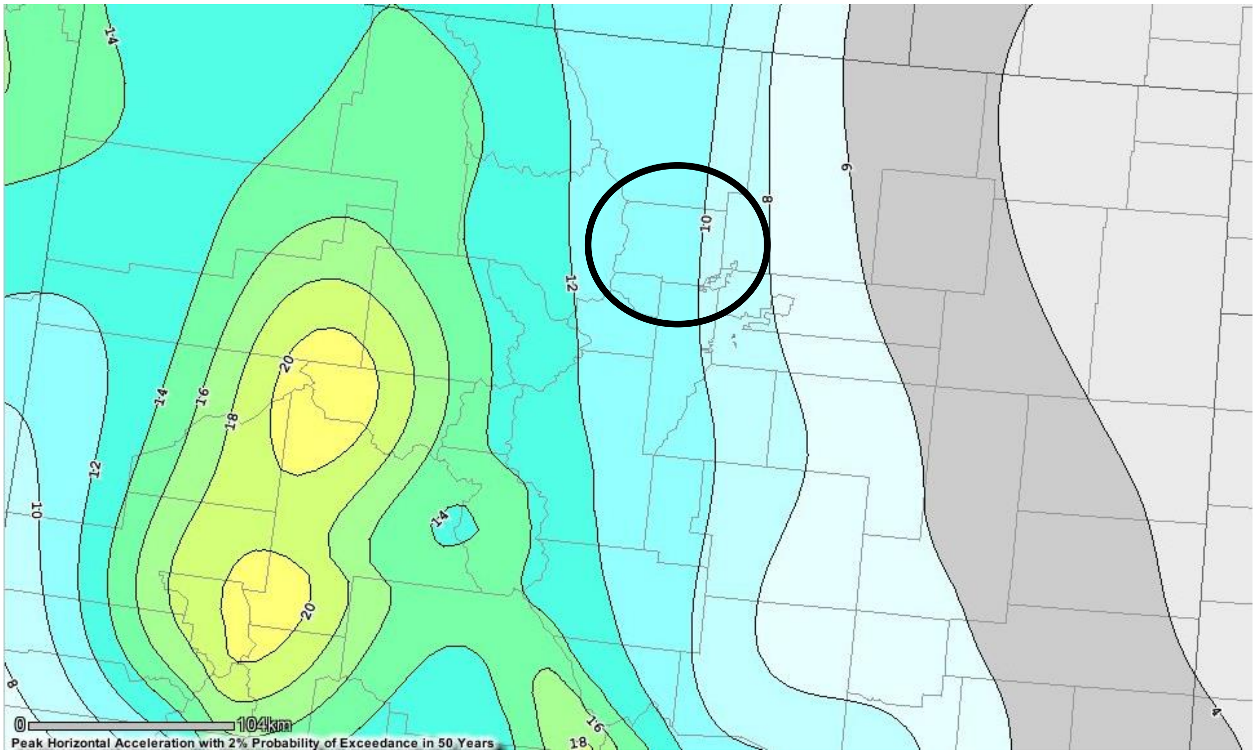
Figure 4.6 depicts the peak horizontal acceleration (%g) with 2% probability of exceedance in 50 years for the city. The figure demonstrates that the city falls in the 10-12%g area.

Figure 4.7. Peak Horizontal Acceleration with 2% Probability of Occurrence in 50 Years



Source: USGS National Seismic Hazard Maps – 2014 Long-term Model.

Figure 4.8. Peak Horizontal Acceleration with 2% Probability of Occurrence in 50 Years



Source: USGS National Seismic Hazard Maps – 2008 Interactive Tool.

The amount of energy released during an earthquake is usually expressed as a magnitude and is measured directly from the earthquake as recorded on seismographs. Seismologists have developed several magnitude scales; one of the first was the Richter Scale, developed in 1932 by the late Dr. Charles F. Richter of the California Institute of Technology. The Richter Magnitude Scale is used to quantify the magnitude or strength of the seismic energy released by an earthquake. This has since been replaced with Moment Magnitude.

Table 4.5. Richter Scale

Magnitude	Mercalli Intensity	Effects	Frequency
Less than 2.0	I	Microearthquakes, not felt or rarely felt; recorded by seismographs.	Continual
2.0-2.9	I to II	Felt slightly by some people; damages to buildings.	Over 1M per year
3.0-3.9	II to IV	Often felt by people; rarely causes damage; shaking of indoor objects noticeable.	Over 100,000 per year
4.0-4.9	IV to VI	Noticeable shaking of indoor objects and rattling noises; felt by most people in the affected area; slightly felt outside; generally, no to minimal damage.	10K to 15K per year

Magnitude	Mercalli Intensity	Effects	Frequency
5.0-5.9	VI to VIII	Can cause damage of varying severity to poorly constructed buildings; at most, none to slight damage to all other buildings. Felt by everyone.	1K to 1,500 per year
6.0-6.9	VII to X	Damage to a moderate number of well-built structures in populated areas; earthquake-resistant structures survive with slight to moderate damage; poorly designed structures receive moderate to severe damage; felt in wider areas; up to hundreds of miles/kilometers from the epicenter; strong to violent shaking in epicentral area.	100 to 150 per year
7.0-7.9	VIII<	Causes damage to most buildings, some to partially or completely collapse or receive severe damage; well-designed structures are likely to receive damage; felt across great distances with major damage mostly limited to 250 km from epicenter.	10 to 20 per year
8.0-8.9	VIII<	Major damage to buildings, structures likely to be destroyed; will cause moderate to heavy damage to sturdy or earthquake-resistant buildings; damaging in large areas; felt in extremely large regions.	One per year
9.0 and Greater	VIII<	At or near destruction - severe damage or collapse to all buildings; heavy damage and shaking extends to distant locations; permanent changes in ground topography.	One per 10-50 years

Another measure of earthquake severity is Intensity. Intensity is an expression of the amount of shaking at any given location on the ground surface based on felt or observed effects. Seismic shaking is typically the greatest cause of losses to structures during earthquakes. Intensity is measured with the Modified Mercalli Intensity Scale.

Table 4.6. Modified Mercalli Intensity (MMI) Scale

MMI	Felt Intensity
I	Not felt except by a very few people under special conditions. Detected mostly by instruments.
II	Felt by a few people, especially those on upper floors of buildings. Suspended objects may swing.
III	Felt noticeably indoors. Standing automobiles may rock slightly.
IV	Felt by many people indoors; by a few outdoors. At night, some people are awakened. Dishes, windows, and doors rattle.
V	Felt by nearly everyone. Many people are awakened. Some dishes and windows are broken. Unstable objects are overturned.
VI	Felt by everyone. Many people become frightened and run outdoors. Some heavy furniture is moved. Some plaster falls.
VII	Most people are alarmed and run outside. Damage is negligible in buildings of good construction, considerable in buildings of poor construction.
VIII	Damage is slight in specially designed structures, considerable in ordinary buildings, and great in poorly built structures. Heavy furniture is overturned.

MMI	Felt Intensity
IX	Damage is considerable in specially designed buildings. Buildings shift from their foundations and partly collapse. Underground pipes are broken.
X	Some well-built wooden structures are destroyed. Most masonry structures are destroyed. The ground is badly cracked. Considerable landslides occur on steep slopes.
XI	Few, if any, masonry structures remain standing. Rails are bent. Broad fissures appear in the ground.
XII	Virtually destruction. Waves are seen on the ground surface. Objects are thrown in the air.

Source: Multi-Hazard Identification and Risk Assessment, FEMA 1997

Extent

Earthquake magnitude/severity for the City of Boulder is considered **limited.** As shown in Figure 4.5, the shaking level that has a 10 percent chance of being exceeded over a period of 50 years is in the range of 10 to 12 percent peak acceleration in Boulder County. Significant earthquake damage typically does not occur until peak accelerations are greater than 30 percent.

Historical impacts cannot be used to identify an extent ranking for earthquakes. Earthquake vulnerability is primarily based upon population and the built environment. Urban areas in high hazard zones are the most vulnerable, while uninhabited areas are less vulnerable. Because the city is highly developed and serves as a major hub for employment and industry, there is an increased risk to Earthquake if an event were to occur. However, because the geologic conditions point to a low probability and low intensity event, the implications are less critical.

Common impacts from earthquakes include damage to infrastructure and buildings (e.g., crumbling of unreinforced masonry, failure of architectural facades, rupturing of underground utilities, gas-fed fires, landslides and rock falls, and road closures). Earthquakes also frequently trigger secondary effects, such as dam failures, explosions, and fires that can become disasters themselves.

Past Occurrences

Colorado's earthquake hazard and risk has historically been rated lower than most knowledgeable scientists in the state consider justified. As a result, local emergency managers are generally unaware of the size and consequences of an earthquake that could occur in the state. Most shocks in the history of Colorado have been centered west of the Rocky Mountain Front Range. The first seismographs in Colorado of sufficient quality to monitor earthquake activity were installed in 1962. Newspaper accounts are the primary source of published data for earthquake events before that time. The following is a summary of known earthquake activity in Colorado with a focus on the Boulder County region.

- **Since 1867**—More than 400 earthquake tremors of magnitude 2.5 or greater have been recorded in Colorado.

- **November 7, 1882**—On this day, the largest recorded earthquake in the state and the first to cause damage in Denver occurred. The epicenter is thought to have been located in the Front Range near Rocky Mountain National Park; the magnitude was estimated to be about 6.2 on the Richter scale. In Boulder County, the walls of the train depot cracked and plaster fell from walls at the University at Colorado. The earthquake was felt as far away as Salina, Kansas, and Salt Lake City, Utah.
- **1962-1967**—A series of earthquakes occurred in the Denver–Boulder area from 1962-1967. The earthquakes were felt by cities and towns within a 100-mile radius of Denver. Some people attribute this earthquake activity to deep-well injections conducted at the Rocky Mountain Arsenal starting in 1962. A few notable occurrences are detailed below.
  - **1965**—Shocks on February 16, September 29, and November 20 caused intensity VI damage in the Commerce City area.
  - **January 4, 1966**—A magnitude 5.0, intensity V earthquake occurred northeast of Denver.
  - **April 10, 1967**—The Colorado School of Mines rated this earthquake of magnitude 5.0. The earthquake broke 118 windowpanes in buildings at the Rocky Mountain Arsenal, cracked an asphalt parking lot in the Derby area, and caused school officials in Boulder to dismiss schools because of cracked walls. Legislators quickly moved from beneath chandeliers in the Denver Capitol Building, fearing they might fall.
  - **April 27, 1967**—Boulder sustained minor damage to walls and acoustical tile ceilings as a result of this magnitude 4.4 earthquake.
  - **August 9, 1967**—Located northeast of Denver, this magnitude 5.2, intensity VI earthquake caused more than $1 million in damage and is considered the most economically damaging earthquake in Colorado history.
  - **November 27, 1967**—A magnitude 5.1, intensity VI earthquake occurred northeast of Denver.
- **Since 1971**, there have been 12 to 15 earthquakes located north and northeast of Denver that were large enough to be felt in the City of Boulder.

Likelihood of Future Occurrences

***Occasional**:* Because the occurrence of earthquakes is relatively infrequent in Colorado and the historical earthquake record is short (only about 144 years), it is not possible to accurately estimate the timing or location of future dangerous earthquakes in Colorado. Seismologists predict that Colorado will again experience a magnitude 6.5 earthquake at some unknown point in the future. The major factor preventing the precise identification of the time or location of the next damaging earthquake is the limited knowledge of potentially active faults.

Climate Change Considerations

Climate change is not likely to have direct impact of on the frequency and severity of earthquakes.

4.2.5 Floods

Hazard/Problem Description

Floods can be among the most frequent and costly natural disaster in terms of human hardship and economic loss and can be caused by many different weather events. Floods can cause injuries and deaths and substantial damage to structures, landscapes, and utilities. Certain health hazards are also common to flood events. Standing water and wet materials in structures can become a breeding ground for microorganisms such as bacteria, mold, and viruses. This can cause disease, trigger allergic reactions, and damage materials long after the flood. Direct impacts such as drowning can be limited with adequate warning and public education about what to do during floods. Where flooding occurs in populated areas, warning and evacuation will be critical to reduce life and safety impacts. Communities in Boulder County, including the City of Boulder, are susceptible to several types of flood events as described herein.

Riverine or Overbank Flooding

This type of flooding is defined as when a watercourse exceeds its "bank-full" capacity and is usually the most common type of flood event. Riverine flooding generally occurs because of prolonged rainfall, or rainfall that is combined with soils or drainage systems that are already saturated or overloaded from previous rain events. The duration of riverine floods may vary from a few hours to several days.

Factors that directly affect the amount of flood runoff include precipitation amount, intensity, and spatial and temporal distribution; the amount of soil moisture; seasonal variation in vegetation; snow depth; and the water resistance of the surface due to urbanization. Other factors, such as debris blocking a waterway or channel, can further aggravate a flood event. In Boulder, development has altered the natural environment, changing and interrupting some of the natural drainageways. As a result, drainage systems can become overloaded more frequently.

The most serious overbank flooding occurs during flash floods that result from intense rainstorms or following a dam failure. The term "flash flood" describes localized floods of great peak flow and magnitude and short duration. In contrast to riverine flooding, this type of flood usually results from a heavy rainfall on a relatively small drainage area. Flash floods occur very quickly and may occur with little or no warning.

Irrigation Ditches/Canals Flooding

The eastern portion of Boulder County has more than 100 irrigation ditches and canals used to convey water collected in the mountain reservoirs to downstream users. Ditches convey irrigation water along hillsides, following contours and, as a result, cut across the natural drainage pattern of stormwater runoff flowing down hillsides. Although efforts are made to separate stormwater runoff and irrigation water, excessive runoff can flow into an irrigation ditch causing overbank flooding or a collapse of the ditch itself. Like flash floods, there is often little warning for these types of events.

Stormwater Drainage Flooding

Urban and stormwater drainage floods typically occur due to the development of land from open or natural areas to buildings, roads and parking lots, which cause the land to lose its ability to absorb rainfall. Urbanization increases runoff two to six times over what would occur on natural terrain. Except at underpasses, street flooding and yard ponding usually do not exceed more than a foot or two and are often viewed more as a nuisance than a major hazard. However, during periods of urban flooding, high velocity flows can occur in streets, even in areas with only shallow flooding.

The city's stormwater collection system consists of a variety of storm sewers and open drainage ditches that collect water and divert it to major drainageways. Irrigation ditches collect stormwater in many places in the city. Depending on the amount of rainfall, stormwater flows may exceed ditch capacity and spill out in an uncontrolled manner. Additionally, runoff may flow into the City's sanitary sewer system, leading to blockages for residents, as well as strain the City's Waste Water Treatment Plant. In the past, an overloaded sanitary sewer system has resulted in blown sewer manholes. Figure 4.14 and Figure 4.15 show the locations of storm sewer mains greater than 24-inches in diameter and irrigation ditches within the city's stormwater system, respectively.

The City of Boulder, in coordination with the Urban Drainage and Flood Control District, controls urban and street flood events with a storm drain system. The Urban Storm Drainage Criteria Manual Volume 3 lays out a four-step process for the City of Boulder to help reduce flooding: Employ Runoff Reduction Practices; Implement Best Management Practices that Provide a Water Quality Capture Volume (WQCV) with Slow Release; Stabilize Drainageways; and Implement Site Specific and Other Source Control BMPs. The Criteria Manual recommends storm water collection design to handle the 2 to 10-year event for all land uses. A basic policy of the District, and city, is that major drainage systems, regardless of type, should be capable of conveying water without flooding buildings and remain relatively stable during the major runoff event (e.g., the 100-year flood) and be based on fully urbanized conditions.

Floodplains

The area adjacent to a channel is the floodplain. Floodplains are illustrated on inundation maps like those in Figure 4.13, which show areas of potential flooding and water depths. In its common usage, the floodplain most often refers to that area that is inundated by the 100-year flood, the flood that has a 1- percent chance in any given year of being equaled or exceeded. The 100-year flood is the federal minimum standard to which communities regulate their floodplains through the National Flood Insurance Program. Specific to the City of Boulder, the following floodplain zones:

- **Conveyance (Floodway) Zone**—All areas in the floodplain that would be required for the passage of the entire flood flow (measured in cubic feet per second) resulting from the encroachment (or blocking out) of the floodplain from the edges, allowing no greater than a maximum six-inch increase in the depth of flood waters. (The floodway zone is usually a narrowed corridor within the floodplain.) This floodway zone definition is more restrictive than that used by FEMA, which allows a maximum one-foot increase in floodwater depth. The State of Colorado floodplain rules now require only a six-inch increase allowance.
- **High Hazard Zone**—All areas in the floodplain where floodwater depth would equal or exceed four feet (or where the product number of the floodwater velocity (in feet per second) multiplied by the floodwater depth (measured in feet) would equal or exceed four). Because of life safety concerns, development in the high hazard zone is the most restricted.
- **Flood Fringe**—Those portions of the floodplain that are not in the conveyance zone or in the high hazard zone.

Also of concern to the City of Boulder is the 500-year flood. The 500-year flood is the flood that has a 0.2 percent chance of occurring in any given year. This is also shown as 'Shaded Zone X' on FEMA flood maps.

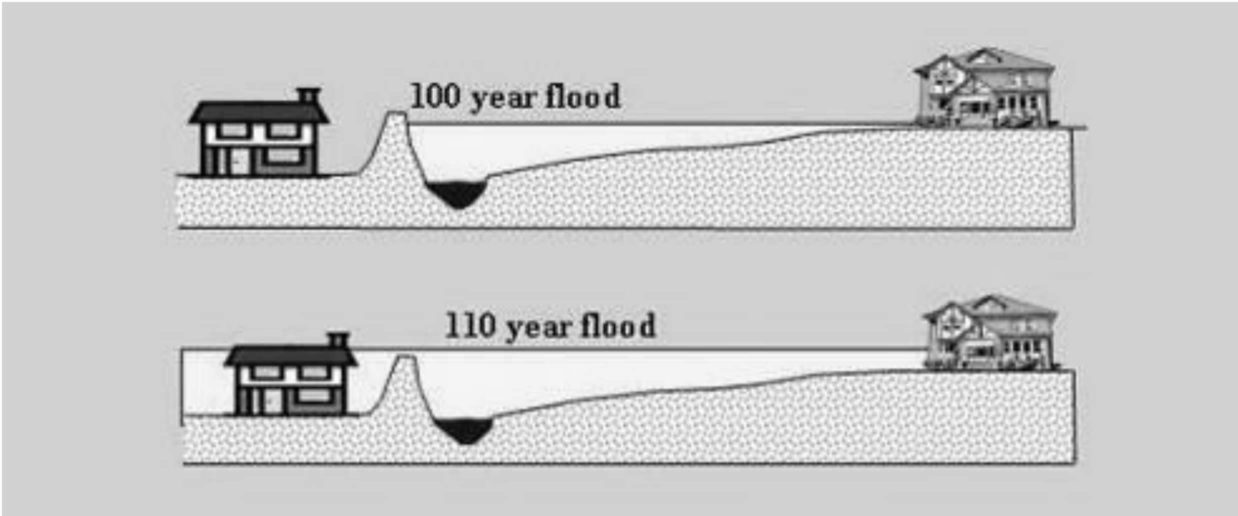
Levee Failure

A levee is a type of dam that runs along the banks of a river or canal. Levees reinforce the banks and help prevent flooding. By confining the flow, levees can also increase the speed of the water. Levees can be natural or man-made. A natural levee is formed when sediment settles on the river bank, raising the level of the land around the river. To construct a man-made levee, workers pile dirt or concrete along the river banks, creating an embankment. This embankment is flat at the top, and slopes at an angle down to the water. For added strength, sandbags are sometimes placed over dirt embankments.

Levees provide strong flood protection, but they are not failsafe. Levees are designed to protect against a specific flood level and could be overtopped during severe weather events. Levees only reduce the risk to individuals and structure behind them, they do not eliminate risk.

Unfortunately, in the rare occurrence when a levee system fails or is overtopped, severe flooding can occur due to increased elevation differences associated with levees (see Figure 4.9) and the increased water velocity that is created. It's also important to remember that no levee provides protection from events for which it was not designed, and proper operation and maintenance are necessary to reduce the probability of failure.

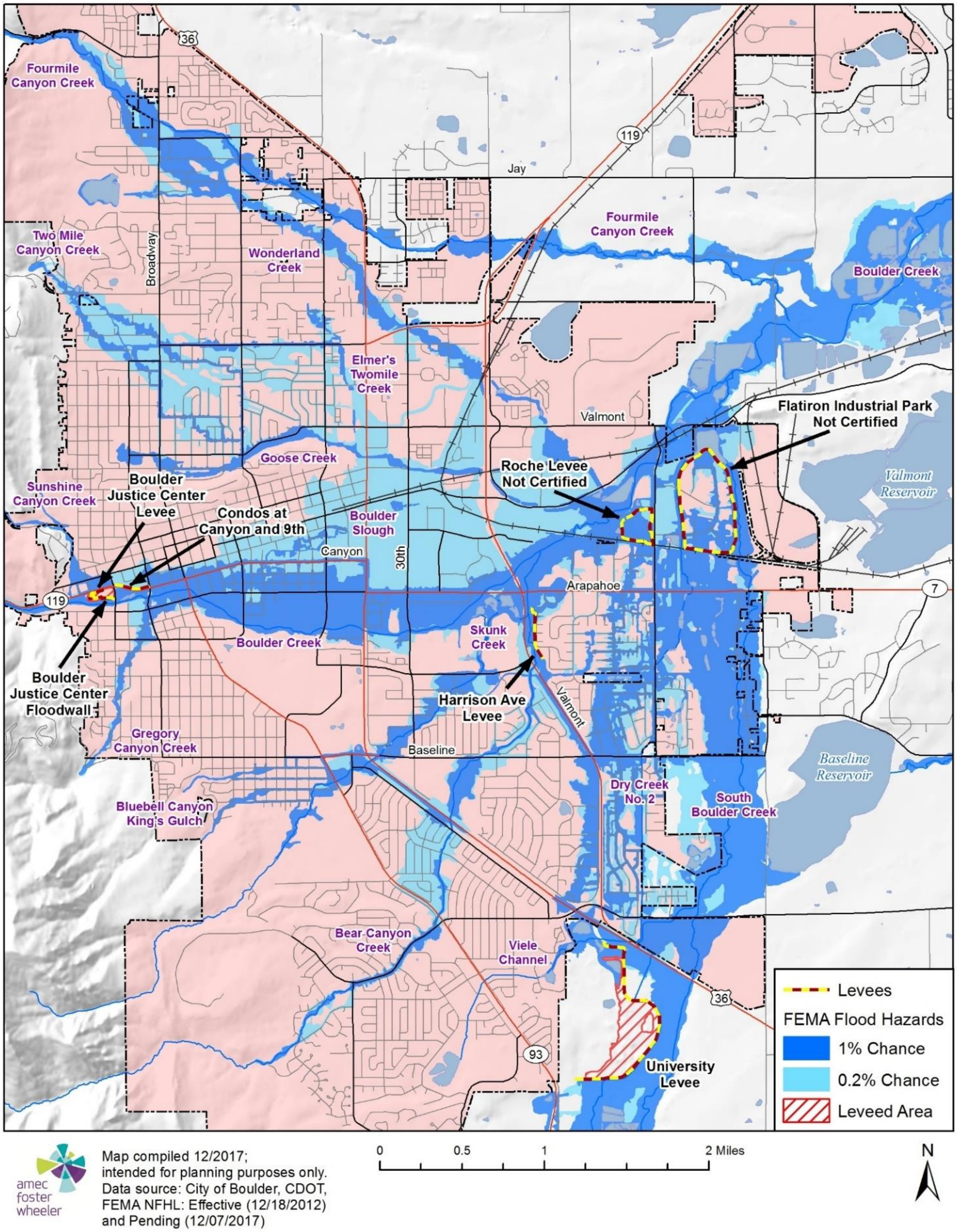
Figure 4.9. Flooding from Levee Overtopping



Source: Levees in History: The Levee Challenge. Dr. Gerald E. Galloway, Jr., P.E., Ph.D., Water Policy Collaborative, University of Maryland, Visiting Scholar, USACE, IWR.
http://www.floods.org/ace-files/leveesafety/lss_levee_history_galloway.ppt

The current DFIRMs identify both those levees that have been fully accredited as providing protection from the 100-year flood and those included on the DFIRMs as Provisionally Accredited Levees (PAL). To best address the issue of levees in the DFIRM process, FEMA provided guidance for the issuance of PAL agreements that would allow for identified levees to be provisionally accredited for purposes of mapping while communities/levee owners are compiling and submitted data and documentation necessary for full accreditation. Fully accredited, PAL designated, and uncertified levees are identified are shown on Figure 4.1 provided in Section 4.3.2 of this document.

Figure 4.10. City of Boulder Levees



Major Sources of Flooding and Flooding Extent

Boulder County has multiple creeks, tributaries, and associated watersheds. The City of Boulder is situated in a region that drops in elevation dramatically from the western foothills at approximately 5,600 feet to the western plains with elevations near 5,200 feet, where excess rain and snow can contribute to downstream flooding. According to data in the 2004 Comprehensive Flood and Stormwater Utility Master Plan, the city is generally split by the west to east flow direction of the main stem of Boulder Creek. The Boulder Creek watershed encompasses 440 square miles and extends from the Continental Divide to the high plains east of the city. Based on this information, the geographic extent rating flooding in the city of Boulder is extensive.

Boulder is crossed by 15 major drainageways or creeks. The primary drainageway through the city is Boulder Creek with its headwaters at the Continental Divide near Arapahoe Pass and Diamond and Jasper Lakes. The tributary drainageways all eventually feed into Boulder Creek north of the Valmont Reservoir. Each of the watersheds for the respective drainages is highly urbanized as a result of the "built-out" condition of the study area. As such, the natural hazards related to stormwater and flood management are particularly complicated by the fact that space is at a premium and thus many structures are within the floodplain.

All drainageways are subject to periodic flooding. The following major drainageways are depicted in Figure 4.11 and the city's basins are shown in Figure 4.12:

- Bear Canyon Creek
- Bluebell Canyon/King's Gulch
- Boulder Creek
- Dry Creek
- Dry Creek Ditch No.2 (part of the South Boulder Creek floodplain)
- Elmer's Twomile Creek
- Fourmile Canyon Creek
- Gregory Canyon Creek
- Lower Boulder Creek
- Skunk Creek
- South Boulder Creek
- Sunshine Canyon Creek
- Twomile Canyon/Goose Creek
- Viele Channel
- Wonderland Creek

Figure 4.11. City of Boulder Major Drainageways

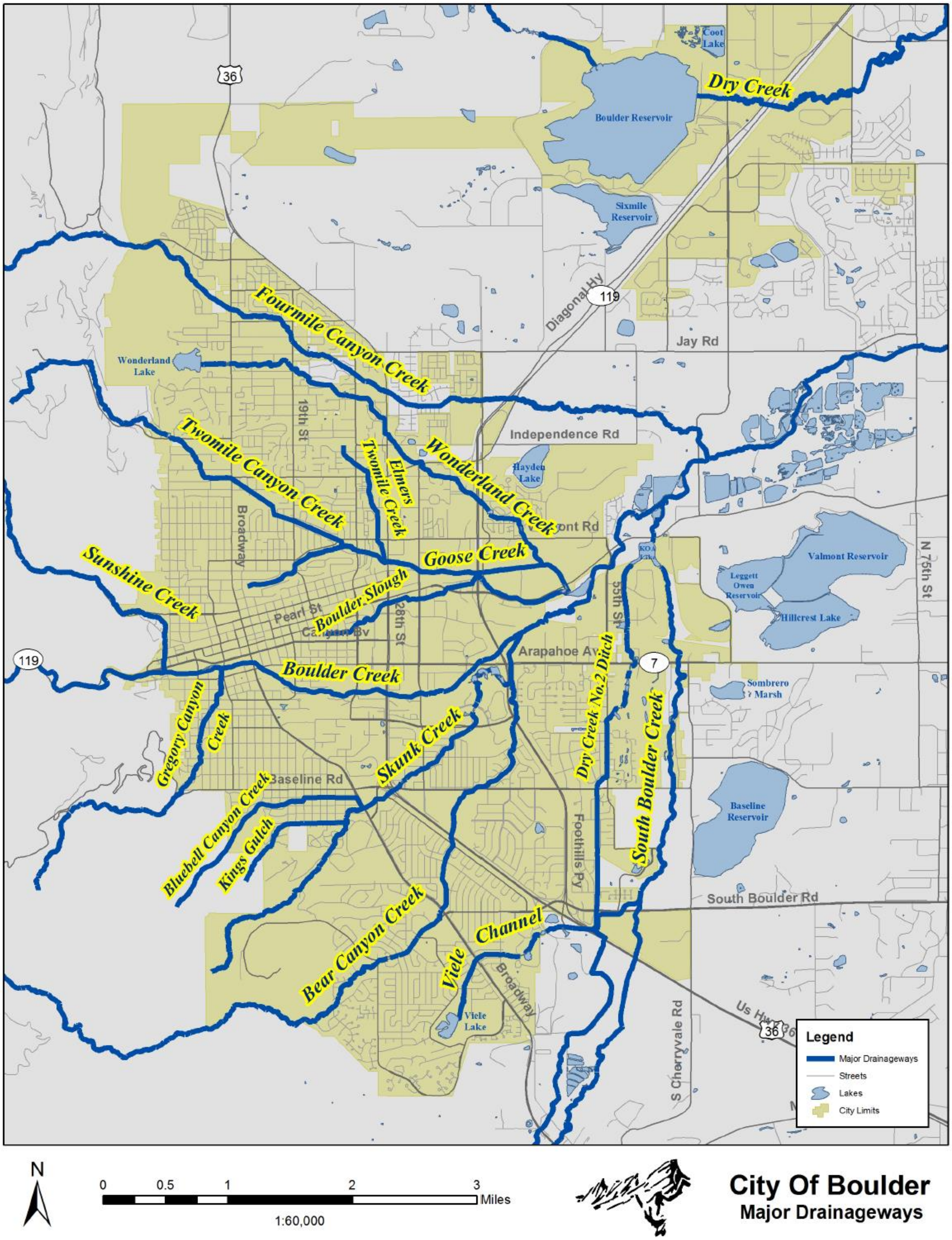
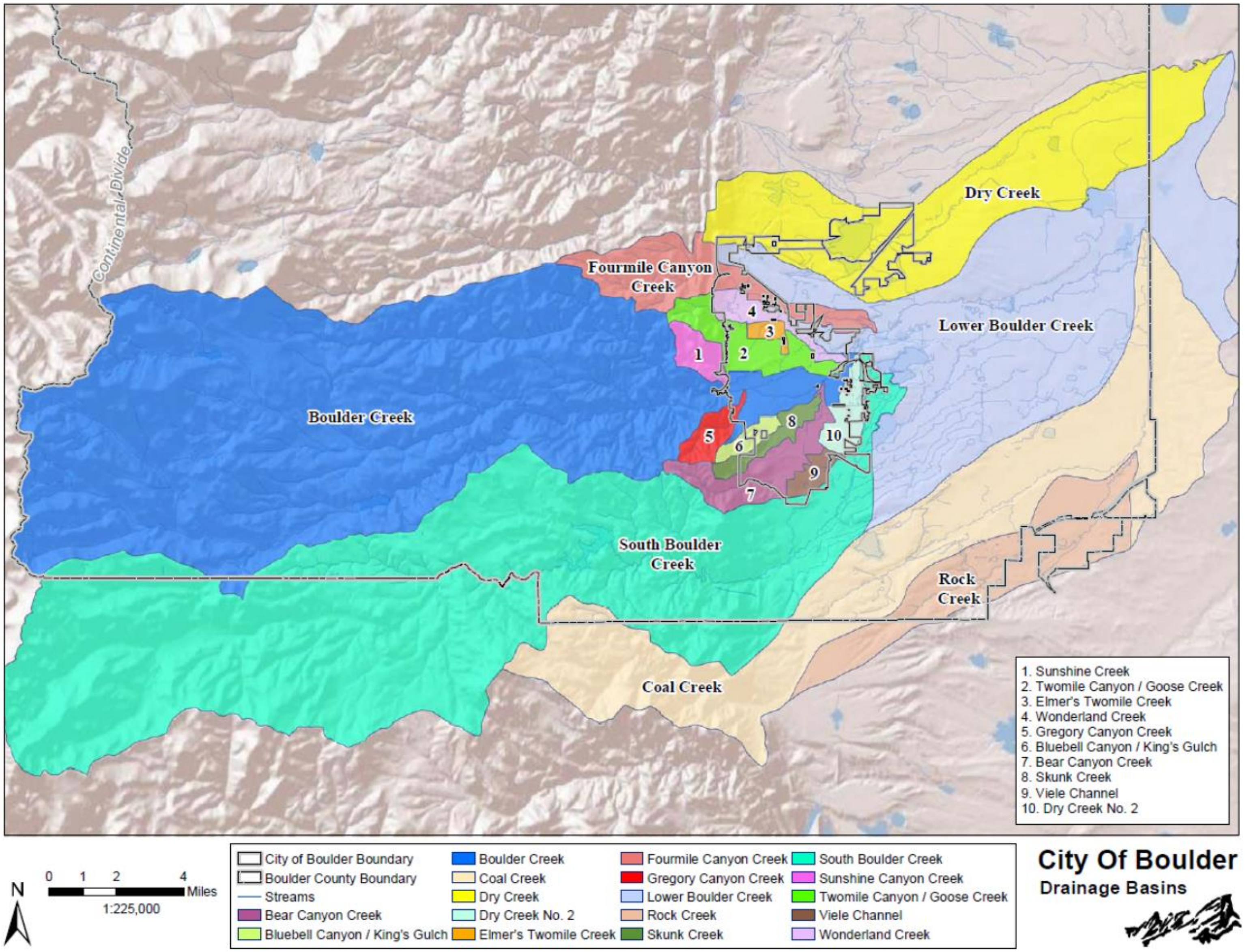


Figure 4.12. City of Boulder Basins



Source: City of Boulder GIS

The state considers Boulder to be the city with the highest flood risk in Colorado. Its location at the base of the foothills of the Rocky Mountains makes it vulnerable to flash flooding that can occur with little or no warning (2004 Comprehensive Flood and Stormwater Utility Plan). Within the city, two types of flooding are of concern: flash flooding that is likely to result in damage to property and life-safety issues and stormwater drainage flooding, which results from more frequent minor storm events that occur every year but are less damaging in nature.

According to the HMPC and a flood vulnerability assessment detailed later in Section 4.3 the drainages in the City of Boulder that are most likely to experience the most damaging flooding based on total structure and content exposure values are:

- Boulder Creek ($2.18B)
- Dry Creek No. 2 ($887.7M)
- Twomile Canyon/Goose Creek ($287.9M)
- Skunk Creek ($246.2M)
- Wonderland Creek ($205.8M)

Of the 15 major drainageways, 100-year floodplain boundaries cover more than 15 percent of the lands inside the city limits, which falls within the geographic extent rating of significant (10-50% of the area affected). Figure 4.13 illustrates the city's mapped flood hazard areas. The areas likely to flood are based on mapping that assumes future build-out conditions. Flood hazard areas periodically change to reflect improved and updated mapping techniques as well as areas that may have been altered by flood mitigation projects, typically reflected in the development of Conditional Letters of Map Revision (CLOMR) or Letters of Map Revision (LOMR).

Figure 4.13. City of Boulder Flood Hazards

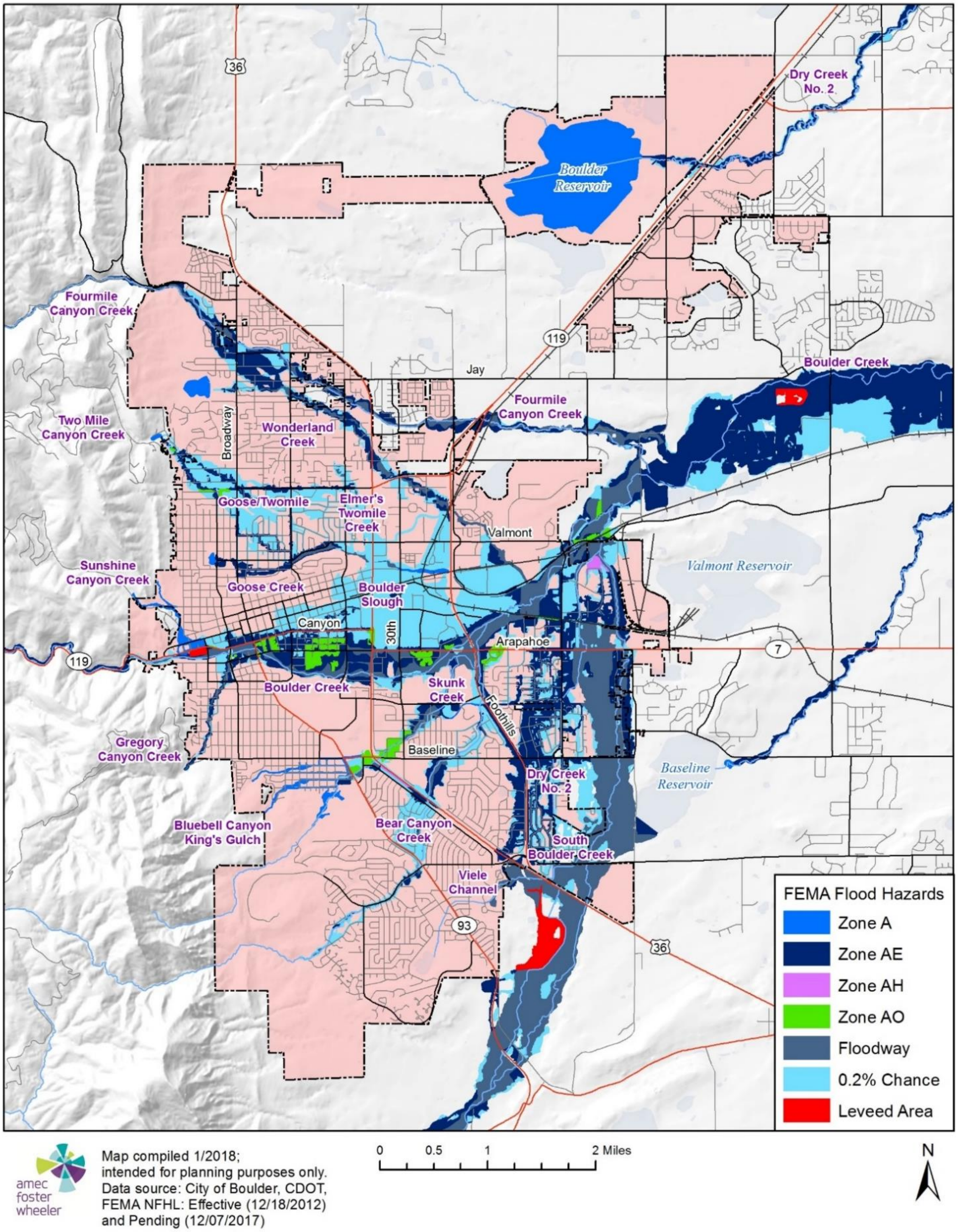


Figure 4.14. City of Boulder Storm Sewer Mains

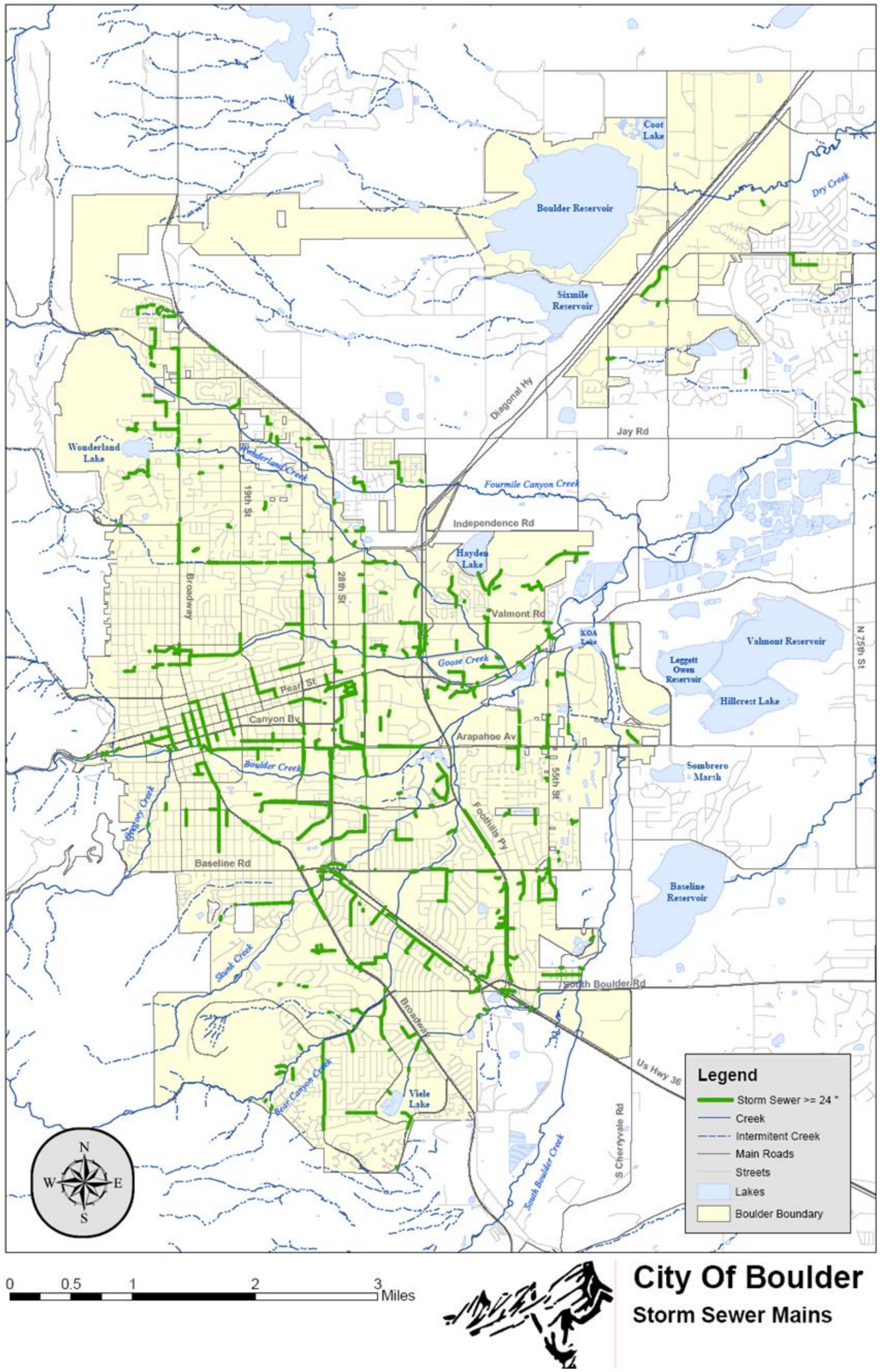
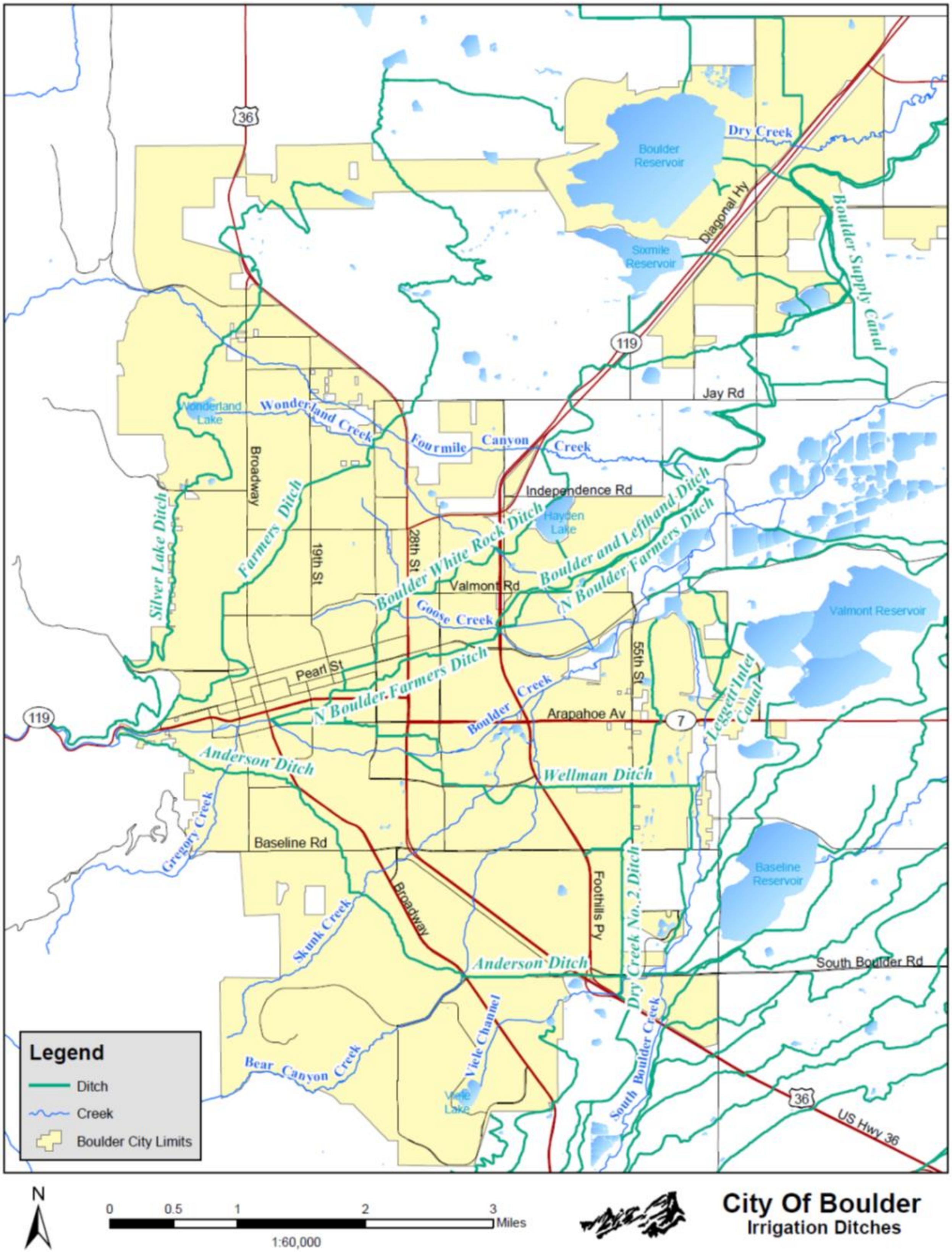


Figure 4.15. City of Boulder Irrigation Ditches



Past Occurrences

The official flood season in Boulder County and the City of Boulder is April 15 through September 15, but floods can happen at any time. Historically, the most frequent mountain stream flooding occurs in May and June when snowmelt increases runoff. However, the most dangerous flooding in Boulder seems to occur from late June through early September due to heavy precipitation from thunderstorms. Creeks with mountainous, upstream watersheds are subject to flash floods as are urban streams and drainageways. Colorado's worst flash flood occurred on July 31, 1976, in the Big Thompson Canyon west of Loveland, claiming over 400 houses and 144 lives.

Major flooding events recorded within Boulder County and along the Front Range include the following detailed by area/drainage:

Boulder Creek

Boulder Creek has a long history of severe flooding:

- **May 23, 1876**—A general storm over the Boulder Creek basin created flooding on the plains of Boulder County up to one and a half miles wide.
- **May 29 to June 2, 1894**—This flood, caused by a downpour, washed away much of Boulder's downtown. Mountain rainfall, combined with snowmelt runoff, produced the greatest flood known in Boulder and inundated the valley. Bridges, buildings, roads, and railroads were washed away. Every bridge in Boulder Canyon was swept away destroying the highway and railroads as far up the canyon as Fourmile Canyon Creek. Buildings were destroyed at Crisman, Sunset, and Copper creeks. The town was isolated from other Colorado communities for five days. Only one person was killed. Records indicate that the floodplain was inundated by water over an area as much as one-mile wide for several days. Floodwater covered the entire area between Canyon Boulevard (previously Water Street) and University Hill to depths as great as eight feet. The rainfall amount has been estimated at 5.5 inches. Computations made 18 years later produced estimates of the peak discharge ranging from 9,000 cubic feet per second (cfs) to 13,600 cfs. This was considered a slow-rising flood and designated as a 100-year event. Agricultural damage included loss of livestock, crops, pastures, fences, and roads, and the deposition of sand and silt on floodplain lands. Although damage was extensive, a dollar amount was not estimated at that time.

Source: City of Boulder

- **July 8, 1906**—Heavy rains over Sunshine Canyon (an estimated 2.8 inches Saturday night through Sunday) led to extensive flooding. The water spread out at the point where the dry gulch comes into Pearl Street, rushed down through gardens at the corner of Third Street, through Pearl, and down into Walnut and Railroad streets. Vast quantities of sand and debris were deposited on lawns and gardens. Water stood two-feet deep on the platform at the Colorado and Southern passenger depot and the yards were so flooded that the tracks were not visible. By building a temporary wall at Third Street, people could direct the water in its natural channel across Pearl and down into Boulder Creek. The flooding did considerable damage to the Silver Lake ditch, which broke and contributed a considerable quantity of water to the flood and affected the west part of town.

- **June 1-2, 1914**—The peak discharge on the creek was estimated at 5,000 cfs. Numerous bridges were washed out between Colburn Mill and Boulder Falls. A portion of the main line for Boulder's water system was destroyed.
- **June 2-7, 1921**—Rainfall totaled 3.36 inches in Boulder. A peak discharge of 2,500 cfs was recorded on June 6, 1921.
- **September 4, 1938**—A maximum discharge of 4,410 cfs occurred near the mouth of Boulder Creek. Numerous bridges were destroyed.
- **May 6-8, 1969**—This flood was the result of a combination of snowmelt in the mountains and four days of continuous rainfall. Total precipitation for the storm amounted to 7.6 inches in Boulder and 9.3 inches at the hydroelectric plant in Boulder Canyon. Bear Canyon Creek, Skunk Creek, and Twomile Canyon Creek overflowed their banks. Damage from this storm was estimated at $325,000. Schools were closed. The gaging records show that floods the size of the May 1969 flood occur on an average of about once every five years on Boulder Creek. The picture at right shows the damage at Bear Canyon Creek.

Source: City of Boulder

- **September 11-18, 2013-** Three days of rain saturated the ground prior to September 11,2013 causing surface runoff and landslides/debris flows throughout Boulder county. The rainfall totals during this event delivered 17 inches causing wide spread flooding. Boulder Creek drainage had 8 inches of rain over this period and sustained approximately 5500 cfs causing localized flooding along the creek and student housing on CU campus. Additionally, South Boulder Creek drainage had 17 inches of rain over this period. See description in 2013 Flood Season section.

Source: City of Boulder

South Boulder Creek

- **September 2, 1938**—In the mountains west of Eldorado Springs, six inches of rain fell resulting in flooding that destroyed many buildings in the Eldorado Springs community and exceeded previous flood records dating back to 1895. Eldorado Springs recorded 4.4 inches of rainfall. This resulted in a peak discharge of 7,390 cfs, which is the highest recorded flood on

South Boulder Creek. The picture at right shows the destroyed dancehall at the Eldorado Springs Resort.

- **May 7, 1969**— A HDR Hydrology/Climatology Report described this event as a long duration, low intensity general rain. This storm was widespread across the basin and resulting in up to 13 inches of rain over 72 hours. Flood flows at US-36 backed up and eventually overtopped the highway, spreading into the West Valley.
- **September 11-18, 2013-** See description in 2013 Flood Season section.

Fourmile Canyon Creek

Fourmile Canyon Creek experiences occasional flooding with notable events occurring in 1916, 1941, and 1951. Railroad bridges were washed out in 1916 and 1941. Localized flooding along the lower reaches of Fourmile Canyon Creek occurs frequently. Damage and losses have generally been low because the area is undeveloped.

- **July 23, 1909**—Heavy rains caused two injuries and two deaths as flash flooding occurred in Twomile Canyon and Fourmile Canyon creeks northwest of Boulder. Damage to bridges and pipelines also resulted. Boulder Creek was not highly affected.
- **July 30, 1916**—Heavy rain (one to three inches) centered over Fourmile Canyon caused a brief but strong flash flood causing flooding of farms and damage to roads, railroad, bridges, and irrigation ditches. Though the Folsom Street (then 26th Street) bridge crossing was covered with three feet of water, it was not damaged by the flood. The flood water was from 10 to 12 feet deep on the Terry ranch. Damage was estimated at several thousand dollars (1916).
- **July 2-7, 1921**—Flooding in Coal Creek and Fourmile canyons occurred destroying numerous structures, injuring and killing livestock, and damaging bridges. The maximum recorded rainfall was 5.3 inches and the greatest recorded rainfall intensity was 4.3 inches in six hours at Longmont. This flood was produced by a combination of rainfall and snowmelt.
- **September 11-18, 2013-** In Fourmile Creek 8 inches of rain fell over this period and sustained approximately 1,000 cfs.

Goose Creek

Significant flooding occurred in September 1951 and July 1954. The 1954 event damaged an addition to the community hospital that was under construction.

Twomile Canyon Creek

- The worst flood on Twomile Canyon Creek occurred in September 1933. Other flooding events occurred in 1909 (see Fourmile event above), 1941, 1942, 1949, and 1965.
- **September 11-18, 2013-** See description in 2013 Flood Season section; Goose Creek flooded homes and overtopped roads in the area.

Miscellaneous

- **August 19, 1896**—A cloudburst over Magnolia tore up the road beyond Salina and made Fourmile Canyon Creek impassable. Considerable damage was done to property in Salina. According to reports, "Boulder has not had such a dashing rain storm as that of yesterday afternoon for a long time." The lightning burned out the telephone of the *Daily Camera* office. The rise of the creek in the south part of town was so rapid and of such threatening proportions as to cause great anxiety for two or three hours to the people living in that section.
- **July 31, 1929**—Nearly five inches of rain fell causing flooding in Fourmile Creek, Boulder Creek, and South Boulder Creek. Water ran in streams down Boulder streets and across University Hill lawns and sidewalks. Damage was estimated at $4,000 to roads, bridges, and culverts in Boulder. Principal damage was on 10th Street from Chautauqua to University Avenue and 12th Street from University Avenue to Arapahoe. A large section of the Armstrong Bridge in Gregory Canyon was washed out and 150 feet of Baseline Road in front of the Chautauqua golf course was covered with rock and gravel. A cement sidewalk across Gregory ditch on Marine Street was washed out.
- **June 22, 1941**—Heavy rains caused flooding in areas of Fourmile Canyon Creek, St. Vrain Creek, Twomile Canyon Creek, and Boulder Creek. Flash floods swept a Longmont man to his death. The storm dropped one inch of rain in Boulder and more to the north and west. Roads, gullies, and some structures were damaged in several areas. Damage estimates were in the thousands of dollars (1941). The storm was centered over Sugarloaf Mountain just west of Boulder and primarily affected Fourmile and St. Vrain canyons. Numerous roads were partially or completely destroyed, most west and north of Boulder.
- **May of 1995**—Boulder received record rainfall (9.4 inches) that combined with above average snowfall in the mountains and caused flooding throughout Boulder County. Boulder Creek ran at its highest level of the year, but did not overtop its banks within the city limits. The biggest threat was a related mudslide at the base of Flagstaff Road that threatened six homes.
- **July 20, 1990**—A thunderstorm caused localized flooding in the City of Boulder. Bear Canyon Creek in the Table Mesa area overflowed its banks. Large rocks tumbled down onto Highway 119 at the mouth of Boulder Canyon.
- **June 1993**—Heavy rain caused low-lying flooding and Boulder Creek overflowed its banks onto the creek path where it passes under Broadway. Heavy rain fell in the mountains near Ward and Nederland. Rockslides were reported on Flagstaff Road. The storm dumped 2½ inches of rain in two days in Boulder County, setting records for rainfall and cool temperatures.
- **August 1994**—A severe thunderstorm accompanied by heavy rain caused street flooding in the Cities of Boulder and Longmont. In Boulder, rivers of water more than a foot deep were reported along Canyon Boulevard, Valmont Road, and Folsom Street. On 17th street between Canyon and Arapahoe, the rushing water washed out part of the street creating a deep pit. Lyons was hit the hardest and suffered the most damage. A gas main burst when street flooding caused the road to collapse. Power outages occurred, and many trees were blown down.
- **July 30, 1997**— Heavy rain and hail triggered a flash flood that sent a wall of water through the window of the financial aid office at the University of Colorado (CU). A pipe draining

rainwater at the Coors Event Center broke and damaged ceiling tiles, carpets, and dressing rooms. In all, 10 CU buildings received water damage estimated at a total of $100,000.

- **August 4, 1999**—Flooding and flash flooding problems developed over portions of the Front Range urban corridor as slow-moving thunderstorms dumped from 2 to 3.5 inches of rain in approximately three hours. Widespread street flooding was reported in Boulder as was damage to the University Memorial Center at CU.
- **August 15, 2007** – This sudden storm hit the southern part of Boulder producing upwards of 1.5 inches of rain between 5:00 and 5:30 PM, and causing alarming water levels on Bear Canyon Creek. This normally small stream runs between the east and westbound lanes of Table Mesa Drive west of Broadway (Colorado Highway 93). The photo on the left below shows that roadway culverts had reached their capacity. Another inch of rain could have resulted in flood damages to adjacent properties as shown by the aerial photo depicting the extents of the 100-year floodplain. The intersection of Table Mesa Drive and Broadway is in the upper right corner of the lower right image.

Figure 4.16. 2007 Flooding on Bear Canyon Creek

Source: Urban Drainage and Flood Control District

- **Tuesday, June 8, 2010** – High snowmelt runoff rates are common in mountain streams at this time of year. What is not common is the issuance of a flash flood watch for snowmelt runoff without any threat of heavy rainfall, but that's precisely what happened on this particular day. The circumstance that led to this decision by the NWS was the partial failure of a private road crossing of Boulder Creek at the Red Lion Inn in the canyon west of Boulder. The main concern was for areas immediately downstream in the event that runoff waters would pile-up against the bridge and release suddenly. Fortunately, nothing serious developed. Peak flows on Boulder Creek were approaching 1,000 cfs when the runoff waters did an end-around leaving the culverts in place with the road crossing impassable. The privately-owned bridge ultimately had to be replaced by the owner. For five consecutive days following for Red Lion incident (June 9-13), a heavy rain threat did exist for the region prompting the NWS to issue subsequent flash flood watches for the 12th and 13th. From June 11-13, the rainfall totals in the Boulder Creek watershed upstream of Boulder ranged from 2 to 3 inches but the intensities were quite low and the resulting runoff remained within the banks (Source: UDFCD).

2011 Flood Season

The 2011 flood season was abnormally lengthy, which can be attributed to the elevated risk associated with the Fourmile Burn Area (FMBA), coupled with an above average snowpack runoff. A storm on July 13 was the most serious, which threatened lives and damaged homes in the mountains of Boulder County less than three miles west of the city boundary in the FMBA.

Spring and summer 2011 had an unusually late runoff season with melting snow from the mountains affecting Colorado streamflows well into July. When the Fourmile Creek flash flood occurred on July 13, the runoff from snowmelt was as least three times its normal rate. The Platte River basin held on to its snowpack through late May into early June, making the runoff more aggressive, nearly matching the maximum recorded event. Consequently, streams like Boulder Creek were flowing well above normal when the monsoon rains arrived in early July.

Fourmile Burn Area Events

In early 2011, dire predictions were being made concerning the elevated flash flood threat posed by the Fourmile Burn Area (FMBA). While there was general agreement that the risk was extremely high for those living in or traveling through the FMBA during a heavy summer downpour, opinions varied widely with respect to how such a relatively small burn area of less than 6,200 acres could seriously threaten the City of Boulder. Post- Fourmile burn hydrologic models indicate that a short duration rainstorm of 2-inches or more over the FMBA could certainly cause problems in Boulder along Boulder Creek. It was also suggested that Fourmile Canyon Creek on the north side of Boulder may pose a greater threat.

Paleoflood investigations conducted by Bob Jarrett of the USGS suggested that the Fourmile Creek minor flood events of 1995 and 2003, with estimated peaks of less than 500 cfs, were likely the largest floods experienced by this area in at least the past 75 years. The Boulder Creek flood of 1969, the largest in recent memory, resulted from four days of moderate intensity rainfall in the mountains that exceeded 9 inches at the Boulder Hydroelectric Plant and produced a peak flow on May 7 through Boulder of 2,500 to 3,000 cfs. The May 30, 1894 flood is the historic flood of record for this area, caused extensive damage along Boulder Creek and Fourmile Creek, and generated an estimated peak through Boulder of 12,000 cfs. Paleoflood studies of the 1894 event revealed that most of the rain-driven runoff came from the 25-square mile Fourmile Creek watershed and that Boulder Creek above the Fourmile Creek confluence showed little geologic evidence of high flows.

A post-fire threat assessment was conducted to evaluate potential impacts for a range of rainfall intensities. A flood hazard inventory for Fourmile Creek and Gold Run suggested that flow rates as small as 100 cfs could overtop and potentially wash-out many private drive crossings, and that larger capacity road crossings like Colorado Highway 119 could handle no more than 2,000 cfs prior to overtopping, and that as many as 80 structures were at risk, with approximately 20 of those—mostly private homes—potentially threatened by flow rates of less than 1,500 cfs.

With a high danger for mud, rock and debris slides, the National Weather Service reported that a very low ¼-inch per hour rain rate was established as the advisory threshold for road problems and minor flooding. The warning threshold for flash flooding in the FMBA was set for one hour rainfalls exceeding ½-inch. For the City of Boulder more rain would be required to cause a serious threat and therefore, the initial warning threshold for the city was set for an hourly amount of 1.5 inches. Prior to the fire, less than 2 inches of rain in the mountains would not likely have posed any serious flooding threat.

On late afternoon of July 7th, 2011, a small amount of rain fell over the FMBA causing a 100-yard wide by 4-foot deep debris/rock/mud slide, forcing the closure of Fourmile Canyon Drive near Emerson Gulch where the 2010 fire started. The burn area rain was on the northern edge of a much larger storm cell that prompted the NWS to issue a flash flood warning for the FMBA at 6:19 pm as it approached. Had the storm cell in Boulder County centered over the FMBA, the impacts in the burn area and downstream through Boulder would have been devastating.

The July 7th conditions caused the biggest rain-related impact to the FMBA to date, drawing considerable media attention. To the south and southwest, rainfall amounts in the Sugarloaf and Nederland areas totaled 1.73 and 2.01 inches respectively. One observer in the FMBA near Long Gulch noted rainfall as intense as 0.96" in 16-minutes. As of 7:50 pm, the WebEOC status board indicated no reports of any infrastructure damage other than road debris blockage in the FMBA, no homes impacted, electricity and phones working. The event summary also noted that people did evacuate to high ground with no injuries reported.

The flash flood of July 13th was the most devastating Boulder County flood of the 2011 flood season. A flash flood warning for the FMBA was issued at 6:17 pm. At 8:08 pm the warning was extended to include Boulder Canyon west of Boulder. Four-foot surges in water levels on Fourmile Creek were observed and publicly reported. Sirens were sounded in the City of Boulder at 8:17 pm and people reacted, some properly while others could have done better. At 8:37 pm the NWS issued a flood advisory (not a warning) that included the City of Boulder. Boulder Creek and Fourmile Canyon Creek on the north side presented concerns. The impacts in the City of Boulder were minimal, with Boulder Creek rising less than a foot and Fourmile Canyon Creek maintaining within its flood channel, with some basement damage reported.

Some of the impacts of the event included these observations from the field:

- 12 people stranded behind a washed out road were found safe.
- Lots of debris and rock on roads.
- Cars trapped between mud and trees.
- Sheriff Deputies saw debris flows and water over roads.
- Bridges and roads washed out.

- Large debris being carried by Fourmile Creek.
- At least 10 private properties, including some homes, were damaged.
- 4 people were treated for exposure and minor injuries at Gold Hill after being rescued. They were covered head-to-toe with mud.
- A fire department vehicle in route to a rescue was washing off Gold Run Road by raging floodwaters. Damages to the vehicle totaled $1,500. No one was hurt.
- Walls of water 6' to 10' high were observed by fire and Sheriff Department officials at a number of locations in both the Fourmile Creek and Fourmile Canyon Creek drainages. Ingram Gulch was one of those locations.
- Surprisingly slow movement of "walls of water" was observed.

Many YouTube videos are available of this flood and its impacts. The UDFCD has also archived many local news broadcasts of the event. In hindsight, the siren sounding in Boulder may not have been necessary but that action did provide a unique opportunity to assess the public's response to the warning. This experience may help save lives in the future.

2013 Flood Season

The City of Boulder experienced a historic flooding event in September 2013 following unusual weather conditions, which lead to a record 432 mm (17 in.) of rainfall over a week. A cold front stalled over Colorado on September 9th and collided with warm humid air from the south. Rain fell continuously from September 9 to September 15. The National Weather Service released a statement on September 11 that the Front Range were already saturated and warned that any further rainfall would have difficulty being absorbed by the ground. The event was deemed a 1,000-year rain event. High flow velocities and debris accumulation contributed to flooding extending beyond banks. On September 12, Governor Hickenlooper declared a state of emergency in Boulder and 17 other counties. On September 15, President Obama declared States of Emergency in Boulder, El Paso, and Larimer counties, followed by 12 other counties on September 16.

The rainfall and subsequent flooding dropped historic levels within the city of Boulder. Some areas within or near the city received rainfall totaling 410 to 510 mm (16 to 20 inches) during the 1-week period. This event set a new 24-hour rainfall record of 9.08 inches which exceeded the previous record of 4.80 inches in 1919.

Eight watersheds comprise the larger Boulder Creek drainage basin: South Boulder Creek, Bear Canyon Creek, Skunk Creek, Gregory Canyon Creek, Boulder Creek, Goose and Twomile Canyon Creeks, Wonderland Creek, and Fourmile Canyon Creek. Only parts of three watersheds experienced peak flows that approached the 100-year event flow rate: Boulder Creek experienced a 50 to 100 plus year event flow rate; Twomile Canyon Creek experienced a 100 plus year event flow rate, and Fourmile Canyon Creek nearly experienced a 100-year event flow rate. In some areas of the city, particularly in areas within the watersheds of Goose and Twomile Canyon Creeks and Skunk Creek and its tributaries, overland flow in urban areas exceeded the effective 100 and 500-year floodplain extents. Areas around South Boulder Creek experienced urban flooding within the creek floodplain. The flooding met or exceeded the effective 100-year floodplain in many locations. Other locations, such as Boulder Creek, where engineered stormwater systems exist, urban flooding was experienced within the creek and floodplain but did not meet or exceed the effective 100-year floodplain extents.

Two 19-yr old teenagers died on the evening of September 11th, after they were swept away by floodwaters after abandoning their vehicle on Lindon Drive in Boulder.

Figure 4.17. Residential Flooding in Boulder, Colorado

A residential area flooded by heavy rains in Boulder, Colorado, on September 14, 2013. (U.S. Army/Staff Sgt. Wallace Bonner)

Likelihood of Future Occurrences

Highly Likely: Localized stormwater flooding at some location in Boulder generally occurs on an annual basis. The extent of damage varies.

Climate Change Considerations

According to the Boulder County Climate Change Preparedness Plan, the nature and frequency of flooding could be altered by climate change, but at this point in time it is difficult to quantify. Heavy precipitation events that lead to flooding occur at the short-term time scales of weather, rather than the multi-year time scales of climate that most climate models examine. However, extreme events are, by their very nature, uncommon. Quantifying trends at a given location is quite difficult, and no trends in the historical record of extreme climate events have been definitively detected in Boulder County. Globally, precipitation extremes and their hydrological impacts (e.g., the magnitude of 100-year floods) are expected to get larger because in most places, higher temperatures will result in increased atmospheric water vapor available to form precipitation. There is no comprehensive technical assessment of how climate change might affect flooding in Boulder County, but research summarized in the Climate Preparedness Plan indicates a trend toward less frequent, but more intense rain events. In that circumstance, rainy days would become less frequent, but if conditions are right for an extreme event, and more moisture is available in the atmosphere, then larger extreme events are possible. The 100-year flood of today might become a more frequent event in the future (i.e., a 50-year event), meaning that current design levels and regulatory practices might be less adequate in the future.

4.2.6 Human Health Hazards: Pandemic Influenza

Hazard/Problem Description

An influenza pandemic occurs when a novel, virulent strain of influenza virus emerges for which people have little or no immunity, and for which there is no vaccine and causes a global outbreak. This disease is transmitted easily from person-to-person, causes serious illness, and can sweep across the country and around the world in very short time. The U.S. Centers for Disease Control and Prevention has been working closely with other countries and the World Health Organization to strengthen systems to detect outbreaks of influenza that might cause a pandemic and to assist with pandemic planning and preparation.

In 2009, the H1N1 strain emerged as a global pandemic but was mitigated by a moderate virulence. Nevertheless, a significant public health response was required to support the most vulnerable target populations. Health professionals are also concerned by the possibility of a pandemic associated with a highly pathogenic avian H5N1 virus. Since 2003, avian influenza has been spreading through Asia. A growing number of human H5N1 cases contracted directly from handling infected poultry have been reported in Asia, Europe, and Africa, and more than half the infected people have died. There has been no sustained human-to-human transmission of the disease, but the concern is that H5N1 will evolve into a virus capable of human-to-human transmission.

An especially severe influenza pandemic could lead to high levels of illness, death, social disruption, and economic loss. Impacts could range from school and business closings to the interruption of basic services such as public transportation, health care, and the delivery of food and essential medicines. Since the hazard can affect 50-100% of the planning area it was given an extensive geographic extent rating.

Extent

An especially severe influenza pandemic could lead to high levels of illness, death, social disruption, and economic loss. Impacts could range from school and business closings to the interruption of basic services such as public transportation, health care, and the delivery of food and essential medicines. Since the hazard can affect 50-100% of the planning area it was given an extensive geographic extent rating.

Past Occurrences

There were three acknowledged pandemics in the twentieth century:

- **1918-19 Spanish flu (H1N1)**—This flu is estimated to have sickened 20-40 percent of the world's population. Over 20 million people lost their lives. Between September 1918 and April 1919, 500,000 Americans died. The flu spread rapidly; many died within a few days of infection, others from secondary complications. The attack rate and mortality was highest among adults 20-50 years old; the reasons for this are uncertain.
- **1957-58 Asian flu (H2N2)**—This virus was quickly identified due to advances in technology, and a vaccine was produced. Infection rates were highest among school children, young adults, and pregnant women. The elderly had the highest rates of death. A second wave developed in 1958. In total, there were about 70,000 deaths in the United States. Worldwide deaths were estimated between 1 and 2 million.
- **1968-69 Hong Kong flu (H3N2)**—This strain caused approximately 34,000 deaths in the United States and more than 700,000 deaths worldwide. It was first detected in Hong Kong in early 1968 and spread to the United States later that year. Those over age 65 were most likely to die. This virus returned in 1970 and 1972 and still circulates today.

To date, the 21st century has seen one acknowledged pandemic.

- **2009 Swine Flu (H1N1)**—This strain caused more than 284,304 deaths worldwide according to the World Health Organization and 12,469 in the U.S., according to the CDC. It was first detected in the Mexico in early 2009 and spread to the world later that year. About 70 percent of people hospitalized with this virus have had one or more medical conditions previously recognized as placing people at "high risk" of serious seasonal flu-related complications. This included pregnancy, diabetes, heart disease, asthma, and kidney disease. Young children were also at high risk of serious complications from 2009 H1N1, just as they are from seasonal flu. And while people 65 and older were the least likely to be infected with 2009 H1N1 flu, if they got sick, they were also at "high risk" of developing serious complications from their illness.

Likelihood of Future Occurrences

Occasional: According to historical data, four influenza pandemics have occurred since 1918. This is an average of a pandemic approximately every 24 years or an approximate 4 percent chance of pandemic in any given year.

Although scientists cannot predict when the next influenza pandemic will occur or how severe it will be, wherever and whenever it starts, everyone around the world will be at risk. If an influenza pandemic does occur, it is likely that many age groups would be seriously affected. The greatest risks of hospitalization and death—as seen during the last two pandemics in 1957 and 1968 as well as during annual outbreaks of influenza—will be to infants, the elderly, and those with underlying health conditions. However, in the 1918 pandemic, most deaths occurred in young adults. In 2009, target populations included children to 18 yr., pregnant women, and the immunocompromised.

4.2.7 Human Health Hazards: Mosquito-borne Viruses

Hazard/Problem Description

The impact to human health that wildlife, and more notably, insects, can have on an area can be substantial. Mosquitoes transmit the potentially deadly West Nile virus to livestock and humans alike. West Nile virus first struck the western hemisphere in Queens, New York, in 1999 and killed four people. Since then, the disease has spread across the United States. In 2003, West Nile virus activity occurred in 46 states and caused illness in over 9,800 people.

Most humans infected by the virus have no symptoms. A small proportion develop mild symptoms that include fever, headache, body aches, skin rash, and swollen lymph glands. Less than 1 percent of those infected develop more severe illness such as meningitis or encephalitis, symptoms of which include headache, high fever, neck stiffness, stupor, disorientation, coma, tremors, convulsions, muscle weakness, and paralysis. Of the few people who develop encephalitis, fewer than 1 out of 1,000 infections die as a result.

There is no specific treatment for the infection or a vaccine to prevent it. Treatment of severe illness includes hospitalization, use of intravenous fluids and nutrition, respiratory support, prevention of secondary infections, and good nursing care. Medical care should be sought as soon as possible for persons who have symptoms suggesting severe illness. People over 50 years of age appear to be at high risk for the severe aspects of the disease.

The Zika virus (Zika) is spread to people primarily through the bite of an infected *Aedes aegypti* species of mosquito. Mosquito transmission of the Zika virus is found in over 50 countries and territories worldwide, including North, Central and South America, the Caribbean, Pacific Islands and Africa.

There have been travel-related cases of Zika virus infection in the country, but as of 2017 there have been no reported cases of Zika infection due to a local mosquito bite. Surveys are being conducted to determine if the types of mosquitoes found in Colorado can carry and spread Zika virus. We know that mosquitoes that transmit West Nile virus are present in our state, so people should take precautions to protect themselves and their families even if Zika virus mosquitoes are not found.

Extent

A severe mosquito-borne illness outbreak could lead to illness, death, and economic loss. Impacts could range from isolated cases, to more widespread strain on resources and basic services. Since the hazard can affect 50-100% of the planning area it is given an extensive geographic extent rating.

Past Occurrences

Information from the Colorado Department of Public Health (CDPHE) indicated that West Nile virus was first detected in Colorado in 2002. The county did not have its first case of the virus in humans until 2003. Table 4.7 summarizes historical West Nile virus information in Colorado and Boulder County. Based on the data, the virus peaked in 2003, with another spike in 2007, but has steadily declined since then. The return of West Nile is associated with stagnant water and drought conditions, which has been observed in areas of the Midwest undergoing severe drought.

Table 4.7. Summary of West Nile Virus Cases in Colorado and Boulder County 2001 to 2017

	Humans		Birds		Mosquitoes		Veterinary		Sentinel Flock	
Year	CO	Boulder	CO	Boulder	CO	Boulder	CO	Boulder	CO	Boulder
2001	0	0	0	0	0	0	0	0	0	0
2002	14	0	137	5	15	0	380	3	3	0
2003	2,947 (63)	421** (7)	766	50	639	118	393	18	213	22
2004	291	14	55	0	168	8	30	0	0	0
2005	106	5	40	1	122	0	0	13	0	0
2006	345 (7)	74 (1)	50	12	419	106	7	1	0	0
2007	555 (6)	95 (2)	121	2	636	55	29	0	0	0
2008	71	13	–	–	–	–	–	–	–	–
2009	68	12	–	–	–	–	–	–	–	–
2010	55	6	–	–	–	–	–	–	–	–
2011	7	2	–	–	–	–	–	–	–	–
2012	134	1								
2013	321	52								
2014	119	11								
2015	101	11								
2016	149	23								
2017	68	9								

Source: U.S. Geological Survey, http://diseasemaps.usgs.gov/; Colorado Department of Public Health and Environment, www.cdphe.state.co.us/dc/zoonosis/, Boulder County Public Health, www.co.boulder.co.us/health/hpe/wnv/
Notes:
*73 were in the City of Boulder
Numbers in parentheses indicate deaths.
After 2007, the CDPHE publishes only human incidents of West Nile Virus

Zika virus was first discovered in 1947 and is named after the Zika Forest in Uganda. In 1952, the first human cases of Zika were detected and since then, outbreaks of Zika have been reported in tropical Africa, Southeast Asia, and the Pacific Islands. Zika outbreaks have probably occurred in many locations. Before 2007, at least 14 cases of Zika had been documented, although other cases were likely to have occurred and were not reported. Because the symptoms of Zika are similar to those of many other diseases, many cases may not have been recognized.

Until recent years, Zika was not a nationally notifiable disease in the United States. In 2015, 61 symptomatic Zika virus disease cases were reported. In 2016, 5,102 symptomatic Zika virus disease cases were reported. In 2017, 231 symptomatic Zika virus disease cases were reported.

Likelihood of Future Occurrences

Occasional: According to the Boulder County Health Department, Boulder County and the City of Boulder will continue to be at risk to West Nile virus. However, the severity of these viruses is expected to change from year to year, depending on variables such as weather patterns, the mosquito population, the bird population, and immunity in humans. The state will continue their surveillance for the disease. The number of incidents of the disease have been declining since 2007.

Climate Change Considerations

According to the Boulder County Climate Change Preparedness Plan milder weather in the current "cold" seasons and warmer weather in the summer could make the county a more suitable habitat for new mosquito species, increasing the potential for additional cases of some mosquito-borne diseases that are already established in the county. At the same time, increases in the precipitation associated with extreme events could increase the habitat suitable for supporting mosquitoes. Drawing definitive conclusions about public health risk changes associated with vector-borne illnesses as a result of climate change are complicated by the need to also account for any associated changes in human behavior that would accompany the associated impacts to seasonal and daily weather conditions. For example, increased temperatures could result in more time spent indoors during extreme heat days, which could potentially reduce exposure to disease carrying vectors.

4.2.8 Landslides and Rockfalls

Hazard/Problem Description

Landslides refer to a wide variety of processes that result in the perceptible downward and outward movement of soil, rock, and vegetation under gravitational influence. According to the Colorado Geological Survey, common names for landslide types include slump, rockslide, debris slide, lateral spreading, debris avalanche, earth flow, and soil creep. Although landslides are primarily associated with steep slopes, they may also occur in areas of generally low relief and occur as cut-and-fill failures, river bluff failures, lateral spreading landslides, collapse of waste piles, and failures associated with quarries and open-pit mines. Landslides may be triggered by both natural and manmade changes in the environment resulting in slope instability.

Human activities, such as mining, construction, and changes to surface drainage areas, also affect the landslide potential. Landslides often accompany other natural hazard events, such as floods, wildfires, or earthquakes. They can occur slowly or very suddenly and may damage or destroy structures, roads, utilities, and forested areas and can cause injuries or death.

Rockfalls are the fastest type of landslide and occur most frequently in mountains or other steep areas during early spring when there is abundant moisture and repeated freezing and thawing. The rocks may freefall or carom down in an erratic sequence of tumbling, rolling and sliding. When many rocks plummet downward at high velocity, it is called a rock avalanche. Rockfalls are caused by the loss of support from underneath or detachment from a larger rock mass. Ice wedging, root growth, or ground shaking, as well as a loss of support through erosion or chemical weathering may start the fall.

A debris flow is a mass of water and earth materials that flows down a stream, ravine, canyon, arroyo, or gulch. The debris flow problem can be exacerbated by wildland fires that remove vegetation that serves to stabilize soil from erosion. Heavy rains on the denuded landscape can lead to rapid development of destructive mudflows. A Boulder County Geologic Hazard Study (March 2017) identifies different geologic features and conditions that make various areas of the county more susceptible to debris flow. Research notes that earth, mud and debris flows may occur in both the foothills and mountainous regions of the county following significant precipitation events, and/or human-induced changes.

Past Occurrences

Development in areas vulnerable to landslides increases the potential for destructive landslides and rockfalls. Most historical landslides that have occurred in Boulder were a secondary impact associated with wildfires and/or heavy rains. For instance, the highway in Boulder Canyon below Sugarloaf Mountain was closed at least six times during the months following the Black Tiger fire in July 1989 after mud, boulders, and other debris slid down onto the highway. One home was destroyed, and two others were damaged. A mudslide also occurred at the base of Flagstaff Road during a period of heavy rains in May and June of 1995. Approximately six homes were threatened by the slide.

During the flooding in September 2013, fatalities were attributed to a fast-moving type of landslide called debris flow. One fatality occurred in Jamestown, and two occurred in the community of Pinebrook Hills immediately west of the City of Boulder. Based on ground and aerial reconnaissance, the USGS Landslide Hazards Group have forecasted that areas where soil and rock were disturbed by the rainfall, especially steep slopes, are likely to be susceptible to catastrophic failure during rainstorms and snowmelt for several years.

In the City of Boulder, landslides and debris flows were triggered along the slopes lining the western margin of the city, damaging several homes, and killing two young adults. Particularly visible from town are slides on grassy slopes along the sandstone/shale contact on Dakota Ridge. Several mountain communities in the Front Range were severely impacted by debris flows, and several of the eight deaths in the storm are attributed to landslides and debris flows (USGS landslides report).

Just days after the storm, Boulder Creek Critical Zone Observatory (CZO) investigators ventured out to examine, photograph, and measure the landslides on the slopes of the Dakota Hogback in north Boulder. It appeared that the landslides were initiated at sites where the topography had focused water flow, both on the surface and in the ground. The slopes failed during or after the heaviest rains, presumably when the hillslope materials would have been fully saturated. The failures appeared to have started as relatively minor slips or rotational slides. Since the materials were so wet, the failures evolved slurries or debris flows, which promoted their ability to travel long distances downslope. The following maps and photographs document the CZO investigators' observations.

Figure 4.19 and Figure 4.20 display images captured by residents of the City of Boulder, documenting various two landslide events that occurred in 2013. Landslides pose a threat to residential structures located on or near steep slopes, and both incidents in the images emphasize the risk for citizens living in Boulder's mountainous topography. Figure 4.18 highlights areas of debris and mud flow surrounding the City.

Figure 4.18. City of Boulder Debris Flow Hazards

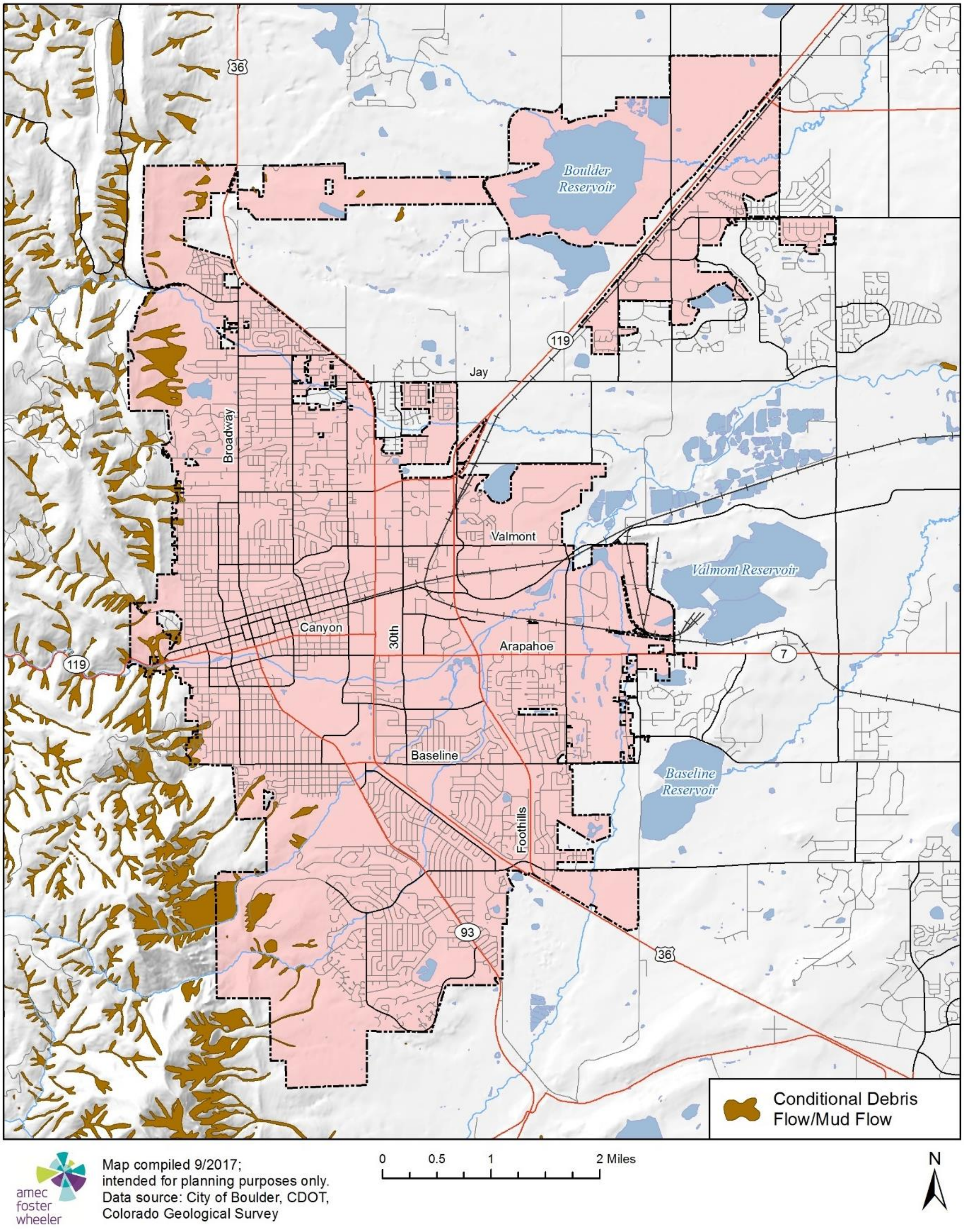


Figure 4.19. 2013 Boulder Landslide Area

This photo from Sept. 16, 2013, shows two landslides that occurred near each other. (Photo by Eric Winchell).

Figure 4.20. 2013 Landslide in North Boulder

The largest landslide flowed ~150 m downslope and hit a house near Forest Ave in north Boulder. The landslide had quite a uniform width along its length. At the time of this photo, Sept. 16, 2013, water was seeping out of the headscarp and for another ~25 downslope (see photo). The headscarp exposes sandstone, which is likely the Dakota Sandstone. (Photo by Eric Winchell).

Extent

Figure 4.21 depicts areas in Boulder with steep slopes, which could be potentially prone to landslides. It was created for the purposes of the Denver Regional Council of Governments Regional Mitigation Plan from a 10-meter resolution digital elevation model. Any areas with slopes greater than 30 degrees were classified as a potential risk area. As illustrated in the following map, areas with slopes greater than 30 degrees are limited to the western edge of the city limits. Figure 4.21 shows Boulder's geological hazards and constraints. Since the hazard affects less than 10% of the planning area it was given **limited** geographic extent rating.

Figure 4.21. Boulder Steep Slope Hazards

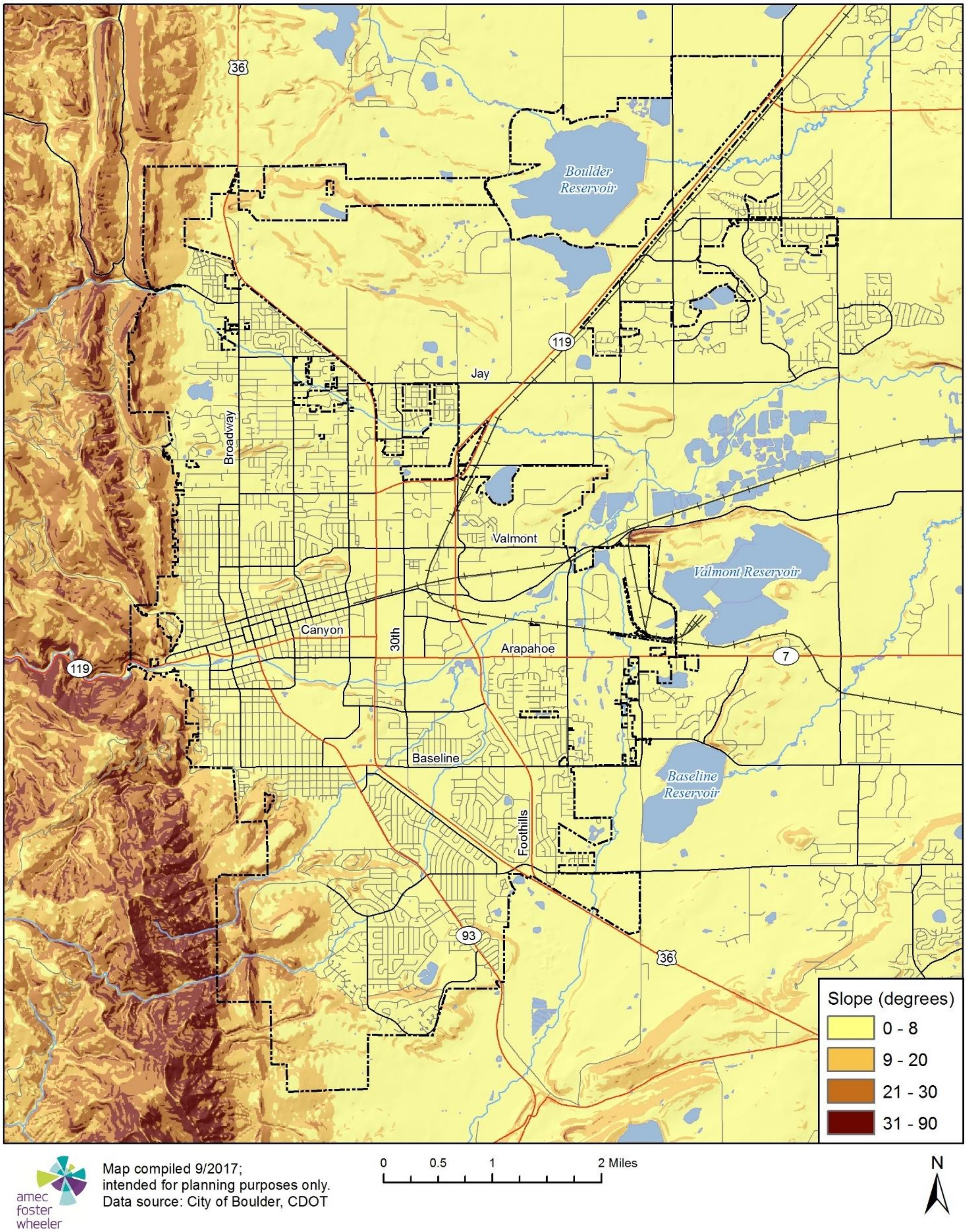
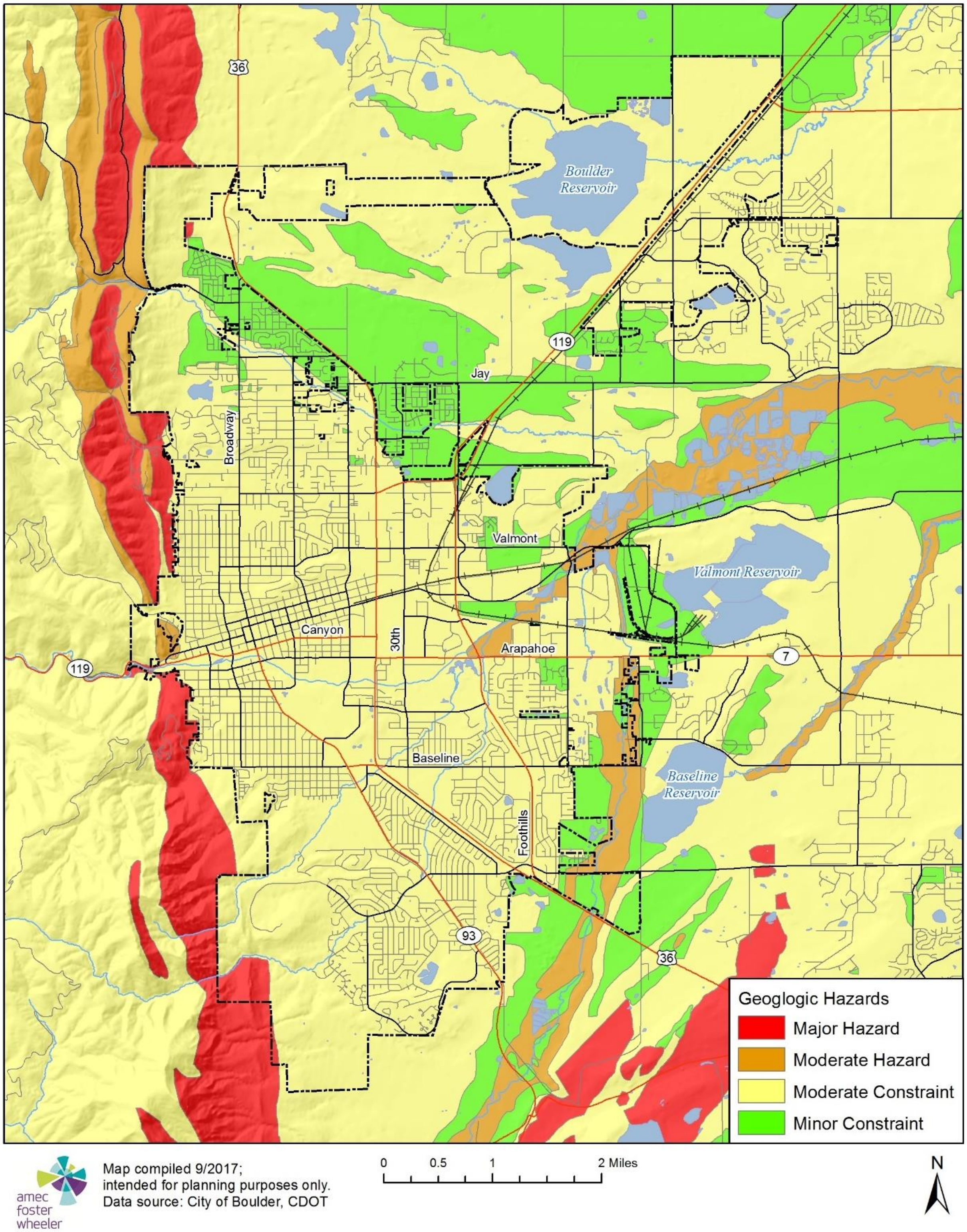


Figure 4.22. Boulder Steep Slope Hazards



Likelihood of Future Occurrences

The Colorado Landslide Hazard Mitigation Plan developed in 1988 identified 49 areas within Colorado where landslides could have the "most serious or immediate potential impact on communities, transportation corridors, lifelines, or the economy." No areas in Boulder County were identified. Most of Boulder has low landslide potential. However, minor landslides and debris flows will likely continue in susceptible areas because of post-fire or post-flood conditions or when heavy precipitation occurs. The Boulder County MHMP classifies the future probability of landslide/debris flow/rockfall occurrence as occasional, with a 1-10 percent change of occurrence in the next year.

Climate Change Considerations

Climate change projections for more intense precipitation events has the potential to increase landslide incidence, particularly debris flows. With increases in heavy precipitation events areas in northwest Boulder including along and below the Dakota Ridge and the west end of Canyon St. could have elevated risk of landslide and debris flow occurrence.

4.2.9 Severe Weather: General

Severe weather conditions occur each year in Boulder County and the City of Boulder. A database maintained by the National Oceanic and Atmospheric Administration National Centers for Environmental Information (NCEI) is normally queried to give severe weather events on a county by county basis. Data was available from 1950 to August 11, 2017 in the downloaded data. This NCEI search identified 401 days of extreme weather in Boulder County between January 1, 1950, and August 11, 2017 (see Table 4.8). Severe winter weather events such as snow, blizzards, and winter storms are not included in the table and are further analyzed later in this chapter (**4.2.21 Winter Storms**)

Table 4.8. Boulder County Severe Weather Events, January 1, 1950 to August 11, 2017

Type of Weather Event	Number of Occurrences* (Days)	Deaths	Deaths/Injuries	Property Damage	Crop Damage
Extreme Heat	-	-	-	-	-
Extreme Cold	1	-	-	-	-
Fog	-	-	-	-	-
Flash Floods	15	4	2	$795,000	$75,000
Hail	113	0	7	$1,005,000	-
Heavy Rain	2	-	-	-	-
High Winds	185	2	10	$22,306,000	$5,000
Lightning	27	1	11	$117,000	-
Thunderstorm Wind	47	-	1	$25,510	-

Type of Weather Event	Number of Occurrences* (Days)	Deaths	Deaths/Injuries	Property Damage	Crop Damage
Tornado	11	-	0	$282,500	-
Totals	**401**	**7**	**31**	**$24,531,010**	**$80,000**

Source: National Centers for Environmental Information (NCEI) Storm Events database,
Note: Not all types of weather event are tracked back to 1950. The NCEI database includes: All weather events from 1993-present as entered into Storm Data plus additional data from the Storm Prediction Center, including tornadoes 1950-1992, thunderstorm winds 1955-1992, and hail 1955-1992.
* Blizzard, snow, and winter storms were absenting from the downloaded NCEI dataset.

For the 401 events listed above, the reported number of deaths totaled 7, injuries totaled 31, and property damage totaled $24.5 million. These totals do not include snow, blizzard, or winter storm events as noted above. Details on notable events identified in the table are included in the plan sections that follow.

This section discusses the following types of severe weather:

- Extreme temperatures
- Fog
- Hailstorms
- Thunderstorms
- Lightning
- Tornadoes
- Windstorms

Climate Change Considerations

The Boulder County Climate Change Preparedness Plan mentions that climate change could alter the nature and frequency of severe weather hazards. There presently is not enough data or research to quantify the magnitude of change for some of these events such as severe windstorms, lightning, tornadoes and fog. Future updates to the mitigation plan should include the latest research on how these hazard vulnerabilities could change. The level of significance of these hazards should be revisited over time. During the 2017 update level of significance for extreme temperatures was evaluated since the available science concludes that average temperatures are expected to increase into the future.

4.2.10 Severe Weather: Extreme Temperatures

Hazard/Problem Description

Extreme temperature events, both hot and cold, can have severe impacts on human health and mortality, natural ecosystems, agriculture, and the economy. Since extreme temperatures affect large areas the hazard extent within city limits is considered extensive, potentially impacting 50-100% of the planning area.

Extreme Heat

According to information provided by FEMA, extreme heat is defined as temperatures that hover 10 degrees or more above the average high temperature for the region and last for several weeks. Heat kills by taxing the human body beyond its abilities. In a normal year, about 175 Americans succumb to the demands of summer heat. According to the National Weather Service (NWS), among natural hazards, only the cold of winter—not lightning, hurricanes, tornadoes, floods, or earthquakes—takes a greater toll. In the 40-year period from 1936 through 1975, nearly 20,000 people were killed in the United States by the effects of heat and solar radiation. In the heat wave of 1980, more than 1,250 people died.

Heat disorders generally must do with a reduction or collapse of the body's ability to shed heat by circulatory changes and sweating or a chemical (salt) imbalance caused by too much sweating. When heat gain exceeds the level the body can remove, or when the body cannot compensate for fluids and salt lost through perspiration, the temperature of the body's inner core begins to rise and heat-related illness may develop. Elderly persons, small children, chronic invalids, those on certain medications or drugs, and persons with weight and alcohol problems are particularly susceptible to heat reactions, especially during heat waves in areas where moderate climate usually prevails. Figure 4.23 illustrates the relationship of temperature and humidity to heat disorders.

Figure 4.23. Relationship of Temperature and Humidity to Heat Disorders

Temperature (ºF)

Relative Humidity (%)	80	82	84	86	88	90	92	94	96	98	100	102	104	106	118	110
40	80	81	83	85	88	91	94	97	101	105	109	114	119	124	130	136
45	80	82	84	87	89	93	96	100	104	109	114	119	124	130	137	
50	81	83	85	88	91	95	99	103	108	113	118	124	131	137		
55	81	84	86	89	93	97	101	106	112	117	124	130	137			
60	82	84	88	91	95	100	105	110	116	123	129	137				
65	82	85	89	93	98	103	108	114	121	126	130					
70	83	86	90	95	100	105	112	119	126	134						
75	84	88	92	97	103	109	116	124	132							
80	84	89	94	100	106	113	121	129								
85	85	90	96	102	110	117	126	135								
90	86	91	98	105	113	122	131									
95	86	93	100	108	117	127										
100	87	95	103	112	121	132										

Likelihood of Heat Disorders with Prolonged Exposure or Streuous Activity

Caution | Extreme Caution | Danger | Extreme Danger

Source: National Weather Service, 2004

Note: Since HI values were devised for shady, light wind conditions, exposure to full sunshine can increase HI values by up to 15°F. Also, strong winds, particularly with very hot, dry air, can be extremely hazardous.

The NWS has in place a system to initiate alert procedures (advisories or warnings) when the Heat Index is expected to have a significant impact on public safety. The expected severity of the heat determines whether advisories or warnings are issued. A common guideline for the issuance of excessive heat alerts is when the maximum daytime high is expected to equal or exceed 105°F and a nighttime minimum high of 80°F or above is expected for two or more consecutive days.

Extreme Cold

Extreme cold often accompanies a winter storm or is left in its wake. Prolonged exposure to the cold can cause frostbite or hypothermia and can become life-threatening. Infants and the elderly are most susceptible. Pipes may freeze and burst in homes or buildings that are poorly insulated or without heat.

In 2001, NWS implemented an updated Wind Chill Temperature index (see Figure 4.24). This index was developed to describe the relative discomfort/danger resulting from the combination of wind and temperature. Wind chill is based on the rate of heat loss from exposed skin caused by wind and cold. As the wind increases, it draws heat from the body, driving down skin temperature and eventually the internal body temperature.

Figure 4.24. National Weather Service Wind Chill Chart

Temperature (°F)

Wind (mph) / Calm	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
5	36	31	25	19	13	7	1	-5	-11	-16	-22	-28	-34	-40	-46	-52	-57	-63
10	34	27	21	15	9	3	-4	-10	-16	-22	-28	-35	-41	-47	-53	-59	-66	-72
15	32	25	19	13	6	0	-7	-13	-19	-26	-32	-39	-45	-51	-58	-64	-71	-77
20	30	24	17	11	4	-2	-9	-15	-22	-29	-35	-42	-48	-55	-61	-68	-74	-81
25	29	23	16	9	3	-4	-11	-17	-24	-31	-37	-44	-51	-58	-64	-71	-78	-84
30	28	22	15	8	1	-5	-12	-19	-26	-33	-39	-46	-53	-60	-67	-73	-80	-87
35	28	21	14	7	0	-7	-14	-21	-27	-34	-41	-48	-55	-62	-69	-76	-82	-89
40	27	20	13	6	-1	-8	-15	-22	-29	-36	-43	-50	-57	-64	-71	-78	-84	-91
45	26	19	12	5	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79	-86	-93
50	26	19	12	4	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81	-88	-95
55	25	18	11	4	-3	-11	-18	-25	-32	-39	-46	-54	-61	-68	-75	-82	-89	-97
60	25	17	10	3	-4	-11	-19	-26	-33	-40	-48	-55	-62	-69	-76	-84	-91	-98

Frostbite Times: 30 minutes, 10 minutes, 5 minutes

$$\text{Wind Chill (°F)} = 35.74 + 0.6215T - 35.75(V^{0.16}) + 0.4275T(V^{0.16})$$

Where, T= Air Temperature (°F) V= Wind Speed (mph)

Effective 11/01/01

Source: National Weather Service, www.nws.noaa.gov/om/windchill/index.shtml

The NWS will issue a Wind Chill Advisory for the Boulder County area when wind and temperature combine to produce wind chill values of 18°F below zero to 25°F below zero.

Extent

To calculate a magnitude and severity rating for comparison with other hazards, and to assist in assessing the overall impact of the hazard on the planning area, information from the event of record is used. In some cases, the event of record represents an anticipated worst-case scenario, and in others, it reflects common occurrence.

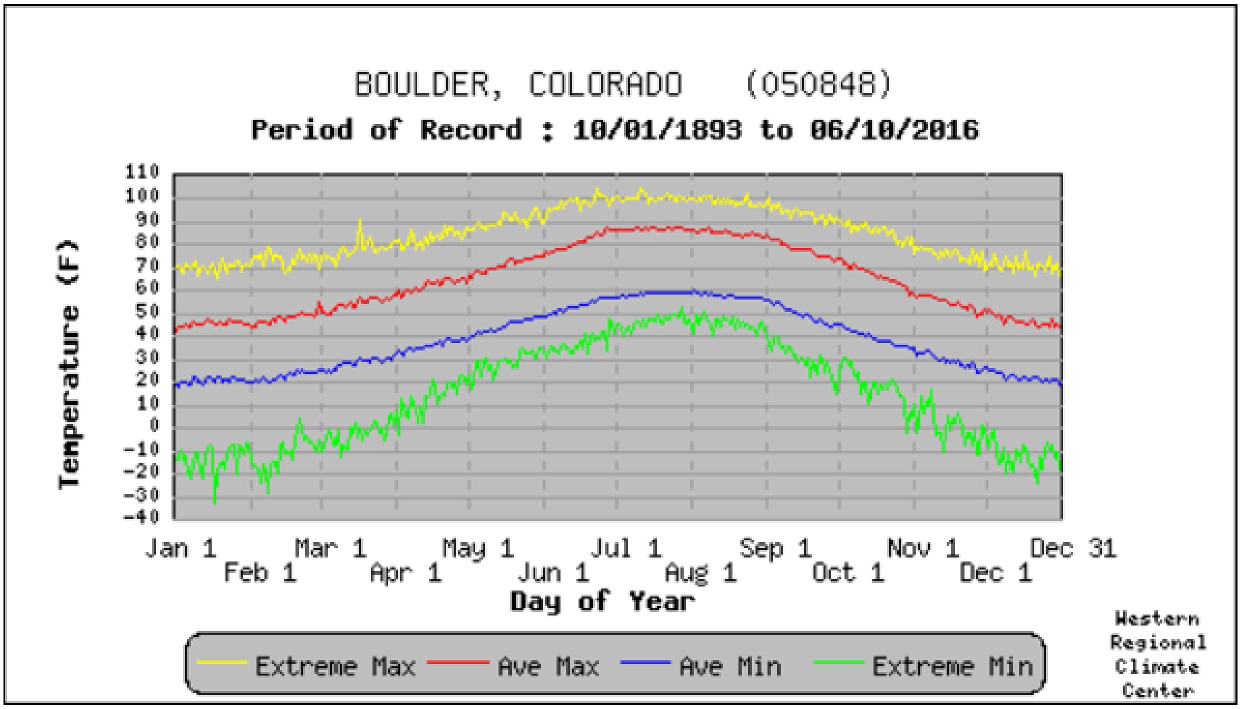
Despite Boulder County's natural propensity for cold weather, an NCEI query in 2017 returned no results involving extreme cold. Further discussed in the section below, the highest recorded temperature in eastern Boulder County was 104°F, while the lowest recorded daily extreme was -24°F. These conditions may be anomalous, but the associated implications can be significant. Extreme cold can cause problems with communications facilities, and danger to people is highest when they are unable to heat their homes and when water pipes freeze. Other issues associated with severe cold temperatures include hypothermia. Extreme heat increases likelihood of dehydration, and the threat of physical overexertion that may lead to heart attacks or strokes.

Though both extreme heat and cold impact all areas of the city, the geographic extent of this hazard is **negligible**. There have been no reported damages, injuries and illnesses, and minimal property damage that does not threaten structural stability. There are also no reported instances where there has been an interruption of essential facilities and services for more than 24 hours.

Past Occurrences

In eastern Boulder County, for the period of record August 1, 1948, through June 10, 2016, the monthly average maximum temperatures in the warmest months (May through October) ranged from the high 60s to the high 80s. Monthly average minimum temperatures from November through April ranged from the low 20s to mid-30s. The highest recorded daily extreme in eastern Boulder County was 104°F on June 23, 1954, and July 11, 1954. The lowest recorded daily extreme was -24°F on December 12, 1963, and December 22, 1990. For the period of record for maximum temperature extremes (on an annual basis), 31.8 days exceeded 90°F and 15.3 days were less than 32°F. For the same period of time for minimum temperature extremes (on an annual basis), 135.3 days were less than 32°F and 4.7 days were less than 0°F.

Figure 4.25. Boulder Daily Temperature Averages and Extremes 1893 to 2016



Source: Western Regional Climate Center, www.wrcc.dri.edu/

The October 1991 freeze ("Halloween Freeze") saw temperature extremes from 60°F to below 0°F. $51,250 in tree damage was tied to this event combined with the November 17, 1991, snowstorm.

Likelihood of Future Occurrences

Highly Likely: Given the history in Boulder County and the City of Boulder, extreme temperature events will continue to occur annually.

Climate Change Considerations

Among the clearest signals from the existing climate change research is the projected warming in the county. The Boulder County Climate Change Preparedness Plan science summary shows that average temperatures are expected to rise by ~ 2–3°F by 2030 and ~ 3.5–5.0°F by 2050, with more warming in summer than in winter. This is expected to result in an increase in average temperatures, daily minimum and maximum temperatures, and the number of days exceeding 100°F. Climate models predict that Colorado could see 10 to 20 days per year over 100°F under the low-emissions scenario and between 20 and 30 days per year over 100°F under the high-emissions scenario. For context, Boulder currently experiences an average of 1 day over 100°F per year. This could have direct impacts on human health in terms of heat related illness. Cascading impacts include increased stress on water quantity and quality, degraded air quality, and increased potential for more severe or catastrophic natural events such as heavy rain, droughts, and wildfire.

Although heat waves will likely become more frequent, there is also the potential for continued cold outbreaks in winter, even in an overall warmer climate. Since the mid-1980s, warmer summers have increased the duration and intensity of wildfires across the western United States, a trend that is likely to continue.

4.2.11 Severe Weather: Fog

Hazard/Problem Description

Dense fog events can significantly reduce visibility. Fog results from air being cooled to the point where it can no longer hold all of the water vapor it contains. A cloud-free, humid air mass at night can lead to fog formation where land and water surfaces that have warmed up during the summer are still evaporating a lot of water into the atmosphere—this is radiation fog. A warm moist air mass blowing over a cold surface can also cause fog to form—this is advection fog. Severe fog incidents can close roads, cause accidents, and impair the effectiveness of emergency responders.

Boulder experiences radiation fog, which settles into the hollows and basins between hills and mountains. When cool air laden with condensed water droplets becomes trapped beneath a layer of lighter, warmer air lodged between ridges and peaks, it cannot escape.

Past Occurrences

The National Centers for Environmental Information data shows no severe fog incidents for Boulder County. Other data sources consulted during this planning process did not identify any notable fog events for Boulder County and the City of Boulder.

Extent

There is very limited information or methods to measure the effects of fog, especially in mountainous/high plains areas (compared to coastal fog).

Likelihood of Future Occurrences

Unlikely: Given the lack of reportable fog history, severe fog events are not of significant concern to the City of Boulder.

Climate Change Considerations

There presently is not enough data or research to quantify the magnitude of potential change that climate change may have on fog in mountainous/high plains areas. Future updates to the mitigation plan should include the latest research on how the fog hazard frequency and severity could change. The level of significance of this hazard should be revisited over time.

4.2.12 Severe Weather: Hailstorms

Hazard/Problem Description

Hail is formed when water droplets freeze and thaw as they are thrown high into the upper atmosphere by the violent internal forces of thunderstorms. Hail is usually associated with severe summer storms, which occur throughout the spring, summer, and fall in the City of Boulder. Hailstorms generally occur more frequently during the late spring and early summer. Hailstones are usually less than two inches in diameter and can fall at speeds of 120 mph.

The National Weather Service classifies hail by diameter size, and corresponding everyday objects to help relay scope and severity to the population. Table 4.9 indicates the hailstone measurements utilized by the National Weather Service.

Table 4.9. Hailstone Measurements

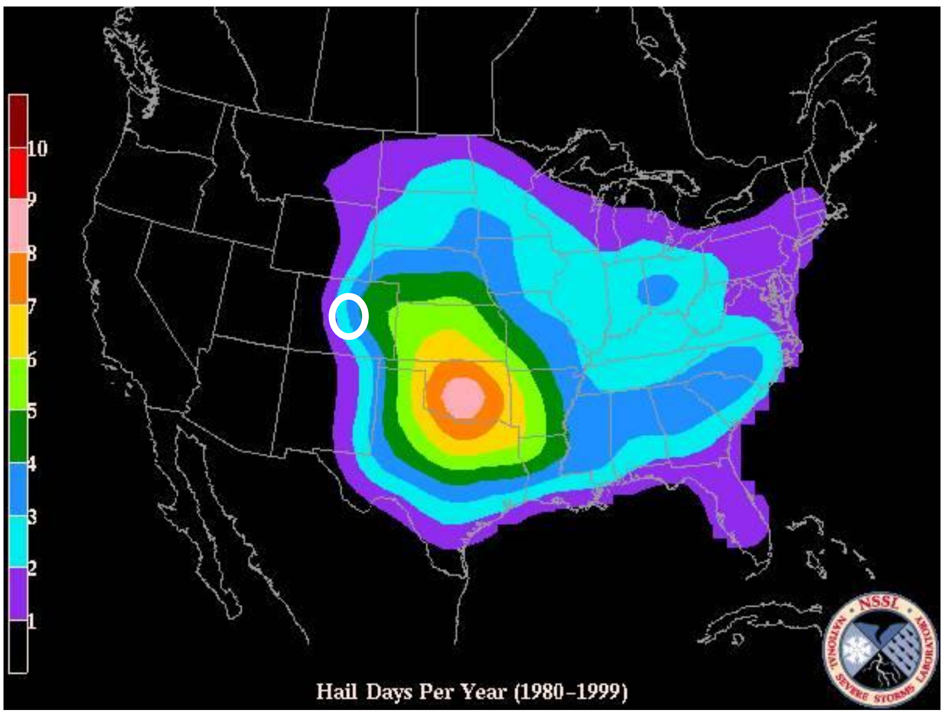
Average Diameter	Corresponding Household Object
.25 inch	Pea
.5 inch	Marble/Mothball
.75 inch	Dime/Penny
.875 inch	Nickel
1.0 inch	Quarter
1.5 inch	Ping-pong ball
1.75 inch	Golf-Ball
2.0 inch	Hen Egg
2.5 inch	Tennis Ball
2.75 inch	Baseball
3.00 inch	Teacup
4.00 inch	Grapefruit
4.5 inch	Softball

Source: National Weather Service

There is no clear distinction between storms that do and do not produce hailstones. Nearly all severe thunderstorms probably produce hail aloft, though it may melt before reaching the ground. Multi-cell thunderstorms produce many hailstones, but not usually the largest hailstones. In the life cycle of the multi-cell thunderstorm, the mature stage is relatively short so there is not much time for growth of the hailstone. Supercell thunderstorms have sustained updrafts that support large hail formation by repeatedly lifting the hailstones into the very cold air at the top of the thunderstorm cloud. In general, hail 2 inches (5 cm) or larger in diameter is associated with supercells (a little larger than golf ball size which the NWS considers to be 1.75 inch.). Non-supercell storms can produce golf ball size hail.

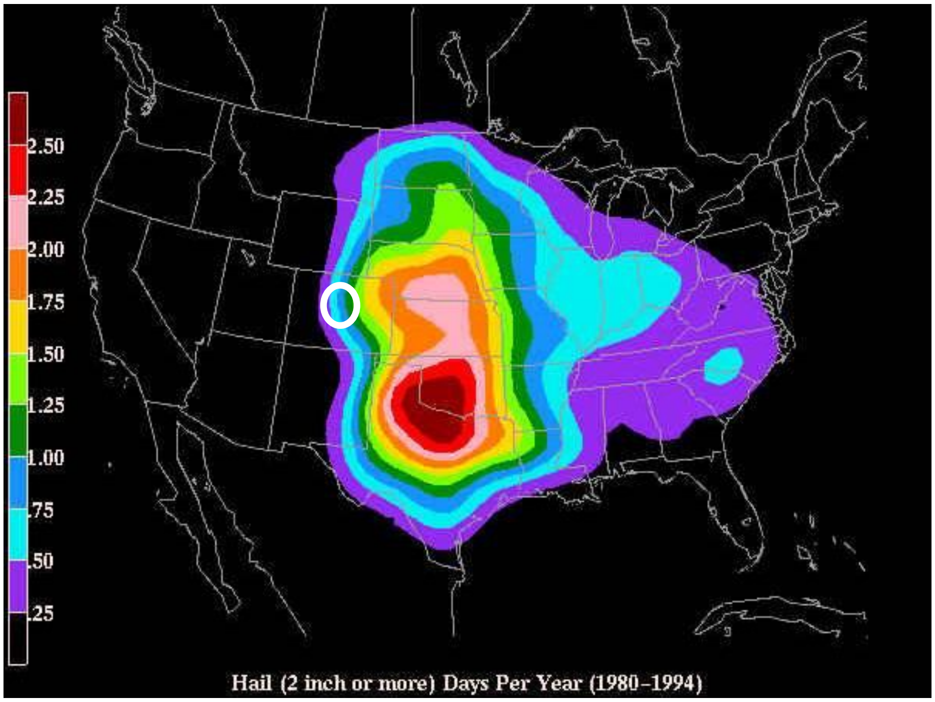
In all cases, the hail falls when the thunderstorm's updraft can no longer support the weight of the ice. The stronger the updraft the larger the hailstone can grow. When viewed from the air, it is evident that hail falls in paths known as hail swaths. They can range in size from a few acres to an area 10 miles wide and 100 miles long. Piles of hail in hail swaths have been so deep, a snow plow was required to remove them, and occasionally, hail drifts have been reported. Figure 4.26 shows the average number of days of hail per year in the United States, with the city outlined in a white oval. The geographic extent rating for hail is considered extensive since the entire city limits is exposed.

Figure 4.26. Average Number of Days of Hail per Year



Source: NOAA National Severe Weather Laboratory; White oval indicates approximate location of City of Boulder

Figure 4.27. Average Days of Large Hail in the Planning Area



Source: NOAA National Severe Weather Laboratory; White oval indicates approximate location of City of Boulder

Past Occurrences

A study conducted in 1994 by the state climatologist looked at recorded hail statistics from 1973 to 1985 and from 1986 to 1993. The data used for this study is limited as systematic observations of hail are taken only at a small number of weather stations. Therefore, this study relied on point weather station data from a small number of sites in and near Colorado along with statewide data on severe hailstorms obtained from the national publication, *Storm Data*. Further, since hail occurs only briefly and tends to be very localized, many storms go undetected by the official weather stations. Regardless, by analyzing the existing data, this study uncovered the following statistics regarding hailstorms in Colorado:

- The hail season in Colorado begins in March and ends in October.
- There has been an average of more than 130 reported severe hailstorms each year since 1986.
- Overall, June has the highest frequency of days with hail with slightly more than 10 on average.
- Hail in Colorado is primarily an afternoon or evening phenomenon; 90 percent of all severe hailstorms reported between 1986 and 1993 occurred between 1:00 and 9:00 p.m.
- Hail usually only falls for a few minutes. Hail that continues for more than 15 minutes is unusual.
- A study of 60 Fort Collins hail events showed the median duration to be six minutes.
- The vast majority of hailstones that fall in Colorado are ½ inch in diameter or smaller.
- The most common size range for damaging hail in Colorado is 1 to 1.5 inches in diameter.

- Six percent of the reported severe hailstorms had maximum hailstone diameters of 2.5 inches or greater.
- The maximum hailstone size reported in this study was 4.5 inches.
- Hail frequency can be very variable. For example, there were only 25 severe hail days in 1988 compared with 51 in 1993.
- Severe hail is not a statewide problem. It is limited to eastern Colorado beginning in the eastern foothills and extending across the eastern plains.

Hail is a major cause of property damage in the plains just east of the Rockies. The past 35 years have brought one catastrophic hailstorm after another to the Front Range. On the night of July 20th, 2009, a strong storm hit the northwest suburbs of Denver, dumping as much as an inch of rain in less than an hour and hail that was one-inch in diameter. The storm damaged numerous cars, windows and roofs. A greenhouse containing plants worth more than $250,000 was destroyed. Straight-line winds of 80 miles per hour uprooted mature trees and damaged roofs. The storm also left 50,000 residents without power.

The $845.5 million event of 2009 was surpassed in May 2017, when the Front Range region was hit with an even more costly event. According to the Rocky Mountain Insurance Information Association, the preliminary losses from the storm are estimated at $1.4 billion. The event battered the area; pummeling cars and houses, and causing extensive damage to the Colorado Mills shopping center. The Rocky Mountain Insurance Information Association estimates that over 150,000 auto insurance claims and 50,000 homeowner insurance claims were filed in connection with the storm. Most of the mall was closed from May until November 2017.

Costly hailstorms identified by the Rocky Mountain Insurance Information Association include those listed in Table 4.10. The extent of damage in the Boulder area from these storms could not be determined from available data.

Table 4.10. Costly Hailstorms in Colorado

Date	Location	Cost (adjusted for 2016 dollars)
May 8, 2017	Denver Metro	$1.4 billion
July 11, 1990	Denver Metro	$1.1 billion
July 20,2009	Denver Metro	$845.5 million
June 6-15, 2009	Denver Metro	$389.2 million
July 28, 2016	Colorado Springs	$352.8 million
June 6-7, 2012	Front Range	$330.5 million

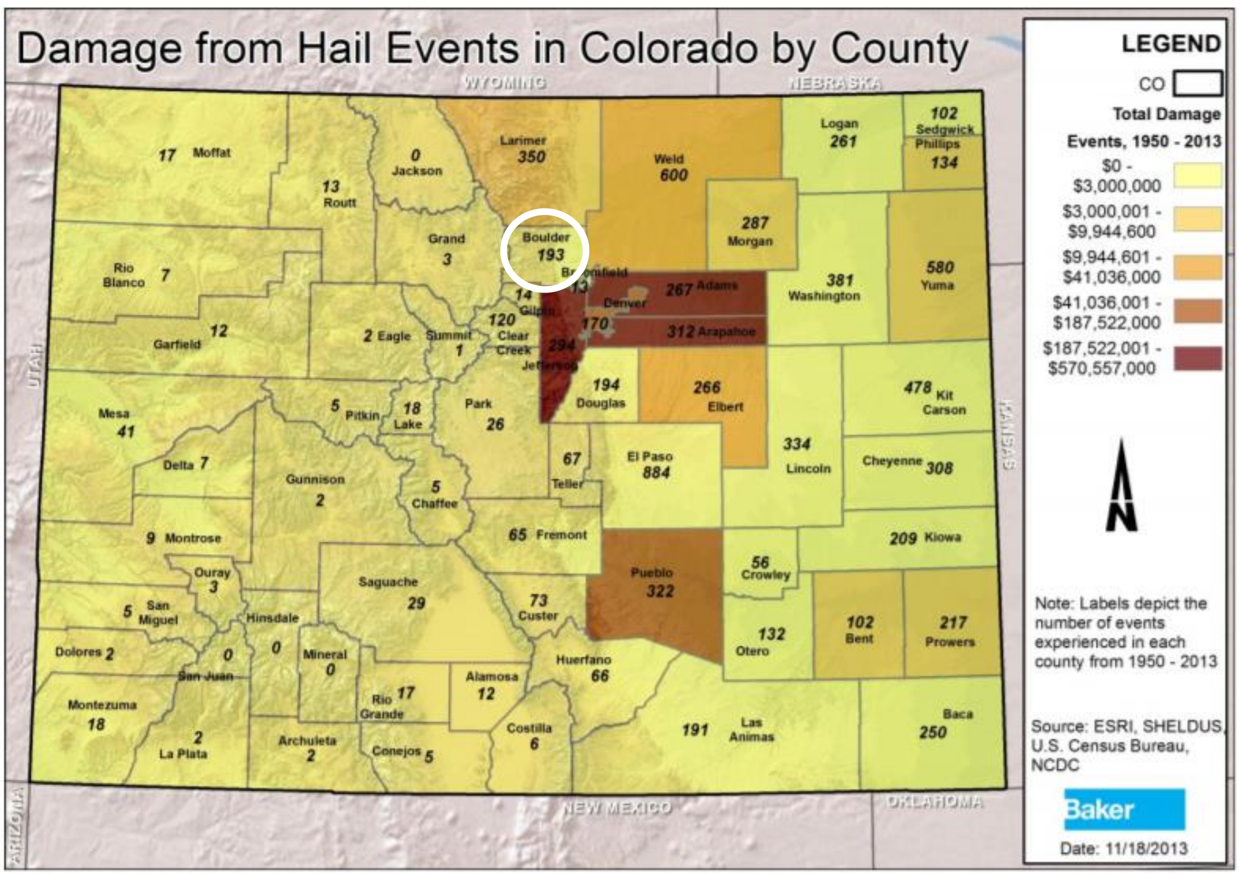
Source: Rocky Mountain Insurance Information Association
*2015 estimated cost calculations based on the Consumer Price Index

Data from the National Centers for Environmental Information identified 226 hail events in Boulder County between January 1, 1955, and August 10, 2017, with hailstones at least ¾ inch in diameter. These events resulted in over $1 million of property damages and 7 injuries. The following four hail events resulted in reported damage to people or property in Boulder County:

- **August 2, 1986, 4:30 p.m.—**Hailstones of 1.75 inches caused six injuries.
- **August 2, 1986, 4:35 p.m.**—Hailstones of 1.75 inches caused one injury.
- **September 17, 1993, 5:06 p.m.—**Hailstones of 0.75 inches (in Lafayette) caused $5,000 in property damage.
- **July 12, 1996, 7:46 p.m.**—Hailstones of 1.25 inches (in Broomfield) caused $1 million in property damage. Large hail, strong winds, and heavy rain caused substantial damage to property in portions of Boulder and northern Jefferson counties. Damage estimates in the Broomfield area alone were approximately $1 million.

The State of Colorado Natural Hazard Mitigation Plan reports that Boulder County experienced 193 hailstorm events between January 1, 1993, and January 31, 2013, that resulted in $1 million in damage. This likely includes the events identified above. Figure 4.28 depicts Colorado's reported hail events by County.

Figure 4.28. Colorado's Reported Hail Events by County



Source: 2013 State of Colorado Natural Hazard Mitigation Plan; White oval indicates approximate location of City of Boulder

Extent

Magnitude and severity of hail is impacted by size, location, and vulnerable infrastructure, and the size of the hail and duration of the storm. The NCEI doesn’t record any property damage, injuries or fatalities for the City in its database, though that isn’t necessarily an indicator that impacts haven’t taken place. In surrounding Boulder County, hailstorms have caused up to $1,000,000 in damage from a single storm; the maximum number of injuries sustained during one storm is six, though the database didn’t provide further explanation on the nature of these injuries.

The National Weather Service classifies hail by diameter size, and corresponding everyday objects to help relay scope and severity to the population. Table 4.9 indicates the hailstone measurements utilized by the National Weather Service.

The HMPC considers that hailstorms are more likely to have a **limited** potential magnitude.

Likelihood of Future Occurrences

Likely: Given the history of severe weather events in the City of Boulder and Boulder County, severe weather, including hailstorms, will continue to occur on an annual basis; however, the extent of impact to the city will vary depending on the location and severity of any given storm and associated hail event.

Climate Change Considerations

NASA’s Earth Observatory provides an analysis on how climate change could, theoretically, increase potential storm energy by warming the surface and putting more moisture in the air through evaporation. The presence of warm, moist air near the surface is a key ingredient for summer storms that meteorologists have termed “convective available potential energy,” or CAPE. With an increase in CAPE, there is greater potential for cumulus clouds to form. The study also counters this theory with the theory that warming in the Arctic could lead to less wind shear in the mid-latitude areas prone to summer storms, making the storms less likely. Based on these differing theories it is difficult at this point in time to summarize the effects climate change may have on hail.

The Boulder County Climate Change Preparedness Plan notes that as precipitation increases during extreme events, it can have an opposite impact on hail formation, thus there is the potential for the amount of hail to decrease.

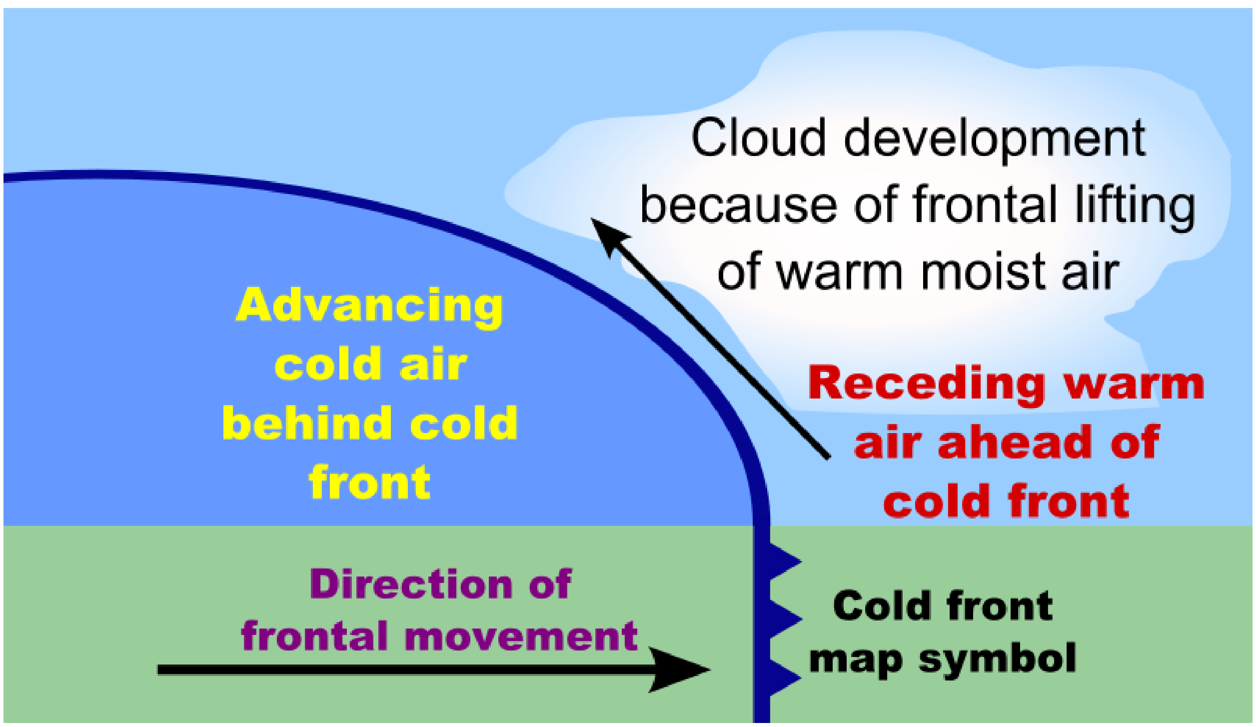
4.2.13 Severe Weather: Thunderstorms

Hazard/Problem Description

Storms in the City of Boulder are generally characterized by heavy rain often accompanied by strong winds and sometimes lightning and hail. Approximately 10 percent of the thunderstorms that occur each year in the United States are classified as severe. A thunderstorm is classified as severe when it contains one or more of the following phenomena: hail that is 1 inch or greater, winds more than 50 knots (57.5 mph), or a tornado (profiled in Section 4.2.15).

Thunderstorms result from the rapid upward movement of warm, moist air (see Figure 4.29). They can occur inside warm, moist air masses and at fronts. As the warm, moist air moves upward, its cools, condenses, and forms cumulonimbus clouds that can reach heights of greater than 35,000 ft. As the rising air reaches its dew point, water droplets and ice form and begin falling the long distance through the clouds towards earth's surface. As the droplets fall, they collide with other droplets and become larger. The falling droplets create a downdraft of air that spreads out at Earth's surface and causes strong winds associated with thunderstorms.

Figure 4.29. Formation of a Thunderstorm



Source: NASA. http://rst.gsfc.nasa.gov/Sect14/Sect14_1c.html

There are four ways in which thunderstorms can organize: single cell, multicell cluster, multicell lines (squall lines), and supercells. Even though supercell thunderstorms are most frequently associated with severe weather phenomena, thunderstorms most frequently organize into clusters or lines. Warm, humid conditions are favorable for the development of thunderstorms. The average single cell thunderstorm is approximately 15 miles in diameter and lasts less than 30 minutes at a single location. However, thunderstorms, especially when organized into clusters or lines, can travel intact for distances exceeding 600 miles.

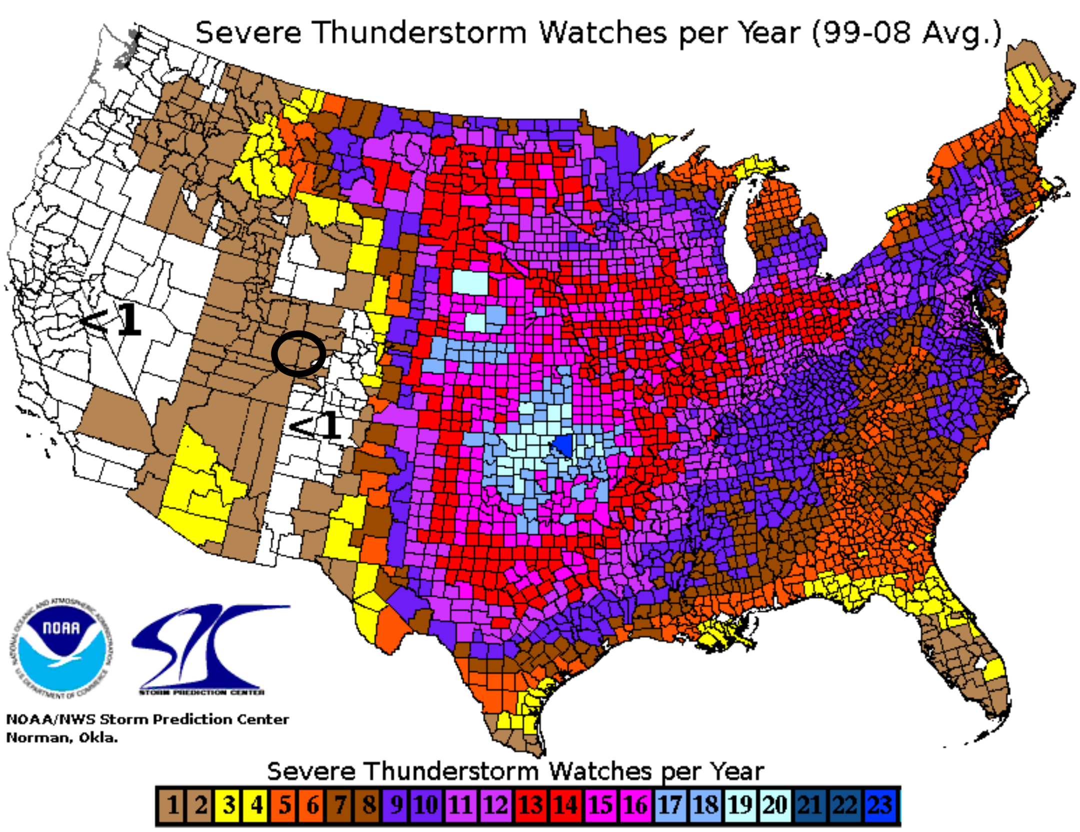
Thunderstorms are responsible for the development and formation of many severe weather phenomena, posing great hazards to the population and landscape. Damage that results from thunderstorms is mainly inflicted by downburst winds, large hailstones, and flash flooding caused by heavy precipitation. Stronger thunderstorms can produce tornadoes and waterspouts.

The National Weather Service issues two types of alerts for severe thunderstorms:

- A Severe Thunderstorm Watch indicates when and where severe thunderstorms are likely to occur. Citizens are urged to watch the sky and stay tuned to NOAA Weather Radio, commercial radio, or television for information. Severe Thunderstorm Watches are issued by the Storm Prediction Center in Norman, OK.
- A Severe Thunderstorm Warning is issued when severe weather has been reported by spotters or indicated by radar. Warnings indicate imminent danger to life and property to those in the path of the storm. Severe Thunderstorm Warnings are issued by the National Weather Service in Pueblo.

Boulder County sees 3-4 severe thunderstorm watches per year. The geographic extent rating for severe thunderstorms is considered extensive since the entire city limits is exposed.

Figure 4.30. Severe Thunderstorm Watches per Year in the Planning Area



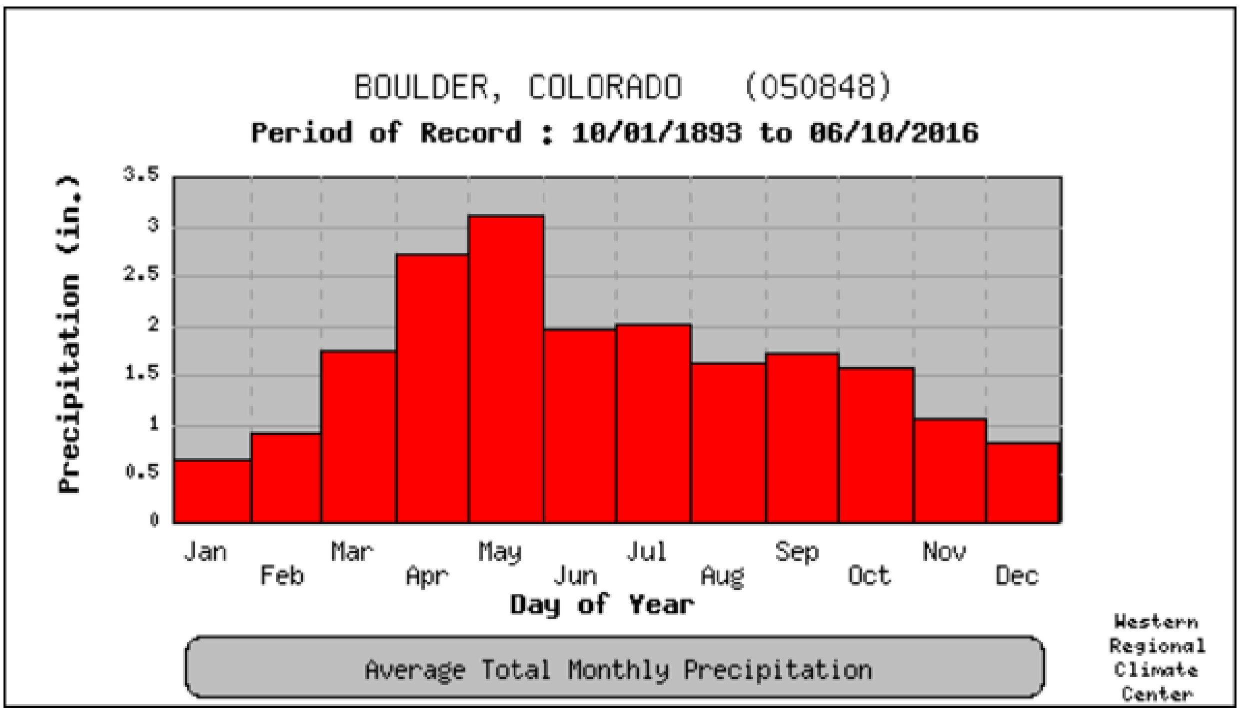
Source: NOAA/NWS Storm Prediction Center; Black oval indicates approximate location of City of Boulder

Past Occurrences

Heavy rains and severe thunderstorms occur in Boulder County and the City of Boulder primarily during the spring, summer, and early fall seasons. The bulk of the rain occurs between March and September but can vary by regions of the county.

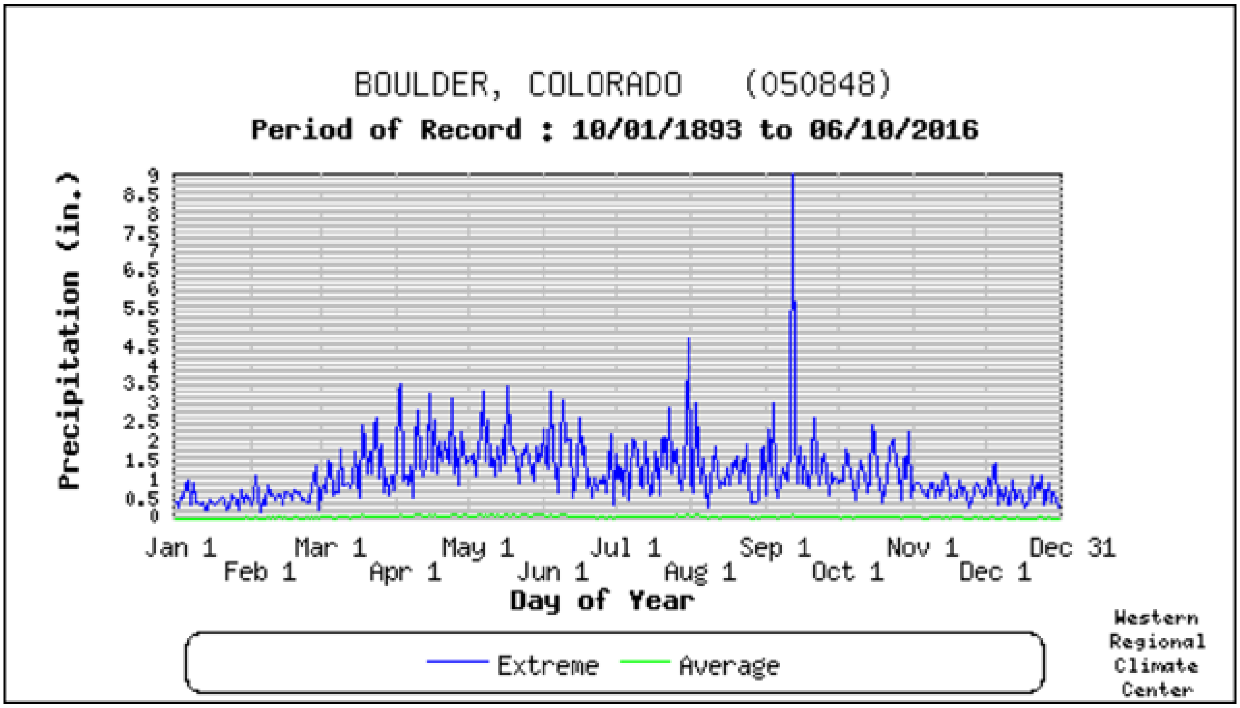
According to the Western Regional Climate Center, the average annual precipitation in the City of Boulder for the period of record 1893 to 2016 was 18.72 inches per year. The highest recorded annual precipitation was 29.43 inches in 1995; the highest recorded precipitation for a 24-hour period was 4.8 inches on July 31, 1919. The lowest annual precipitation total was 10.91 inches in 1954. Figure 4.31 illustrates the average total monthly precipitation for this same time period and Figure 4.32 illustrates the average and extreme daily precipitation amounts, also for the same time period.

Figure 4.31. Boulder Monthly Average Total Precipitation, 1893 to 2016



Source: Western Regional Climate Center, www.wrcc.dri.edu/

Figure 4.32. Boulder Daily Precipitation Average and Extreme, 1893 to 2016



Source: Western Regional Climate Center, www.wrcc.dri.edu/

Thunderstorms are frequently accompanied by heavy rains and hail. Sudden onset of heavy rains can lead to flash flooding, while hailstorms cause significant property and crop damage. More information on severe storms that have caused flooding or hail can be found in Section 4.2.5 and 4.2.12.

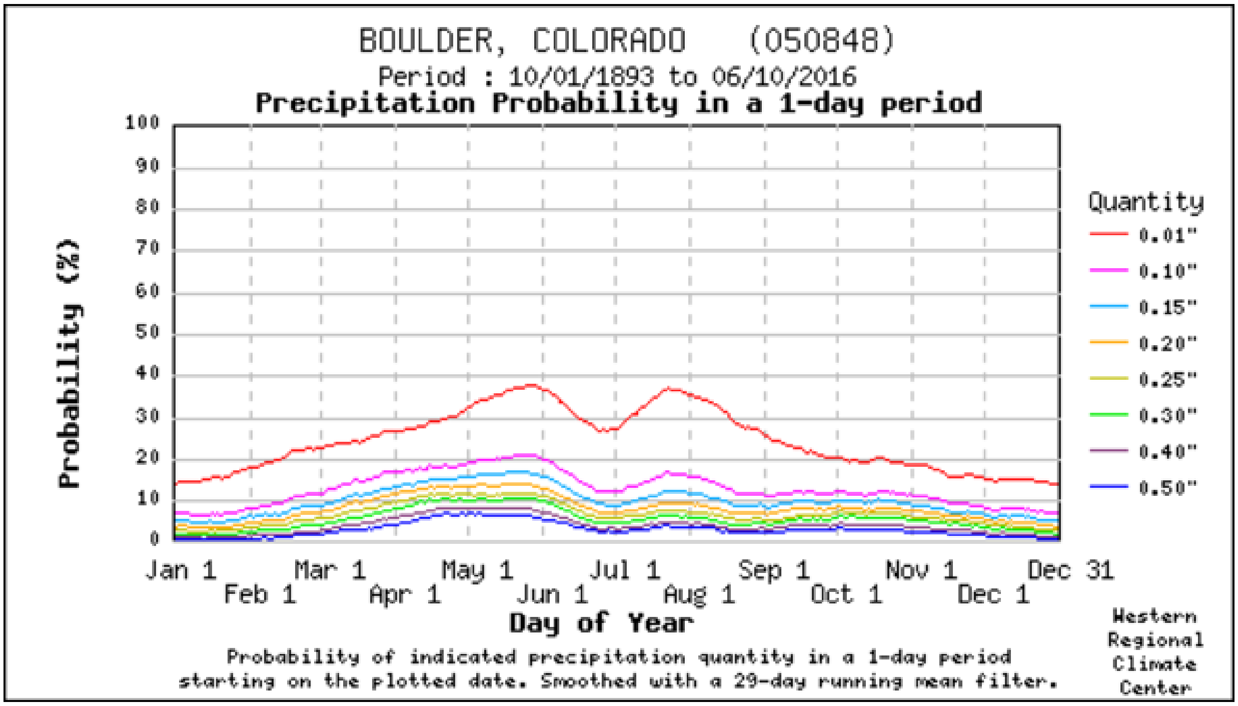
Extent

Thunderstorms and the associated heavy rain can occur anywhere in the City, however, the magnitude of impact is **limited** due to the minimal impact to quality of life and critical facilities or services.

Likelihood of Future Occurrences

Highly Likely: Given the history of severe weather events in Boulder County and the City of Boulder, severe weather, including thunderstorms and heavy rain will continue to occur annually. Figure 4.33 illustrates precipitation probability in a one-day period based on the time period 1893 to 2016.

Figure 4.33. Precipitation Probability in a One-Day Period 1893 to 2016



Source: Western Regional Climate Center, www.wrcc.dri.edu/

Climate Change Considerations

NASA's Earth Observatory provides an analysis on how climate change could, theoretically, increase potential storm energy by warming the surface and putting more moisture in the air through evaporation. The presence of warm, moist air near the surface is a key ingredient for summer storms that meteorologists have termed "convective available potential energy," or CAPE. With an increase in CAPE, there is greater potential for cumulus clouds to form. The study also counters this theory with the theory that warming in the Arctic could lead to less wind shear in the mid-latitude areas prone to summer storms, making the storms less likely. Based on these differing theories it is difficult at this point in time to summarize the effects climate change may have on thunderstorms.

4.2.14 Severe Weather: Lightning

Hazard/Problem Description

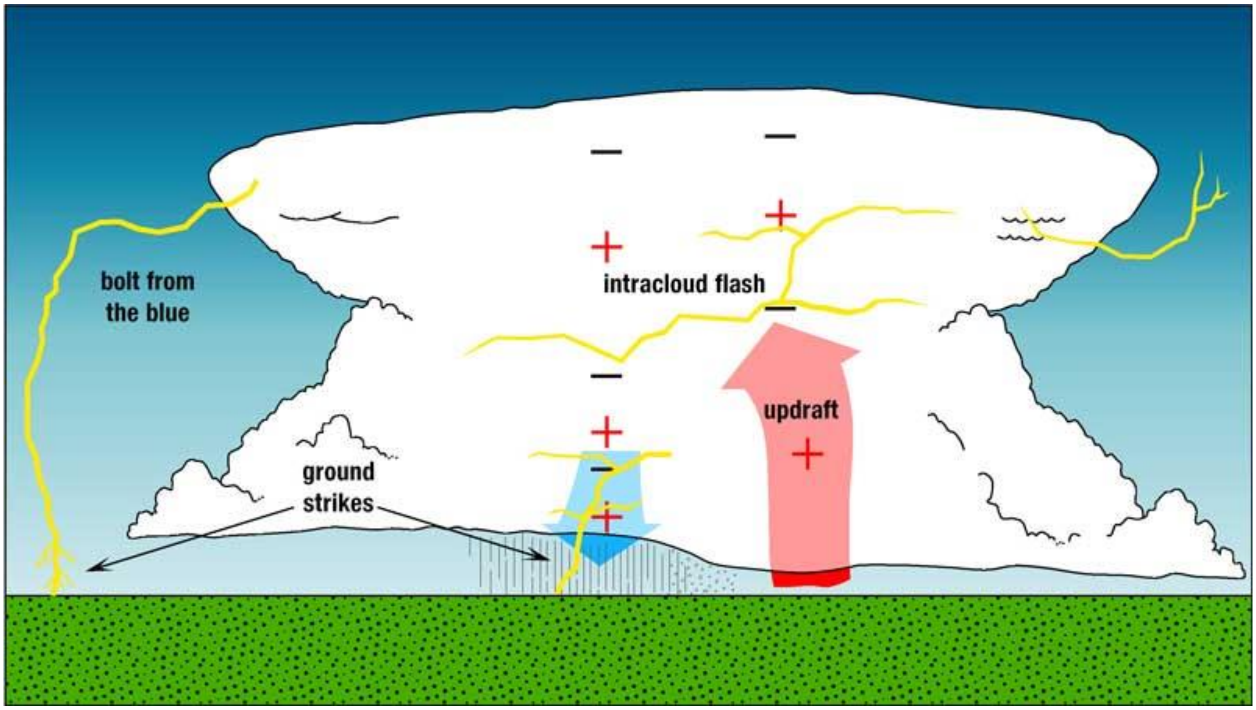
Lightning is an electrical discharge between positive and negative regions of a thunderstorm. A lightning flash is composed of a series of strokes with an average of about four. The length and duration of each lightning stroke vary, but typically average about 30 microseconds.

Lightning is one of the more dangerous weather hazards in the United States and in Colorado. Each year, lightning is responsible for deaths, injuries, and millions of dollars in property damage, including damage to buildings, communications systems, power lines, and electrical systems. Lightning also causes forest and brush fires, and deaths and injuries to livestock and other animals. According to the National Lightning Safety Institute, lightning causes more than 26,000 fires in the United States each year. The institute estimates property damage, increased operating costs, production delays, and lost revenue from lightning and secondary effects to be in excess of $6 billion per year. Impacts can be direct or indirect. People or objects can be directly struck, or damage can occur indirectly when the current passes through or near it.

Intra-cloud lightning is the most common type of discharge. This occurs between oppositely charged centers within the same cloud. Usually it takes place inside the cloud and looks from the outside of the cloud like a diffuse brightening that flickers. However, the flash may exit the boundary of the cloud, and a bright channel, like a cloud-to-ground flash, can be visible for many miles.

Cloud-to-ground lightning is the most damaging and dangerous type of lightning, though it is also less common. Most flashes originate near the lower-negative charge center and deliver negative charge to earth. However, a large minority of flashes carry positive charge to earth. These positive flashes often occur during the dissipating stage of a thunderstorm's life. Positive flashes are also more common as a percentage of total ground strikes during the winter months. This type of lightning is particularly dangerous for several reasons. It frequently strikes away from the rain core, either ahead or behind the thunderstorm. It can strike as far as 5 or 10 miles from the storm in areas that most people do not consider to be a threat. Positive lightning also has a longer duration, so fires are more easily ignited. And, when positive lightning strikes, it usually carries a high peak electrical current, potentially resulting in greater damage.

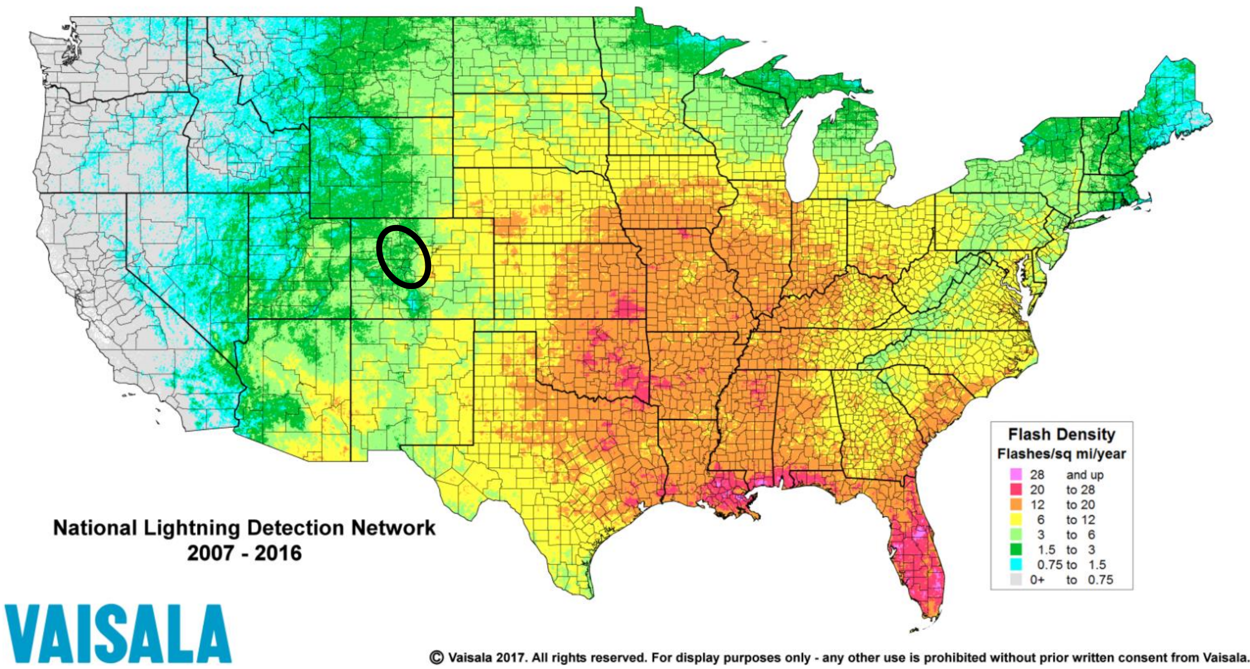
Figure 4.34. Cloud to Ground Lightning



Source: National Weather Service Pueblo Office

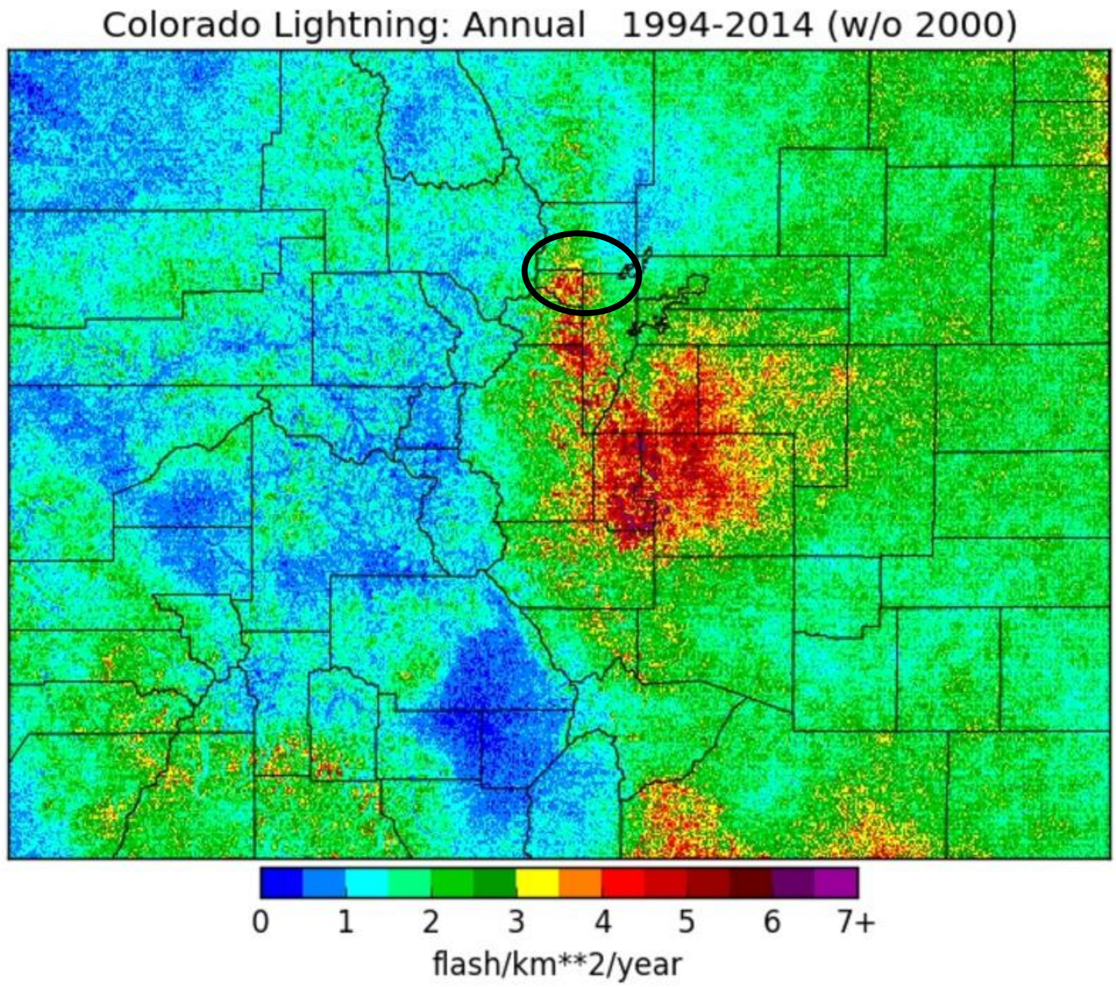
The ratio of cloud-to-ground and intra-cloud lightning can vary significantly from storm to storm. Depending upon cloud height above ground and changes in electric field strength between cloud and earth, the discharge stays within the cloud or makes direct contact with the earth. If the field strength is highest in the lower regions of the cloud, a downward flash may occur from cloud to earth. Using a network of lightning detection systems, the United States monitors an average of 25 million strokes of lightning from the cloud-to-ground every year. Figure 4.35 depicts cloud to ground lightning in the United States and the City of Boulder (circled in black). Figure 4.36 from the National Weather Service in Pueblo, depicts a more detailed lightning flash density map for the State of Colorado and the planning area (boxed in black). The geographic extent rating for lightning is considered extensive since the entire city limits is exposed.

Figure 4.35. Lightning Flash Density Map 2007-2016



Source: Vaisala's US National Lightning Detection Network

Figure 4.36. Colorado Lightning Flash Map 1994-2014



Source: National Weather Service Pueblo Office. http://www.crh.noaa.gov/pub/?n=/ltg/flash_density_maps_index.php
Black oval indicates approximate location of City of Boulder

Past Occurrences

According to the National Weather Service, an average of 62 people are killed each year by lightning in the United States. The true injury number is likely higher than this, because many people do not seek help, and not all lightning-related injuries are reported as such by doctors. Table 4.11 contains information from the National Weather Service on lightning casualties in Boulder County:

Table 4.11. Lightning Casualties in Boulder County, 1980-2010

Date	Time	Killed	Injured
June 27, 1980	2:12 p.m.	0	4
June 3, 1981	12:00 p.m.	1	2
August 22, 1981	Morning	0	2
August 5, 1983	5:00 p.m.	0	1
July 2, 1987	5:34 p.m.	0	4
August 7, 1987	7:30 p.m.	0	1
August 19, 1989	12:35 p.m.	1	1
June 25, 1988	3:30 p.m.	1	1
June 13, 1991	2:00 p.m.	0	1
August 30, 1992	11:30 a.m.	0	1
June 27, 1995	3:30 p.m.	0	1
June 5, 1997	2:00 p.m.	0	1
June 7, 1997	12:00 p.m.	0	1
June 19, 1997	2:04 p.m.	0	1
July 10, 2000	3:40 p.m.	0	3
July 12, 2000	2:00 p.m.	1	0
July 24, 2000	3:00 p.m.	0	2
August 3, 2009	12:00 p.m.	0	1
August 3, 2010	3:00 pm	0	1
Totals		**4**	**29**

Source: National Weather Service, www.crh.noaa.gov/pub/?n=/ltg/ltg_stats_index.php

Data from the National Centers for Environmental Information (NCEI) identified 44 lightning events in Boulder County between January 1, 1993, and August 10, 2017 (note: since this data is from a different source, it does not track exactly with the incidents reported in Table 4.11). The 10 lightning events that resulted in death/injury and/or property damage in or near the City of Boulder are detailed below:

- **May 15, 1993, 4:00 p.m**.—Lightning resulted in property damage of $5,000.
- **July 27, 1994, 4:00 p.m**.—Lightning resulted in property damage of $5 million. (The damage occurred when lightning struck a furniture store in Boulder, igniting a fire which caused major damage to the building and contents).
- **June 2, 1995, 5:30 p.m.**—Lightning resulted in property damage of $20,000.
- **July 10, 2000, 3:40 p.m.**—Lightning resulted in three injuries.
- **June 19, 2002, 5:30 p.m.**—Lightning resulted in property damage of $25,000.
- **August 5, 2002, 2:00 p.m.**—Lightning resulted in one injury.
- **May 21, 2007** –Lightning sparked a fire at a Boulder home and caused a fuel tank in a farm field to explode, near Teller Farm Open Space on Valmont Road. Lightning struck the roof of

the residence, causing the rafters in the attic to catch fire. $15,000 in property damages were reported as a result.

- **June 10, 2009 –** Lightning struck a veterinary hospital, damaging an exterior electrical box.
- **August 3, 2009** – Lightning injured a bicyclist in Boulder and sparked a fire in a wheat field near Deer Trail.

Extent

Lightning is measured by the Lightning Activity Level (LAL) scale, created by the National Weather Service to define lightning activity into a specific categorical scale. The LAL is a common parameter that is part of fire weather forecasts nationwide. The LAL is reproduced below:

Table 4.12. Lightning Activity Level Scale

LIGHTNING ACTIVITY LEVEL	
LAL 1	No thunderstorms
LAL 2	Isolated thunderstorms. Light rain will occasionally reach the ground. Lightning is very infrequent, 1 to 5 cloud to ground strikes in a five-minute period
LAL 3	Widely scattered thunderstorms. Light to moderate rain will reach the ground. Lightning is infrequent, 6 to 10 cloud to ground strikes in a five-minute period.
LAL 4	Scattered thunderstorms. Moderate rain is commonly produced. Lightning is frequent, 11 to 15 cloud to ground strikes in a five-minute period.
LAL 5	Numerous thunderstorms. Rainfall is moderate to heavy. Lightning is frequent and intense, greater than 15 cloud to ground strikes in a five-minute period.
LAL 6	Dry lightning (same as LAL 3 but without rain). This type of lightning has the potential for extreme fire activity and is normally highlighted in fire weather forecasts with a Red Flag warning.

Source: National Weather Service

Boulder is at risk to experience lightning in any of these categories, however, the magnitude of impact is **limited** due to the minimal impact to quality of life and critical facilities or services.

Likelihood of Future Occurrences

Highly Likely: Given the history of lightning occurrences in Colorado and the Boulder area, lightning is an annual occurrence and will continue to be a concern.

Climate Change Considerations

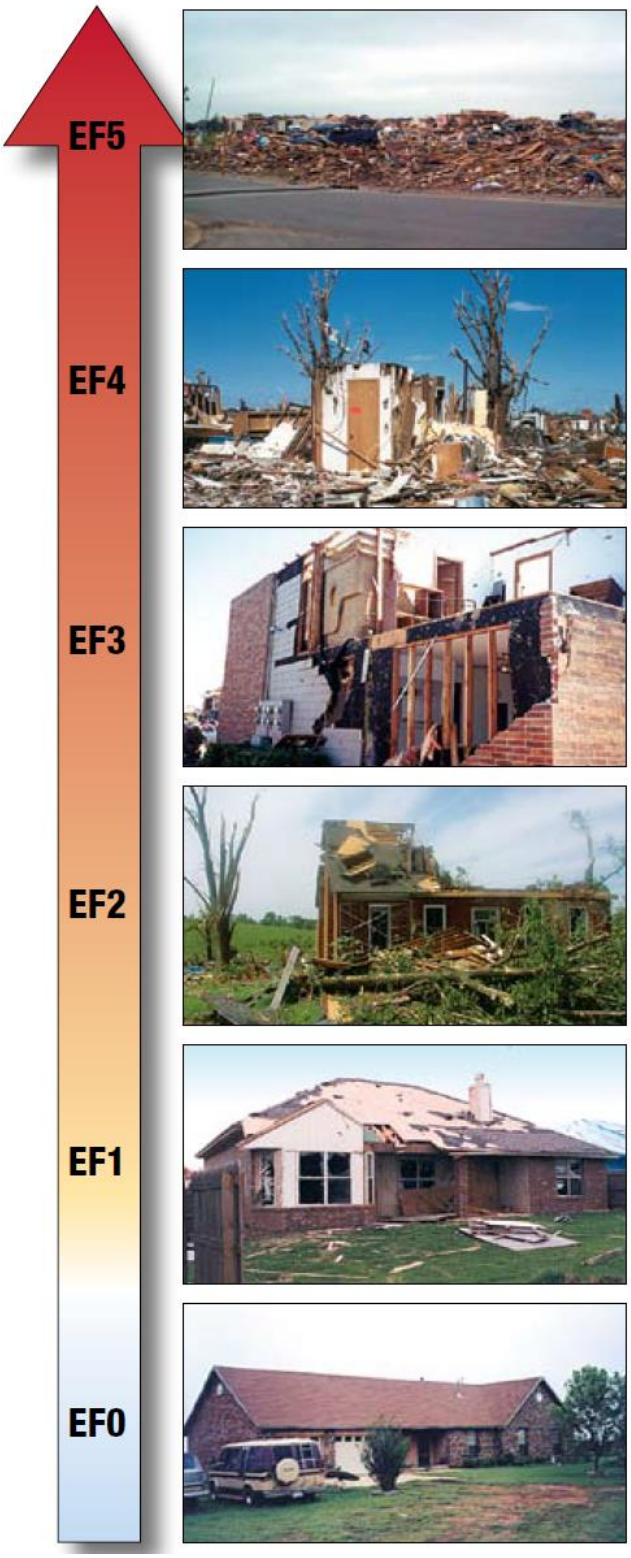
With additional heat in the atmosphere storms are projected to become more severe in the future, and thus lightning may become more prevalent, though Boulder's geographic setting may still temper the likelihood of direct strikes.

4.2.15 Severe Weather: Tornadoes

Tornadoes also affect Boulder County and the City of Boulder. Tornadoes form when cool, dry air sits on top of warm, moist air. In the plains areas of Colorado, this most often happens in the spring and early summer (i.e., May, June, and July) when cool, dry mountain air rolls east over the warm, moist air of the plains.

Tornadoes are rotating columns of air marked by a funnel-shaped downward extension of a cumulonimbus cloud whirling at destructive speeds of up to 300 mph, usually accompanying a thunderstorm. Tornadoes are the most powerful storms that exist. They can have the same pressure differential that fuels 300-mile-wide hurricanes across a path only 300-yards wide or less.

Figure 4.37. Potential Impact and Damage from a Tornado



Incredible: Strong frame houses are lifted from foundations, reinforced concrete structures are damaged, automobile-sized missiles become airborne, trees are completely debarked.

Devastating: Well-constructed houses are destroyed, some structures are lifted from foundations and blown some distance, cars are blown some distance, large debris becomes airborne.

Severe: Roofs and some walls are torn from structures, some small buildings are destroyed, non-reinforced masonry buildings are destroyed, most trees in forest are uprooted.

Considerable: Roof structures are damaged, mobile homes are destroyed, debris becomes airborne (missiles are generated), large trees are snapped or uprooted.

Moderate: Roof surfaces are peeled off, windows are broken, some tree trunks are snapped, unanchored mobile homes are overturned, attached garages may be destroyed.

Light: Chimneys are damaged, tree branches are broken, shallow-rooted trees are toppled.

Source: FEMA

Prior to February 1, 2007, tornado intensity was measured by the Fujita (F) scale. This scale was revised and is now the Enhanced Fujita scale. Both scales are sets of wind estimates (not measurements) based on damage. The new scale provides more damage indicators (28) and associated degrees of damage, allowing for more detailed analysis, better correlation between damage and wind speed. It is also more precise because it considers the materials affected and the construction of structures damaged by a tornado. Table 4.13 shows the wind speeds associated with the original Fujita scale ratings and the damage that could result at different levels of intensity. Table 4.14 shows the wind speeds associated with the Enhanced Fujita Scale ratings. The Enhanced Fujita Scale's damage indicators and degrees of damage can be found online at www.spc.noaa.gov/efscale/ef-scale.html.

Table 4.13. Original Fujita Scale

Fujita (F) Scale	Fujita Scale Wind Estimate (mph)	Typical Damage
F0	< 73	Light damage. Some damage to chimneys; branches broken off trees; shallow-rooted trees pushed over; sign boards damaged.
F1	73-112	Moderate damage. Peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos blown off roads.
F2	113-157	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.
F3	158-206	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.
F4	207-260	Devastating damage. Well-constructed houses leveled; structures with weak foundations blown away some distance; cars thrown and large missiles generated.
F5	261-318	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.

Source: National Oceanic and Atmospheric Administration Storm Prediction Center, www.spc.noaa.gov/faq/tornado/f-scale.html

Table 4.14. Enhanced Fujita Scale

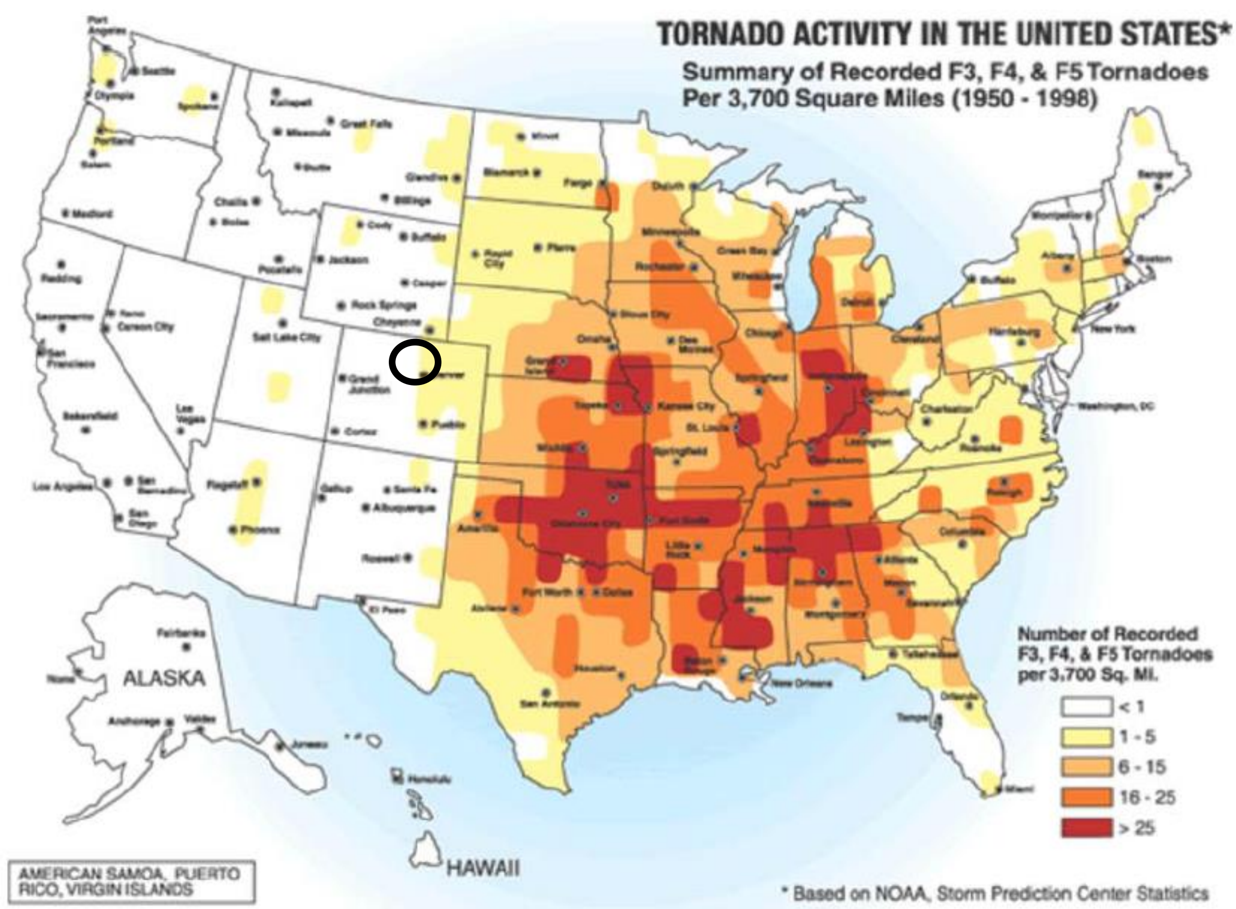
Enhanced Fujita (EF) Scale	Enhanced Fujita Scale Wind Estimate (mph)
EF0	65-85
EF1	86-110
EF2	111-135
EF3	136-165
EF4	166-200
EF5	Over 200

Source: National Oceanic and Atmospheric Administration Storm Prediction Center, www.spc.noaa.gov/faq/tornado/ef-scale.html

Tornadoes can cause damage to property and loss of life. While most tornado damage is caused by violent winds, most injuries and deaths result from flying debris. Property damage can include damage to buildings, fallen trees and power lines, broken gas lines, broken sewer and water mains, and the outbreak of fires. Agricultural crops and industries may also be damaged or destroyed. Access roads and streets may be blocked by debris, delaying necessary emergency response.

Figure 4.38 shows tornado activity in the United States based on the number of recorded tornadoes per 1,000 square miles. Eastern Boulder County is generally more susceptible than central and western Boulder County. The geographic extent rating for tornadoes is considered limited since a tornado is not anticipated to impact more than 10% of the planning area.

Figure 4.38. Tornado Activity in the United States



Source: NOAA; Black oval indicates approximate location of City of Boulder

Past Occurrences

According to data obtained by the HMPC, tornadoes are rare and usually only affect the lower elevations in the eastern portion of Boulder County. The National Centers for Environmental Information documents 4 incidents of tornadoes in or near the city between January 1, 1950, and February 29, 2017. Information on these events is detailed below:

- **September 17, 1953, 3:00 p.m**.—Magnitude F1, property damage of $3,000

- **October 15, 1980, 6:22 p.m.**—Magnitude F2, property damage of $25,000 (roof at Vo-Tech on East Arapahoe)
- **June 1, 1990, 5:03 p.m.**—Magnitude F0, no property damage
- **June 6, 1997, 1:15 p.m.**—Magnitude F1, no property damage (Other sources indicate a home was damaged in the vicinity of Baseline Reservoir during this event.)

While not in Boulder County, the Windsor tornado of May 22, 2008 occurred just to the northeast of the County and followed an unusual north-south path. Damage from the tornado resulted in a presidential disaster declaration.

Extent

Negligible—As previously stated, there have only been 4 tornadoes documented in Boulder County, of which the highest magnitude was F2 with $25,000 of associated damages. The most likely, a tornado incident would be recorded as F1, with minor injuries and illnesses, minimal property damage that does not threaten structural stability, and/or minimal interruption of essential facilities and services.

Likelihood of Future Occurrences

Occasional: 4 tornadoes occurred in Boulder County during a 62-year period of record keeping, which equates to one tornado every 15.5 years, on average, and a 6.4 percent chance of a tornado occurring in any given year. Based on this data, tornadoes will continue to occur in Boulder County; the risk to the city is dependent upon the nature and location of any given tornado.

Climate Change Considerations

There presently is not enough data or research to quantify the magnitude of change that climate change may have related to tornado frequency and intensity. NASA's Earth Observatory has conducted studies which aim to understand the interaction between climate change and tornadoes. Based on these studies meteorologists are unsure why some thunderstorms generate tornadoes and others don't, beyond knowing that they require a certain type of wind shear. Tornadoes spawn from approximately one percent of thunderstorms, usually supercell thunderstorms that are in a wind shear environment that promotes rotation. Some studies show a potential for a decrease in wind shear in mid-latitude areas. Because of uncertainty with the influence of climate change on tornadoes, future updates to the mitigation plan should include the latest research on how the tornado hazard frequency and severity could change. The level of significance of this hazard should be revisited over time.

4.2.16 Severe Weather: Windstorms

Hazard/Problem Description

High winds are a frequent occurrence throughout the Boulder area. High winds can result in property damage and injury. Strong gusts can rip roofs from buildings, snap power lines, shatter windows, down trees, and sandblast paint from cars. Other associated hazards include utility outages, arcing power lines, debris blocking streets, dust storms, and occasional structure fires.

Boulder has some of the highest peak winds of any city in the United States. The peak of the wind season is December and January, but downslope windstorms have been recorded in every month except July. Damage from Boulder's winds averages about a million dollars per year. One exceptionally strong storm on January 17, 1982, caused more than $10 million in damage. Table 4.15 outlines the Beaufort scale, describing the damaging effects of wind speed.

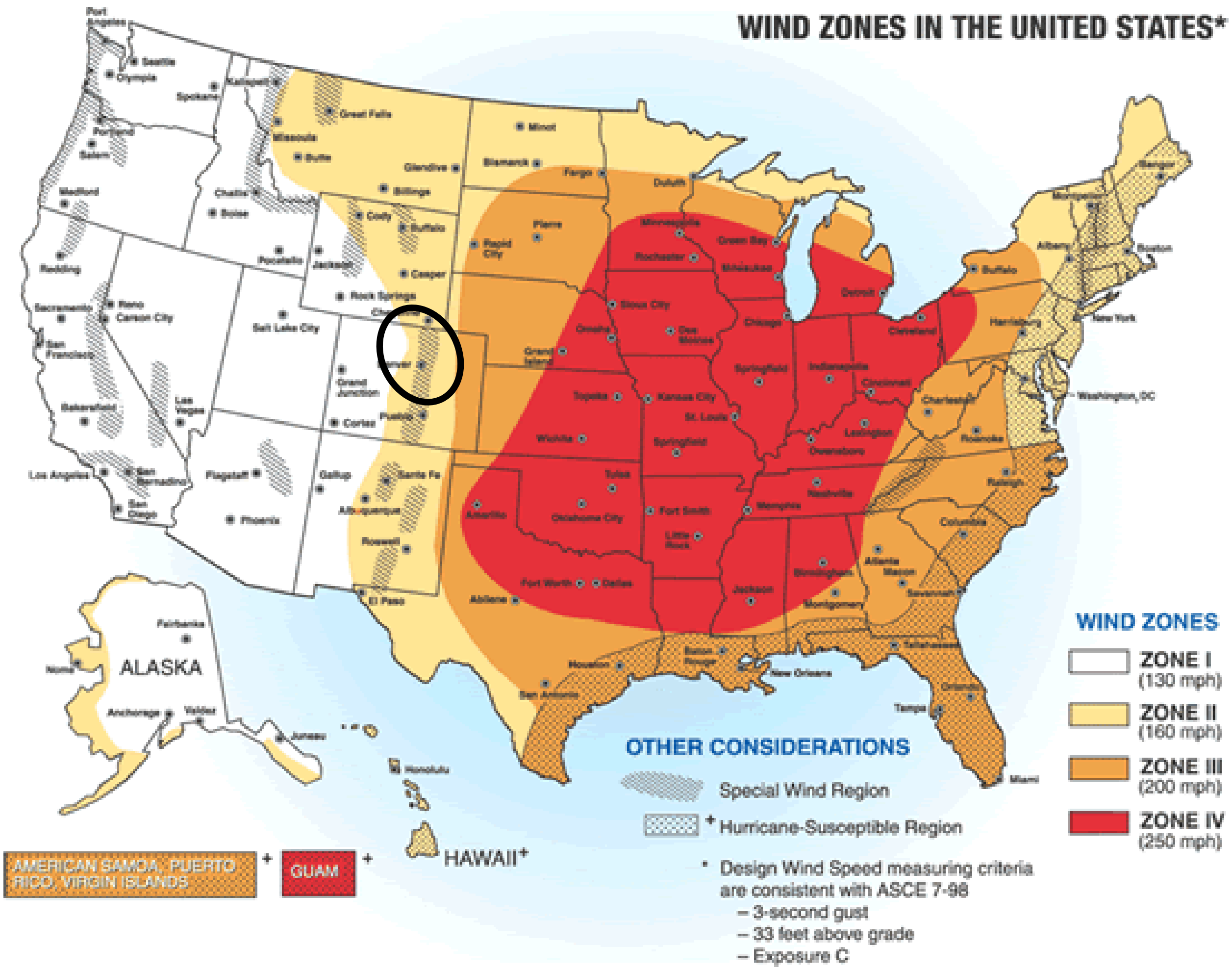
Table 4.15. Beaufort Wind Scale

Wind Speed (mph)	Description—Visible Condition
0	Calm; smoke rises vertically
1-4	Light air; direction of wind shown by smoke but not by wind vanes
4-7	Light breeze; wind felt on face; leaves rustle; ordinary wind vane moved by wind
8-12	Gentle breeze; leaves and small twigs in constant motion; wind extends light flag
13-18	Moderate breeze; raises dust and loose paper; small branches are moved
19-24	Fresh breeze; small trees in leaf begin to sway; crested wavelets form on inland water
25-31	Strong breeze; large branches in motion; telephone wires whistle; umbrellas used with difficulty
32-38	Moderate gale whole trees in motion; inconvenience in walking against wind
39-46	Fresh gale breaks twigs off trees; generally, impedes progress
47-54	Strong gale slight structural damage occurs; chimney pots and slates removed
55-63	Whole gale trees uprooted; considerable structural damage occurs
64-72	Storm very rarely experienced; accompanied by widespread damage
73+	Hurricane devastation occurs

Source: NOAA

Figure 4.39 depicts wind zones for the United States. The map denotes that the city falls into Zone II and a special wind region. Zone II is characterized by high winds of up to 160 mph. Special wind regions are characterized by winds exceeding 200 mph. Special winds that affect the city are Chinook and Bora Winds. The geographic extent rating for windstorms is considered extensive since the entire city limits are exposed.

Figure 4.39. Wind Zones in the United States

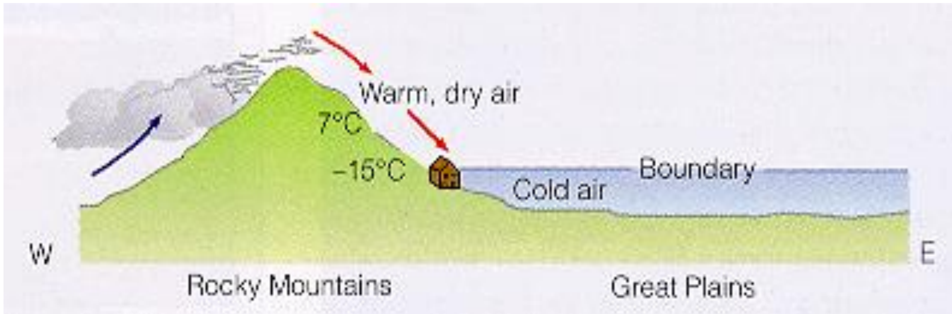


Source: Federal Emergency Management Agency; Black oval indicates approximate location of City of Boulder

Chinook Winds

Boulder's often violent, downslope winds are referred to as Chinook winds, after Native Americans of the Pacific Northwest. These downslope winds, typically warm and dry, occur in areas where mountains stand in the path of strong air currents. In Boulder, these warm, downslope winds occur when the winds blow across the Continental Divide from the west and descend the foothills into Boulder. They are caused by high pressure west of Boulder, low pressure over or east of Boulder, and strong westerly winds in the mountains. During these Chinooks, wind speeds can reach extreme values and do quite a bit of damage.

Figure 4.40. Chinook Wind Pattern



Source: University of Colorado at Boulder ATOC Weather Lab http://wxpaos09.colorado.edu/windstorms/windstorms.htm

Bora Winds

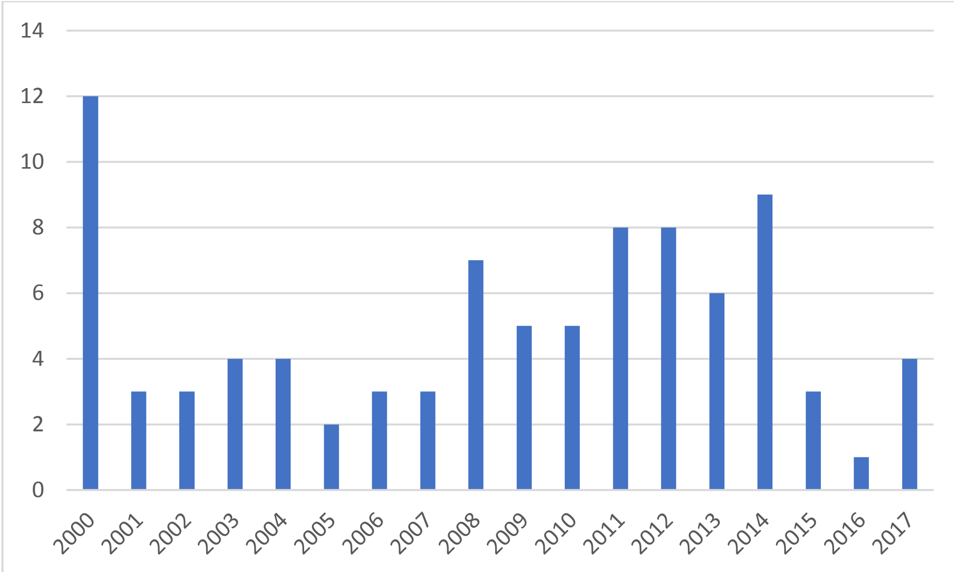
Bora winds, downslope winds that replace relatively warm light wind conditions with cold temperatures and strong wind gusts may also be observed in Boulder. Bora winds that strike Boulder blow from the west, are relatively dry, but are also cold. The arrival of a Bora in Boulder can be like the onset of a Chinook, with strong westerly, but colder and drier air, whereas a Chinook brings warmer and drier air. Generally, Bora winds are less extreme than winds generated during Chinook events.

Past Occurrences

High wind events are one of the most notable natural hazards affecting the Boulder area. According to NOAA's Climate Diagnostics Center, Boulder has some of the highest peak winds of any city in the United States. One location in or near the City of Boulder experiences wind gusts in excess of 100 mph almost every year. Gusts have been measured as high as 147 mph. The National Center for Atmospheric Research (NCAR) reports that a severe windstorm in January 1982, comparable to the landfall of a Category 2-3 hurricane, resulted in more than $10 million in damage and damaged nearly half of all buildings in Boulder.

To define this hazard, information was extracted from NOAA's Earth System Research Laboratory (ERSL) website. There were 90 notable Boulder wind events from 2000 through 2017. The data generally focuses on days in which wind gusts above 70 mph were reported somewhere in the area. Figure 4.41 shows the number of days of high winds per year.

Figure 4.41. Boulder Wind Events over 70 MPH, 2000-2017



Source: NOAA, http://www.esrl.noaa.gov/psd/boulder//wind.html

Other significant wind events identified by the HMPC include the following:

- **January 11, 1972**—Winds gusting to 97 mph damaged 40 trailers at Boulder Valley Village, including three that burned. Damage was estimated near $3 million.
- **January 17, 1982**—In one of the most devastating windstorms in Boulder County, winds were clocked at 137 mph at NCAR. Twenty gusts in excess of 120 mph were measured during a 45-minute period. South Boulder was the hardest hit area of the county. At least 15 people were treated for cuts and bruises at Boulder Community Hospital after being struck with flying debris and glass. Trees were uprooted, power lines toppled, roofs blown off, houses torn apart, and cars damaged. Damage totaled approximately $17 million.
- **November 17, 2013**—high winds developed over the foothills of Larmier and Boulder Counties. Peak wind gusts of 77 mph were recorded near Estes Park. Several trees were downed in the foothills of Boulder County, near Allenspark, Jamestown, and Nederland. One of the trees also downed a power line near Jamestown. There was $10,000 of property damage associated with this event.
- **February 10, 2017--** The wind toppled dozens of trees near Estes Park and Glen Haven. In Glen Haven, two sheds and several decks were damaged by fallen trees. Downed power lines caused scattered electrical outages in Boulder and Larimer Counties. Nearly four thousand residents in Boulder County were left without power. The wind toppled dozens of trees near Estes Park and Glen Haven. In Glen Haven, two sheds and several decks were damaged by fallen trees. Downed power lines caused scattered electrical outages in Boulder and Larimer Counties. Nearly four thousand residents in Boulder County were left without power. $100,000 of property damage was reported.

Wind-related deaths in Boulder County include the following:

- **January 7, 1969**—One half of all the houses in the city were damaged by wind. Winds clocked at 96 mph downtown and 130 mph at NCAR. One person died when he was blown off a Cherryvale fire department truck that was responding to a grass fire near the Boulder Airport.
- **June 1969**—A University of Colorado at Boulder student died while sailing under a parachute in 80 mph winds.
- **December 4, 1978**—148 mph, one death
- **January 10, 1990**—One person was killed in a three-car accident on the Boulder Turnpike two miles west of Broomfield. Winds gusting to 107 mph caused poor visibility.
- **October 29, 1996**—A Boulder County man died as he was trying to secure his pop-up camper trailer during winds more than 100 mph. The trailer blew over on top of him. Trees were downed and cars and property damaged.
- **December 31, 2011**—A Lyons man was killed when high winds caused a tree branch to smash through his car windshield while driving on US 36 north of Boulder.

Other significant storms with wind velocities above 90 mph or where damage occurred include the following:

- **October 1949**—85 mph, 300-ton crane toppled Valmont Plant
- January 15, 1967—125 mph, NCAR
- **June 25, 1969**—123 mph, NCAR
- January 24, 1970—122 mph, NCAR
- January 25, 1971—147 mph, NCAR
- **December 11, 1973**—120 mph, Marshall Mesa
- **November 26, 1977**—119 mph, Davidson Mesa
- **January 24, 1982**—140 mph, Wondervu
- **December 25, 1984**—112 mph, $100,000 damage
- **September 24, 1986**—131 mph, $100,000 damage
- **January 23, 1988**—90 mph, damaged bridge on Highway 157
- **February 9, 1988**—96 mph, 1,600 homes without power
- **May 7, 1988**—110 mph, 12,000 residents without power; annual Boulder Kinetics event canceled
- **January 8, 1990**—110 mph, minor damage
- **December 14, 1990**—120 mph, roof, trees, and cars damaged
- **January 24, 1992**—143 mph, NCAR, minor damage
- **January 3, 1995**—104 mph, Boulder Airport
- **December 4, 1995**—95 mph, NCAR, minor damage
- **November 13, 1995**—124 mph, NCAR, power outages in Nederland, a downed power line started a wildfire in Pine Brook Hills

- **February 16, 2007**—101 mph, National Wind Technology Center. Roads closed from blowing snow. Large scale winds from Berthoud Pass to Front Range.
- **June 6, 2007**—92 mph. Boulder. 101 Carter Lake.
- **January 5, 2008--** 90 mph 11 miles southwest of Boulder
- **January 27, 2009—**100 mph 6 miles northwest of Boulder
- **September 30, 2009—**93 mph at Red Feather Lakes and 88 mph at Coal Creek Canyon.
- **January 17, 2012**—104 mph in south Boulder
- **November 18, 2015**—94 mph NCAR; 90 mph 3 miles south-southwest of Boulder

Extent

While scales exist to measure the effects of wind, they can be conflicting or leave gaps in the information. For the purposes of this plan, the Beaufort Wind Scale was used because it is specifically adapted to wind effects on land. The Beaufort Wind Scale can be found in Table 4.15. The entire City of Boulder is susceptible to all twelve Beaufort Wind categories.

Wind storms in Boulder County threaten public safety, disrupt daily activities, cause damage to buildings and structures, increase the potential for other hazards (e.g., wildfire), and have adverse economic impacts from business closures and power loss.

Likelihood of Future Occurrences

Highly Likely: High winds are common in the Boulder area. Given historical data, topography of the area, and weather patterns, high winds in the City of Boulder will continue to occur annually.

Climate Change Considerations

There presently is not enough data or research to quantify the magnitude of potential change that climate change may have on windstorms. Future updates to the mitigation plan should include the latest research on how the windstorm hazard frequency and severity could change. The level of significance of this hazard should be revisited over time.

4.2.17 Soil Hazards: Expansive Soils

Hazard/Problem Description

Expansive (swelling) soils or soft bedrock are those that increase in volume as they get wet and shrink as they dry. Commonly, they are known as bentonite, expansive, or montmorillinitic soils. Swelling soils contain high percentages of certain kinds of clay particles that are capable of absorbing large quantities of water and expanding up to 10 percent or more as the clay becomes wet. The force of expansion is capable of exerting pressures of 20,000 pounds per square foot or greater on foundations, slabs, and other confining structures.

In Colorado, swelling soils tend to be at a constant moisture content in their natural state and are usually relatively dry prior to any construction disturbance. Exposure to water sources during or after development generally results in swelling. Colorado, with its arid or semiarid areas and seasonal changes in soil moisture, experiences a much higher frequency of swelling problems than eastern states that have higher rainfall and more constant soil moisture. Rocks that contain swelling clay are generally softer and less resistant to weathering and erosion than other rocks; therefore, expansive soil events occur more often along the sides of mountain valleys and on the plains than in the mountains.

Technical Description-Shrink-Swell Potential of Soil

Linear extensibility refers to the change in length of an unconfined clod as moisture content is decreased from a moist to a dry state. It is an expression of the volume change between the water content of the clod at 1/3 or 1/10 bar tension (33kPa or 10kPa tension) and oven dryness. The volume change is reported as percent change for the whole soil. The amount and type of clay minerals in the soil influence volume change.

Linear extensibility is used to determine the shrink-swell potential of soils. The shrink-swell potential is low if the soil has a linear extensibility of less than 3 percent; moderate if 3 to 6 percent; high if 6 to 9 percent; and very high if more than 9 percent. If the linear extensibility is more than 3, shrinking and swelling can cause damage to buildings, roads, and other structures and to plant roots. Special considerations for structural design are common to mitigation against expansive soils.

Technical Description- Heaving/Dipping Bedrock

Heaving bedrock is a geological hazard that is related to expansive soils, but it is more complex in terms of its uplift morphologies, deformation mechanisms, and regional distribution. It is common along Colorado’s Front Range piedmont where steeply dipping sedimentary bedrock containing zones of expansive claystone is encountered near to the ground surface.

The heave features associated with heaving bedrock are distinctly linear and are caused by differential swelling and/or rebound movements within the bedrock. Heaving bedrock has caused exceptional damage to houses, roads, and utilities along the Front Range piedmont since suburban-type development began in the early 1970s. Much of this damage may be attributed to the longstanding tendency to assume that the bedrock may be treated, for site-exploration and design purposes, as an expansive soil having essentially uniform properties. This approach ignores the strong heterogeneity that is often present in the bedrock.

Extent

In areas of high swelling soils damage to foundations can lead to buildings being condemned. No evidence of this extent level has been recorded. Based on this information, the geographic extent rating for expansive soils in the city of Boulder is negligible.

Swelling soils are one of the nation's most prevalent causes of damage to buildings. Annual losses are estimated in the range of $2 billion. In Colorado, the cost is estimated at $16 million annually. Damage can include severe structural damage; cracked driveways, sidewalks, and basement floors; heaving of roads and highway structures; condemnation of buildings; and disruption of pipelines and other utilities. Destructive forces may be upward, horizontal, or both. Buildings designed with lightly loaded foundations and floor systems often incur the greatest damage and costly repairs from expansive soils. Building in and on swelling soils can be done successfully, although more expensively, if appropriate construction design and mitigation measures are followed.

Past Occurrences

The HMPC had no data on the historic occurrences of expansive soils that have caused significant damages within the City of Boulder.

Likelihood of Future Occurrences

Without historic data, the HMPC was unable to accurately assess the nature and extent of future occurrences of expansive soils. Expansive soils have been recognized as a potential problem along the Colorado Front Range for several decades. Mitigation of problem soils is typically addressed in new building and site development regulations. Based on this information, the occurrence rating for damaging expansive soils events in the City of Boulder is unlikely.

Climate Change Considerations

The rapid temperature changes from freezing to melting that are associated with climate change may have an effect on expansive soils in Boulder.

4.2.18 Soil Hazards: Land Subsidence

Hazard/Problem Description

The Colorado Geological Survey defines land subsidence as the sinking of the land over manmade or natural underground voids. In Boulder County, the type of subsidence of greatest concern is the settling of the ground over abandoned mine workings. Past coal and clay mining activities have created surface subsidence in some areas and created the potential for subsidence in other areas. 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 hydro compaction.

Natural and human activities cause subsidence. Activities that lead to subsidence include underground mining, pumping groundwater or petroleum out of the ground, hydro compaction, and draining organic soils. 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 which have not visibly subsided. In Colorado, it is most common in the sedimentary rocks over 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 percent. Surface ground displacement of several feet can result. Similar processes frequently affect old landfills or poorly placed earth fills.

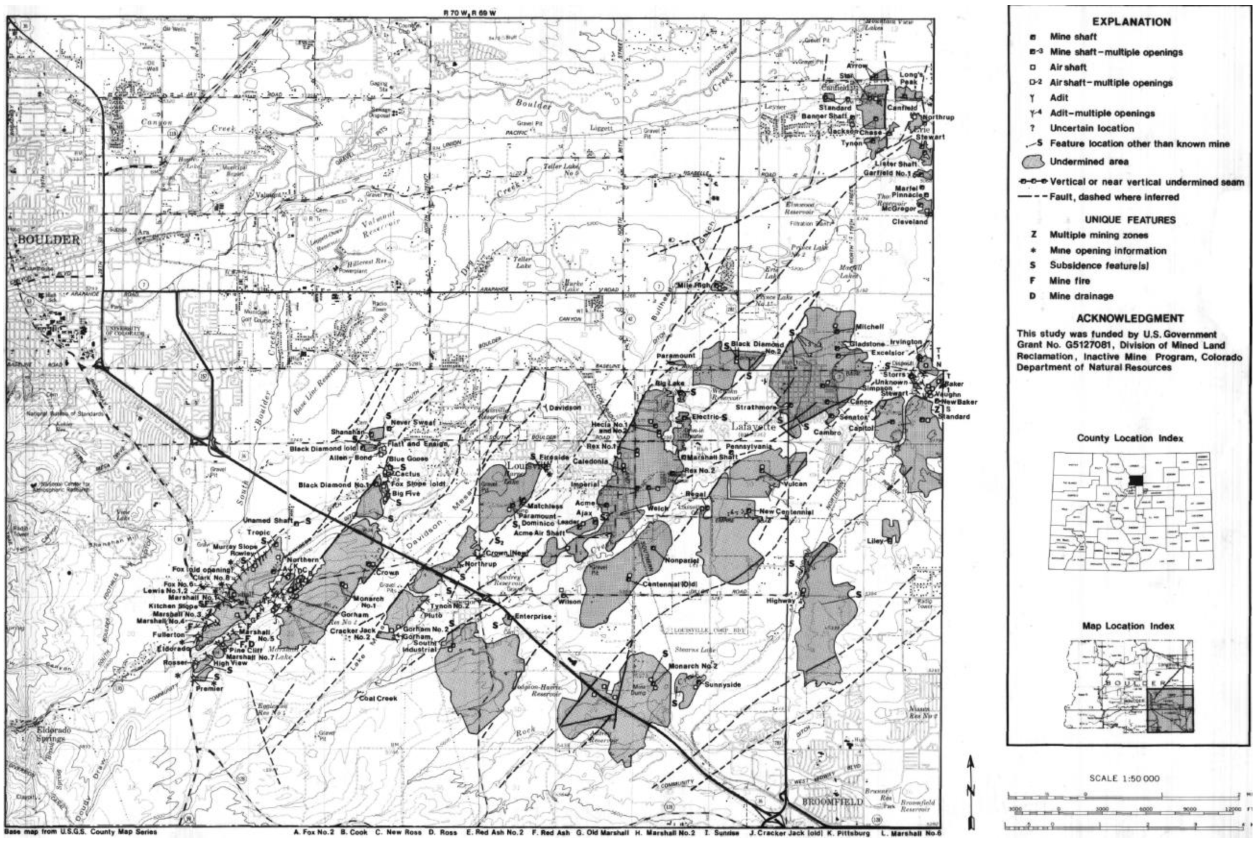
Extent

Impacts related to subsidence historically have been isolated and affected foundations of residential housing. Based on this information, the geographic extent rating for land subsidence in the city of Boulder is negligible.

Subsidence and collapsible soils tends to be problematic along the Front Range. The largest concern for subsidence generally occurs where land with sedimentary rock is undermined around historic coal and clay mines. In addition to undermined areas, ground subsidence hazards also occur where evaporitic bedrock (gypsum, anhydrite, and rock salt) dissolves. Subsidence sags and ground downwarping, caverns and opens fissures, ground seepage and streams flowing from bedrock, and several types of sinkholes, are landforms collectively called karst morphology.

The Colorado Geological Survey has a series of maps available showing the extent of coal mining in communities along the Front Range. Figure 4.42 provides a map from Boulder County. They gray areas on the maps indicate the location of undermined land.

Figure 4.42. Boulder County Undermined Land Map



Source: 2011 Colorado Natural Hazards Mitigation Plan

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. Weight, including surface developments such as roads, reservoirs, and buildings and manmade vibrations from such activities as blasting or heavy truck or train traffic can accelerate the natural processes of subsidence. Fluctuations in the level of underground water caused by pumping or by injecting fluids into the earth can initiate sinking to fill the empty space previously occupied by water or soluble minerals. The consequences of improper use of land subject to ground subsidence can be excessive economic losses, including the costs of repair and maintenance for buildings, irrigation works, highways, utilities, and other structures. This results in direct economic losses to citizens as well as indirect economic losses through increased taxes and decreased property values.

Past Occurrences

Subsidence has occurred in Boulder County. Based on information included in the state hazards mitigation plan, a substantial area within Boulder County is a major mining district and a portion of the eastern county is a coal region. Boulder County is second in the state in terms of number of abandoned mines with 183 abandoned coal mines and 3,600 abandoned mines of other types. In Lafayette in 1974, an abandoned coal mine created a sinkhole in a trailer park area that expanded to 25 feet deep and 25 feet in diameter in about a 24-hour period.

The HMPC had no data on the historic occurrences of subsidence within the City of Boulder.

Likelihood of Future Occurrences

Without historic data, the HMPC was unable to determine the nature and extent of future occurrences of subsidence within the city. Based on this information, the occurrence rating for land subsidence in the city of Boulder is unlikely.

Climate Change Considerations

The increases in precipitation that are associated with climate change are not likely to impact land subsidence in Boulder.

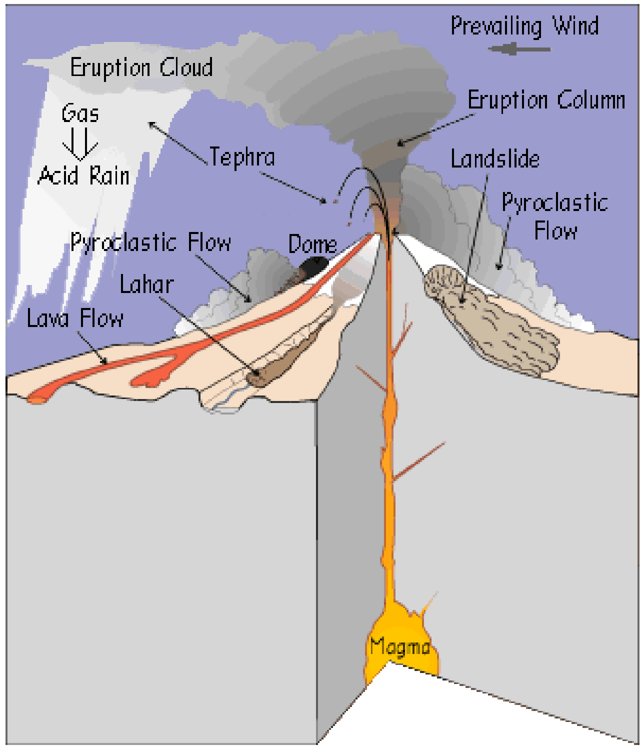
4.2.19 Volcanoes

Hazard/Problem Description

Of the almost 70 active and potentially active volcanoes in the United States, more than 50 have erupted one or more times in the past 200 years. Volcano hazards are the greatest in five western states: Alaska, Hawaii, California, Oregon, and Washington. Volcanoes create a wide variety of hazards that can kill people and destroy property.

Populations living near volcanoes are most vulnerable to volcanic eruptions and lava flows; although, large explosive eruptions can endanger people and property hundreds of miles away and even affect global climate. Volcanic ash can also travel and affect populations many miles away. The ash from the 1980 eruption of Mount St. Helens in Washington fell over a large area of the western United States. Heavy ash fall can collapse buildings, and even minor ash fall can damage crops, electronics, and machinery. Some volcanic hazards, such as landslides, can occur even when a volcano is not erupting. Figure 4.43 depicts a volcano typical of those found in the western United States.

Figure 4.43. Typical Western U.S. Volcano



Source: http://pubs.usgs.gov/fs/fs002-97/

The only volcano of concern in Colorado is Dotsero, which, according to the U.S. Geological Survey is a moderate threat volcano. The Dotsero crater, about a half-mile north of I-70 on the east side of Glenwood Canyon has not erupted in 4,000 years. Should Dotsero erupt again, it would likely not have much of an impact on the Boulder area.

Another volcanic risk in the Rocky Mountain region is the Yellowstone Caldera. This large but somewhat distant area of volcanic activity could pose regional ash fall threats. Very large-scale explosive volcanic activity has occurred in the Yellowstone area within the past 2.5 million years, which, in geologic time, is very recent. Because of this, the Yellowstone volcanic area is considered a substantial threat across Wyoming and much of the western United States. It is possible that another eruption of similar magnitude will occur, but probably not within the next 20,000 or more years. If another large-scale eruption did occur, thickness of the volcanic material produced would be immense. Some studies predict that ash in southeastern Wyoming would be over three feet deep. Because of the overly long expected occurrence of frequency (greater than 10,000 years) for explosive volcanism at Yellowstone, and the fact that effective mitigation for an event of this low frequency and magnitude is difficult, it was not analyzed in further this document.

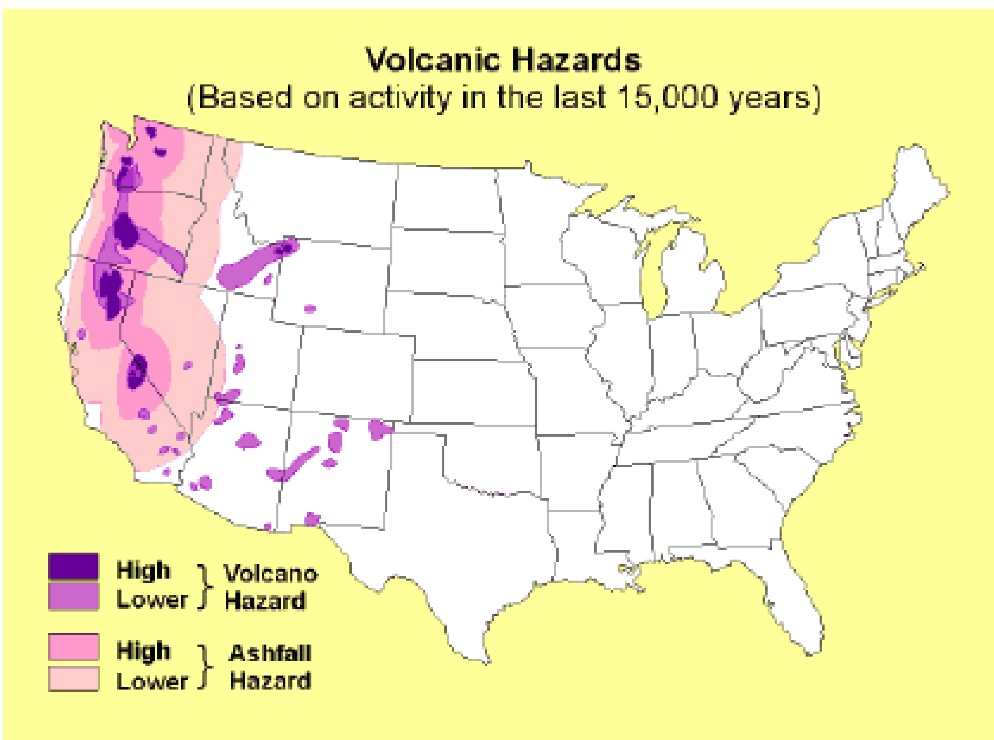
Past Occurrences

The HMPC indicated that the only evidence of volcanic activity in the Boulder area occurred during the 1980 eruption of Mt. St. Helens when ash fell in the city.

Likelihood of Future Occurrences

Unlikely: Given its location regarding potentially active volcanoes in the United States, the Boulder area is not at great risk to volcanic hazards. Volcanic hazards would likely be limited to ash fall from a large eruption of a volcano in the western United States. Figure 4.44 illustrates volcanic hazards based on activity in the last 15,000 years. Areas in blue or purple show regions at greater or lesser risk of local volcanic activity, including lava flows, ashfall, lahars (volcanic mudflows), and debris avalanches. Areas in pink show regions at risk of receiving five or more centimeters of ashfall from large or very large explosive eruptions originating at the volcanic centers shown in blue. An eruption of an active volcano in the western United States is not likely to adversely impact the City of Boulder. For the purposes of this plan volcanoes were considered to have a 'limited' geographic extent rating.

Figure 4.44. Volcanic Hazards Ash Dispersion Map



Source: U.S. Geological Survey

Climate Change Considerations

There presently is not enough data or research to quantify the magnitude of potential change that climate change may have on volcanic activity.

Extent

Based on the information provided in this profile, the potential magnitude of the volcanic hazard is considered **negligible**.

4.2.20 Wildfire

Hazard/Problem Description

Wildfire and urban wildfire are an ongoing concern for Boulder County and the City of Boulder. Generally, the fire season extends from spring to late fall. Fire conditions arise from a combination of hot weather, an accumulation of vegetation, and low moisture content in air and fuel. These conditions, especially when combined with high winds and years of drought, increase the potential for wildfire to occur. The wildfire risk is predominantly associated with the wildland-urban interface, areas where development is interspersed or adjacent to landscapes that support wildland fire. A fire along this wildland-urban interface can result in major losses of property and structures. Significant wildfires can also occur in heavily populated areas. Rangeland and grassland fires are a concern in the eastern portion of Boulder County, including areas of the city, due to increased residential development in semi urban and rural areas.

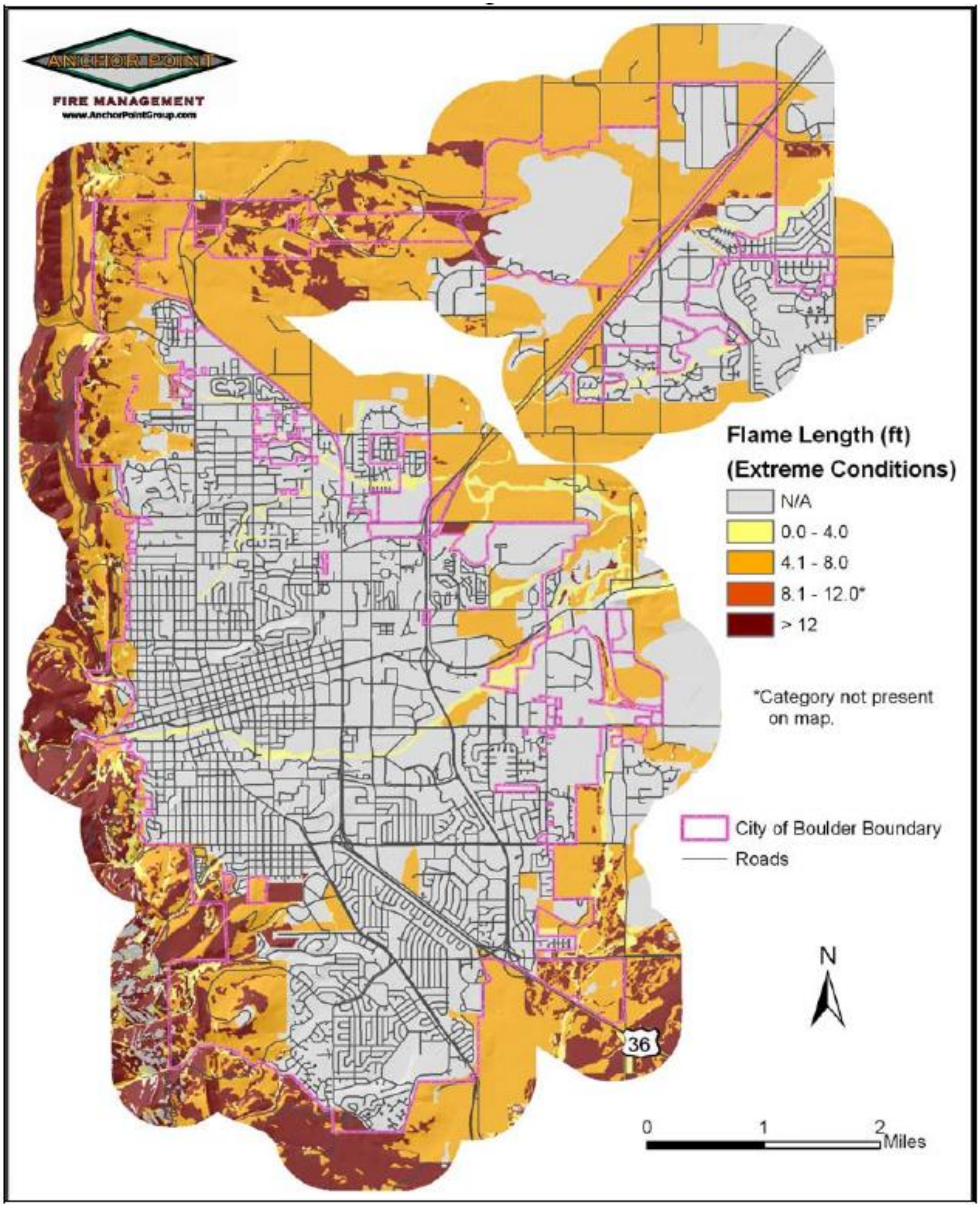
Generally, there are three major factors that sustain wildfires and predict a given area's potential to burn. These factors are fuel, topography, and weather.

- **Fuel**—Fuel is the material that feeds a fire and is a key factor in wildfire behavior. Fuel is generally classified by type and by volume. Fuel sources are diverse and include everything from dead tree needles and leaves, twigs, and branches to dead standing trees, live trees, brush, and cured grasses. Also, to be considered as a fuel source are manmade structures, such as homes and associated combustibles. The type of prevalent fuel directly influences the behavior of wildfire. Light fuels such as grasses burn quickly and serve as a catalyst for fire spread. In addition, "ladder fuels" can spread a ground fire up through brush and into trees, leading to a devastating crown fire that burns the upper canopy and cannot be controlled. The volume of available fuel is described in terms of fuel loading. Certain areas in and surrounding Boulder County are extremely vulnerable to fires as a result of dense vegetation combined with a growing number of structures being built near and within rural lands. The presence of fine fuels, 1,000 hour fuels (1,000-hour dead fuel moisture levels are computed from a 7-day average boundary condition composed of day length, hours of rain, and daily temperature/humidity ranges. Fuel sizes range from 3 to 6 inches in diameter.), and needle cast combined with the cumulative effects of previous drought years, vegetation mortality, tree mortality, and blowdown across Boulder County has added to the fuel loading in the area. Fuel is the only factor that is under human control.

- **Topography**—An area's terrain and land slopes affect its susceptibility to wildfire spread. Both fire intensity and rate of spread increase as slope increases due to the tendency of heat from a fire to rise via convection. The arrangement of vegetation throughout a hillside can also contribute to increased fire activity on slopes.
- **Weather**—Weather components such as temperature, relative humidity, wind, and lightning also affect the potential for wildfire. High temperatures and low relative humidity dry out the fuels that feed the wildfire creating a situation where fuel will more readily ignite and burn more intensely. Wind is the most treacherous weather factor. The greater the wind, the faster a fire will spread, and the more intense it will be. Winds can be significant at times in Boulder. In addition to wind speed, wind shifts can occur suddenly due to temperature changes or the interaction of wind with topographical features such as slopes or steep hillsides. Lightning also ignites wildfires, which are often in terrain that is difficult for firefighters to reach. Drought conditions contribute to concerns about wildfire vulnerability. During periods of drought, the threat of wildfire increases.

Figure 4.45 represents a classification of the expected relative wildfire severity based on modeled flame lengths under extreme weather conditions. The figure is from the City Community Wildfire Protection Plan (CWPP) and is representative of fire behavior from weather conditions on the five most severe fire weather days in each season for a thirty-year period averaged together. This information was used to generate "areas of concern" and for the CWPP. The geographic extent rating for wildfire is considered limited with less than 10% of the planning area affected, but the entire western edge of city is potentially exposed.

Figure 4.45. Wildfire Flame Length, Extreme Conditions



Source: City of Boulder CWPP

Potential losses from wildfire include human life; structures and other improvements; natural and cultural resources; quality and quantity of the water supply; assets such as timber, range and crop land, and recreational opportunities; and economic losses. Smoke and air pollution from wildfires can be a severe health hazard. In addition, catastrophic wildfire can lead to secondary impacts or losses, such as future increased flooding and landslides debris flows during heavy rains (see related discussion in the flood hazard profile).

A report completed by JW Associates in 2015 studied the potential wildfire impacts on Boulder's watershed. This is discussed further in Section 4.3.

Past Occurrences

Wildfires are of significant concern throughout Colorado. According to the Colorado State Forest Service, vegetation fires occur on an annual basis; most are controlled and contained early with limited damage. For those ignitions that are not readily contained and become wildfires, damage can be extensive. There are many causes of wildfire, from naturally caused lightning fires to human-caused fires linked to activities such as smoking, campfires, equipment use, and arson. Historically, Boulder County has experienced numerous wildfires dating back to June 29, 1916. Details are provided below.

- **June 29, 1916**—1,000 acres burned around Bear Mountain.
- **July 5, 1924**—1,600 acres burned near Nederland.
- **August 9, 1978**—Fire caused by lightning burned more than 1,000 acres in the northwestern portion of Boulder County in Rocky Mountain National Park.
- **October 6, 1980**—A fire caused by an arsonist burned 150 acres in the Pine Brook Hills subdivision, destroying a $150,000 home.
- **September 1988**—The Lefthand Canyon fire (1,500 acres) and Beaver Lake fire (700 acres) occurred in the canyon above Buckingham Park and close to Beaver Lake near Ward. Houses were threatened, but no structures were lost. Both were thought to be human-caused fires.
- **July 9, 1989**—The Black Tiger fire destroyed 44 homes on Sugarloaf Mountain and burned over 2,100 acres. Hot temperatures, low humidity, and gusty winds contributed to this human-caused fire. Costs were estimated at $10 million.
- **November 24, 1990**—Olde Stage Road fire, considered the fourth major wildfire in Boulder County, started when a man threw a burning mattress out his front door. Wind gusts up to 80 mph fanned the fire out of control. Ten homes, five out-buildings, and approximately 3,000 acres were burned in the fire.
- **September 15, 2000**—Walker Ranch/Eldorado fire, likely a human-caused fire, burned approximately 1,000 acres. No structures were lost; but over 250 homes were threatened. Firefighting costs were estimated at $1.5 million. A FEMA fire management assistance declaration was made to help cover firefighting costs. This area had previously undergone fuels treatment, which mitigated the severity of the fire.
- **October 29, 2003**—The Overland fire likely started when the top half of a tree that was sheared off by 60 mph winds fell onto a power line on or near the Burlington Mine cleanup site in

Jamestown. High winds and dry weather conditions existed. 3,500 acres were burned; 12 residences and several outbuildings were destroyed. Firefighting costs were approximately $400,000. FEMA approved a request from the governor for federal fire management assistance.

- **February 14, 2006**—The Elk Mountain fire consumed an estimated 600 acres of brush and grassland north of Boulder. The fire originated in a pile of fireplace ashes that had been dumped outside of a mobile home. The gusting winds spread the hot ash, igniting nearby grasses that were tinder-dry after a prolonged period of dry, hot weather. Winds pushed the fire into a blaze that expanded rapidly, threatening at least three homes. No structures were lost, and damage was largely limited to fences, an apple orchard, and two old farm trucks.
- **January 7, 2009** – At about 1:00 pm on Wednesday, January 7, 2009, 60 + mile per hour winds snapped a power pole, dropping its energized power line onto a wire fence at 45th and Neva road. The sparks from the line on the fence ignited a fire in the grasses, shrubbery and subsequently, a home. This was the first in a series of events, which would be known as the Olde Stage Fire Complex. Due to the extreme wind event, a home at 45th St. was quickly consumed by the fire. Flying embers started a series of running grass fires to the east of the structure. As these fires were being fought, large plumes of smoke became visible to the west of Hwy 36. A second fire had started on Olde Stage Road and was rapidly spreading through the Crestview community, Joder Ranch and east towards the community of Lake Valley.
- **September 13, 2010** – The Fourmile Canyon Fire, which destroyed 169 homes and other personal property in the foothills just northwest of Boulder, was the most expensive wildfire in Colorado history, according to early insurance estimates. Preliminary damage estimates totaled in excess of $217 million from insurance claims that include smoke damage, additional living expenses, damaged and destroyed homes, as well as personal belongings and vehicles. The estimated insured losses make the Fourmile Canyon Fire Colorado's most expensive wildfire with an insurance price tag four times higher than 2002's Hayman Fire which resulted in $46.1 million in insured damage when adjusted for inflation.
- **October 29, 2010** – Following the Fourmile Canyon Fire was the Dome Fire. The Dome Fire forced the evacuation of more than 1,800 people and threatened the city's western edge near downtown. It began around 8 a.m. Friday near the Dome Rock formation in Boulder Canyon and quickly burned north, cresting the ridge between Boulder and Sunshine canyons after a few hours. Boulder Community Hospital's Maxwell and Mapleton facilities were also evacuated and were temporarily closed. The hospital's north Broadway location was not affected. Xcel Energy temporarily cut power to about 10,000 Boulder-area homes on Friday afternoon as the company rerouted power from the burn area. Xcel later cut power to residences in the Knollwood and Seven Hills areas. Periodic outages also affected downtown Boulder. Fortunately, firefighters could contain the fire before it spread to structures near downtown Boulder.
- **March 11, 2011** – The Lefthand Canyon Fire Started around 10:35 a.m. in Chaos Canyon and was believed to be human-caused. Residents of Lake of the Pines, North Foothills Ranch and Mountain Ridge were evacuated. In total, 622 acres were burned.

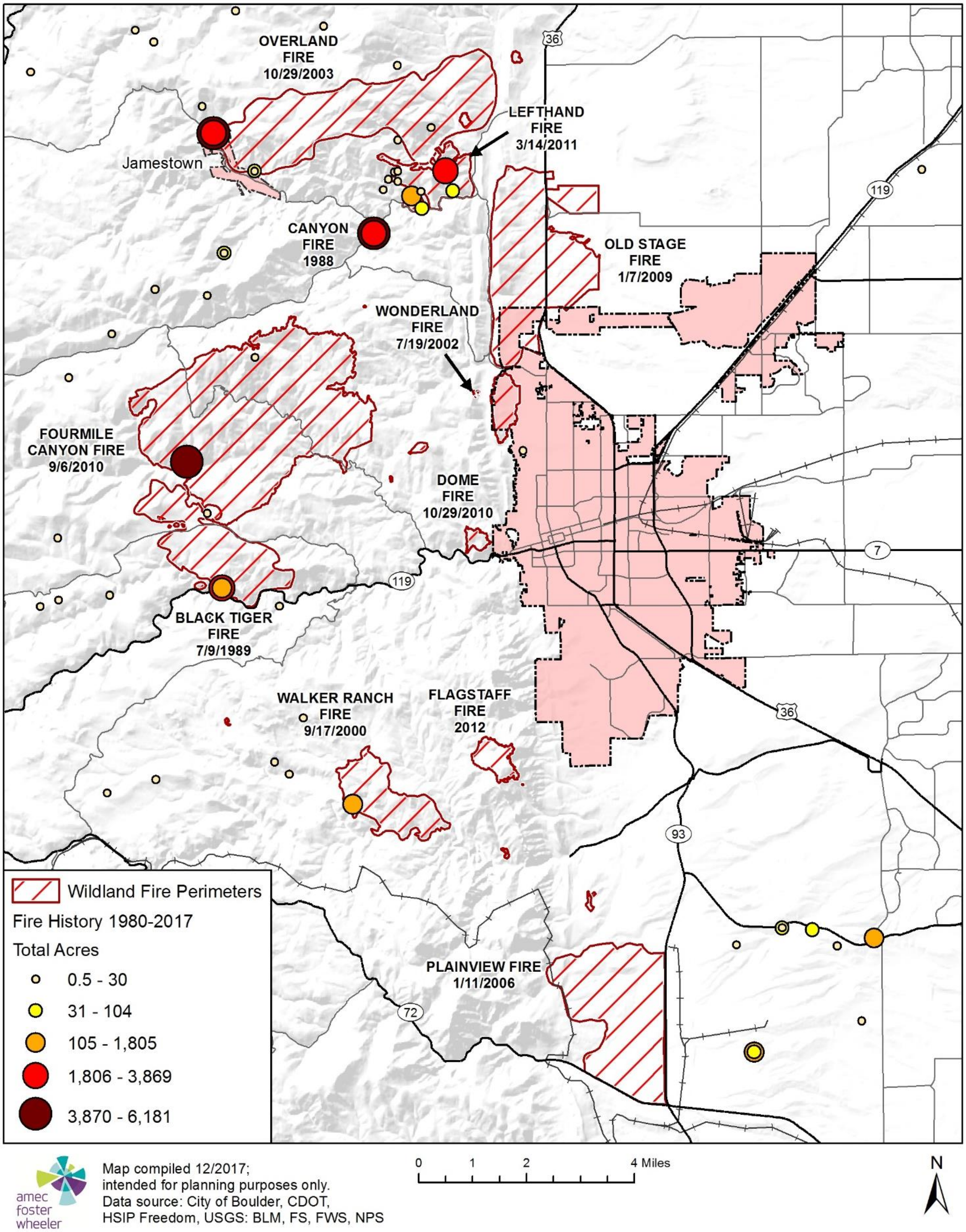
- **July 12, 2016—** The Cold Springs Fire burned 528 acres near Nederland Colorado. Nearly 2,000 people were evacuated, and eight homes were destroyed by the blaze, which is believed to have been caused by a campfire that wasn't probably extinguished.

Other notable fires (greater than 50 acres in size) in the Boulder area include the following:

- **November 1, 1964**—Near Eldorado Springs (100 acres)
- **May 28, 1974**—Near Gold Hill (160 acres)
- **June 1976**—Comforter Mountain (256 acres)
- **August 1979**—Coal Creek Canyon (50 acres)
- **September 21, 1984**—U.S. Forest Service land near Lyons (60 acres)
- **August 1, 1987**—Between Boulder and Lyons (50 acres)
- **November 4, 1987**—Southwest of Highway 36 (100 acres)
- **February 21, 1988**—Sunshine Canyon (200 acres)
- **September 7, 1988**—North of Ward (160 acres)
- **July 15,1991**—West of Boulder Hills subdivision, six miles north of Boulder (135 acres)
- **July 14, 1994**—Near Ward (50 acres)
- **September 3, 1996**—Rabbit Mountain, Lyons (50 acres)
- **September 1, 2005**—North Foothills fire, Foothills Ranch subdivision above Mt. Ridge/Lake of the Pines area (55 acres)
- **June 26, 2011** – Maxwell fire, burned 60 acres.

Figure 4.46 shows some of the above described fire perimeters. The map shows known fire perimeters near the City of Boulder from 1980 to 2017.

Figure 4.46. Fire Perimeters near the City of Boulder 1980 to 2017



Extent

The extent of impacts from wildfires in the City of Boulder are considered significant due to the overall far-reaching implications of this hazard. Quantification of impacts was extrapolated using a GIS-based vulnerability analysis. For the nine different CWPP communities, total value of fire prone structures and estimated contents is over $2.5 billion. The potential for loss of life is also high, with 5,389 people living in CWPP communities. Certain fire locations and conditions could conceivably isolate the City and make evacuations difficult or impossible. Fires occurring in the surrounding areas could also cause smoke, ash and air quality issues.

More information on potential losses and potential impacts to people, property, critical infrastructure and the environment is included in the Vulnerability and Potential Loss section.

Likelihood of Future Occurrences

Likely: Based on historical data, Boulder County experienced at least 29 significant (>50 acres) fires since 1916. This is an average of one fire every 3.31 years and a 30.2 percent chance of a fire in any given year. Depending on the severity and location of a fire, Boulder County and the City of Boulder are at risk to future fires.

From spring through fall each year, Boulder County faces a serious wildland fire threat. Much of the county and surrounding open space is susceptible to wildland fires. According to the State of Colorado Natural Hazard Mitigation Plan, a century of aggressive fire suppression combined with cycles of drought and changing land management practices has left many of Colorado's forests unnaturally dense and ready to burn. Further, the threat of wildfire and potential losses are constantly increasing as human development and population increases and the wildland-urban interface expands. Due to the existing fuel loads, semiarid conditions, and continued development, the Boulder area continues to be at risk from wildfire.

Climate Change Considerations

The Boulder County Climate Preparedness Plan notes that climate change could have an adverse effect on future wildfires. Although there are no studies on wildfires in Boulder County, there is good evidence that wildfires across the western United States have been increasing and will likely continue to increase in the future. A 2006 study found a fourfold increase in the number of wildfires since 1986 compared to the 1970–1986 period, with a six-fold increase in burned acreage. Those results were attributed to a 78-day increase in active wildfire season and a fivefold increase in average fire duration. Much of that, in turn, can be attributed to earlier snowmelt and hotter summertime temperatures. Tree-ring records of fire scars and debris found in alluvial fans show that warmer and drier periods are associated with more frequent and severe wildfires. Given that climate projections indicate continued advance in snowmelt timing and increasing summer temperatures, wildfire conditions across the West are likely to worsen in the future.

Intense wildfires can produce highly erodible soils that can lead to increased sediment loading in reservoirs and streams, damaging water infrastructure and degrading water quality. Although most of the city's water supplies are in low or moderate fire risk areas, a catastrophic fire would have serious impacts on higher-elevation water supplies, notably Barker Reservoir. In addition, the City of Boulder's main water treatment plant at Betasso, located in the foothills, leaves it vulnerable to fire. During the Fourmile Canyon fire, the city was nearly forced to evacuate and shut down the Betasso Treatment Plant. This shut down would have resulted in the city relying entirely on treated water from Boulder reservoir and the 63rd St. treatment plant.

4.2.21 Winter Storms

Hazard/Problem Description

Heavy snow, ice, severe winter storms, and blizzards are common occurrences in Colorado. The size of such events varies and may range in size from isolated (impacting only a portion of a county) to statewide. Generally, severe winter storm events are considered to be a regional occurrence, impacting multiple counties simultaneously and for extended time periods.

The National Weather Service Glossary defines common winter storm characteristics as follows:

- **Blizzard**: A blizzard means that the following conditions are expected to prevail for a period of 3 hours or longer:
  - Sustained wind or frequent gusts to 35 miles an hour or greater; and
  - Considerable falling and/or blowing snow (i.e., reducing visibility frequently to less than ¼ mile).
- **Heavy Snow**: This generally means:
  - snowfall accumulating to 4" or more in depth in 12 hours or less; or
  - snowfall accumulating to 6" or more in depth in 24 hours or less.
  - In forecasts, snowfall amounts are expressed as a range of values, e.g., "8 to 12 inches." However, in heavy snow situations where there is considerable uncertainty concerning the range of values, more appropriate phrases are used, such as "up to 12 inches" or alternatively "8 inches or more"
- **Ice Storm**: An ice storm is used to describe occasions when damaging accumulations of ice are expected during freezing rain situations. Significant accumulations of ice pull down trees and utility lines resulting in loss of power and communication. These accumulations of ice make walking and driving extremely dangerous. Significant ice accumulations are usually accumulations of ¼" or greater.

Heavy snow can immobilize a region, stranding commuters, stopping the flow of supplies, and disrupting emergency and medical services. Accumulations of snow can collapse roofs and knock down trees and power lines. The cost of snow removal, damage repair, and business losses can have a tremendous impact on cities and towns. Heavy accumulations of ice can bring down trees, electrical wires, telephone poles and lines, and communication towers. Communications and power can be disrupted for days until damages are repaired. Even small accumulations of ice may cause extreme hazards to motorists. The geographic extent rating for winter storms is considered extensive since the entire city limits can be impacted.

Some winter storms are accompanied by strong winds, creating blizzard conditions with blinding wind-driven snow, severe drifting, and dangerous wind chills. Strong winds with these intense storms and cold fronts can knock down trees, utility poles, and power lines. Blowing snow can reduce visibilities to only a few feet in areas where there are no trees or buildings. Serious vehicle accidents can result with injuries and deaths. Heavy snowfall during winter can also lead to flooding or landslides during the spring if the area snowpack melts too quickly.

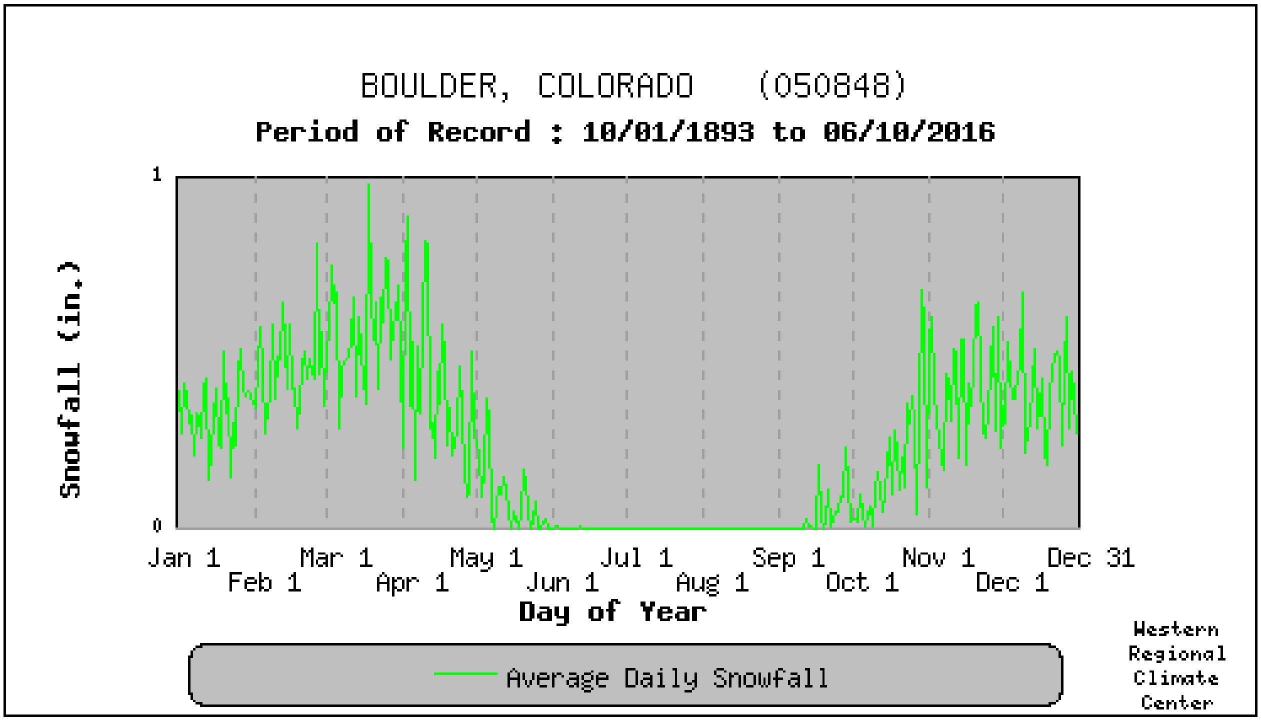
Past Occurrences

Both the western and eastern portions of Boulder County receive snowfall on a regular seasonal basis, predominantly from October through April; however, the western portion of the county receives substantially more snow than the eastern portion. The following summarizes the effects of snow in the City of Boulder based on data from the Western Regional Climate Center.

According to the Western Regional Climate Center, for the period of record of 1893 to 2016, the average annual total snowfall for the Boulder area was 84.07 inches. The two snowiest months were February and March, with 11.98 and 16.18 average inches of snow, respectively. The highest recorded monthly snowfall for the period of record was 56.7 inches for the month of March in 1970. The highest annual snowfall for the same time period was 125.4 inches over the 1986-1987 winter season.

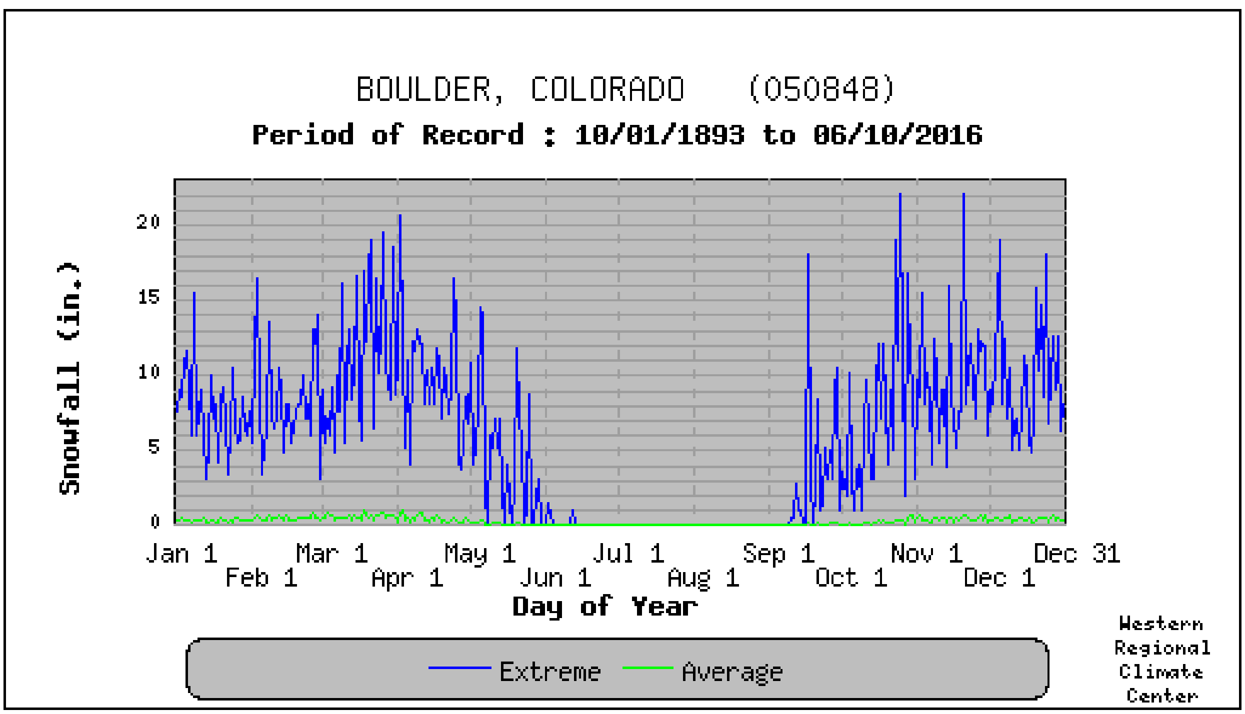
The average snow depth ranged from 0-1 inches during the winter months; however, daily extremes include snow depths up to 27 inches. Figure 4.47 and Figure 4.48 show Boulder's daily snowfall averages and extremes between 1893 and 2016.

Figure 4.47. Boulder Daily Snowfall Average 1893 to 2016



Source: Western Regional Climate Center, www.wrcc.dri.edu/

Figure 4.48. Boulder Daily Snowfall Average and Extreme, 1893 to 2016



Source: Western Regional Climate Center, www.wrcc.dri.edu/

Data from the NCEI identified 156 winter storm events between 1993 and 2017 that impacted Boulder.

Table 4.16. Summary of Boulder County Winter Storm Events 1996-2016

Year	# of Winter Storm Events	# of Blizzard Events	# of Winter Weather Events	# of Heavy Snow Events	Total Events
1996	7	0	0	70	77
1997	11	1	0	38	50
1998	27	3	0	12	42
1999	10	0	0	28	38
2000	7	0	0	21	28
2001	7	1	0	16	24
2002	6	0	0	7	13
2003	14	1	0	4	19
2004	15	0	1	0	16
2005	22	0	0	0	22
2006	20	1	1	4	26
2007	11	0	9	4	24
2008	13	0	8	1	22
2009	20	0	7	0	27
2010	18	0	27	0	45
2011	23	0	31	0	54
2012	4	2	20	0	26
2013	19	0	11	3	33
2014	20	0	12	3	35
2015	9	0	20	2	31
2016	8	0	15	4	27
Totals	**291**	**12**	**163**	**217**	**683**

Source: NCEI

Of these, the following events resulted in reported injuries and/or property damage:

- **February 11, 1994**—Heavy snow, two injuries, property damage of $50,000. Moist upslope winds and an upper-level system produced heavy snow over portions of the Front Range. Amounts ranged from 6 to 12 inches.

- **January 28, 1995**—Heavy snow, two deaths, property damage of $25,000. All mountains, northeast Front Range. A strong, very moist, and slow-moving winter storm system struck Colorado. In the high country, all mountain ranges received at least three feet of snow with some locations in the Elk Mountains collecting six to eight feet. Two people were killed by avalanches during the week. Road closures were common in the high-country due to poor visibilities and avalanches. Interstate 70 was closed when an avalanche crossed the westbound lanes west of the Eisenhower Tunnel. At lower elevations, including the foothills and northern Front Range, the snow started falling the morning of the 10th. Most of the snow fell during the 24-hour period after onset. Locations in and near the foothills received the most snow as they collected between 10 and 15 inches. Golden and south sections of Boulder collected 15 and 14 inches, respectively.
- **February 8, 1995**—Blizzard, property damage of $3.1 million. The storm that moved into eastern Colorado developed into a blizzard across the northeast plains as an intense surface cyclone formed. The combination of freezing rain, followed by heavy snow and damaging winds led to widespread electrical outages. Snowfall totals generally ranged from 6 to 18 inches. The heaviest snow occurred near the Front Range foothills; the Palmer Divide; in the area from just south of Denver, east and northeast into northern Lincoln and Washington counties; and near the Nebraska state line. Sustained winds from 35 to 58 mph with gusts to around 75 mph were recorded. Denver International Airport was completely shut down for the first time in its brief history. Power surges and outages constantly crippled the airport’s massive computer system. The airport was closed at 5:00 a.m. and did not reopen until midafternoon. Power outages affected nearly all northeast Colorado. Some areas only had scattered outages for a few hours, while more remote areas were blacked out for over a week. As a result, most businesses were closed and school classes canceled. The only businesses that remained open during the storm were those using backup generators. Overall, 220,000 Xcel Energy customers were affected, making it the worst outage in the company’s history.
- **March 17, 2003**— A very moist, intense, and slow-moving Pacific storm system made its way across the four corners area and into southeastern Colorado from March 17-19, allowing for a deep easterly upslope flow to form along the Front Range. The storm dumped 31.8 inches of snow at the former Stapleton International Airport, enough for second place in the Denver weather history record book. The storm also placed March 2003 in first place for the snowiest March in Denver history and fifth place for the wettest March on record. In addition, the storm broke a 19-month streak of below normal precipitation in Denver. The heavy wet snow caused roofs of homes and businesses to collapse across the urban corridor. The snow also downed trees, branches, and power lines. Up to 135,000 people lost power at some point during the storms, and it took several days in some areas to restore power. Avalanches in the mountains and foothills closed many roadways, including Interstate 70 in both directions, stranding hundreds of skiers and travelers. Denver International Airport was also closed, stranding approximately 4,000 travelers. In all, the estimated cost of the damage to property alone (not including large commercial buildings) was $93 million, making it easily the costliest snowstorm ever in Colorado. According to this NCEI report, the second costliest snowstorm was the 1997 blizzard, where damage totaled $10.5 million (see description in the following

grouping of events). The areas hardest hit by heavy snow were the northern mountains east of the Continental Divide, the Front Range foothills, and Palmer Divide, where snowfall totals ranged from three feet to more than seven feet. Boulder received 22.5 inches of snow. Tree cleanup costs for this storm and a subsequent storm in May were estimated at $3,000.

- **December 20, 2006—**This storm resulted in a presidential emergency declaration. Some of the largest snowfall totals during this event ranged from 21 inches in Fort Collins to 42 inches at Conifer, southwest of Denver. Meteorologists at the National Weather Service office in Boulder measured 19 inches of snowfall. This blizzard forced the closure of interstates, businesses, schools, and airports, stranding thousands of holiday travelers.

Other winter storm events identified by the HMPC include the following:

- December 4-5, 1913—43 inches
- November 2-5, 1946—31 inches
- January 23-27, 1948—21 inches
- April 7-11, 1959—26 inches
- March 29-31, 1970—26 inches
- September 17-18, 1971—21 inches
- November 20, 1979—22 inches
- **May 1978**—The spring storm of 1978 dropped 30 inches of snow over Boulder and was responsible for at least one death and a severe injury. It also collapsed an old hotel building (the Arnett Hotel) on Pearl Street across from the *Daily Camera*. The snow started before dawn on Friday, May 5, accumulating about 8 inches in town and 26 in the foothills by later that day. It snowed all day Saturday and into Sunday.
- **Winter of 1978-1979**—A series of winter storms collapsed the roof of the Fairview High School.
- **Christmas storm of 1982**—The storm began on Christmas Eve, lasting through Christmas Day. Winds created large drifts, closing roads and stranding travelers.
- November 26-27, 1983—23 inches
- **December 24-29, 1987**—20 inches of snow fell over a period of a few days. Countywide snow removal operations were estimated at $280,000.
- **March 6, 1990**—More than two feet of wet snow dumped in the foothills, paralyzing traffic, stranding travelers, preventing mail delivery, and causing hundreds of accidents and power outages in Boulder County. Winds of 37 mph qualified the storm as a blizzard.
- **November 17, 1991**—The October 1991 freeze ("Halloween Freeze") saw temperature extremes from 60°F to below 0°F. This snowstorm, combined with a freeze the previous month caused $51,250 in tree damage.
- **March 9, 1992**—Twenty inches of snow fell in Boulder County. The storm began early in the afternoon with spring-like thunder and lightning and turned winter-like in about one hour. More than 25,000 residents were without electricity when wet, wind-driven snow toppled power lines. Many cars were stranded on Highway 36 between Boulder and Denver, and on

Highway 93 between Boulder and Golden. The storm caused $32,045 in tree damage (an additional $20,000 was spent on pruning and $23,600 on removal).

- **September 20, 1995**—This storm damaged 80-90 percent of the tree population. Total damage and associated costs equaled $363,710.
- **April 24, 1997**—A snowstorm dumped over 16 inches of snow in Boulder; mountain areas received around 30 inches.
- **October 24, 1997**—During this "Blizzard of 1997," Boulder received 30 inches of snow in 48 hours. A total of 51 inches fell in Coal Creek Canyon, just west and south of Boulder. Power outages were sporadic and tree breakage was minimal. Areas south and east of Boulder County were impacted more by the storm than Boulder County due to high winds that created blizzard conditions. The storm resulted in five deaths, two injuries, and significant dollar losses. This storm was the largest October storm in Boulder history and ranked as the fourth largest snowstorm on record. Snow totals made the 1997 calendar year the snowiest on record with a total of approximately 130 inches. Estimated tree cleanup costs were $7,000.
- **Fall 2000**—Tree cleanup costs were estimated at $2,000.
- **December 28, 2006**—This large storm arrived a mere week after another winter storm of significance (see above).
- **March 23, 2016**-- 25.5 inches 4 miles east of Boulder, 12.5 inches 3 miles north-northwest of Boulder; 17.3 inches measured at the National Weather Service Office in Boulder.
- **January 3-4, 2017**—The first in a series of powerful winter storms resulted in 13.8 inches of snow in Boulder.

Extent

The extent of winter storms and cold that cause issues in Boulder County includes storms forecasted to be Winter Storm Warnings, Wind Chill Warnings or Blizzard Warnings. Heavy snows, or a combination of snow, freezing rain or extreme wind chill due to strong wind, may bring widespread or lengthy road closures and hazardous travel conditions, plus threaten temporary loss of community services such as power and water. Deep snow and additional strong wind chill or frostbite may be a threat to even the appropriately dressed individual or to even the strongest person exposed to the frigid weather for only a brief period. The impacts associated with a winter storm event can be considered extensive since it will cover and effect the entire City.

Likelihood of Future Occurrences

Highly Likely: Based on historical data, winter storms are an annual occurrence in the Boulder area. The potential exists for a severe winter storm to occur during any year in the City of Boulder due to its geographic location.

Climate Change Considerations

Climate change has the potential to exacerbate the severity and intensity of winter storms, including potential heavy amounts of snow. A warming climate may also result in warmer winters, the benefits of which may include lower winter heating demand, less cold stress on humans and animals, and a longer growing season. However, these benefits are expected to be offset by the negative consequences of warmer summer temperatures.

4.3 Assessing Vulnerability

Requirement §201.6(c)(2)(ii):

[The risk assessment shall include a] description of the jurisdiction's vulnerability to the hazards described in paragraph (c)(2)(i) of this section. This description shall include an overall summary of each hazard and its impact on the community.

Requirement §201.6(c)(2)(ii)(A):

The plan should describe vulnerability in terms of the types and numbers of existing and future buildings, infrastructure, and critical facilities located in the identified hazard areas.

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)(i)(A) of this section and a description of the methodology used to prepare the estimate.

Requirement §201.6(c)(2)(ii)(C):

[The plan should describe vulnerability in terms of] providing a general description of land uses and development trends within the community so that mitigation options can be considered in future land use decisions.

With the City of Boulder's hazards identified and profiled, the HMPC conducted a vulnerability assessment to describe the impact that each hazard would have on the City of Boulder. The vulnerability assessment quantifies, to the extent feasible, assets at risk to natural hazards and estimates potential losses.

This vulnerability assessment followed the methodology described in the FEMA publication *Understanding Your Risks—Identifying Hazards and Estimating Losses,* as well as Tasks 5 and 6 of the 2013 *FEMA Local Mitigation Planning Handbook*. The vulnerability assessment first describes the total vulnerability and values at risk and then discusses vulnerability by hazard.

4.3.1 Total Vulnerability and Values at Risk

As a starting point for analyzing the City of Boulder's vulnerability to identified hazards, the HMPC used a variety of data to define a baseline against which all disaster impacts could be compared. If a catastrophic disaster were to occur in the city, the following information describes significant assets at risk. Data used in this baseline assessment included:

- Total values and assets at risk,
- Critical facility inventory,
- Cultural and natural resource inventory, and
- Development trends.

Total Values and Assets at Risk

The Boulder County Assessor's Office parcel layer and associated assessor's building improvement valuation data (May 2017) were provided by the City of Boulder and were used as the basis for the inventory. Parcel and building footprint datasets were related spatially so that the critical information from each could be tied together for the hazards analysis. When a single building resides on a single parcel, there is a simple one-to-one relationship between the building data and the parcel data. Where there are multiple buildings on a parcel, the improvement value reflected in the parcel data is a sum of the combined structure value, which is then divided by the total number of structures or building footprints (to obtain an equal value across all buildings due to parcel and assessor data limitations). The Building Class Code (BLDGCLSCD) within the Assessor Data was used to obtain property classes with a statewide building Abstract Code to define the property use. The property classes utilized for this plan are: Agriculture, Commercial, Exempt, Industrial, Natural Resources, Other Non-Residential, Residential Common Area, Residential (Multi-Family is rolled into this class) and Vacant Land.

It is important to keep in mind in the event of a disaster, it is generally the value of the infrastructure or improvements to the land that is of concern or at risk. Generally, the land itself is not a loss. In total, the City of Boulder has over $29 billion of exposed property and contents. Most of exposed structures are residential (20,627), representing 83% of the total number of structures. Though residential properties represent a substantial portion of structural counts and building values, the contents of commercial properties make up 42% of total exposed content values. The city's total structure exposure is provided in Table 4.17.

Table 4.17. City of Boulder Structure Exposure

Land Use	Structure Count	Improved Value	Estimated Contents Value	Total Value
Agricultural	39	$20,813,000	$20,813,000	$41,626,000
Commercial	2,986	$5,037,926,000	$5,037,926,000	$10,075,852,000
Exempt	868	$971,790,000	$971,790,000	$1,943,580,000
Industrial	176	$171,818,000	$257,727,000	$429,545,000
Natural Resources	10	$24,762,000	$24,762,000	$49,524,000
Other Non-Residential	115	$40,964,000	$40,964,000	$81,928,000

Land Use	Structure Count	Improved Value	Estimated Contents Value	Total Value
Res Common Area	10	$801,000	$801,000	$1,602,000
Residential	20,627	$11,324,025,000	$5,662,013,000	$16,986,038,000
Vacant Land	12	$0	$0	$0
Total	**24,843**	**$17,592,899,000**	**$12,016,796,000**	**$29,609,695,000**

Source: City of Boulder GIS, Boulder County Assessor's Office

Critical Facility Inventory

The definition of a 'Critical Facility' was updated in 2012 based on proposed Ordinance no. 7815. This ordinance amends floodplain regulations to protect critical facilities and mobile populations in the 100 and 500 year floodplains. A "Critical facility" means any structure or related infrastructure, the loss of which may result in severe hazards to public health and safety or may interrupt essential services and operations for the community at any time before, during, and after a flood. Critical facilities are classified as follows: (1) Essential Services Facility, (2) Hazardous Material Facility, and (3) At-risk Populations Facility. "Essential services facility" means any facility providing essential services that, if flooded, may result in severe hazards to public health and safety or interrupt essential services and operations for the community at any time before, during, or after a flood that include without limitation, public safety, emergency response, emergency medical, designated emergency shelters, communications, public utility plant facilities and equipment, and government operations. "At-risk population facility" means a pre-school, public or private primary or secondary school, before and after school care center with twelve or more students, daycare center with twelve or more children, group home, or assisted living residential or and congregate care facility with twelve or more residents. "Hazardous material" means any material used, generated, or stored at a facility of a type and in a quantity, that would classify the facility as a hazardous materials facility. "Hazardous material building" means any structure on a hazardous materials facility in which hazardous material is used, generated, or stored.

The 2018 update of this plan tried to revisit the list of critical facilities so that analysis reflects the definition as stated under Ordinance no. 7815.

Facilities layers were organized and obtained from the City of Boulder Utilities from the following source: Boulder OEM, CDPHE, EPA and HIFLD. Facilities were grouped by the ordinance categories and then sorted by facility sub-classifications. A summary of Boulder's critical facilities is shown in Table 4.18, while Figure 4.49, Figure 4.50, Figure 4.51 show the same facilities grouped by the three critical facility classifications. More detail on the critical facilities is provided in Appendix G.

Table 4.18. City of Boulder Critical Facility Summary

Aggregate	Classification	Classification Count
At Risk Population Facilities	Congregate Care	83
	Residential Care	27
	School	53
	Senior Center	2
	Total	**165**
Essential Services Facilities	Air Transportation	1
	Communication	19
	Emergency Medical Facility	9
	Government Building	16
	Public Safety Facility	15
	Public Utility	25
	Shelter	4
	Total	**89**
Hazardous Material Facilities	Hazardous Waste Biennial Reporter	7
	Hazardous Waste Large Quantity Generator	1
	Hazardous Waste Small Quantity Generator	7
	Toxic Release Inventory	28
	Total	**43**
	Grand Total	**297**

Source: Boulder OEM, CDPHE, City of Boulder, HIFLD, EPA

As described in Chapter 4.4. Assessing Capabilities**,** the City of Boulder introduced the Critical Facilities and Lodging Facilities Ordinance in 2014. Addressing the need for regulation of new construction and improvements for critical facilities within the 500-year floodplain, this ordinance protects facilities from flood losses and regulates mobile populations. The ordinance includes language that ensures access to, use of and uninterrupted service for critical facilities such as fire and police stations, water and wastewater treatment facilities, utility infrastructure for water, sewer, gas, electric and communications, schools, day care and senior care facilities, hospitals, major roads and bridges, and hazardous material storage. For more information, refer to **Section 4.4.3 Hazard-Related Policies, Floodplain Regulations.**

Figure 4.49. At-Risk Population Critical Facilities

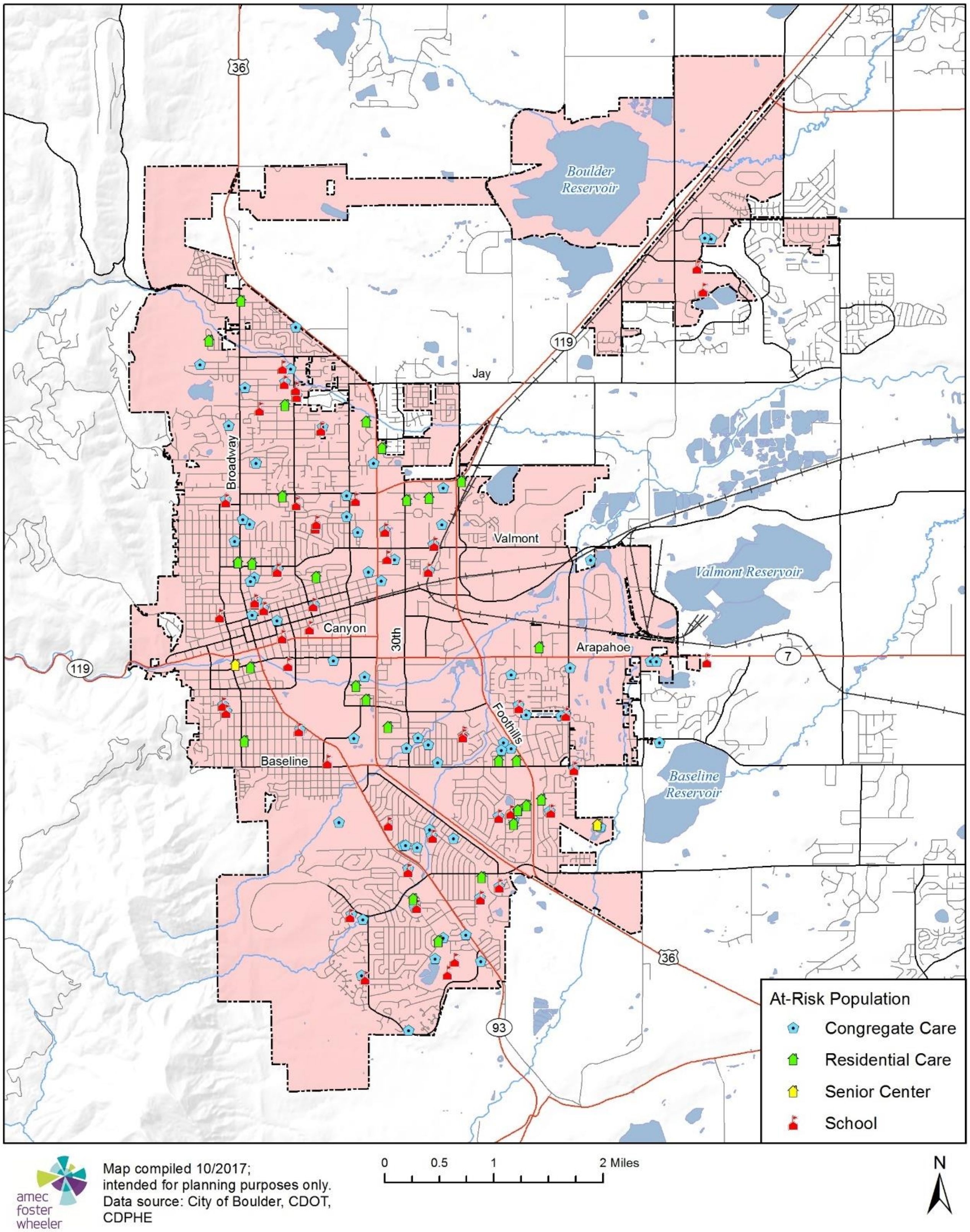


Figure 4.50. Essential Services Facilities

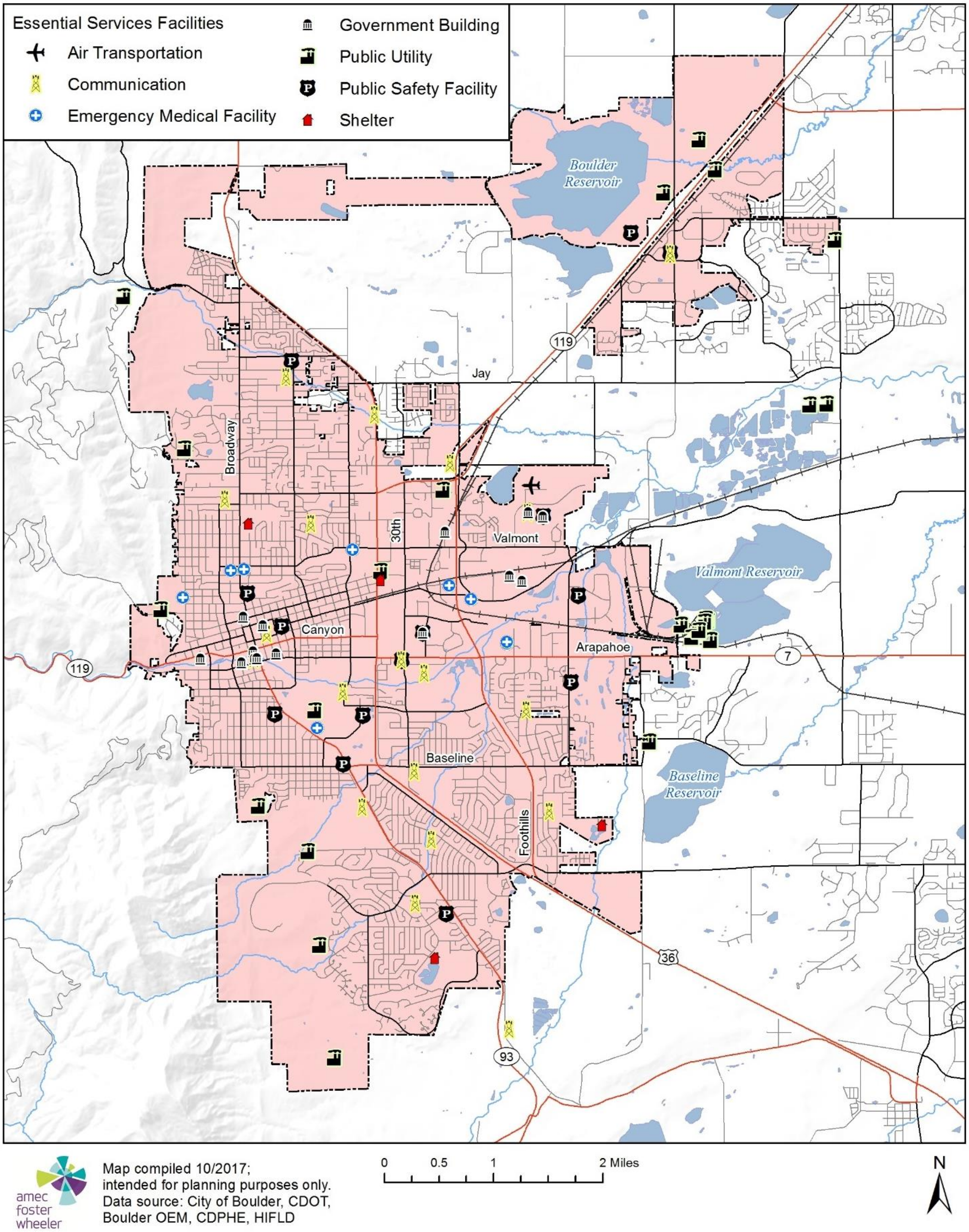
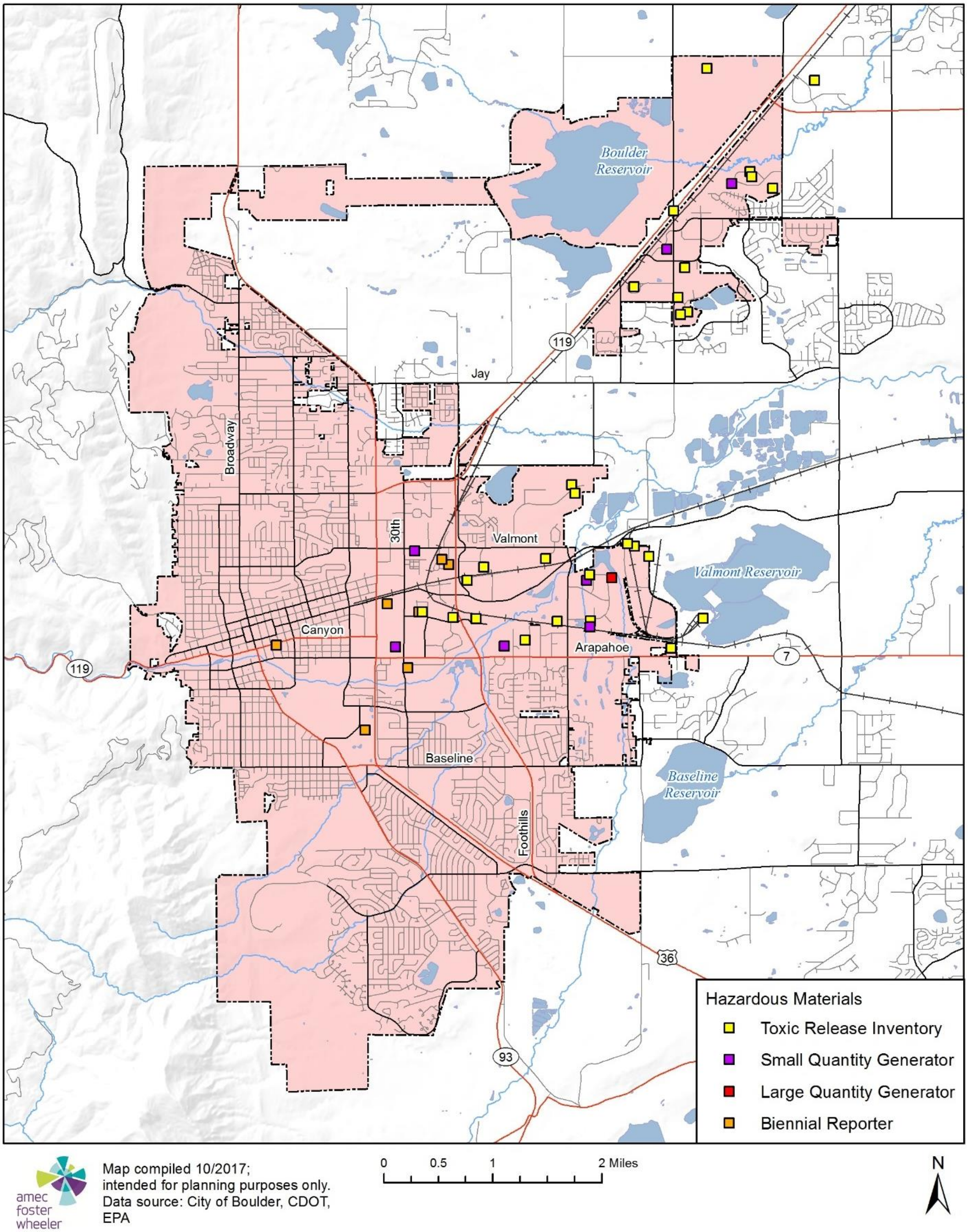


Figure 4.51. Hazardous Materials Facilities



Separate summary tables were created based on each aggregate to show individual facility risk to mapped hazards including flood and wildfire. These are shown in Appendix G and discussed in the respective hazard's vulnerability summary.

Cultural and Natural Resource Inventory

In evaluating the vulnerability of a given area to disaster, it is important to inventory the cultural and natural resources specific to that area. Cultural and natural resources are important to identify pre-disaster for four reasons:

- The city may decide that these areas are worthy of a greater degree of protection than currently exists due to their unique and irreplaceable nature.
- Should these resources be impacted by a disaster, knowing about them ahead of time allows for more prudent care in the immediate aftermath, when the potential for additional impacts is high.
- The rules for repair, reconstruction, restoration, rehabilitation, and/or replacement usually differ from the norm.
- Natural resources, such as wetlands and riparian habitat, can have beneficial functions that contribute to the reduction of flood levels and damage.

Cultural Resources

The City of Boulder, with its history extending back to 1859, has an extensive inventory of architectural and historical resources. This inventory includes neighborhoods with late-nineteenth century to early-twentieth century buildings and scattered individual landmarks. In 1974, recognizing the value of these resources, the city passed the Boulder Historic Preservation Ordinance, creating authority to designate and prevent the demolition or destruction of historical, architectural, and cultural resources considered valuable assets to the community.

There are two basic types of landmark designations. An "individual" landmark designation recognizes the significance of a particular building and its site. Individual landmarks are evaluated based on criteria relating to historical, architectural, and environmental significance. "District" designation recognizes a particular area or neighborhood that has a collection of buildings that have architectural or historical significance to the community and are also judged against established criteria.

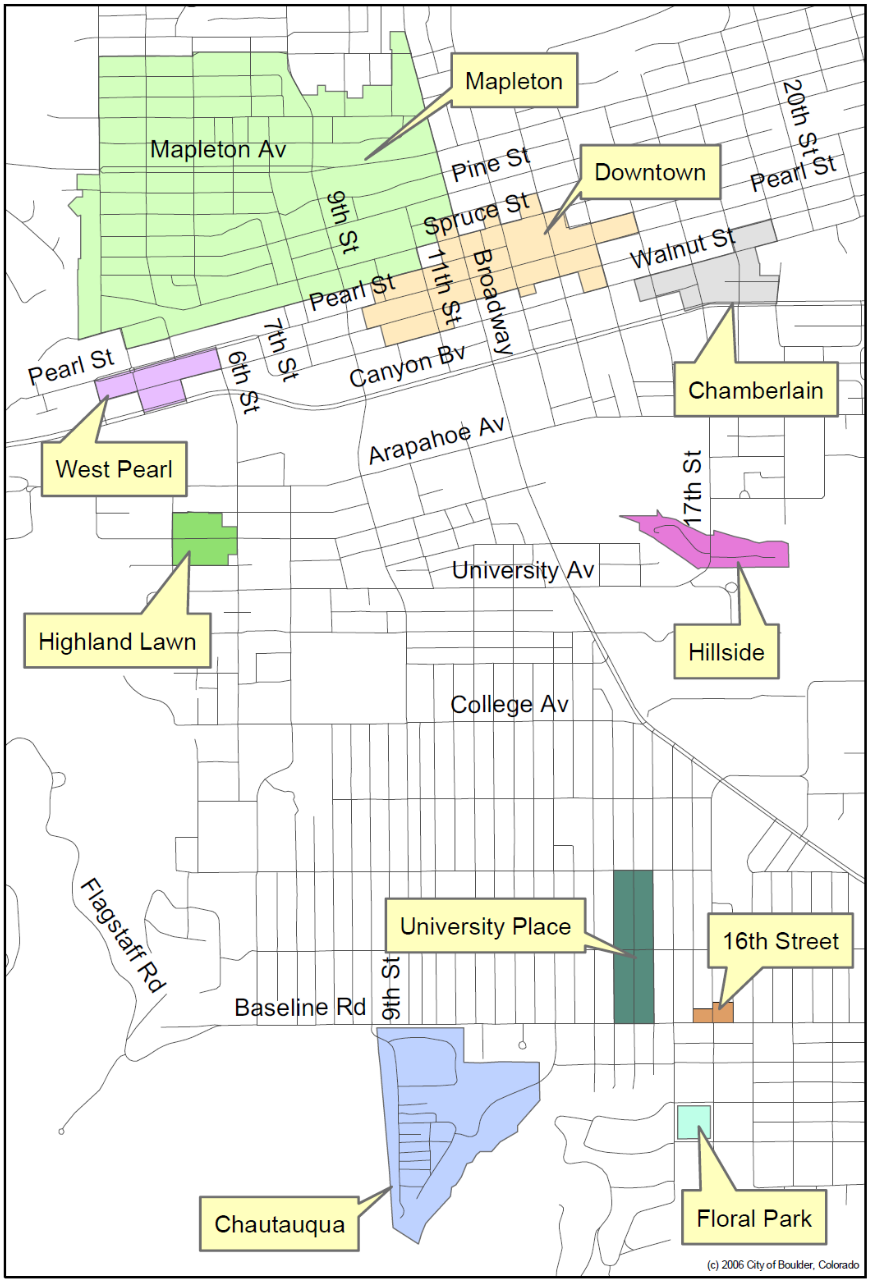
Both types of designations have the same protection and require the same procedures for renovation, though buildings within districts are further differentiated as "contributing" and "noncontributing." Buildings in the noncontributing category are held to less strict standards for alterations.

To inventory the city's cultural resources, the HMPC collected information from the City of Boulder Historic Preservation Office. The inventory of cultural resources included:

- Local historic designations
  - 175 Individual landmark designations
  - 10 historic district designations
- State and national designations
  - 10 historic properties on the Colorado Register of Historic Places
  - 5 properties and 1 district on the National Register of Historic Places

Details on these properties and districts are can be referenced on the City's website: https://bouldercolorado.gov/historic-preservation/landmarked-buildings-and-historic-districts. Figure 4.52 depicts the City of Boulder's designated local historic districts.

Figure 4.52. Designated Local Districts, City of Boulder



Natural Resources

With the goal of preserving or restoring natural resources in the area, Boulder County and the City of Boulder have many ongoing programs defining the protection and management of significant agricultural lands, wildlife and plant habitats, wetlands, and natural areas. For purposes of this plan, natural resource inventories primarily focus on threatened and endangered species, wetlands, and resources unique to their urban forest.

Threatened and Endangered Species

To further evaluate the city's vulnerability to a disaster, it is important to inventory key natural resources such as threatened and endangered species.

- **Endangered species** means any species of fish, plant life, or wildlife that is in danger of extinction throughout all or a significant part of its range and is protected by law.
- **Threatened species** means any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range and is protected by law.
- **Special concern** means any species about which problems of status or distribution are suspected but not documented. This is not considered a statutory category; however, many animal species listed as special concern can be protected under other state and federal laws addressing hunting, fishing, collecting, and harvesting.

State and federal species of concern lists were used to create the Boulder Valley List of Species of Special Concern as set forth in the Boulder Valley Comprehensive Plan (BVCP), which covers the City of Boulder planning area. Information was collected from the U.S. Fish and Wildlife Service, Colorado Division of Wildlife, and Colorado Natural Heritage Program. At least one of these agencies recognizes each species on the list as having a global, federal, or state ranking of concern. Table 4.19 and Table 4.20, which are from the BVCP, identify plant and wildlife species of concern, respectively, within the Boulder Valley area.

Table 4.19. Boulder Valley Comprehensive Plan Plant Species of Concern

Common Name	Scientific Name
Utes Ladies'-tresses	*Sprianthese diluvialis*
Colorado Butterfly Plant	*Guara neomexican ssp. Coloradensis*
Dwarf Leadplant	*Amorpha nana*
Chaffweed	*Anagallis minima*
American Groundnut	*Apios Americana*
Fork-tip Three-awn	*Aristida basiramea*
Black Spleenwort	*Asplenium adianturn-nigrum*
Paper Birch	*Betula papyrifera*
Rattlesnake fern	*Botrypus virginianus ssp. Europaeus*
Rocky Mountain Sedge	*Carex saximontana*
Sprnegel's Sedge	*Carex sprengelii*
Torrey Sedge	*Carex torreyi*
Yellow Hawthorn	*Crataegus chyrsocarpa*
Small-headed Rush	*Juncus brachycephalus*
Gay-feather	*Liatris ligulisylis*
Broad-leaved Twayblade	*Listera convallarioides*
White Adder's-mouth	*Malaxis monophyllos spp. Brachypoda*
Wavy-leaf Stickleaf	*Nuttallia sinuate*
Bell's Twinpod	*Physaria bellii*
Western Polypody	*Polypodium saximontanum*
Toothcup	*Rotala ramosior*
Prairie Violet	*Viola pedatifida*

Source: Boulder Valley Comprehensive Plan

Table 4.20. Boulder Valley Comprehensive Plan Wildlife Species of Concern

Common Name	Scientific Name	Criteria for Listing
American Peregrine Falcon	*Falco peregrinus anatum*	LE, S2
American Redstart	*Setophaga ruticilla*	S1
Argos Skipper	*Atrytone argos*	S2
Bald Eagle	*Haliaeetus leucocephalus*	LT, S1, state threatened
Banded Physa	*Physa utahensis*	G1, S1
Black-tailed Prairie Dog	*Cynomys ludovicianus*	C
Blue-Ringed Dancer	*Argia sedula*	S2
Burrowing Owl	*Athene cunicularia*	state threatened
Chestnut-sided Warbler	*Dendroica pensylvanica*	S2
Colorado Blue	*Euphilotes rita coloradensis*	S2
Common Shiner	*Notropis cornutus*	S2
Cylindrical Papershell	*Anodontoides ferussacianus*	S2
Great Egret	*Ardea alba*	S1
Greenback cutthroat trout	*Oncorhynchus clarki virginalis*	LT, S2, state threatened
Hops Azure	*Celastrina humulus*	G2, S2
Lake Chub	*Couesius plumbeus*	LE, S1
Lake Darner	*Aeshna eremita*	S1
Long-billed Curlew	*Numenius americanus*	S2
Moss's Elfin or Schryver's Elfin	*Callophrys mossii schryveri*	C, S2
Mottled Duskywing	*Erynnis martialis*	S2
Mountain Plover	*Charadrius montanus*	S2
Northern Goshawk	*Accipiter gentilis*	S2
Northern Redbelly Dace	*Phoxinus eos*	S1, state endangered
Ottoe Skipper	*Hesperia ottoe*	S2
Ovenbird	*Seiurus aurocapillus*	S2
Plains sharp-tailed Grouse	*Tympanuchus phasianellus jamesi*	S1, state endangered
Plains Topminnow	*Fundulus sciadicus*	C, S2
Preble's Meadow Jumping Mouse	*Zapus hudsonius preblei*	LT, S1, state threatened
Regal Fritillary	*Speyeria idalia*	C, S1
Rhesus Skipper	*Polites rhesus*	S2
Rocky Mountain Arctic Jutta	*Oeneis jutta reducta*	S1
Rocky Mountain Capshell	*Acroloxus coloradensis*	S2
Sharp Sprite	*Promenetus exacuous*	S2
Short-eared Owl	*Asio flammeus*	S2
Stonecat	*Noturus flavus*	S1
Two-spotted Skipper	*Euphyes bimacula*	S2
White-winged Crossbill	*Loxia leucoptera*	S1

Common Name	Scientific Name	Criteria for Listing
Extirpated species		
American Bison	*Bison*	
Black-footed Ferret	*Mustela frenata*	G1, LE, S1, state endangered
Grizzly Bear	*Ursus arctos horribilis*	LT, state endangered
Northern River Otter	*Lutra canadensis*	state endangered
Pronghorn Antelope	*Antilocapra americana*	
Timber Wolf	*Canis lupus lycaon*	

Source: Boulder Valley Comprehensive Plan

1The species is listed under the provisions of the federal Endangered Species Act as; LE – Listed Endangered; LT – Listed Threatened; PT – Proposed threatened; or C – Candidate for listing

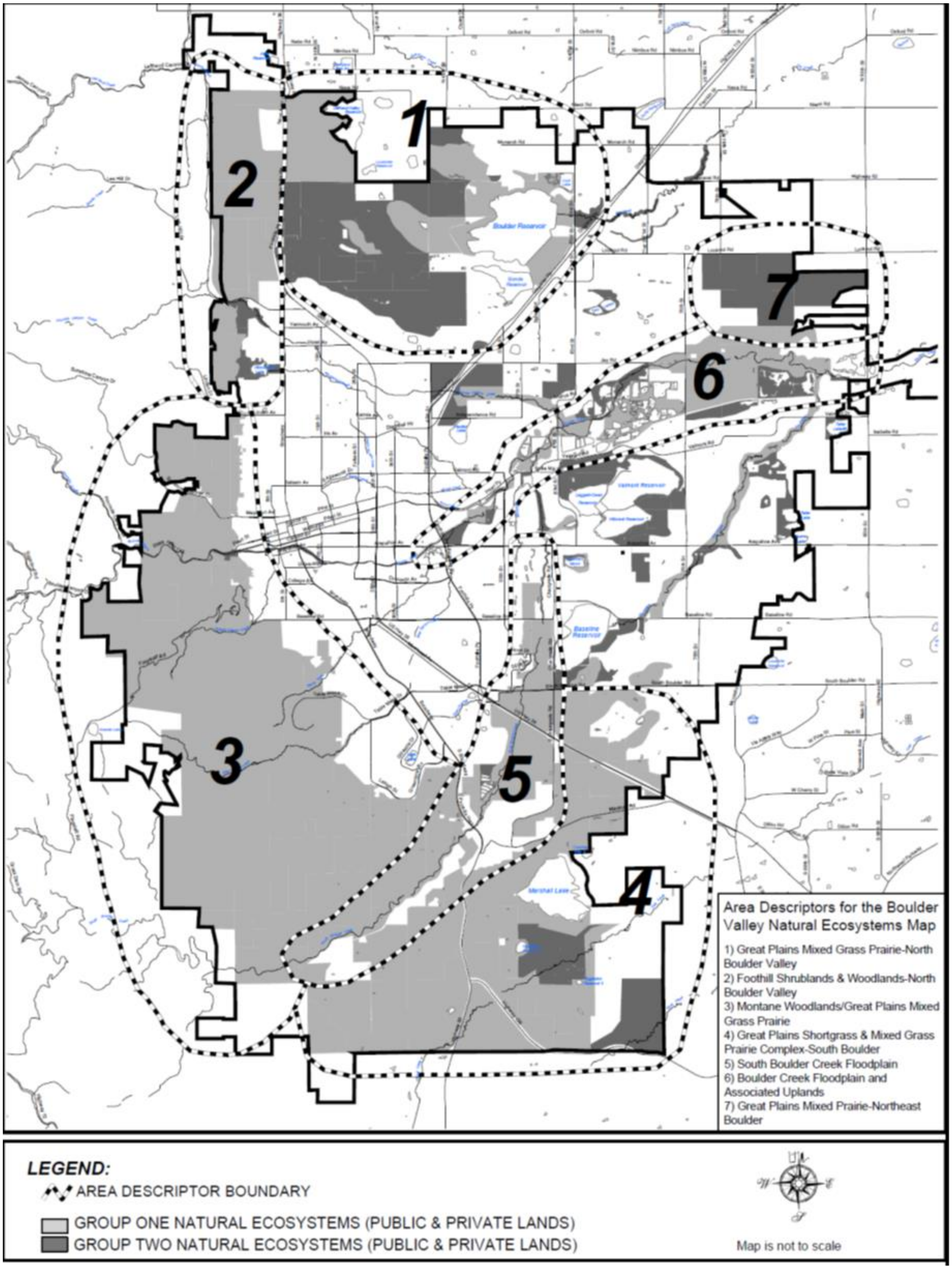
2. The species is listed by the Colorado Department of Natural Resources, Division of Wildlife as: Threatened or Endangered

3. The species is listed by the Colorado Natural Heritage Program as: G1 – Globally critically imperiled; typically 5 or fewer occurrences; G2 – Globally imperiled; typically 6 to 20 occurrences; S1 – State critically imperiled; typically 5 or fewer occurrences or; S2 – State imperiled; typically 6 to 20 occurrences.

Staff from Planning, Parks and Recreation, and Open Space and Mountain Parks have created an Urban Wildlife Management Plan. The plan establishes a set of policies and procedures for managing wildlife, including species of special concern, within Boulder on both public and private land. Phase I of the planning process established a vision statement, guiding principles, and goals for the plan. Phase II, which is ongoing, involves the development of individual species management plans. The Black-Tailed Prairie Dog Component of the plan, approved in August 2006, was the first species plan. On October 18, 2011, the Bear and Mountain Lion Component of the plan was added.

To encourage environmental preservation, a Natural Ecosystem overlay is applied over Comprehensive Plan Land Use Designations throughout the Boulder Valley Planning Area. Natural ecosystems are defined as areas that support native plants and animals or possess important ecological, biological or geological values that represent the rich natural history of the Boulder Valley. The Natural Ecosystems overlay also identifies connections and buffers that are important for sustaining biological diversity and viable habitats for native species, for protecting the ecological health of certain natural systems, and to buffer potential impacts from adjacent land uses. This map is shown in Figure 4.53.

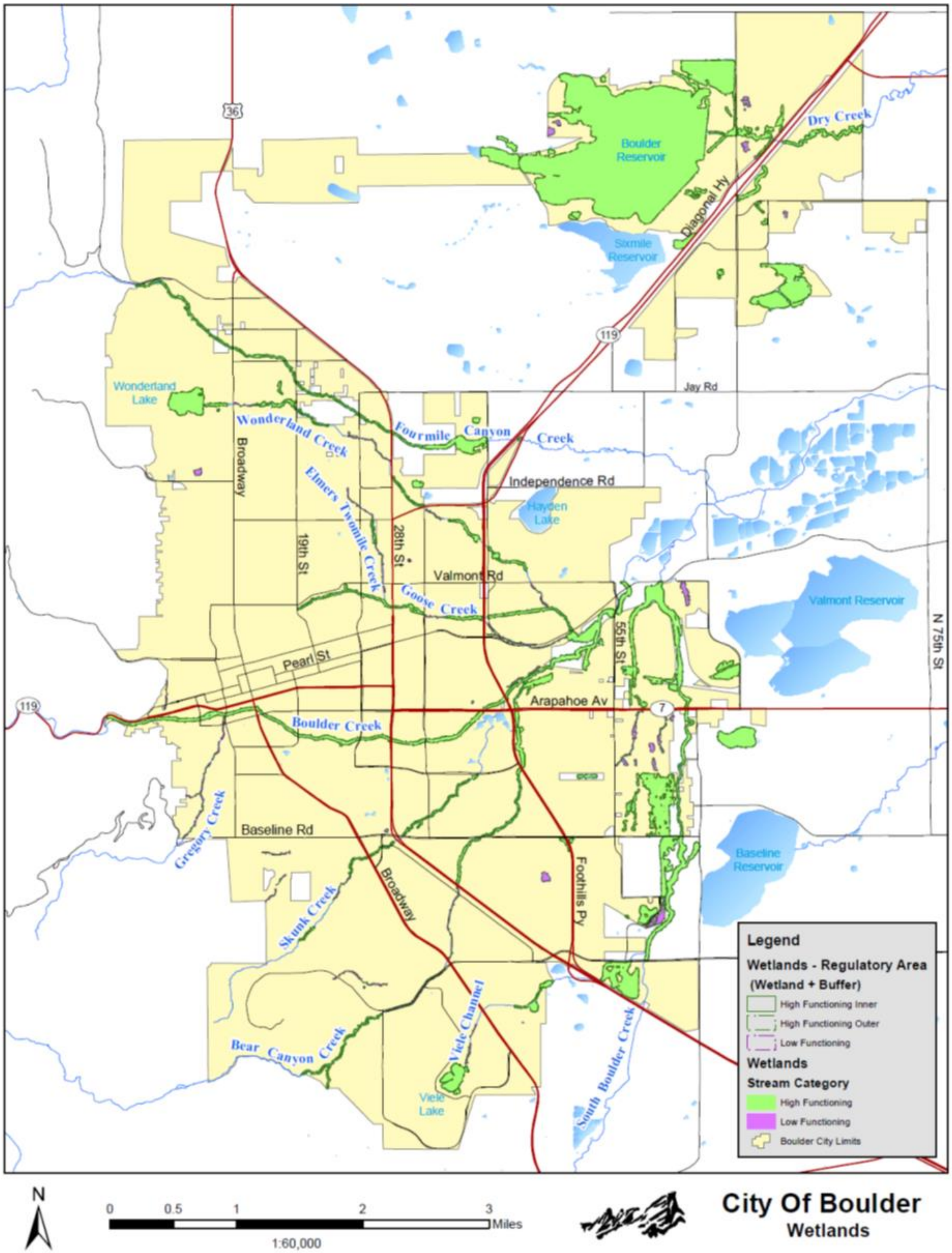
Figure 4.53. City of Boulder Natural System Overlay



Wetlands

Wetlands are also an important and legally protected resource. Wetland communities play a vital role in groundwater recharge and water quality protection and provide habitat for dependent plant and wildlife species. Wetlands also help absorb excess runoff and precipitation, and thus reduce flood magnitudes. A variety of wetlands can be found throughout the City of Boulder. This includes those wetlands meeting the regulatory definition of wetlands under Section 404 of the Federal Clean Water Act and those defined by Boulder's Wetlands Protection Ordinance, which was first adopted in 1992. Boulder's ordinance is generally more stringent than the federal regulation, stipulating a 50-foot buffer around high functioning wetlands, and a 25-foot buffer around low functioning wetlands. The city ordinance adopts a wetlands map as the official determination of wetland boundaries within the city limits. The wetlands areas are shown in the regulatory map in Figure 4.54. Section 4.4 of this plan contains more discussion on the Wetlands Protection Ordinance and Wetlands Protection Program.

Figure 4.54. Regulatory Wetlands, City of Boulder



Urban Forest Assets

The trees that make up the urban forest are also considered major capital assets in the city. The City of Boulder's Parks and Recreation Urban Forestry Section maintains approximately 40,000 trees in city parks and public street rights-of-way. In addition, there are over 400,000 trees on both public and private property within Boulder's urban forest that contribute to the city's quality of life. It is estimated that there are over 100 distinct species of trees in the city.

Boulder's urban forest provides many environmental benefits to the community. Aside from the obvious aesthetic benefits, trees within the urban forest improve the air, protect valuable water resources, save energy, improve economic sustainability, and provide food and shelter for wildlife. The following information quantifying the value of this asset is based on several different studies conducted for the city:

- Trees remove carbon dioxide from the atmosphere through photosynthesis and return oxygen back to the atmosphere as a byproduct. About half of the greenhouse effect is caused by carbon dioxide. Trees act as a carbon sink by removing the carbon and storing it in their trunk, branches, leaves, and roots. Boulder's urban forest stores approximately 112,000 tons of carbon and removes an additional 2,250 tons per year, removing a significant amount of vehicle and industrial emissions from the air. This carbon storage is valued at over $1,000,000.
- Trees also remove other air pollutants, such as sulfur dioxide, nitrogen dioxide, ozone, carbon monoxide, and particulate matter, through the photosynthetic process. The filtration provided by Boulder's urban trees is valued at approximately $730,000 per year.
- During a major rainstorm, trees intercept the rain on their leaves, branches, and trunks and thereby reduce stormwater runoff by preventing the water from reaching the ground. The tree cover in Boulder reduces stormwater runoff by approximately 12.2 million cubic feet (the volume of a 20-story building the size of a football field) per two-inch rain storm. For every 5 percent of tree cover added to a community, stormwater runoff is reduced by approximately 2 percent.
- Trees reduce topsoil erosion, prevent harmful land pollutants contained in the soil from getting into the waterways, and ensure that the groundwater supplies are continually being replenished.
- Trees lower local air temperatures by transpiring water and shading surfaces. It is six to 19 degrees cooler under a tree canopy during the summer months. Because they lower air temperatures, shade buildings in the summer, and block winter winds, trees can reduce building energy use and cooling costs. Boulder's urban forest reduces energy costs citywide by approximately $1,400,000 per year.
- A community's trees and, collectively, its urban forest is usually the first impression a community projects to its visitors. A community's urban forest is an extension of its pride and community spirit. People linger and shop longer along tree-lined streets, and businesses with offices surrounded by trees find their workers are more productive and absenteeism is reduced.

- Urban trees provide honeybees, birds, squirrels, raccoons, and deer, just to name a few, with shelter and food needed to survive in the City of Boulder.
- Trees in native areas such as stream corridors provide food, shelter, and nesting habitats to many diverse and sometime rare species.

Due to the species' broad adaptability and the great shade potential, ash trees have been widely planted throughout Boulder County communities. Now the City of Boulder faces a unique and significant threat to the prosperity of urban tree coverage; the Emerald Ash Borer. The Emerald Ash Borer (EAB) is a non-native, wood-boring beetle that attacks ash tree species. It is an invasive pest that is rapidly killing millions of ash trees across the country. In 2013, the EAB was detected in the City of Boulder. EAB is widely considered to be the most destructive forest pest in North America. The insect has the potential to kill all ash trees and permanently change the landscape and surrounding ecosystems. In 2015, Boulder County adopted its Emerald Ash Borer Management Plan, providing a framework to proactively manage ash trees, reduce the overall ash population throughout county owned and/or managed lands, protecting select high value ash trees, replanting trees in high public-use areas, and maintaining public safety.

Development Trends

Managing growth in the City of Boulder has long been a priority to retain the city's small-town character and natural setting. In the 1950s, Boulder's population grew from 25,000 to 37,000, and during the 1960s, it reached 66,000. The U.S. Census Bureau estimated that 108,090 people resided in the city as of July 1, 2016. In 2016 the City of Boulder issued 1,849 new building permits, of which 716 were single family units and 1,087 had 5 or more units. This reflects the growing development in the City, increasing the number of building permits by almost 5% from 1,249 in 2015.

Table 4.21 below provides details regarding anticipated land use patterns and the proposed structural counts for annexed areas surrounding the City. In total, the City of Boulder should expect to add 3,931 new structures, most of which (91%) will be residential. The new development will add $1.84 trillion of building value and $1 trillion of contents, with a combined value of $2.85 trillion.

Table 4.21. Annexed Areas Building Exposure

Land Use	Structure Count	Improved Value	Estimated Contents Value	Total Value
Agricultural	2	$11,000	$11,000	$22,000
Commercial	286	$124,664,000	$124,664,000	$249,328,000
Exempt	39	$27,010,000	$27,010,000	$54,020,000
Industrial	19	$7,268,000	$10,902,000	$18,170,000
Other Non-Residential	11	$3,870,000	$3,870,000	$7,740,000
Residential	3,573	$1,681,018,000	$840,509,000	$2,521,527,000

Land Use	Structure Count	Improved Value	Estimated Contents Value	Total Value
Vacant Land	1	$0	$0	$0
Total	**3,931**	**$1,843,841,000**	**$1,006,966,000**	**$2,850,807,000**

Source: City of Boulder GIS, Boulder County Assessor's Office

In response to rapid growth, the city created a system for controlling the rate of population growth by limiting building permits, enacted special taxes to finance acquisition of 27,000 acres of open space around the city, and established a defined urban growth boundary (i.e., the "blue line") to control development in the surrounding foothills. Due to the growth restrictions and open space, much of the city is "built out." Development that occurs is typically re-development of a previously developed area. The 2006 redevelopment of the Crossroads Mall into the 29th Street shopping district is an example. This development considers flood hazard risk from Boulder Creek and includes a Home Depot elevated to provide protection from the 100-year flood.

Based on established community goals and policies as set forth in the Boulder Valley Comprehensive Plan (BVCP), the city implements these growth management tools to control the scale, location, type, intensity, and timing of new development as well as redevelopment. As described in the BVCP, future land use and growth is categorized in the BVCP Future Land Use and Area I, II, and III maps. The Future Land Use map defines the desired future land use pattern for the Boulder Valley Figure 4.55. The Area I, II, III map defines the city's service area, which sets the city's urban growth boundary and ensures a logical extension of urban services (Figure 4.56).

Figure 4.55. Future Land Use Map Boulder Valley Comprehensive Plan

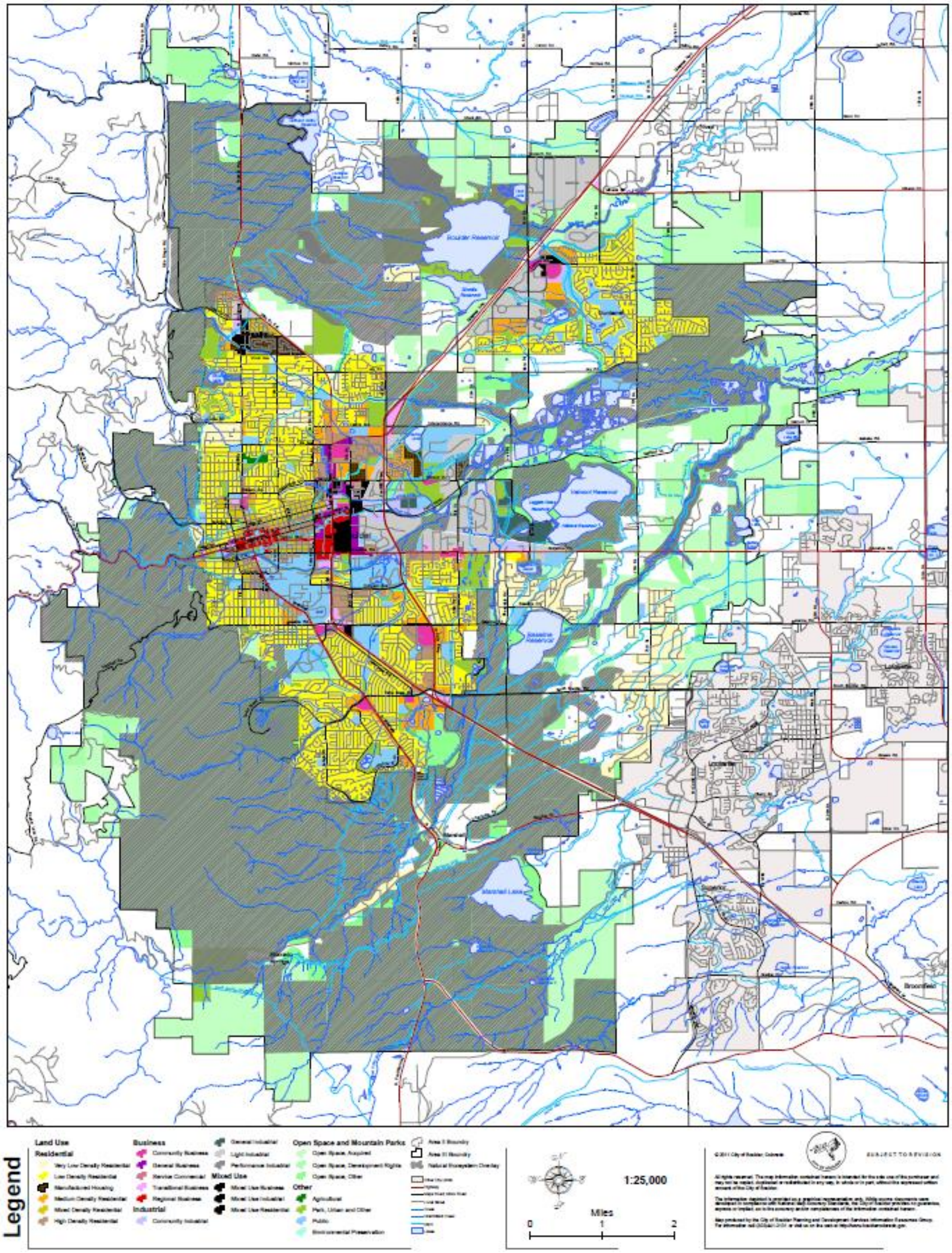
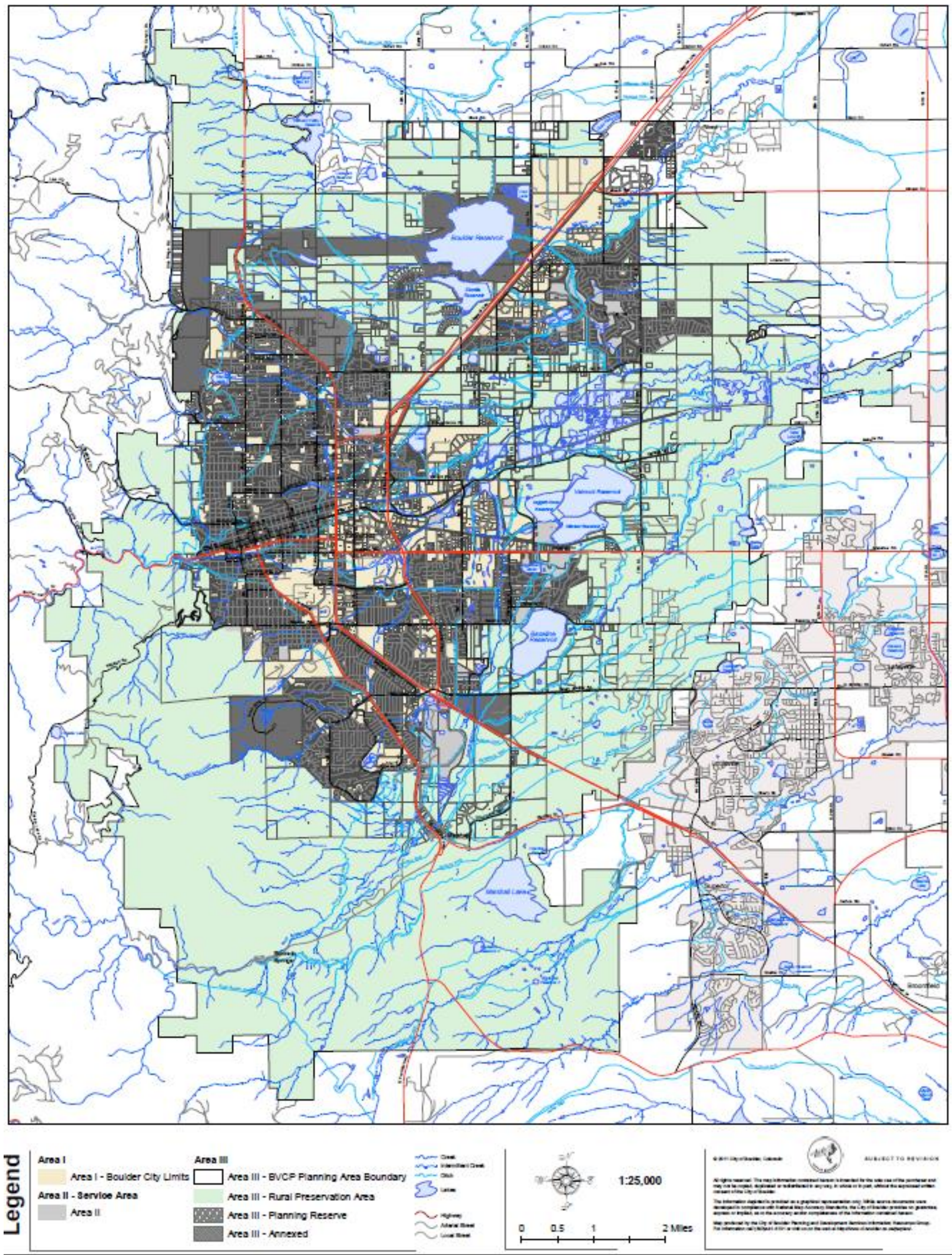


Figure 4.56. Planning Area I, II, and III Boulder Valley Comprehensive Plan



4.3.2 Vulnerability of the City to Specific Hazards

The Disaster Mitigation Act regulations require that the HMPC evaluate the risks associated with each of the hazards identified in the planning process. This section summarizes the possible impacts and quantifies, where data permits, the vulnerability of the city to each of the hazards identified as a risk. The HMPC has determined that the risk of avalanche, fog, landslides and rockfalls, and volcanoes to the City of Boulder is minimal or nonexistent and they are no longer addressed in this plan.

The hazards that the city continues to consider are the following:

- Dam Failure
- Drought
- Earthquakes
- Floods
- Human Health Hazards
  - Pandemic Flu
  - West Nile Virus
- Severe Weather
  - Extreme Temperatures
  - Hailstorms
  - Thunderstorms
  - Lightning
  - Tornadoes
  - Windstorms
- Soil Hazards
  - Expansive Soils
  - Land Subsidence
- Wildfire
- Winter Storms

An estimate of the vulnerability of the city to each identified hazard, in addition to the estimate of risk of future occurrence, is provided in each of the hazard-specific sections that follow. Vulnerability is measured in general, qualitative terms and is a summary of the potential impact based on past occurrences, spatial extent, and damage and casualty potential. It is categorized into the following classifications:

- **Extremely Low**—The occurrence and potential cost of damage to life and property is very minimal to nonexistent.
- **Low**—Minimal potential impact. The occurrence and potential cost of damage to life and property is minimal.

- **Medium**—Moderate potential impact. This ranking carries a moderate threat level to the general population and/or built environment. Here the potential damage is more isolated and less costly than a more widespread disaster.
- **High**—Widespread potential impact. This ranking carries a high threat to the general population and/or built environment. The potential for damage is widespread. Hazards in this category may have occurred in the past.
- **Extremely High**—Very widespread and catastrophic impact.

Vulnerability can be quantified in those instances where there is a known, identified hazard area, such as a mapped floodplain. In these instances, the numbers and types of buildings subject to the identified hazard can be counted and their values tabulated. Further, other information can be collected, such as the location of critical historic structures and valued natural resources that are within the specific hazard area. Together, this information portrays the impact, or vulnerability, of that area to that hazard.

The HMPC identified two hazards in the City of Boulder for which specific geographical hazard areas have been defined: flood and wildfires. For these two hazard areas, the HMPC has inventoried the following for the city, to the extent feasible, as a means of quantifying the vulnerability and meeting the requirement of how risk varies across the planning area:

- General hazard-related impacts, including impacts to life, safety, and health
- Insurance coverage, claims paid, and repetitive losses
- Values at risk (i.e., types, numbers, and value of land and improvements)
- Identification of critical facilities at risk
- Identification of cultural and natural resources at risk
- Overall community impact
- Development trends within the identified hazard area

Vulnerability and potential impacts from hazards that do not have specific mapped areas, such as drought and severe weather, are discussed in more general terms based on past events.

The sections that follow present the vulnerability analysis for the City of Boulder.

Vulnerability to Avalanches

Likelihood of Occurrence—Unlikely
Vulnerability—Low

Except within limited areas, the topography of the city is well below the slopes of 25-50 degrees on which the CAIC data indicate that 98 percent of all avalanches occur; potentially some risk within the City of Boulder's water supply watershed in the Indian Peaks though this area is off limits to the public. Although future avalanches are likely to occur, the spatial extent is limited and the magnitude is low. Therefore, avalanches are a low significance hazard in the City.

People

It is public safety that is most threatened by this hazard. Outdoor recreationalists who travel into backcountry areas are most at risk. Impacts are generally isolated to backcountry users and possibly first responders and Search and Rescue based in Boulder. Additionally, while road closures help to mitigate impacts to travelers in avalanche-prone areas, snowplow drivers can still be exposed while clearing roads of snow or avalanche debris.

Property

In general, structures located below an area at high risk to avalanches are likely to be exposed to the impacts of an avalanche.

Critical Facilities

Any critical facility located below an area at high risk to avalanches is likely to be exposed to the impacts of an avalanche. No known critical facilities or cultural resources in the City of Boulder were in avalanche paths at the time this plan was written.

Natural Environment

Avalanches can erode topsoil, cover the environment with debris, and damage surrounding vegetation. For the most part, the environment is resilient and would be able to rebound from whatever damages occurred, though this process could take years.

Future Development

Avalanche vulnerability could increase with future development and population growth as there will be a higher number of people driving on roadways and taking part in backcountry recreation. It is unlikely that risk to structures will increase if future development is planned outside of mapped or suspected avalanche hazard zones.

Vulnerability to Dam Failures

Likelihood of Occurrence—Unlikely
Vulnerability—High

There are seven high hazard and five significant hazard dams that could affect the City of Boulder. Barker Reservoir has the potential to have the worst impacts on the city if a dam failure occurred. The dam failure hazard extent within city limits is considered significant, potentially impacting 10-50% of the planning area. The overall impacts to the city from a dam failure include those previously identified for flood events. The biggest difference is that a catastrophic dam failure has the potential to result in a much greater loss of life and destruction to property and infrastructure due to the potential speed of onset and greater depth, extent, and velocity of flooding. While the vulnerability is high, the probability of a dam failure event is low.

People

Persons located underneath or downstream of a dam are at risk of a dam failure, though the level of risk can be tempered by topography, amount of water in the reservoir and time of day of the breach. Injuries and fatalities can occur from debris, bodily injury and drowning. Once the dam has breached, standing water presents all the same hazards to people as floodwater from other sources. People in the inundation area may need to be evacuated, cared for, and possibly permanently relocated.

Property

In general, communities located below a dam and along a waterway are likely to be exposed to the impacts of a dam failure. Specific inundation maps and risk information are included in the dam-specific emergency action plans. Due to the sensitive nature of this information, it is not included in this plan. Inundation maps that identify anticipated flooded areas (which may not coincide with known floodplains) are produced for all high hazard dams and are contained in the Emergency Action Plan (EAP) required for each dam. However, the information contained in those plans is considered sensitive and is not widely distributed. For reference, high hazard dams are the structures which, if failed, would threaten life and property, while significant hazard dams would only threaten property.

The potential impacts from a dam failure in the City are largely dependent on the specific dam or area in question. Generally, any buildings or other infrastructure located in a dam inundation area is vulnerable to the impacts from rising waters.

Assets at Risk to Barker Dam Failure

According to GIS overlays of the inundation zone from a catastrophic failure of Barker Dam, approximately 2,754 structures with a total structural and contents value of $8.74 billion would be affected, primarily in the Boulder Creek basin. This does not consider damage to bridges, roads, utilities, and other infrastructure. The failure of Gross dam would impact 3,020 structures, with a total structural and contents value of $4.82 billion. These results are displayed in the table below.

Table 4.22. Barker Dam Inundation Estimated Damages

Land Use	Structure Count	Inundation-Prone Structures at Risk Values	Estimated Contents Value	Total Value	Estimated Loss (30%)
Commercial	1,045	$2,921,222,000	$2,921,222,000	$5,842,444,000	$1,752,733,200
Exempt	195	$214,846,000	$214,846,000	$429,692,000	$128,907,600
Industrial	54	$60,380,000	$90,570,000	$150,950,000	$45,285,000
Other Non-Residential	44	$15,061,000	$15,061,000	$30,122,000	$9,036,600
Residential	1,414	$1,525,248,000	$762,624,000	$2,287,872,000	$686,361,600
Vacant Land	2	$0	$0	$0	$0
Total	**2,754**	**$4,736,757,000**	**$4,004,323,000**	**$8,741,080,000**	**$2,622,324,000**

Source: City of Boulder GIS, Boulder County Assessor's Office

Table 4.23. Gross Dam Inundation Estimated Damages

Land Use	Structure Count	Inundation-Prone Structures at Risk Values	Estimated Contents Value	Total Value	Estimated Loss (30%)
Commercial	329	$979,516,000	$979,516,000	$1,959,032,000	$587,709,600
Exempt	88	$179,136,000	$179,136,000	$358,272,000	$107,481,600
Industrial	30	$47,741,000	$71,611,000	$119,352,000	$35,805,600
Other Non-Residential	16	$5,401,000	$5,401,000	$10,802,000	$3,240,600
Residential	2,556	$1,244,168,000	$622,084,000	$1,866,252,000	$559,875,600
Vacant Land	1	$0	$0	$0	$0
Total	**3,020**	**$2,455,962,000**	**$1,857,748,000**	**$4,313,710,000**	**$1,294,113,000**

Source: City of Boulder GIS, Boulder County Assessor's Office

Critical Facilities

A total dam failure can cause catastrophic impacts to areas downstream of the water body, including critical infrastructure. Any critical asset located under the dam in an inundation area would be susceptible to the impacts of a dam failure. Of particular risk would be roads and bridges that could be vulnerable to washouts, further complicating response and recovery by cutting off impacted areas.

Natural Environment

Dam failure effects on the environment would be similar to those caused by flooding from other causes. Water could erode topsoil, cover the environment with debris. For the most part, the environment is resilient and would be able to rebound from whatever damages occurred, though this process could take years.

Future Development

Areas slated for future development should be cognizant of potential impacts from dam failure risk upstream. In the case of a dam failure, inundation would likely follow some existing FEMA mapped floodplains, which contains development restrictions for areas in the 1% annual chance floodplain, but it could exceed those floodplains. It should be noted that development below a low hazard dam could increase its hazard rating.

Dam failure flooding can occur as the result of partial or complete collapse of an impoundment. Dam failures often result from prolonged rainfall and flooding causing overtopping of the structure. The primary danger associated with dam failure is the high velocity flooding of those properties downstream of the dam. Of the 24 Class I and 16 Class II dams identified in Boulder County, 12 (according to the HMPC) have the potential to adversely impact the City of Boulder planning area should they fail:

- High Hazard: Barker, Boulder, Gross, Hayden, Jasper, Six Mile, and Silver Lake
- Significant Hazard: Davis #1, Isabelle Lake, Mesa Park (also known as Wonderland Lake), Albion, and Goose Lake

Many of these reservoirs are in mountain drainages several miles west of the city (see Figure 4.1). Albion, Goose, Isabelle Lake, Silver Lake, and Jasper are near the Continental Divide. Of all these dams, a failure of Barker Dam would have the most catastrophic impacts on the city. Boulder, Six Mile, Mesa Park, and Hayden Reservoirs are other high hazard dams in the city limits, but impacts from a failure of either of these dams would largely be outside of the city.

The Division of Water Resources runs the Dam Safety Program in Colorado. According to the State of Colorado Natural Hazards Mitigation Plan, Colorado has emergency action plans for nearly all the state-regulated high- and significant-hazard dams. Inundation maps for some dams have also been developed and exist for Barker Dam and Gross Dam in a GIS format.

Vulnerability to Drought

Likelihood of Occurrence—Likely
Vulnerability—High

The Drought Impact Reporter at the National Drought Mitigation Center is a comprehensive database of drought impacts that are published in a periodical or other media outlet. While not a perfect measure of net or relative drought impacts, it can give an idea of the variety of societal effects a drought can have on a geographical area.

In the past 10 years, Boulder County suffered 23 impacts related to drought. Those impacts were felt in the following categories: agriculture (5), business & industry (1), fire (7), plants & wildlife

(6), relief, response, & restrictions (11), society & public health (2), tourism & recreation (1), water supply & quality (8).

People

The most significant qualitative impacts associated with drought in the Planning Area are those related to water intensive activities such as wildfire protection, municipal usage, commerce, tourism, recreation, and wildlife preservation. Mandatory conservation measures are typically implemented during extended droughts, which can affect people.

Drought may cause health problems related to low water flows and poor water quality; it may also cause health problems due to an excess of dust and poor air quality. According to the Centers for Disease Control,[i] viruses, protozoa and bacteria can pollute both groundwater and surface water when rainfall decreases. Acute respiratory and gastrointestinal illnesses are more easily spread from person to person, bacteria can more easily contaminate and cause infectious diseases, and recreational waters can become infected with pathogens that thrive in the shallow warm waters that exist during drought conditions. Generally, drought may require conservation of water resources, which could mean that water use is restricted to critical uses; this could impact how people use water daily. Those who are young, old and suffering from chronic diseases could be especially vulnerable to the impacts of drought.

Like most Colorado communities, Boulder depends on stored water most of the year. According to the 2003 City of Boulder Drought Plan, the city treats and delivers approximately 24,000 acre-feet of water (7.8 billion gallons) to its customers each year. Water provided by the city serves purposes ranging from critical uses that require an assured supply, such as water for drinking or firefighting, to those uses which can tolerate occasional restrictions, such as landscaping or car washing.

Property

Direct structural damage from drought is rare, though it can happen. Drought can affect soil shrinking and swelling cycles, and can result in cracked foundations and infrastructure damage. The city provides sufficient water to meet all municipal water needs up to and through a drought severe enough to occur only once every 20 years on average. However, water for landscaping needs may be restricted for droughts of a severity that occurs less frequently than once every 20 years. Water for landscaping may be curtailed to the point that some landscaping die-back occurs for droughts that occur no more often than once every 100 years. As droughts increase in severity, the amount of restrictions also increases to the point that outdoor water use (with the exception of emergency uses) is totally eliminated during droughts that occur once every 1,000 years.

Critical Facilities

Much like the general built environment, direct structural damage from drought is rare, though it can happen. Of greater concern is the need for water to continue the essential functions of critical infrastructure. Should a drought be long-term or severe enough, the lack of water could interrupt the provision of essential services of critical infrastructure.

The City of Boulder obtains water from two distinct sources: the watershed of Boulder Creek via Middle and North Boulder Creeks (native basin—eastern slope) and the upper Colorado River via the Colorado-Big Thompson and Windy Gap projects (western slope). Boulder's ability to obtain water from both eastern slope and western slope sources provides some reliability against localized droughts; although widespread droughts may affect all of Boulder's sources. The city owns approximately 23,000 acre-feet of reservoir storage capacity plus its share of the Colorado-Big Thompson storage.

Natural Environment

Severe, prolonged drought can negatively impact the natural environment. Wildlife and natural habitats can be affected, including the shrinkage of habitat, dwindling of food supplies and the migration of wildlife to more palatable areas. Prolonged drought can cause poor soil quality, loss of wetlands, and increased soil erosion. One of the prevailing impacts of drought to the natural environment is the increased risk of wildfires that burn larger and more intensely during dry conditions. Drought conditions can also cause soil to compact and not absorb water well, potentially making an area more susceptible to flooding and flash flooding. Dust can be exacerbated by the extremely dry conditions, and regional dust storms can occur.

Furthermore, decreased revenues for state agencies resulting from drought can reduce management budgets, which can have a detrimental impact on lands and wildlife. 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.

Future Development

Drought vulnerability will increase with future development, as there will be increased demands for limited water resources. Water resources planning and water conservation that accounts for future development can play a role in mitigating drought impacts.

Vulnerability to Earthquakes

Likelihood of Occurrence— Occasional
Vulnerability— Medium

Colorado has very minimal seismic activity; however, since earthquakes affect large areas, an earthquake event could potentially impact 50-100% of the planning area. According to the 2,500-year probabilistic HAZUS scenario, there is the potential for 14% (4,914) of the total number of buildings in the city to be slightly damaged, roughly 2,312 buildings experiencing at least moderate damage and $496 million in economic losses.

People

In the 2008 State Hazard Mitigation Plan, extensive discussion about earthquake hazards indicates that the historical assumption about earthquake vulnerability in the state (namely, that said vulnerability is low) may be false. The "Earthquake Evaluation Report" issued by the Colorado Geological Survey (CGS) is included as an Annex in the 2008 State Plan. This report extensively reviews the history of earthquake analysis in the State, and indicates that significant funding and time investments are required to determine a more realistic evaluation of the earthquake threat to the State.

Using HAZUS, FEMA's loss-estimation software, the state identified the five most potentially damaging faults in Colorado: Rocky Mountain Arsenal, Golden, Rampart Range, Ute Pass, and Walnut Creek. Of these five faults, Rocky Mountain Arsenal, Golden, and Walnut Creek are within close proximity to Boulder County. According to the City of Boulder, the only known fault in Boulder County, located along North 75th Street near Valmont Drive, has been quiet for over 10,000 years. The state plan also identifies the Rock Creek fault in Boulder County. The Rock Creek fault is considered a Quaternary fault (and therefore may not be considered an active fault), while the Valmont fault is considered a middle to late Quaternary fault. In estimating potential earthquake hazards in Boulder County, the state analyzed impacts associated with the Frontal, Golden, Mosquito, Ute Pass, Valmont, Walnut Creek, and Williams Fork faults. Only the Valmont fault is in Boulder County; the others are in nearby counties.

Property

As part of the report, the CGS ran HAZUS (FEMA's Hazards United States software) to perform several different loss prediction analyses. One of these is presented in a county summary format. Table 4.24 summarizes this information.

Table 4.24. Potential Earthquake Losses in Boulder County by Fault

Fault	Magnitude	Default Attenuation Function	Estimated Fatalities	Estimated Total Damages	Loss Ratio of Total Building Stock	Previous Events
Frontal	M7.0	-	0 fatal	$31.8 Million	0.14%	
Golden	M6.5	Reverse WUS	41 fatal	$1.44 Billion	6.1%	
	M6.0	Reverse WUS	5 fatal	$467.5 Million	2.0%	
	M5.5	Reverse WUS	1 fatal	$135 Million	0.6%	
	M5.0	Reverse WUS	0 fatal	$33.5 Million	0.14%	
Mosquito	M7.0	-	0 fatal	$31.7 Million	0.13%	
Ute Pass	M7.0	-	0 fatal	$42.2 Million	0.18%	
Valmont	M5.0	-	1 fatal	$256 Million	1.1%	
Walnut Creek	M6.0	CEUS	42 fatal	$2.14 Billion	9.1%	
Williams Fork	M6.75	-	0 fatal	$29.3 Million	0.12%	
	M6.5	-	0 fatal	$18 Million	0.08%	
	M6.0	-	0 fatal	$4.8 Million	0.02%	
	M5.5	-	0 fatal	$0.2 Million	0.00%	
1882 Earthquake	M6.2		0 fatal,	$53.8Million	0.23%	

WUS: Western U.S. Attenuation Function
CEUS: Central U.S. Attenuation Function
Loss Ratio of Total Building Stock: This refers to the percentage of total building stock value damaged. The higher the ratio, the more difficult it is to restore a community to viability.
Source: Colorado Geological Society Earthquake Evaluation Report

A 2,500-year probabilistic HAZUS earthquake scenario was performed as part of this mitigation plan's update to analyze the impacts to Boulder specifically. The results can be referenced in Table 4.25. This scenario considers worst case ground shaking from a variety of seismic sources and analyzed data aggregated to census tracts for the city. Due to the low probability of a damaging earthquake occurring, as discussed below, the planning significance of earthquakes is considered low by the HMPC.

Table 4.25. City of Boulder HAZUS-MH 2,500-year Earthquake Scenario Results

Impact Category	Modeled Impacts	
Residential Buildings Damaged (Based upon 35,000 buildings)	Slight: 4,914 Moderate: 2,312 Extensive: 458 Complete: 28	
Building Related Loss	$457,130,000	
Total Economic Loss	$496,430,000	
Injuries (Based upon 2am time of occurrence)	Without requiring hospitalization: 44 Requiring hospitalization: 6 Life Threatening: 0 Fatalities: 1	
Injuries (Based upon 2pm time of occurrence)	Without requiring hospitalization: 74 Requiring hospitalization: 11 Life Threatening: 1 Fatalities: 2	
Injuries (Based upon 5pm time of occurrence)	Without requiring hospitalization: 56 Requiring hospitalization: 8 Life Threatening: 1 Fatalities: 1	
Essential Facility Damage (Based upon 52 buildings)	None with at least moderate damage	
Transportation and Utility Lifeline Damage	None with at least moderate damage	
Households w/out Power & Water Service (Based upon 48,080households)	Power loss @ Day 1: 0 Power loss @ Day 3: 0 Power loss @ Day 7: 0 Power loss @ Day 30: 0	Water loss @ Day 1: 0 Water loss @ Day 3: 0 Water loss @ Day 7: 0 Water loss @ Day 30: 0
Displaced Households	312	
Shelter Requirements	196	
Debris Generation	120,000 tons	

Source: HAZUS MH 4.0, Amec Foster Wheeler

Critical Facilities

Based on the Hazus probabilistic scenario described in Table 4.25, an earthquake would have a minimal effect on essential facilities in the City of Boulder. There are 52 identified critical facilities, and all of which would have at least 50% functionality by the end of Day 1.

Natural Environment

Generally, hazard specific impacts to the natural environment from an earthquake would be quickly absorbed by the surrounding area. An earthquake could cause cascading effects, including dam failure or rockslide that would impact the natural environment in different ways, depending on the scope of the cascading hazard. Other types of ground deformation could result as well.

Future Development

Building codes substantially reduce the costs of damage to future structures from earthquakes. Future buildings built to should be built to account for potential earth shaking and earthquake impacts.

As Boulder is largely built out, exposure will remain relatively constant, except where redevelopment and infill development occurs. Any new construction built to code in Boulder should generally be able to withstand earthquakes.

Vulnerability to Floods

Likelihood of Occurrence—Occasional
Vulnerability—High

People

The number of residential parcels with structures in the high hazard, floodway, 100-year, and 500-year floodplains was obtained to estimate populations in flood hazard zones. The total number of residential properties in each floodplain was multiplied by the average household size of 2.16 persons for the City of Boulder (2010 census), and that total was multiplied by the City of Boulder Occupancy Factor (95%) to estimate resident population.

Land use information combined with parcel analysis was used to determine the number of residents living within different flood hazard zones. Of the 9,101 citizens (4063 residential structures) living in a flood prone area,

- Approximately 179 people live in the high hazard zone (based on 80 residential structures)
- Approximately 871 people live in the floodway zone (based on 389 residential structures),
- Approximately 3,179 people live in the 100-year floodplain (based on 1,419 residential structures)
- Approximately 4,872 people live in the 500-year floodplain (based on 2,175 residential structures).

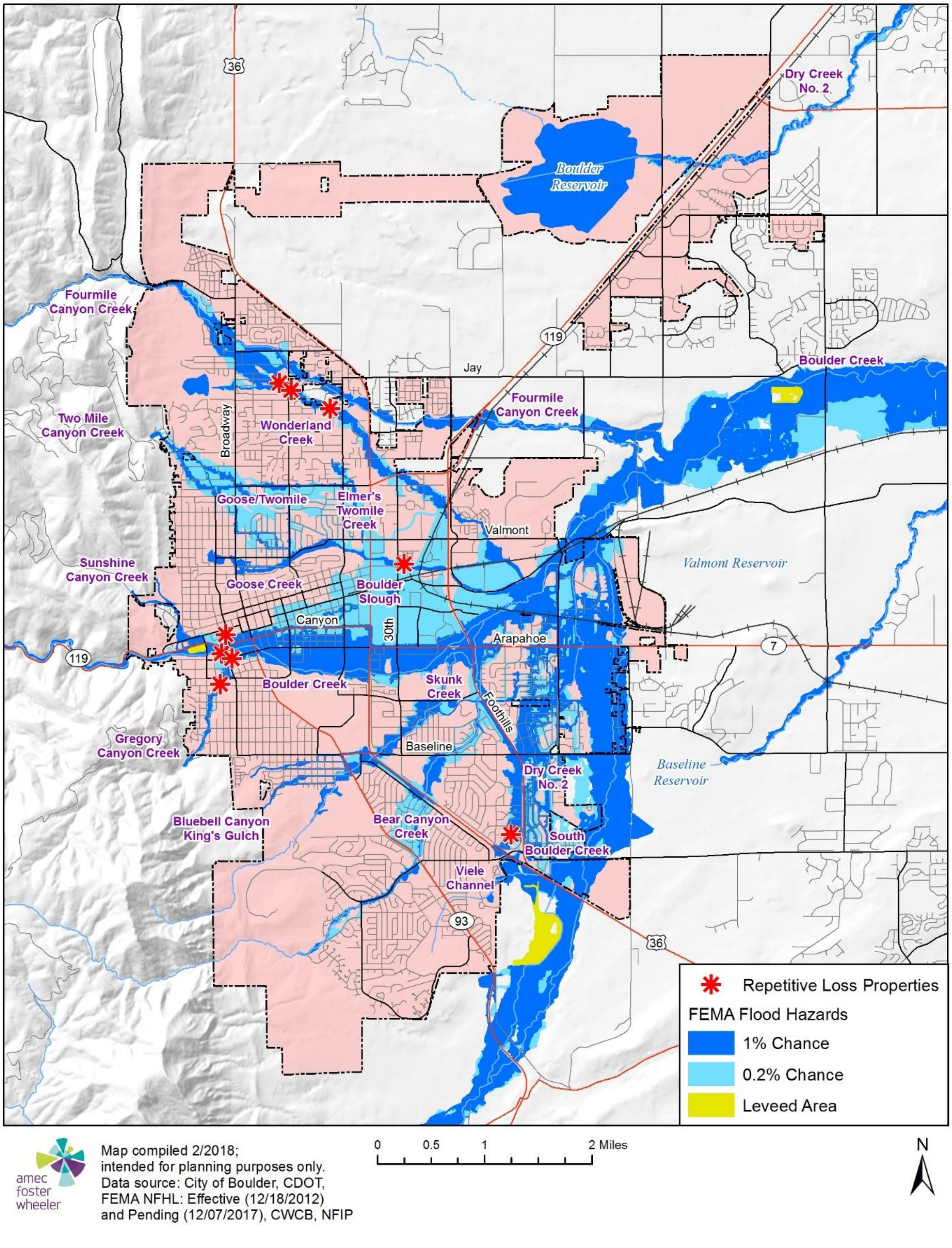
In addition to the direct impacts floods can have on people, floods can also affect the health and wellbeing of community members. Serious flood events can lead to health risks for humans such as unsafe food, contaminated drinking water, and poor sanitation. Floodwaters can carry disease causing bacteria, dirt, human/animal wastes, and industrial chemicals. Foods kept inside cardboards, plastic bags, jars, bottles, and paper packaging are equally subject to disposal if contaminated by floodwaters. Even though the packages do not appear to be wet, they may be unhygienic with mold contamination and deteriorate rapidly (CDC Fact Sheets 10 September 2004 and 2 September 2005). Also, unclean drinking and washing water and sanitation, coupled with lack of adequate sewage treatment, can lead to disease outbreaks. Other diseases such as malaria, dengue, and West Nile may be caused by an increase in the number of mosquitos from wet areas and stagnant pools. Mold and mildews are also associated health risks for flood victims. Molds grow in as short a period in wet and damp areas of the buildings and homes that have not been cleaned after flooding such as water infiltrated walls, floors, carpets, toilets and bathrooms. If inhaled, the mold spores can cause allergic reactions, asthma episodes, and other respiratory problems.

Property

Insurance Coverage, Claims Paid, and Repetitive Losses

NFIP data provided by the Colorado Water Conservation Board indicates that as of May 31, 2017, there were 4,251 flood insurance policies in the City of Boulder representing $1,023,011,100 of insurance coverage in force. Of these, 1,880 are located in the A zones (100-year flood); 1,268 standard and 1,103 preferred policies are located in the B, C, and X zones (the area between the limits of the 100 and 500 years, including the 500-year flood). Historically, there have been 844 claims for flood losses (closed paid losses) totaling $21,036,638. These included 273 claims for properties in A zones, and 85 standard and 350 preferred policies were for properties located in B, C, and X zones. 2,189 were for post-FIRM structures; 2,062 were for pre-FIRM structures, and one was unknown. Prior to the 2013 flood events, the City did not have any repetitive loss structures, however, there are now 8 repetitive loss buildings that account for 19 repetitive losses. The general locations of repetitive losses are shown on the figure below. This analysis was prepared as part of this plan's update in 2017, providing an initial analysis of repetitive loss areas. Based on this initial analysis, the repetitive loss properties are dispersed around the city, with some clusters in the Wonderland Creek (3 properties) floodplain, but specific areas that might be indicative of adjacent properties at risk are difficult to ascertain without a site-specific analysis. Other properties are within the Boulder Creek, Dry Creek No. 2, Goose Creek, Sunshine Canyon Creek and Gregory Canyon Creek floodplains.

Figure 4.57. Repetitive Loss Property General Locations



Values at Risk

The following section discusses the results of an effort to quantify the city's vulnerability to both the 100- and 500-year flood events. The HMPC used data provided by the city to quantify the potential flood losses within the mapped floodplain areas. The first step was to identify what is exposed to the various flood hazards. The City's high hazard and floodway zones were also analyzed as these zones represent the highest risk areas. The latest parcel-level data and structure footprints were used in the analysis to quantify structure counts and values. The methodology described below was performed for each of the four types of floodplain.

Methodology

Due to the numerous drainages in the city, it was necessary to develop a methodology that allowed loss estimates to be summarized by creek to show how the risk varies across the planning area. The city prepared a spatial overly of structure footprints in the various flood hazard zones within the city limits using GIS. Only structures larger than 725 square feet were included in the analysis so that garages and outbuildings would not be considered as individual structures. The city attributed the building footprint layer with the names of the stream that poses the flood risk. The structure counts by flood zone are presented in Table 4.26. In some cases a structure may be at risk from more than one stream where the floodplains merge (i.e. Sunshine Canyon and Boulder Creek). In those cases, the structure is accounted for twice in the table. It is noted that it would be unlikely for each of these streams to flood during any single event, but the table gives an indication of the magnitude of impacts should a flood occur on any single or multiple drainages.

Based on this analysis the Boulder Creek and South Boulder Creek floodplains contain the greatest number of structures in the 100 and 500-year floodplains. Goose, Boulder, and Skunk creeks have the largest numbers of structures at risk in the high hazard zone.

Table 4.26. Structures at Risk to the 100 yr., 500 yr., High Hazard and Floodway Zones

Basins	1% Chance	0.2% Chance	High Hazard	Floodway	Leveed Area
Bear Canyon Creek	39	469	3	13	0
Bluebell Canyon/King's Gulch	39	1	4	0	0
Boulder Creek	720	687	58	74	4
Dry Creek	2	0	0	0	0
Dry Creek No. 2	454	492	2	33	0
Elmer's Twomile Creek	10	89	0	2	0
Fourmile Canyon Creek	76	50	21	24	0
Gregory Canyon Creek	76	30	27	45	0
Lower Boulder Creek	0	0	0	0	0

Basins	1% Chance	0.2% Chance	High Hazard	Floodway	Leveed Area
South Boulder Creek	63	38	6	29	0
Skunk Creek	141	90	25	75	0
Sunshine Canyon Creek	18	0	5	0	0
Twomile Canyon/Goose Creek	225	948	2	40	0
Viele Channel	11	11	0	1	0
Wonderland Creek	177	135	16	32	0
Total*	**2,051**	**3,040**	**169**	**368**	**4**

Source: City of Boulder Public Works & Utilities GIS, Boulder County Assessor's Office, FEMA
Only structures larger than 725 sq. ft. counted
*included in Boulder Creek 500 yr.
**structures in multiple floodplains counted twice

Estimating Potential Losses

Estimating potential losses requires quantifying additional information about the structure inventory within the floodplain, including property types and value. Using GIS, a spatial overlay (union) was performed to merge the various flood zones with the parcels. This layer was intersected with the building footprint layer attributed with the creek name. Any flooded parcels with a building footprint in the floodplain were identified in the GIS database. The intent of this was to be able to discern between flood prone parcels that have their structure in the floodplain versus those that have structures located outside of the floodplain. This also allows for analysis of acres at risk with and without structures.

The result of the flood hazard analysis summarizes the values at risk in the various floodplains by flood zone and creek in terms of total building exposure. The next step was to estimate potential losses. Potential losses from flooding are related to a variety of factors, including flood depth, flood velocity, and building type and construction. Based on FEMA's flood depth-damage functions, the percent of damage is directly related to the flood depth. FEMA's flood benefit-cost module uses this simplified approach to model flood damage based on building type and flood depth. FEMA's depth-damage functions indicate that a one-story structure with no basement flooded to two feet will incur damage of at least 22 percent of the value of the structure and 20 percent of the contents value. While there are several limitations to this model, it does present a methodology to estimate potential damage for this planning level analysis.

The following assumptions were also made:

- Building content values were estimated as a percentage of the building structure value, based on guidance used in FEMA HAZUS models (Section 14.2.2 HAZUS-MH Flood Technical Manual) to estimate contents based on building occupancy classes. The percentages of building value used to estimate contents are listed below. In some occupancy classes, such as Industrial, the value of the contents is considered greater than the building value itself.
  - Agriculture – 100%

- Commercial – 100%
- Exempt – 100%
- Industrial – 150%
- Natural Resources – 100%
- Other Non-Residential – 100%
- Res-Common Area – 100%
- Residential – 50%
- Vacant Land – 0%

- Boulder's Land Use classifications were simplified into HAZUS occupancy classifications.
- A total value was calculated equaling structure + contents
- An assumed flood damage of 25% of the structure total value was calculated, based on flood depth-damage curves assuming a 2-foot flood depth. The 2-foot flood depth was assumed for all flood hazard areas for this planning level analysis.

The results show an estimate of the flood damages for a 100-year (1% Annual Chance) flood on the various creeks in Boulder. The above steps were repeated for the 500-year (0.2% Annual Chance) flood analysis.

An analysis of Pre-FIRM structures was also performed. These are structures built before floodplain management regulations went into effect July 17th, 1978. The pre-FIRM structure count represents the most-at risk structures, as the post-FIRM structures should be mitigated to withstand the 100-year flood. Roughly one half of Boulder's structures in the 100-year floodplain are pre-FIRM structures.

Results

Table 4.27 summarize the results of this analysis. The loss ratio column shows the ratio of the loss estimate for a particular creek divided by the total loss across all the creeks. This allows for a creek by creek comparison of the loss potential and may help in prioritizing mitigation projects. Boulder Creek has the potential for the greatest loss from a 100-year flood (approximately $2.18B), followed by South Boulder Creek. The total loss from a 500-year event would be almost double that of a 100-year event. Buildings footprints that are in the 100-year and 500-year floodplains are shown in Figure 4.58 and Figure 4.59, after the tables.

Limitations

This analysis does not account for multi-story and assumes all structures and values are at ground level. Multi-Family parcels create a limitation to the structure and value analysis because the parcel layer sometimes uses a "Condo Box" system where small individual boxes within the main condo parcel represent each unit owner, but not a structure location. When intersecting these parcels with a hazard, the location of these boxes can sway results as all-in or all-out of the hazard zone. Thus, losses may be inflated as some properties may be outside of a hazard and not prone to risk. To avoid inflated values, we have developed a methodology to better estimate values and structure counts at risk to hazards.

Where a single building resides on a single parcel, there is a simple one-to-one relationship between the building data and the parcel data. Parcel polygons for multiple owned units in a structure (such as condos or business suites) that share a commonly managed area (CMA) are often represented schematically within the parcel layer. This means that their boundaries are not meant to represent location and size as other parcel polygons do; instead, they are spatial ‘placeholders’ that only show approximate location within a central parcel. It is also difficult to identify owners and their values to these condo boxes within a parcel boundary.

To more accurately associate parcel values with buildings, parcels in these situations were grouped by CMA for the analysis. All building and parcel values within a group were summarized to a parent ‘CMA Group Parcel’ created for this analysis. Improvement values within in the parcel data were summed into a combined structure value and then divided by the total number structures or building footprints. By using this methodology, hazard analysis was refined to better reflect structures and values at risk more specific to the hazards they intersect.

Table 4.27.   100-Year Floodplain Structure Values by Creek

Creek Name	Structure Count	Flood-Prone Structures at Risk Values	Estimated Contents Value	Total Value	Estimated 100-Year Flood Loss (25% of total value)	Loss Ratio*
Bear Canyon Creek	39	$18,520,000	$14,844,000	$33,364,000	$8,341,000	0.8%
Bluebell Canyon / King's Gulch	39	$19,851,000	$9,925,000	$29,776,000	$7,444,000	0.7%
Boulder Creek	720	$1,157,331,000	$1,020,503,000	$2,177,834,000	$544,458,500	52.6%
Dry Creek	2	$5,811,000	$5,811,000	$11,622,000	$2,905,500	0.3%
Dry Creek No. 2	454	$492,680,000	$395,069,000	$887,749,000	$221,937,250	21.4%
Elmer's Twomile Creek	10	$9,925,000	$5,598,000	$15,523,000	$3,880,750	0.4%
Fourmile Canyon Creek	76	$23,980,000	$14,373,000	$38,353,000	$9,588,250	0.9%
Gregory Canyon Creek	76	$45,279,000	$23,733,000	$69,012,000	$17,253,000	1.7%
Lower Boulder Creek	0	$0	$0	$0	$0	0.0%
South Boulder Creek	63	$38,024,000	$24,541,000	$62,565,000	$15,641,250	1.5%
Skunk Creek	141	$134,540,000	$111,635,000	$246,175,000	$61,543,750	5.9%
Sunshine Canyon Creek	18	$12,200,000	$8,342,000	$20,542,000	$5,135,500	0.5%

Creek Name	Structure Count	Flood-Prone Structures at Risk Values	Estimated Contents Value	Total Value	Estimated 100-Year Flood Loss (25% of total value)	Loss Ratio*
Twomile Canyon / Goose Creek	225	$171,434,000	$116,469,000	$287,903,000	$71,975,750	6.9%
Viele Channel	11	$34,417,000	$22,934,000	$57,351,000	$14,337,750	1.4%
Wonderland Creek	177	$127,651,000	$78,173,000	$205,824,000	$51,456,000	5.0%
Total**	**2,051**	**$2,291,643,000**	**$1,851,950,000**	**$4,143,593,000**	**$1,035,898,250**	

Source: City of Boulder, Boulder County Assessor's Office with valuation analysis by Amec Foster Wheeler, FEMA
* indicates ratio of the loss estimate for a particular creek divided by the total loss across all the creeks
** structures in multiple floodplains counted twice

Table 4.28. 500-Year Floodplain Structure Values by Creek

Creek Name	Structure Count	Flood-Prone Structures at Risk Values	Estimated Contents Value	Total Value	Estimated 100-Year Flood Loss (20% of total value)	Loss Ratio*
Bear Canyon Creek	469	$131,318,000	$71,139,000	$202,457,000	$50,614,250	3.3%
Bluebell Canyon / King's Gulch	1	$742,000	$742,000	$1,484,000	$371,000	0.0%
Boulder Creek	688	$1,934,070,000	$1,629,592,000	$3,563,662,000	$890,915,500	57.3%
Dry Creek	0	$0	$0	$0	$0	0.0%
Dry Creek No. 2	492	$308,363,000	$206,566,000	$514,929,000	$128,732,250	8.3%
Elmer's Twomile Creek	89	$91,138,000	$58,758,000	$149,896,000	$37,474,000	2.4%
Fourmile Canyon Creek	50	$36,424,000	$25,188,000	$61,612,000	$15,403,000	1.0%
Gregory Canyon Creek	30	$18,529,000	$9,387,000	$27,916,000	$6,979,000	0.4%
Lower Boulder Creek	0	$0	$0	$0	$0	0.0%
South Boulder Creek	38	$20,731,000	$15,050,000	$35,781,000	$8,945,250	0.6%
Skunk Creek	90	$68,595,000	$57,608,000	$126,203,000	$31,550,750	2.0%
Sunshine Canyon Creek	0	$0	$0	$0	$0	0.0%
Twomile Canyon / Goose Creek	949	$736,201,000	$562,918,000	$1,299,119,000	$324,779,750	20.9%
Viele Channel	11	$21,611,000	$16,771,000	$38,382,000	$9,595,500	0.6%
Wonderland Creek	135	$116,419,000	$83,980,000	$200,399,000	$50,099,750	3.2%
Total**	**3,042**	**$3,484,141,000**	**$2,737,699,000**	**$6,221,840,000**	**$1,555,460,000**	

Source: City of Boulder, Boulder County Assessor's Office with valuation analysis by Amec Foster Wheeler, FEMA
* indicates ratio of the loss estimate for a particular creek divided by the total loss across all the creeks

** structures in multiple floodplains counted twice

Table 4.29. Mitigated Structures Based on Elevation Certificates 100-Year Flood Zone

Basins	Structure Count	Flood-Prone Structures at Risk Values	Estimated Contents Value	Total Value	Estimated 100-Year Flood Loss Avoided (25% of total value)
Bear Canyon Creek	4	$1,031,000	$515,500	$1,546,500	$386,625
Bluebell Canyon / King's Gulch	10	$8,284,500	$4,142,250	$12,426,750	$3,106,688
Boulder Creek	339	$1,383,942,500	$1,203,258,628	$2,587,201,129	$646,800,282
Dry Creek	1	$4,782,460	$4,782,460	$9,564,920	$2,391,230
Dry Creek No. 2	62	$176,568,784	$184,072,584	$360,641,367	$90,160,342
Elmer's Twomile Creek	2	$7,842,270	$7,842,270	$15,684,540	$3,921,135
Fourmile Canyon Creek	57	$20,936,900	$10,549,300	$31,486,200	$7,871,550
Gregory Canyon Creek	23	$17,773,000	$9,026,450	$26,799,450	$6,699,863
Lower Boulder Creek	11	$2,726,623	$2,134,973	$4,861,596	$1,215,399
South Boulder Creek	12	$16,243,700	$14,199,400	$30,443,100	$7,610,775
Skunk Creek	35	$73,216,872	$71,975,872	$145,192,744	$36,298,186
Sunshine Canyon Creek	4	$3,300,900	$1,650,450	$4,951,350	$1,237,838
Twomile Canyon / Goose Creek	124	$169,740,068	$145,402,998	$315,143,065	$78,785,766
Viele Channel	0	$0	$0	$0	$0
Wonderland Creek	148	$110,097,259	$74,838,110	$184,935,369	$46,233,842
Total*	**832**	**$1,996,486,836**	**$1,734,391,244**	**$3,730,878,080**	**$932,719,520**

Source: City of Boulder, Boulder County Assessor's Office with valuation analysis by Amec Foster Wheeler, FEMA

Table 4.30. Adjusted Total Unmitigated Structures 100-Year Flood Zone

Basins	Structure Count	Flood-Prone Structures at Risk Values	Estimated Contents Value	Total Value	Estimated 100-Year Flood Loss (25% of total value)	Loss Ratio
Bear Canyon Creek	38	$18,234,378	$14,701,239	$32,935,617	$8,233,904	1.4%
Bluebell Canyon / King's Gulch	36	$17,214,300	$8,607,150	$25,821,450	$6,455,363	1.1%
Boulder Creek	518	$490,500,380	$404,149,616	$894,649,996	$223,662,499	38.3%
Dry Creek	1	$1,028,250	$1,028,250	$2,056,500	$514,125	0.1%
Dry Creek No. 2	411	$379,036,533	$273,922,034	$652,958,567	$163,239,642	27.9%
Elmer's Twomile Creek	10	$9,924,760	$5,598,470	$15,523,230	$3,880,808	0.7%
Fourmile Canyon Creek	62	$15,550,190	$10,158,120	$25,708,310	$6,427,078	1.1%

Basins	Structure Count	Flood-Prone Structures at Risk Values	Estimated Contents Value	Total Value	Estimated 100-Year Flood Loss (25% of total value)	Loss Ratio
Gregory Canyon Creek	63	$35,460,893	$18,684,027	$54,144,920	$13,536,230	2.3%
Lower Boulder Creek	0	$0	$0	$0	$0	0.0%
South Boulder Creek	55	$33,935,136	$22,496,686	$56,431,821	$14,107,955	2.4%
Skunk Creek	120	$96,890,012	$75,225,494	$172,115,506	$43,028,876	7.4%
Sunshine Canyon Creek	15	$9,266,940	$6,875,240	$16,142,180	$4,035,545	0.7%
Twomile Canyon / Goose Creek	204	$125,899,034	$74,796,521	$200,695,555	$50,173,889	8.6%
Viele Channel	11	$34,417,000	$22,933,800	$57,350,800	$14,337,700	2.5%
Wonderland Creek	121	$81,504,826	$48,577,280	$130,082,107	$32,520,527	5.6%
Total*	**1,665**	**$1,348,862,632**	**$987,753,925**	**$2,336,616,558**	**$584,154,139**	

Source: City of Boulder, Boulder County Assessor's Office with valuation analysis by Amec Foster Wheeler, FEMA

The data in the tables above highlights the number of structures that are exposed and also unmitigated. Though there are 2,051 structures located in the 100-year flood hazard zone, however, mitigation efforts have reduced the number of structures at risk to 1,665. There is $4.14 trillion of contents and structural value in the 100-year flood hazard zone, but 92.5% ($3.73 trillion) is mitigated based on certified elevation. The result, as displayed in Table 4.30, is that adjusted exposure to 100-year flood is $2.34 trillion in total unmitigated structures and contents.

Figure 4.58. Buildings in the 100-Year Floodplain

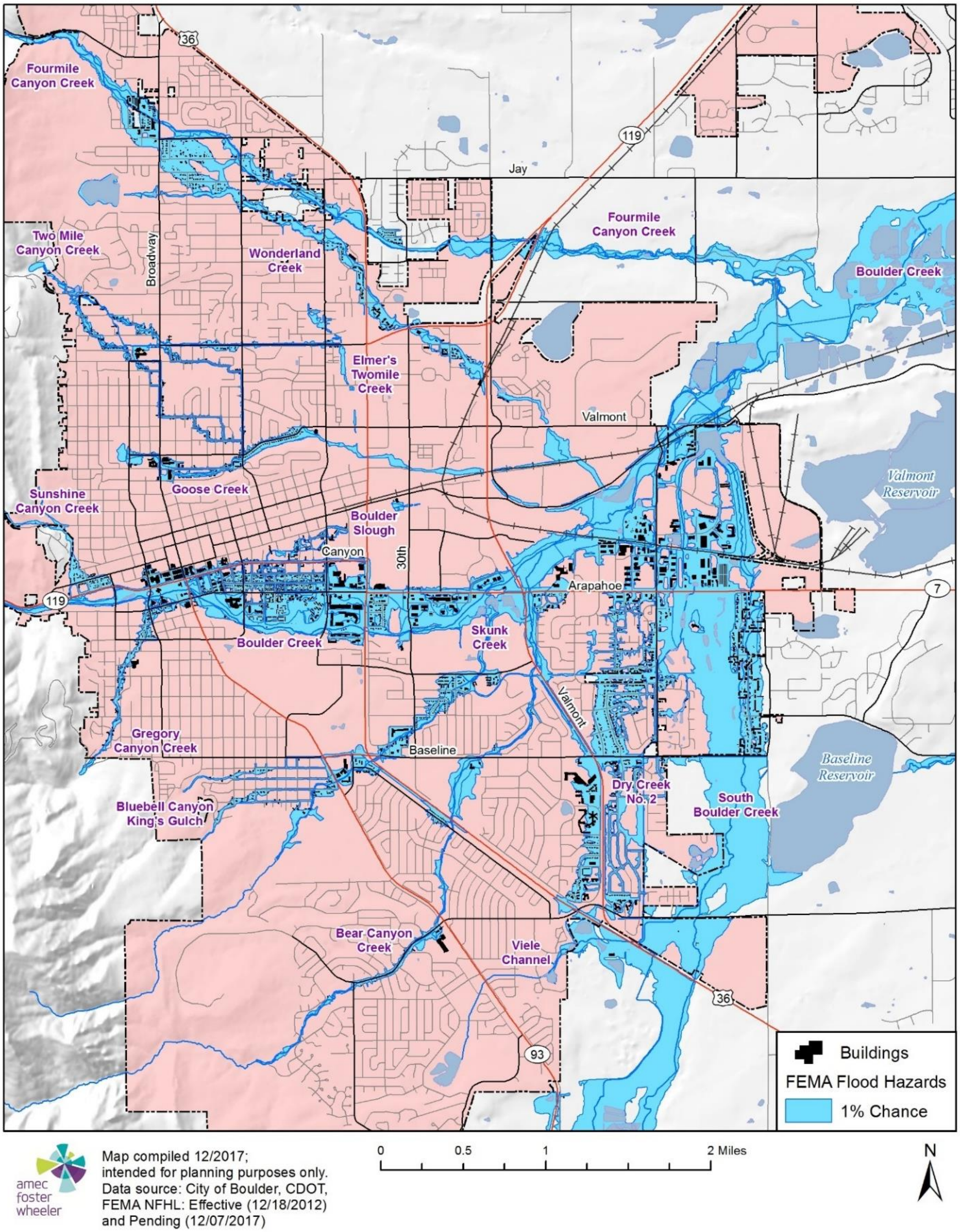


Figure 4.59. Buildings in the 500-Year Floodplain

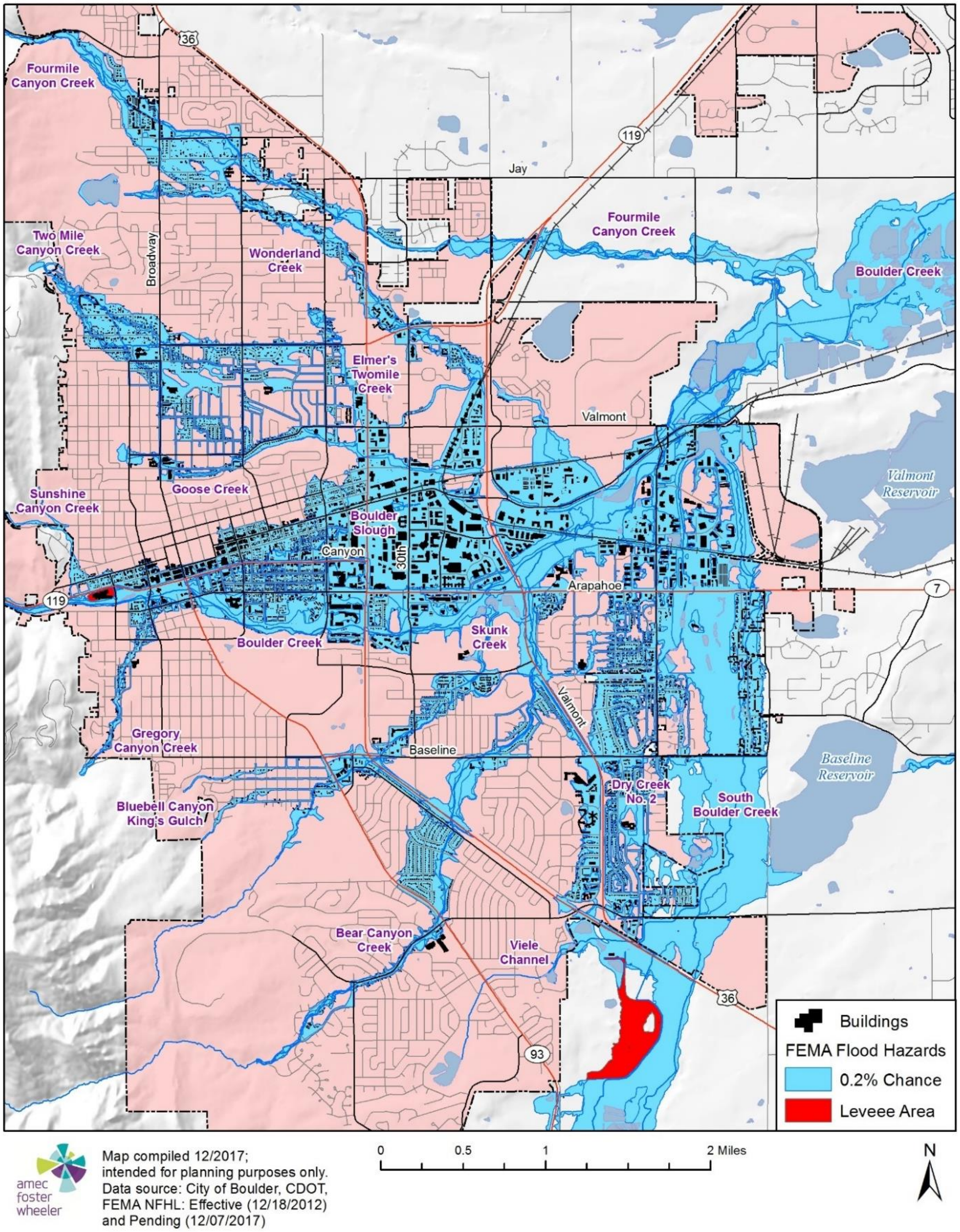


Figure 4.60. Buildings in the Floodway Flood Zone

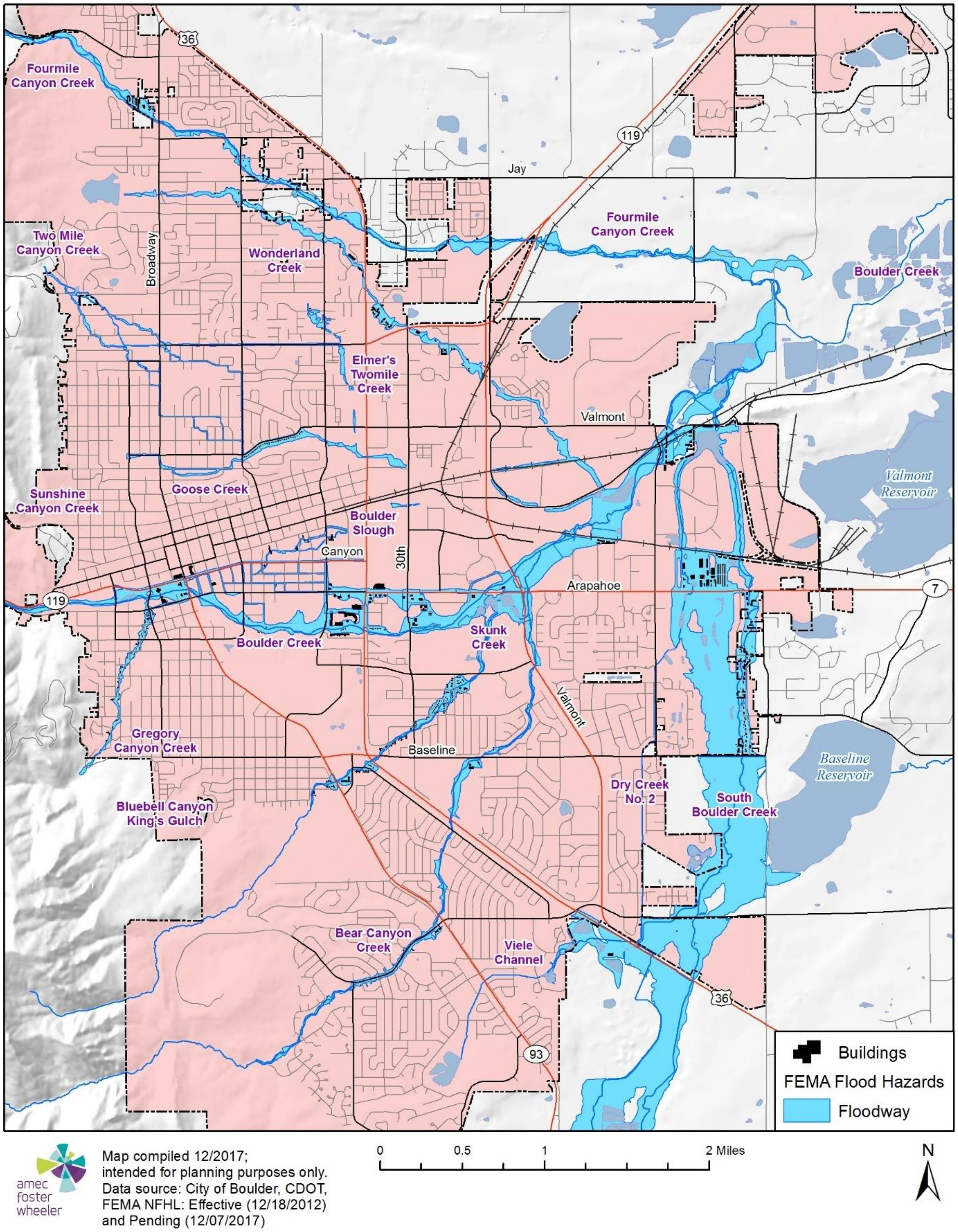


Table 4.31 and Table 4.32 summarize total property exposure by occupancy class in the 100 year and 500 year floodplains. The analysis indicates that residential structures comprise almost 71% of the structures at risk for both the 100-year and 74% for 500-year floods. Commercial and industrial properties make up the remainder. For the CRS and floodplain management, it is important to quantify areas that are not, or will not be, developed in the floodplain.

Table 4.31. City of Boulder Floodplain Occupancy – 100-year Floodplain

Occupancy Based on Property Types	Structure Count	% of Total Structures
Commercial	364	18.2%
Exempt	154	7.7%
Industrial	37	1.8%
Natural Resources	3	0.1%
Other Non-Residential	20	1.0%
Res Common Area	7	0.3%
Residential	1,419	70.8%
Vacant Land	1	0.05%
Total	**2,005**	

Source: City of Boulder, Boulder County Assessor's Office with valuation analysis by Amec Foster Wheeler, FEMA

Table 4.32. City of Boulder Floodplain Occupancy – 500-year Floodplain

Occupancy Based on Land Use	Structure Count	% of total structures
Agriculture	1	0.03%
Commercial	607	20.4%
Exempt	102	3.4%
Industrial	37	1.2%
Natural Resources	7	0.2%
Other Non-Residential	39	1.3%
Res Common Area	2	0.1%
Residential	2175	73.2%
Vacant Land	2	0.1%
Total	**2,971**	

Source: City of Boulder, Boulder County Assessor's Office with valuation analysis by Amec Foster Wheeler, FEMA

Critical Facilities

As described earlier, critical facilities are located throughout the City of Boulder. Critical facilities in the floodplain are summarized in by each of the four floodplains. More detail on each facility can be found in Appendix G.

Table 4.33. Critical Facilities at Risk to Flooding in the City of Boulder

Aggregate	Classification	Classification Count	1% Annual Chance Flood Prone	0.2% Annual Chance Flood Prone	Protected by Levee	Prone to Floodway Flooding	Prone to High Hazard Flooding	Prone to 10 Year Flooding
At Risk Population	Congregate Care	83	10	14	0	3	3	2
	Residential Care	27	4	3	0	1	0	1
	School	53	3	8	0	0	0	0
	Senior Center	2	0	0	0	0	0	0
	Total	**165**	**17**	**25**	**0**	**4**	**3**	**3**
Essential Services	Air Transportation	1	0	0	0	0	0	0
	Communication	19	5	1	0	4	4	2
	Emergency Medical Facility	9	1	2	0	0	0	1
	Government Building	16	6	4	1	4	3	2
	Public Safety Facility	15	1	5	0	1	1	0
	Public Utility	25	1	1	0	0	0	0
	Shelter	4	0	2	0	0	0	0
	Total	**89**	**14**	**15**	**1**	**9**	**8**	**5**
Hazardous Material	Hazardous Waste Biennial Reporter	7	2	4	0	0	0	0
	Hazardous Waste Large Quantity Generator	1	0	1	1	0	0	0
	Hazardous Waste Small Quantity Generator	7	0	1	2	0	0	0
	Toxic Release Inventory	28	1	5	3	0	0	1
	Total	**43**	**3**	**11**	**6**	**0**	**0**	**1**
	Grand Total	**297**	**34**	**51**	**7**	**13**	**11**	**9**

Source: City of Boulder Utilities Division, Boulder OEM, CDPHE, City of Boulder, HIFLD, EPA, FEMA

Some of these structures are elevated out of the floodplain. Boulder Community Hospital is elevated above the 100-year floodplain as is its access road. Most of the municipal buildings are either elevated or floodproofed. All of these buildings are in the 500-year floodplain as well. The Boulder County Justice Center, municipal building, and library are adjacent to the 100-year floodplain but floodproofed. The facilities in the high hazard or floodway zones would be good targets for mitigation.

Scour Critical Bridges

Included with HAZUS-MH is a database of bridges called the National Bridge Inventory (NBI) developed by the Federal Highway Administration. One of the database items is a "scour index", which is used to quantify the vulnerability of a bridge to scour during a flood. Bridges with scour index between 1 and 3 are considered "scour critical", or a bridge with a foundation element determined to be unstable for the observed or evaluated scour condition. Those with a scour index of 3 are potentially susceptible to damage from the 100-year flood. The 2016 National Bridge Inventory identifies four bridges in the City of Boulder Planning area. A list of potentially at-risk bridges is detailed in the table below

Table 4.34. Scour Critical Bridges in the City of Boulder

Stream	Location	Name	Year Built	Scour Score
Boulder Creek	Arapahoe Ave in Boulder	SH 7 ML WBND	1938	3
Boulder Creek	28th Street in Boulder	US 36 ML WBND	1952	3
Boulder Creek	Boulder	US 36 ML EBND	1960	3
Four Mile Canyon Creek	28th St in Boulder	US 36 ML	1957	3

Source: 2015 HSIP Freedom

Levee Failure Risk

During the 2012 update levees within the city were inventoried based on available GIS data A certified, or "Accredited Levee or provisionally accredited levee" means a system of artificial embankment(s) or flood control structure(s) used for property protection, flood control, and flood hazard mitigation accredited or provisionally accredited and mapped Zone X (shaded) by the Federal Emergency Management Agency (FEMA) under the National Flood Insurance Program (NFIP). This means that it has been certified, or not, to provide 100-year flood protection. Note that levees or floodwalls protect the Boulder Justice Center and condos from Boulder Creek flooding. It should also be noted that repair and improvement work is occurring on the Boulder Justice Center levee and floodwall to lower the risk of levee failure to the Justice Center and surrounding buildings. The City of Boulder is seeking levee accreditation on this levee. Roche Industries is a hazardous materials facility located along the Boulder Creek floodplain in the eastern portion of the city. The data indicates that the levee protecting the facility is not certified to provide 100-year protection.

Table 4.35. City of Boulder Levees and Floodwall Inventory

Levee	Creek or Water Source
Harrison Ave Levee	Bear Canyon Creek
Boulder Justice Center - Floodwall	Boulder Creek
Boulder Justice Center - Levee	Boulder Creek
Flatiron Industrial Park-Not Certified	Boulder Creek
Condos at Canyon and 9th	Canyon Boulevard Overflow
Roche - Floodwall-Not Certified	Boulder Creek

Levee	Creek or Water Source
Roche - Levee East-Not Certified	Boulder Creek
Roche - Levee West-Not Certified	Boulder Creek
Harrison Ave Levee	Bear Canyon Creek

Source: FEMA, USACE

Cultural and Natural Resources at Risk

Cultural and natural resources are located throughout the city. Table 4.36 identifies the historic districts and structures in the 100-year floodplain. These numbers were updated using counts and values based on intersecting Final Parcel Analysis layer with Historic Building layer provided by the City of Boulder Utilities.

Table 4.36. Historic Districts and Structures in the 100-Year Floodplain

District Name	Building Count	Building Value
Boulder High School	3	N/A
Chamberlain	11	$3,784,435
Downtown	2	$1,041,120
Hillside	3	$2,937,300
Mapleton	7	$4,500,600
West Pearl	25	$12,671,320
Total	**51**	**$24,934,775**

Source: City of Boulder, Boulder County Assessor's Office with valuation analysis by Amec Foster Wheeler, FEMA

Historic preservation reviews are required by the city for alterations of any structures within the historic districts. Under state and local historic preservation laws, modifications, repairs to, or demolition of any building over 50-years old may be subject to review by the city Landmarks Board and State Historic Preservation Office. In the event of a flood, there could be restrictions on how these structures are rebuilt, such as building materials used.

Natural Environment

Floods are naturally occurring events that can significantly effect ecosystem processes and permanently alter the landscape. As large volumes of fast moving water overtop riverbanks, erosion can lead to soil destabilization, in addition to increased levels of sediment in the water. The sediments can congest streams, and once the flood waters recede, deposition will alter the shape of the existing fluvial patterns. Floods also impact the ecological functionality of the area by introducing new pollutants and debris. Pollutants can range from small sediment particles, to foliage, rocks, and pieces of man-made structures. When nutrients and minerals are carried and dispersed by flood waters, the chemical makeup and pH balance of the ecosystem is altered. Sometimes, the introduction of nutrients and organic materials can improve the fertility and diversity of the hydrologic system, while other conditions can lead to an imbalanced and dysfunctional environment.

Future Development

Flooding and floodplain management are significant issues for the City of Boulder. The potential or likelihood of a flood event in the city increases with the annual onset of heavy rains in April combined with snowmelt runoff from May through June. Much of the historical growth in the Boulder area occurred adjacent to streams. This leaves the potential for significant damage to property, losses from disruption of community activities, and potential loss of life when the streams overflow. Other problems connected with flooding and stormwater runoff include erosion, sedimentation, degradation of water quality, losses of environmental resources, and certain health hazards.

Growth in Boulder is restricted, largely by open space and park land surrounding the city limits. The city has been actively managing growth to preserve the quality of life and decrease urban sprawl. The resulting development pressures are typically focused on existing areas within the city limits, often in the form of redevelopment. An example is the redevelopment of the Crossroads Mall area into the 29th street shopping district. Some of this development is within the floodplain, which has been developed according to the city's floodplain management regulations. Another example is the Foothills Hospital, which is sited and elevated in the 500-year floodplain as there were few alternative sites for this large facility.

Future annexations of unincorporated enclaves within the city limits as well as near the eastern edge of town could significantly add to the number of flood-prone structures in Boulder. Table 4.37 presents information related to new development in basins within the City of Boulder. Using data provided by the City's Utilities, there are 120 anticipated structures in developable areas that are at-risk to flooding, with a total value of $62.8M. Most new development within the ten watersheds are not flood prone, however, there could be 50 new structures in the Fourmile Canyon Creek area, representing over 20% ($12.4M) of total exposure.

Table 4.37. 100-Year Flood Exposure for Annexed Properties

Basins	Structure Count	Flood-Prone Structures at Risk Values	Estimated Contents Value	Total Value	Estimated 100-Year Flood Loss (25% of total value)	Loss Ratio
Bear Canyon Creek	0	$0	$0	$0	$0	0.0%
Bluebell Canyon / King's Gulch	0	$0	$0	$0	$0	0.0%
Boulder Creek	4	$1,251,000	$1,323,000	$2,574,000	$643,500	4.1%
Dry Creek	0	$0	$0	$0	$0	0.0%
Dry Creek No. 2	20	$7,542,000	$4,841,000	$12,383,000	$3,095,750	19.7%
Elmer's Twomile Creek	0	$0	$0	$0	$0	0.0%
Fourmile Canyon Creek	50	$15,621,000	$10,581,000	$26,202,000	$6,550,500	41.7%
Gregory Canyon Creek	0	$0	$0	$0	$0	0.0%
Lower Boulder Creek	0	$0	$0	$0	$0	0.0%

Basins	Structure Count	Flood-Prone Structures at Risk Values	Estimated Contents Value	Total Value	Estimated 100-Year Flood Loss (25% of total value)	Loss Ratio
South Boulder Creek	36	$13,027,000	$6,671,000	$19,698,000	$4,924,500	31.4%
Skunk Creek	0	$0	$0	$0	$0	0.0%
Sunshine Canyon Creek	0	$0	$0	$0	$0	0.0%
Twomile Canyon / Goose Creek	0	$0	$0	$0	$0	0.0%
Viele Channel	0	$0	$0	$0	$0	0.0%
Wonderland Creek	10	$1,209,000	$722,000	$1,931,000	$482,750	3.1%
Total*	**120**	**$38,650,000**	**$24,138,000**	**$62,788,000**	**$15,697,000**	

Source: City of Boulder, Boulder County Assessor's Office with valuation analysis by Amec Foster Wheeler, FEMA

Vulnerability to Human Health Hazards: Pandemic Flu

Likelihood of Occurrence—Occasional
Vulnerability—High

People

Disease spread and mortality is affected by a variety of factors, including virulence, ease of spread, aggressiveness of the virus and its symptoms, resistance to known antibiotics and environmental factors. While every pathogen is different, diseases normally have the highest mortality rate among the very young, the elderly or those with compromised immune systems. As an example, the unusually deadly 1918 H1N1 influenza pandemic had a mortality rate of 20%.

Property

For the most part, property itself wouldn't be impacted by a human disease epidemic or pandemic. As concerns about contamination increase, property may be quarantined or destroyed as a precaution against spreading illness.

Critical Facilities

A widespread pandemic would not generally cause specific structural damage a critical facility itself. Depending on the nature and widespread impact of the disease, it may have an impact on the functioning of different critical facilities. A disease could have an impact on staff availability, as well as placing extra pressure and stress on medical facilities and medical systems.

Natural Environment

A widespread pandemic would not have an impact on the natural environment unless the disease was transmissible between humans and animals.

Future Development

Future development would not be impacted by a pandemic.

Vulnerability to Human Health Hazards: Mosquito-borne Viruses

Likelihood of Occurrence—Likely
Vulnerability—Low

People

Preventive steps can be taken to reduce exposure to mosquitos carrying the virus; these include insect repellent, covering exposed skin with clothing and avoiding the outdoors during twilight periods of dawn and dusk, or in the evening when the mosquitos are most active.

Property

Property would not generally be affected by a mosquito-borne illness.

Critical Facilities

A mosquito-borne illness would not generally cause specific structural damage a critical facility itself. Depending on the nature and widespread impact of the disease, it may have an impact on the functioning of different critical facilities. A disease could have an impact on staff availability, as well as placing extra pressure and stress on medical facilities and medical systems.

Natural Environment

Diseases including West Nile Virus can impact a variety of animals, including bats, horses, cats, dogs, chipmunks, skunks, squirrels and domestic rabbits.

Future Development

Future development would not be impacted by a mosquito-borne illness.

Vulnerability to Landslides

Likelihood of Occurrence—Occasional
Vulnerability—Low

People

People are susceptible if they are caught in a landslide or rockfall; falling debris can cause injury or death. There is also a danger to drivers operating vehicles, as rocks and debris can strike vehicles passing through the hazard area or cause dangerous shifts in roadways.

Property

While the City of Boulder planning area has areas susceptible to landslides and rockfall, the greatest risk occurs in locations without much development. The following table indicated developed parcels that intersect debris flow hazard areas and the exposure of property. Table 4.38 summarizes estimated damages for structures located in debris flow/mud flow susceptible areas.

Table 4.38. City of Boulder Debris Flow/Mud Flow Susceptibility Estimated Damages

Land Use	Structure Count	Debris Flow-Prone Structures at Risk Values	Estimated Contents Value	Total Value	Estimated Loss (30%)
Commercial	3	$1,449,000	$1,449,000	$2,898,000	$869,400
Residential	88	$73,462,000	$36,731,000	$110,193,000	$33,057,900
Total	**91**	**$74,911,000**	**$38,180,000**	**$113,091,000**	**$33,927,300**

Source: Colorado Geological Survey, City of Boulder, Boulder County Assessor's Office with valuation analysis by Amec Foster Wheeler

Critical Facilities

With GIS analysis, there are no critical facilities that intersect with the landslide layer.

Natural Environment

Landslides and rockfalls have minimal impacts to the natural environment; these impacts would be confined to a small area. There is a slight chance that a rockfall or landslide in the drainages above the City could cause blockage and water backup from temporary landslide dams.

Future Development

The severity of landslide problems is directly related to the extent of human activity in hazard areas. Human activities such as property development and road construction can also exacerbate the occurrence of landslides. Future development in areas near Dakota Ridge should be done carefully to prevent landslide damage to property or people. Adverse effects can be mitigated by early recognition and avoiding incompatible land uses in these areas or by corrective engineering. Improving mapping and information on landslide hazards and incorporating this information into the development review process could prevent siting of structures and infrastructure in identified hazard areas.

Vulnerability to Wildfires

Likelihood of Occurrence—Likely
Vulnerability—Medium

In the larger Boulder County area, high fuel loads, along with geographical and topographical features of the foothills area, create the potential for both natural and human-caused fires that could result in loss of life and property. These factors, combined with natural weather conditions common to the area, including periods of drought, high temperatures, low relative humidity, and periodic high wind conditions, can result in frequent and sometimes catastrophic fires.

The City of Boulder is at risk to wildfire because of large areas of potentially flammable vegetation in the open space surrounding the city, plus the potential for natural and human-caused ignitions. Any wildland fire, once ignited, has the potential to quickly become a large, out-of-control fire if weather and fuel conditions are favorable. The 2007 City Community Wildfire Protection Plan further describes the city wildfire risk situation.

Potential impacts to the community from a wildfire include:

- Injury and loss of life;
- Commercial and residential structural damage;
- Decreased water quality in area watersheds;
- Increase in post-fire hazards such as flooding, sedimentation, and mudslides;
- Damage to natural resource habitats and other resources;
- Loss of water, power, roads, phones, and transportation, which could impact, strand, and/or impair mobility for emergency responders and/or area residents;
- Economic losses (jobs, sales, tax revenue) associated with loss of commercial structures;
- Negative impact on commercial and residential property values;
- Loss of churches, synagogues, mosques, community centers, and other places of communal gathering or worship; which could severely impact the social fabric of the community;
- Loss of schools, which could severely impact the entire school system and disrupt families and teachers, as temporary facilities and relocations would likely be needed; and
- Impact on the overall mental health of the community.

People

The 2007 CWPP identified 10 communities within the city that have wildland urban interface areas. Each community was designated a hazard rating (very high, high, moderate, and low) during the CWPP development process based on local fire behavior modeling and community assessments of existing defensible space, emergency access/egress, typical construction and other factors. The communities are shown on Figure 4.61. During the update of this mitigation plan an effort was made to further quantify the population at risk as well as the number and value of structures at risk within these CWPP communities. Using a methodology similar to that used for the floodplain analysis in this plan, an estimated 5,389 people living in CWPP communities in Boulder. Of the ten CWPP communities listed, three are considered ‘very high’ wildfire hazard ranking and three communities are considered ‘high’ wildfire hazard. There are 2,563 people in these areas, which represents 48% of all residents in CWPP communities.

Property

This section attempts to further quantify the impacts that wildland fire could have on people, property, and critical infrastructure in the city. GIS was used to analyze the communities at risk based on the number of improved parcels (i.e. those that have a structure). Contents values were also estimated (assumed to be 50% of the structure value based on FEMA values for residential structures). The amount of improved values and estimated structure value exposed was grouped by community and is shown in Table 4.39. Of the 2,544 total structures within these communities, 532, or 16%, are located in communities with a 'very high' hazard rating. The majority of these structures are residential.

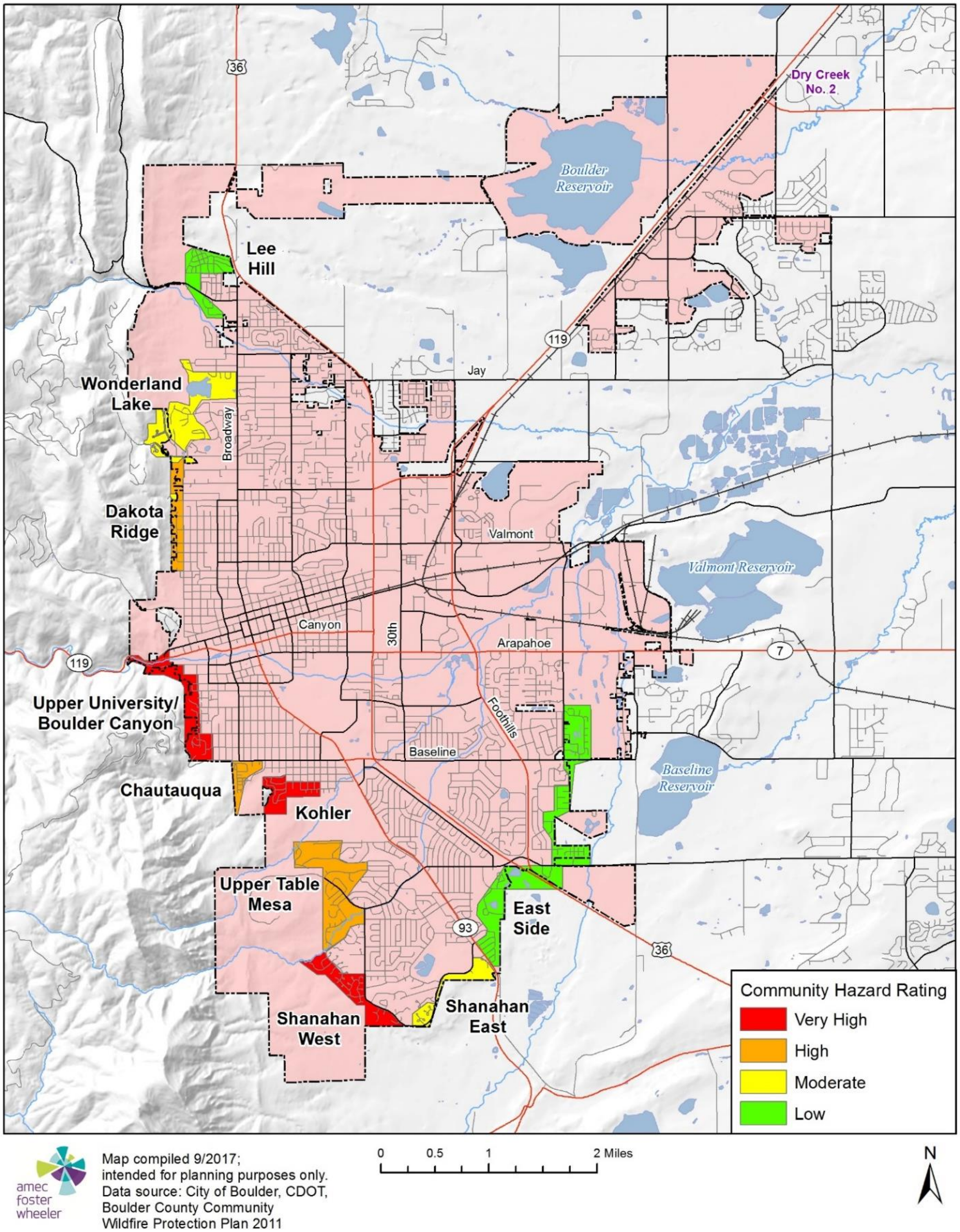
Table 4.39. Summary of Structures and Populations at Risk in CWPP Communities

CWPP Community	Hazard Ranking	Structure Count	Fire-Prone Structures at Risk Values	Estimated Contents Value	Total Value	Population*
Chautauqua	High	95	$60,760,000	$52,257,000	$113,017,000	29
Dakota Ridge	High	148	$86,380,000	$43,190,000	$129,570,000	332
East Side	Low	736	$353,537,000	$189,546,000	$543,083,000	1,566
Kohler	Very High	137	$98,700,000	$49,350,000	$148,050,000	305
Lee Hill	Low	200	$220,424,000	$110,212,000	$330,636,000	448
Shanahan East	Moderate	94	$126,467,000	$63,331,000	$189,798,000	208
Shanahan West	Very High	208	$117,245,000	$58,623,000	$175,868,000	466
Upper Table Mesa	High	465	$202,671,000	$102,608,000	$305,279,000	1,030
Upper University/Boulder Canyon Area	Very High	187	$188,974,000	$96,070,000	$285,044,000	401
Wonderland Lake	Moderate	274	$171,220,000	$85,640,000	$256,860,000	605
Total		**2,544**	**$1,626,378,000**	**$850,827,000**	**$2,477,205,000**	**5,389**

Source: City of Boulder, Boulder County Assessor's Office, Amec Foster Wheeler based on analysis of data from Boulder Community Wildfire Protection Plan, 2007

* Based on US Census average household size of 2.16 multiplied by the residential structure count

Figure 4.61. Boulder CWPP Communities



The City of Boulder completed a detailed, parcel-level evaluation of wildfire risk potential in 2004 prior to the development of the CWPP. The city defines the wildland-urban interface, or "Red Zone," as parcels that are adjacent to the Open Space and Mountain Parks land bordering the western city limits. The city used GIS to identify and inventory all the parcels and structures in the Red Zone that are predominantly single family residential properties. This inventory includes 637 properties. Of these properties, 588 are within the city limits. The city used software and a handheld computer to complete a detailed risk assessment of the wildfire risk for each property in the Red Zone. Each property was evaluated on multiple factors, including access, terrain, vegetation adjacent to the structure, construction type, siding material, roofing material, and water availability, among others. The software allowed for the calculation of a relative hazard score for each property with respect to wildfire vulnerability. For the purposes of this plan, relative hazard is defined in Table 4.40.

Table 4.40. Relative Hazard Classification from Red Zone assessment

Relative Hazard Score	Classification	Structure Count by Category
9-25	Low	30
26-50	Medium	213
51-75	High	275
76-105	Very High	70

Source: City of Boulder

This data can help prioritize and track mitigation efforts. Maps displaying properties with hazard rankings are not included in this plan due to privacy concerns and private property rights.

Wildland-urban interface fires cause physical damage to buildings, contents, and infrastructure and may result in casualties. Based on observations in wildland-urban interface fires, structures and contents are often destroyed, thus the estimated total building value exposed in Table 4.39 also represents potential dollar losses. Note: a wildland fire is not likely to burn all the wildland-urban interface areas in the city at once. Although the physical damage and casualties arising from wildland-urban interface fires may be severe, it is very important to recognize that wildland-urban interface fires may also cause significant economic impacts on communities when damage results in loss of function of buildings and infrastructure. In some cases, the economic impact of such loss of function may be comparable to the economic impact of physical damage. In some cases, it may be even greater.

Examples of economic impacts arising from wildland-urban interface fires damage include displacement costs, loss of public services, business and rental income losses, and loss of transportation and utility services. Displacement costs are the cost of temporary quarters when occupants of damaged residential, commercial, or public buildings are displaced during repairs. Displacement costs include rent; other monthly costs of displacement, such as furniture rentals; and one-time costs, such as those associated with moving and utility hookup. Economic impacts of loss of transportation and utility services include traffic delays/detours from road and bridge closures and loss of electric power, potable water, and wastewater services.

Fire suppression and rehabilitation costs have totaled millions of dollars based on past events in the City of Boulder, with the occasional loss of structures. According to FEMA guidance, standard loss estimation tables do not currently exist for wildfires. Most wildfire-related deaths are the result of fire suppression activities. However, if access is impaired and warning time is insufficient, citizens could be injured or killed. Homes that are ignited by wildfires often result in a complete loss.

Critical Facilities

Much of Boulder's critical facilities at risk are outside of the city limits. Using GIS overlays of the wildfire hazard from the County CWPP, Boulder's Water Treatment Plant at Betasso was identified as a critical facility in an area of concern for wildfire (note: the forest around this facility was treated in 2015/2016 under a FEMA Pre-Disaster Mitigation Grant as part of a joint effort with Boulder County according to a Water Resources Advisory Board Memo dated July 20, 2015). Three hydroelectric plants were identified in areas of severe wildfire concern, including the Boulder Hydro Plant, Barker Hydroelectric Generator, and Orodell Hydroelectric Generator. More details on these facilities can be referenced in Appendix G.

Natural and Cultural Resources at Risk

In addition to previously identified wetlands and threatened and endangered species, there are other natural resources at risk to wildfire. These include watersheds and other ecological functions, the forest and ground cover assets that support the area's recreational lifestyle, and the aesthetic value of the area. Major fires that result in visible damage detract from aesthetic value. Given the location of the city and the importance of assets such as watershed health, wildlife, recreation, and tourism are all critical to the city and are all at risk from the wildfire hazard. In addition to fire suppression and impacts to environment and economy, wildfires can have direct and indirect associated costs to water quality and reliability that may include need for wildfire-related sediment and pollution controls and mitigation, degradation of municipal and hydropower supplies, system repairs, administrative costs, increased operation and maintenance, remediation, and long-term changes in water yield.

The city's water supplies come from high elevation forested areas in the North and Middle Boulder Creek watersheds and from the Colorado-Big Thompson Project through Boulder Reservoir. Forest health and fires within these watersheds can significantly impact water quantity and quality. How wildfire may impact water quality and supply depends on wildfire extent and intensity, post wildfire precipitation, topography, and local soils and vegetation. Potential effects of wildfire on the city's water supplies, treatment facilities and downstream aquatic ecosystems can include changes in the amount and timing of snowmelt runoff; increased erosion and transport of sediment and debris; temporary system shutdowns; and increased loading of nutrients, natural organic matter, and metals. For example, if sediment and debris accumulated in the city's reservoirs following a wildfire, the city could experience serious treatment challenges, taste and odor issues, and a potential reduction in the city's usable water supplies.

In 2013, the city contracted with JW Associates Inc., to refine the prioritization and hazard assessment for the smaller watersheds within the city's water supply system, incorporate water supply components, include opportunities and constraints to reducing wildfire hazard to water supplies, and collaborate with watershed stakeholders to develop a wildfire watershed protection plan. The highest priority post-wildfire hazard risk for the city water supply is an area above Barker Reservoir. This area has lodge pole pine and aspen and open area that provide opportunity for hazard reduction efforts.

One of Boulder's historic districts, Chautauqua Park, is located in the wildland-urban interface. This district is characterized by historic cottage homes (36) and includes seven historic landmark designations, including the Chautauqua Auditorium and Dining Hall. Another historic landmark located in the wildland-urban interface is in Mapleton Hill.

Future Development

Boulder's growth into wildland-urban interface areas is restricted by the Open Space and Mountain Parks land that borders the city along its western limit. The majority of the parcels along the western city limit are already developed. Thus, structure exposure to wildland fire is not anticipated to increase, except when development occurs on the few remaining undeveloped parcels next to the wildland-urban interface. Boulder's past purchases of Open Space and Mountain Parks land has helped keep development out of forested interface areas surrounding the city.

Vulnerability to Severe Weather: General

Looking at historical hazard data for Boulder County and the City of Boulder, severe weather is an annual occurrence; damage and disaster declarations related to severe weather events have occurred in the past and will continue to occur in the future. The severe weather evaluated as part of this risk assessment included extreme temperatures, fog, hailstorms, thunderstorms, lightning, tornadoes, and windstorms. The historical damage associated with the primary effects of severe weather has been limited within the planning area. It is the secondary effects of weather such as flood and fire that have had the greatest impact on the city. The risk and vulnerability associated with these secondary impacts are discussed in the associated sections.

Vulnerability to Fog

Likelihood of Occurrence— Unlikely
Vulnerability—Low

People

As mentioned in Section 4.2.11, Boulder is subject to radiation fog, which happens when cool air becomes trapped beneath a lighter, warmer air lodged between ridges, hollows, and basins. Most frequently these conditions occur in the morning, and dense fog can significantly reduce visibility and threaten the safety of drivers and pedestrians. Beyond visual impairment, foggy conditions perceptual judgments of speed and distance, increasing probability of an accident. Localized fog is especially dangerous, as drivers can be caught by surprise. The National Centers for Environmental Information data shows no severe fog incidents for Boulder County. Other data sources consulted during this planning process did not identify any notable fog events for Boulder County and the City of Boulder. However, fog events often go unreported due to the lack of associated costs and damages.

Property

Though property damage can be significant for vehicles, real property and structures are usually unaffected by fog.

Critical Facilities

Fog does not directly impair the functionality and structural integrity of critical facilities in the City of Boulder planning area.

Natural Environment

Fog is a natural process and the impacts are part of meteorological processes and do not cause long-term consequential damage.

Future Development

Future development would not be impacted by fog.

Vulnerability to Extreme Temperatures

Likelihood of Occurrence—Highly Likely
Vulnerability—Low

People

Based on historical data, the vulnerability of the city to extreme temperatures is low. The HMPC did not identify any historical events related to extreme temperatures within the City of Boulder planning area. However, as discussed in the hazard profile section, this vulnerability could increase in the future as a result of climate change, particularly for extreme heat. Both hot and cold extremes impact on the most vulnerable segments of the population—the elderly, young children and infants, impoverished individuals, and persons who are in poor health. Even indoors, hypothermia is a concern for individuals living in without adequate heat. Concrete and asphalt surfaces reflect sunlight, air pollutants trap heat, and lessened circulation of air through densely-developed areas make urban areas especially vulnerable to extreme heat conditions. Individuals working outdoors, the elderly, and children at most at-risk during hot conditions, as they are most at risk for heat exhaustion, and fatal heat stroke.

Property

Water infrastructure can be vulnerable to damage from freezing temperatures. Damage to buildings and pipelines can also occur in extreme cold; leading to costly repairs . Extreme heat puts a strain on the energy demands for an area, as air conditioning becomes vital for vulnerable populations. Power outages can occur when an area’s power infrastructure is overwhelmed during extended periods of excessive heat.

Critical Facilities

Infrastructure malfunctioning and outages can have far reaching consequences and impacts on economy and society.

Extreme cold threatens both exterior and interior pipes with severe consequences, as burst pipes can damage all units connected to the plumbing system. Transportation impacts related to cold temperatures include engine stress for trucking, while ice threatens bridges and can close major highways. Buried water pipes can burst causing severe ice problems and loss of water pressure throughout the City.

Highways, bridges, and roads are susceptible to damage by excessive heat. Asphalt roads soften, while concrete roads may lift. The combination of extreme heat, sagging power lines, and the added demand for electricity to run air conditioning causes transmission line temperatures to rise.

Natural Environment

Any change in the climate of an area can affect the plants and animals living there, as well as the makeup of the entire ecosystem.

Companies that supply electricity typically rely on fossil fuel power plants to meet the demand for air conditioning, which in turn leads to an increase in air pollutant and greenhouse gas emissions. In addition to the impact on energy-related emissions, elevated temperatures can increase the rate of ground-level ozone formation. In highly urbanized areas like the City of Boulder, high pavement and rooftop surface temperatures can heat stormwater runoff. Tests have shown that pavements that are 100ºF (38°C) can elevate initial rainwater temperature from roughly 70ºF (21ºC) to over 95ºF (35ºC)[1]. The City of Boulder has recorded multiple days over 100, with the highest of note being 104 in This heated stormwater generally becomes runoff, which drains into storm sewers and raises water temperatures as it is released into streams, rivers, ponds, and lakes. High water

[1] James, W. 2002. Green roads: research into permeable pavers. Stormwater 3(2):48-40.

temperatures degrade quality and negatively impact fish populations. Extreme heat is linked to algae blooms, causing fish kills in rivers and lakes. Urban heat islands raise demand for electrical energy in summer.

Future Development

Future development would not be impacted by extreme temperatures.

Vulnerability to Hailstorms

Likelihood of Occurrence—Highly Likely
Vulnerability—Medium

People

Serious injury and loss of human life is rarely associated with hailstorms. While national data shows that lightning causes more injuries and deaths than any other natural hazard except extreme heat, there doesn't seem to be any trend in the data to indicate that one segment of the population is at a disproportionately high risk of being directly affected.

Property

The primary impact associated with hail is damage to property. Homes and exposed cars are inevitably impacted with varying effects based on size of hail. Additionally, business and commodities can be damaged or destroyed, having negative consequences for the economic livelihood of the City. According to the National Data Climatic Center, Boulder County experienced 226 hailstorm events between 1950 and 2017 resulting in $1 million in damage. The HMPC did not specifically identify any historical insurance claims for hail within the City of Boulder. However, given the magnitude of historical hailstorms and associated losses in Boulder County and the Denver Front Range, the entire City of Boulder planning area remains at risk and is vulnerable to future hailstorms.

Critical Facilities

Though there have not been any documented events within Boulder's city limits, there have been hail stones over 2 inches in diameter reported in the surrounding area. Hail can cause structural damage to hospitals and schools, destroying roofs and lead to temporary closures. Most roofs that are made from metal can be resistant to damage from the hailstorms, and it is important that critical facilities are built to withstand damage. Hail also threatens the functionality of emergency response vehicles because they can cause a lot of damage to roofs, hoods, and crack or shatter windshields.

Natural Environment

The primary environmental impact associated with hail is localized damage to plants. As a natural process, the impacts of most severe hail events are part of the overall natural cycle and do not cause long-term consequential damage.

Future Development

Future development would not be impacted by hailstorms. New critical facilities, such as communication towers should be built to withstand hail damage. Future development projects should consider severe weather hazards at the planning, engineering and architectural design stage with the goal of reducing vulnerability. Development trends in the County are not expected to increase overall vulnerability to the hazard, but population growth will increase potential exposure to hazards such as lightning.

Vulnerability to Thunderstorms

Likelihood of Occurrence—Highly Likely
Vulnerability—Low

People

Exposure is the greatest danger to people from severe thunderstorms. People can be hit by lightning, pelted by hail, and caught in rising waters. Anyone who is outside during a thunderstorm is at risk of being struck by lightning. Aspects of the population who rely on constant, uninterrupted electrical supplies may have a greater, indirect vulnerability to lightning. As a group, the elderly or disabled, especially those with home health care services relying on rely heavily on an uninterrupted source of electricity. Resident populations in nursing homes, residential facilities, or other special needs housing may also be vulnerable if electrical outages are prolonged. If they do not have a back-up power source, rural residents and agricultural operations reliant on electricity for heating, cooling, and water supplies are also especially vulnerable to power outages.

Property

Utility outages, downing of trees, debris blocking streets and damage to property can be a direct result of thunderstorm events. Given the nature of these types of storms, the entire City of Boulder planning area is potentially at risk. The primary effect of thunderstorms has not resulted in significant injury or damages to people and property, or the losses are typically covered by insurance. It is the secondary hazards caused by weather, such as floods, that have had the greatest impact in the City.

Critical Facilities

Because of the unpredictability of severe thunderstorm strength and path, most critical infrastructure that is above ground is equally exposed to the storm's impacts. Due to the random nature of these hazards, a more specific risk assessment was not conducted for this plan.

Natural Environment

Severe thunderstorms are a natural environmental process. Environmental impacts include the sparking of potentially destructive wildfires by lightning and localized damage to plants by hail. As a natural process, the impacts of most severe thunderstorms by themselves are part of the overall natural cycle and do not cause long-term consequential damage.

Future Development

Future development would not be impacted by hailstorms. New critical facilities, such as communication towers should be built to withstand hail damage. Future development projects should consider severe weather hazards at the planning, engineering and architectural design stage with the goal of reducing vulnerability. Development trends in the County are not expected to increase overall vulnerability to the hazard, but population growth will increase potential exposure to hazards such as lightning.

Vulnerability to Lightning

Likelihood of Occurrence—Highly Likely
Vulnerability—Medium

People

According to NCEI data, there have been 11 injuries and one fatality related to lightning in Boulder County since 1960. NOAA reports that there have been 144 deaths in the State of Colorado since 1959. Cloud-to-ground lightning is the most dangerous form of lightning. Boulder County averages 3.5 thousand cloud-to-ground flashes per year. Additional statistics for Colorado estimate that one out of 52 lightning flashes results in an insurance claim.

It is difficult to quantify where specific losses will occur due to the random nature of this hazard. Given the lightning statistics for Colorado and Boulder County, residents throughout the City of Boulder planning area remain at risk and are vulnerable to the effects of lightning.

Property

Though rare, lightning can damage or even destroy personal property. When a bolt of lightning enters and passes through a home, the result can be fire and charring. Wood and other flammable building materials can easily be ignited. When lightning current travels through wires, it will commonly burn them up - presenting a fire ignition hazard anywhere along the affected circuits.

The bolt may travel through gas and water pipes, electrical lines, cable/internet lines, gutters, metal window frames, or any other conductive material. Lightning current will produce considerable damage to a house that is not equipped with a good protection system.

Critical Facilities

Because of the unpredictability of lightning strength and path, most critical infrastructure that is above ground is equally exposed to impacts. Lightning can sometimes affect communications and power infrastructure.

Natural Environment

With the exception of lightning-sparked wildfires, no significant impacts are anticipated.

Future Development

Future development would not be impacted by lightning if appropriate mitigation is incorporated.

Vulnerability to Tornados

Likelihood of Occurrence—Occasional
Vulnerability—Low

NCEI data indicates that during a 67-year period (1950-2017), eleven tornadoes occurred in Boulder County, which equates to one tornado every 6 years, on average. Of these tornadoes, two were magnitude F0, six were F1, two were F2, and one was EF3. Further, tornadoes in the front range of Colorado tend to be small, short-lived, and relatively weak as compared with plains states' tornadoes. Given the low frequency and nature of tornadoes near the foothill areas of Colorado, tornadoes pose a low risk to the City of Boulder planning area.

People

According to NOAA, Colorado has had 5 tornado fatalities since 1950. The number of deaths has significantly decreased as warning technology has advanced. Persons exposed to tornadoes without shelter are at greatest risk for injury or death. Tornadoes can pick up debris that can injure or kill exposed persons. It is assumed that impacts to the citizens of Boulder will be relatively minimal due to low risk and warning systems available.

Property

In terms of property losses, the actual damages will depend on the building density in the impacted area. A tornado path in an older residential area with older homes, large trees, and overhead utility lines will have a significantly greater impact with the same storm in a new development with lower building density, modern constructed buildings, small or newly planted trees, and underground power lines.

Critical Facilities

Because of the unpredictability of tornado paths, most critical infrastructure that is above ground is equally exposed to the hazard. Power lines, communications networks, and other above-ground infrastructure are vulnerable to the effects of windstorms both directly and indirectly.

Natural Environment

No significant impacts are anticipated.

Future Development

Future development would not be impacted by tornadoes.

Vulnerability to Windstorm

Likelihood of Occurrence—Highly Likely
Vulnerability—Medium

Boulder has some of the highest peak winds of any city in the United States. According to data compiled by the University Corporation for Atmospheric Research, damage from Boulder's winds averages about a million dollars per year.

People

There have been 6 deaths from windstorms noted in Boulder County. While most of these have been beyond city limits the potential exists for injuries and possible fatalities if people do not have adequate shelter. The homeless populations in Boulder are potentially more vulnerable to windstorms.

Property

Strong gusts will frequently lead to toppled trees that clutter streets and fall on nearby homes and cars. Damage can range from small nuisances and debris removal, to full on structural destruction. Especially pertinent to the City of Boulder is the risk of toppled ash trees. Dead ash trees are less resilient and more vulnerable to high winds. In recent years, due to the EAB infestations throughout the planning area and state-wide, a vast number of ash trees have been (and continue to be) impacted within the City of Boulder foothill and mountain communities and beyond, where dead trees fall and pose a risk to people, buildings, power lines, roads and other infrastructure.

Critical Facilities

The wind itself may damage the infrastructure, or the wind may damage tree branches and throw other debris into the air, which may cause secondary damage to buildings and critical facilities or capabilities. Occasionally tree limbs on powerlines cause outages in the city and surrounding area.

Emergency response vehicles with high profiles may be more exposed to high winds, which may hinder response times. In addition, wind may exacerbate dangerous conditions, such as fires, making response more difficult and dangerous. Due to the random nature of this hazard, a more specific risk assessment was not conducted for this plan.

Natural Environment

The primary environmental impact associated with high winds is damage to plants. Impact of wind related to the Emerald Ash Borer is of increasing concern for the City of Boulder. The EAB is rapidly destroying the urban tree coverage across the City, and dead/dying trees are more vulnerable to high winds. Ash trees become very brittle as they decline and are more susceptible to storm damage. High winds will contort and stress tree limbs, causing either the part to fail or the supporting soil to fail. The 2013 United States Forest Service Metro Denver Urban Forest Assessment Report estimates that there are 6,016 ash trees (12.6 percent of the public tree population) in Boulder. About 78,000 ash trees are located on Boulder's private property. If infested with the Emerald Ash Borer, these effected trees are prone to toppling or breaking in high wind conditions.

Future Development

Future development would not be impacted by windstorm.

Vulnerability to Winter Storms

Likelihood of Occurrence—Highly Likely
Vulnerability—Medium

Impacts to the City of Boulder planning area as a result of winter snowstorms include damage to infrastructure, frozen pipes, utility outages, road closures, traffic accidents, and interruption in business and community activities. Delays in emergency response services can also be of significant concern. Further, there are economic impacts associated with areas prone to heavy snow. Depending on the nature of a given storm, the entire planning area is at risk to winter storms.

People

While all aspects of the population are potentially vulnerable to severe winter weather, there are segments of the population that are more vulnerable to the potential indirect impacts of a severe winter storm than others, particularly the loss of electrical power. If they do not have a back-up power source, rural residents reliant on electricity for heating and water supplies are also especially vulnerable to power outages. As a group, the elderly or disabled, especially those with home health care services that rely heavily on an uninterrupted source of electricity. Resident populations in nursing homes, residential facilities, or other special needs housing may also be vulnerable if electrical outages are prolonged.

Public education efforts may help minimize the risks to future populations by increasing knowledge of appropriate mitigation behaviors, clothing, sheltering capacities, and decision making regarding snow totals, icy roads, driving conditions, and outdoor activities (all of which are contributors to decreased public safety during severe winter storms.) New establishments or increased populations who are particularly vulnerable to severe winter storms (such as those with health concerns or those who live in communities that may be isolated for extended periods of time due to the hazard) should be encouraged to maintain at least a 72-hour self-sufficiency as recommended by FEMA. Encouraging contingency planning for businesses may help alleviate future economic losses caused by such hazards while simultaneously limiting the population exposed to the hazards during commuting or commerce-driven activities.

Historical impacts to persons during severe winter weather include

- Injuries and fatalities caused by exposure to the elements without shelter
- Motorists stranded in cars, potentially suffering from the elements
- Injuries and fatalities to motorists involved in winter weather-related traffic accidents
- Injuries and/or fatalities caused by building collapse
- Impacts from extended power outages due to downed power lines and poles

Property

Property vulnerabilities to severe weather include damage caused by high winds, ice, or snow pack and subsequently melting snow. Vehicles may be damaged by the same factors, or temporarily un-useable due to the driving conditions created by severe winter weather. Contents of homes, storage units, warehouses and storefronts may be damaged if the structures are compromised or fail due to the weather, or during potential flooding caused by melting snow. The density of very wet snow packs may create strains on structures, causing partial or entire collapses of walls, roofs, or windows. Vulnerability is influenced both by architecture (flat roofs being more vulnerable), age and type of construction material, and should be assessed on a building-by-building basis.

Critical Facilities

Because of the unpredictability of severe winter storm strength and path, most critical infrastructure that is above ground is equally exposed to the storm’s impacts. Roads are especially susceptible to the effects of a winter storm. The City and surrounding areas have a history of downed power lines and poles, interrupting power and causing issues throughout the area.

Natural Environment

Natural resources may be damaged by the severe winter weather, including broken trees and death of wildlife. Unseasonable storms may damage or kill plant and wildlife, which may impact natural food chains until the next growing season. Most of these impacts would be short-term.

Future Development

Future residential or commercial buildings should be built to be able to withstand snow loads from severe winter storms. Population growth in the City and growth in visitors could increase problems with road, business, and school closures, and increase the need for snow removal and emergency services related to severe winter weather events. Development in the City will increase the number of vehicles and persons vulnerable to this hazard.

Future power outages or delays in power delivery to future developments may be mitigated by construction considerations such as buried power lines. Future development will also require considerations for additional snow removal capacity including equipment, personnel, and logistical support.

Vulnerability to Soil Hazards: Expansive Soils

Likelihood of Occurrence—Occasional
Vulnerability—Low

People

No direct impacts on people are anticipated. Should an impact occur, it is anticipated to be localized.

Property

While impacts are slow to accumulate, costly damages to roads and other infrastructure could occur. The majority of the hazard's significance is drawn from the exposure of existing development to this hazard. Older construction may not be resistant to the swelling soil conditions and, therefore, may experience expensive and potentially extensive damages. This includes heaving sidewalks, structural damage to walls and basements, the need to replace windows and doors, or dangers and damages caused by ruptured pipelines. Newer construction may have included mitigation techniques to avoid most damage from the hazard, but the dangers continue if mitigation actions are not supported by homeowners. For example, the maintenance of grading away from foundations and the use of appropriate landscaping near structures must be continued to prevent an overabundance of water in vulnerable soils near structures. While continued public education efforts may help increase compliance for landscaping and interior finishing mitigation actions, physical reconstruction of foundations is probably not feasible in all but the most heavily impacted of existing development. Therefore, damages may be expected into the future for existing structures.

Critical Facilities

Roads, pipelines and facilities can be effected but significant impacts are not anticipated.

Natural Environment

No significant impacts are anticipated.

Future Development

The severity of expansive soils is directly related to the extent of human activity in hazard areas. Human activities such as property development highlight the occurrence of expansive soils. Future development in areas near Dakota Ridge should be done carefully to prevent expansive soil damage to structures. Adverse effects can be mitigated by early recognition and avoiding incompatible land uses in these areas or by corrective engineering. Improving mapping and information on soil hazards and incorporating this information into the development review process could prevent siting of structures and infrastructure in identified hazard areas.

Vulnerability to Soil Hazards: Land Subsidence

Likelihood of Occurrence— Unlikely
Vulnerability— Low

People

Typically this hazard results in property damage, not risk to human life.

Property

Subsidence data is limited and available information could not be used to assess property impacts.

Critical Facilities

Linear infrastructure (roads, buried pipelines) tends to have the most risk to land subsidence. Due to the lack of specific mapping of this hazard a more specific risk assessment was not conducted for this plan.

Natural Environment

Typically there is little impacts to the natural environment from this hazard.

Future Development

Soils issues can typically be avoided by careful geotechnical testing before construction. As such, vulnerability to this hazard is not anticipated to increase with new development, provided that land use planning and engineering practices are followed. Increased efforts to monitor mining operations, increased accuracy of mapping, and emphasis on appropriate grading and ground compaction during development will help alleviate vulnerability for future development in unknown areas of risk.

4.4 Assessing Capabilities

Identification of loss prevention mechanisms already in place provides an assessment of Boulder's "net vulnerability" to natural disasters and the City's capability to mitigate them. This more accurately focuses the goals, objectives, and proposed actions of this plan. This part of the planning process is referred to as the mitigation capability assessment.

The HMPC took two approaches to conducting this assessment for the city. First, an inventory matrix of common mitigation activities was made. The purpose of this effort was to identify activities and actions that were either in place, needed improvement, or could be undertaken, if deemed appropriate. Second, the HMPC conducted an inventory of existing policies, regulations, and plans. These documents were collected and reviewed to determine if they contributed to reducing hazard-related losses or if they inadvertently contributed to increasing such losses. This section summarizes the city's mitigation capabilities currently in place.

This mitigation capability assessment describes the City's existing mitigation policies, procedures, and plans. Table 4.41 summarizes the results of the mitigation capability assessment. Excerpts from applicable plans, rules, and regulations follow, which provide more detail on the existing policies related to hazard mitigation and highlight where the city has made efforts above and beyond the standard policies.

Table 4.41. City of Boulder Mitigation Capabilities

Planning and Regulatory	Y/N	Comments
Building Codes	Y	International Building Code
Building Codes Year	Y	2012
BCEGS Rating	Y	3 for 1 and 2 family residential properties 3 for commercial and industrial properties
Capital Improvements Program (CIP) or Plan	Y	
Community Rating System (CRS)	Y	5, working towards Class 4; Change from Class 6 in 2012
Community Wildfire Protection Plan (CWPP)	Y	City of Boulder Wildland Urban Interface Community Wildfire Protection Plan, 2007
Comprehensive, Master, or General Plan	Y	Boulder Valley Comprehensive Plan
Economic Development Plan	Y	City of Boulder Economic Vitality Program
Elevation Certificates	Y	For new construction since 1991
Erosion/Sediment Control Program	Y	
Floodplain Management Plan	Y	
Flood Insurance Study	Y	
Growth Management Ordinance	Y	
Hazard-Specific Ordinance or Plan (Floodplain, Steep Slope, Wildfire)	Y	Comprehensive Flood and Stormwater Utility Master Plan, Greenways Master Plan, Raw Water Master Plan, Fire and Emergency Medical Services Master Plan, West Nile Virus Mosquito Management Plan, Drought, CWPP (currently being updated), Climate Preparedness, Wetlands Protection Program
NFIP	Y	Since July 1978

Planning and Regulatory	Y/N	Comments
Site Plan Review Requirements	Y	
Stormwater Program, Plan or Ordinance	Y	
Zoning Ordinance	Y	Chapter 9-5 Boulder Revised Code

Table 4.42. City of Boulder Administrative/Technical Mitigation Capabilities

Personnel Resources	Y/N	Comments
Emergency Manager	Y	
Floodplain Administrator	Y	
Community Planning		
Planner/Engineer (Land Development)	Y	
Planner/Engineer/Scientist (Natural Hazards)	Y	
Engineer/Professional (Construction)	Y	
Resiliency Planner	Y	
Transportation Planner	Y	
Full-Time Building Official	Y	
GIS Specialist and Capability	Y	
Grant manager, Writer, or Specialist	Y	
Warning Systems/Services		
- General	Y	Emergency Warning and Evacuation System, Citizens Alert System, Cable Television Interrupt, Emergency Alert System, Metropolitan Emergency Telephone System, National Warning System
- Flood	Y	Flood Warning Detection System
- Wildfire	Y	
- Tornado	Y	
- Geological Hazards	Y	

Table 4.43. City of Boulder Financial Capabilities

Financial Resources	Y/N
Has the community used any of the following to fund mitigation?	
Levy for Specific Purposes with Voter Approval	Y
Utilities Fees	Y
System Development Fee	Y
General Obligation Bonds to Incur Debt	Y
Special Tax Bonds to Incur Debt	Y
Withheld Spending in Hazard-Prone areas	Y
Stormwater service Fees	Y
Capital Improvement Project Funding	Y
Community Development Block Grants	Y

Table 4.44. City of Boulder Education and Outreach Capabilities

Education & Outreach	Y/N
Local citizen groups that communicate hazard risks	Y
Firewise	Y
StormReady	Y
Other – Annual flood awareness and flood safety outreach	Y

4.4.1 City Mitigation Capabilities by Organization

The section begins with a discussion of city departments that have a role in reducing hazard losses within the City of Boulder. These departments include the Boulder Office of Emergency Management (OEM), Department of Public Works, Planning and Development Services, Open Space and Mountain Parks, Parks and Recreation, Police and Fire. OEM has the primary responsibility for all-hazards preparedness, response, mitigation and recovery for the city. The primary city division/department responsible for flood hazard mitigation is the Stormwater and Flood Management Utility in the Department of Public Works. The Fire Department has the lead for wildfire mitigation activities. The specific loss prevention capabilities and planning mechanisms associated with these agencies are discussed later in this section.

Boulder Office of Emergency Management

Emergency preparedness is part of the city's strategy to protect life and property from floods and other disasters. The Office of Emergency Management (OEM) is a joint office of the City of Boulder and Boulder County and coordinates the activities of public, private and volunteer agencies in emergency planning, mobilizing, and direction of emergency preparedness personnel in mitigation, preparing for, responding to and recovery from disasters or emergencies. The OEM develops plans, programs, and training for response to emergencies in the City of Boulder and Boulder County. The OEM obtains assistance and resources from federal, state, local, public, and private sources. The OEM is funded and staffed jointly by the Boulder County Sheriff and City of Boulder with additional support from FEMA through the Colorado Division of Homeland Security and Emergency Management. OEM has five full-time staff dedicated to improving operations plans, continuity of operations/continuity of government plans (COOP/COG), hazardous materials preparedness planning, and leadership of the Multi Agency Coordination (MACs) group.

Department of Public Works

The Public Works Department sustains and improves the quality of life in Boulder and provides many basic services. The department oversees the city's water resources, maintains the city's infrastructure, completes a variety of street, sewer, and construction projects each year; and keeps roadways safe for passage. The department also serves as first responders in emergency situations where Public Works services are required. The department oversees several divisions including Transportation, Utilities, Facilities and Asset Management (FAM), and Fleet Services, and jointly oversees the Planning & Development Services workgroups.

Utilities Division

The City of Boulder's Utilities Division manages the city's three municipal utilities (water, wastewater and flood control). The division manages the city's raw water supplies and provides high-quality treated water that meets all standards in a cost-effective manner. The Utilities Division effectively collects and treats wastewater and mitigates the potential loss from floods through the development of flood channels and the installation and maintenance of storm sewers.

Stormwater and Flood Management Utility Program

The Stormwater and Flood Management Utility was established in 1973 and is responsible for the city's flood management, stormwater quality, and stormwater drainage programs. Its responsibilities include the following:

- Administration and operations
- Utility rates and finance
- Program development and management
- Flood and stormwater regulation and compliance

- System master planning and design
- Public education and community outreach
- Flood prediction and response
- Stormwater quality management
- Emergency preparedness and day-to-day operations
- Capital improvements and land management

The Stormwater and Flood Management Utility provides funding for both stormwater and flood channel maintenance activities. Flood utility staff remove sediment from channels, stabilize banks, and remove trees or tree limbs that have fallen into the creeks. Adjacent landowners are required to handle leaning trees or trees that have fallen away from the creek channel.

Management of information is an important component of the city's Stormwater and Flood Management Utility program. Since 1989, significant advances have been made in computerized information management techniques, including GIS.

Capital Improvement Program

The Capital Improvement Program covers a six-year time period within which funding priorities are reflected in the staging and timing of projects. In the Stormwater and Flood Management Utility, the majority of the project funding is focused on life safety and critical facility hazard mitigation issues. Capital Improvement Program expenditures are prioritized based on the following criteria:

- Life safety (high hazard) mitigation
- Flood emergency response capability
- Critical facility (vulnerable population) hazard mitigation
- Property damage mitigation
- Collaboration with other Greenways Program Objectives
- Potential for operation and maintenance cost savings
- Accommodating new growth and development

Water Resources Advisory Board

The Water Resources Advisory Board (WRAB) consists of five members appointed to five-year terms by City Council that meet monthly. The WRAB was formed to review capital improvement programs, the community and environmental assessment process, and the utilities master plan; advise City Council, the Planning Board, and city staff; and provide recommendations concerning policy issues on operating programs.

Greenways Program

The Greenways Program provides recreation and transportation opportunities along Boulder Creek, its 14 major tributaries and Boulder Slough. The Program for these riparian corridors is guided by six program objectives: environmental protection, wetland habitat restoration, water quality enhancements, preservation of cultural resources, flood mitigation, and storm drainage improvements.

Greenways projects are funded from the Transportation Fund, Stormwater and Flood Management Utility Fund, and the Lottery Fund. The activities of the program are coordinated by the Greenways Coordinator who works under the direction of the Utilities Project Coordinator in the Public Works Department.

In 1984, the city adopted the Boulder Creek Corridor Plan, which recommended development of a continuous path and other improvements along the entire length of Boulder Creek. These improvements provided flood hazard mitigation, a linear urban park for recreational and transportation use, and restoration and enhancement of wetlands and fish and wildlife habitat. Design guidelines were established to set standards for appearance, quality, and placement of elements that were incorporated into the Boulder Creek corridor.

When completed in 1987, the Boulder Creek corridor provided recreational and transportation opportunities as well as a buffer zone between the stream channel and nearby development. Wetlands were restored along the corridor to provide stormwater and flood retention and filtering. The project also restored the riparian habitat along the creek, which had become considerably degraded. Natural vegetation was planted and corridor use was redirected to the Boulder Creek path to reduce ongoing damage. Aquatic habitat, which had been severely affected by diminished stream flows and creek channelization, was restored. A self-sustaining creek channel and healthy aquatic habitat were established with the implementation of minimum streamflow agreements for Boulder Creek.

The Greenways Program was an outgrowth of the Boulder Creek Corridor Plan. The basis of the program is the understanding that stream corridors are a vital link in the larger ecosystem, and that each stream is an important natural and cultural resource in the community. The public support of the Boulder Creek Corridor Plan led to an interest in expanding the program to include six additional tributaries within the city. The city designated over 20 miles of stream corridors along the following tributaries of Boulder Creek for inclusion in the original Greenways Program:

- South Boulder Creek
- Bear Canyon Creek
- Skunk Creek
- Goose Creek
- Wonderland Creek
- Fourmile Canyon Creek

- Elmer’s Twomile Creek (this creek was later added as a tributary to Goose Creek because it was considered an important transportation corridor)

Funding for a Greenways Master Plan was approved by City Council in December 1987. The plan was developed by staff from the Planning, Public Works, Parks and Recreation, and Open Space and Mountain Parks, and Real Estate departments and adopted by City Council in January 1989. A refined master plan, design guidelines, a capital improvement program, and a more detailed reproducible map were approved in September 1990. An interdepartmental staff group, under the direction of the Greenways Coordinator updated the Greenways Master Plan in December 2001. The plan included an evaluation of the program to date and historical information about the program, an identification and evaluation of projects and opportunities for each of the Greenways objectives, and a maintenance strategy, organization structure, procedures and processes for project planning and public involvement, and a proposed financing plan.

The latest update was in 2011 and includes two key components:

- The expansion of the Greenways Program to include all the fourteen major tributaries to Boulder Creek within the City of Boulder;
  - Bear Canyon Creek
  - Bluebell Canyon Creek
  - Dry Creek No. 2
  - Elmer’s Two Mile Creek
  - Fourmile Canyon Creek
  - Goose Creek
  - Gregory Canyon Creek
  - Kings Gulch
  - Skunk Creek
  - South Boulder Creek
  - Sunshine Creek
  - Two Mile Canyon Creek
  - Viele Canal
  - Wonderland Creek, and;
- A summary of current changes to policies and plans that affect implementation of the Greenways Program. The update also provides descriptions of current conditions based on changes that have occurred within the system since the last plan update in 2001. The purpose and objectives of the Greenways Program have not changed.

In 2017, The Greenways Advisory Committee recommended a “2018-2023 Greenways Program Capital Improvement Plan” to the City Council. The focus of the Greenways CIP in 2018-2020 is on flood mitigation, bicycle and pedestrian multi-use paths and underpasses, and habitat and water quality improvements along the Fourmile Canyon Creek corridor. These improvements are also being coordinated with the development of the Violet Park site. In addition, possible habitat restoration projects during the next few years include:

- Habitat improvements along Fourmile Canyon Creek upstream of Broadway in conjunction with OSMP flood mitigation efforts (sediment removal)
- Creek widening and restoration on Boulder Creek at Valmont and 55th in conjunction with OSMP
- Goose Creek, railroad to 47th Street tree plantings
- Removal of Russian Olive trees east of 75th Street along Boulder Creek

Transportation Division

The Transportation Division and the Transportation Master Plan acknowledge that trails and bikeways are an important planning consideration, which, when in keeping with other program goals, may be accommodated in or near creek corridors. In many cases, stream corridors can be creatively developed to function as efficient bicycle and pedestrian transportation systems while simultaneously functioning as storm drainage and flood channels, open space and wildlife corridors, and attractive recreation corridors. The Stormwater and Flood Management Utility, the Transportation Department, and the Greenways Program frequently cooperate to achieve goals and objectives in common areas.

Loss prevention capabilities include:

- Numerous major access routes for emergency preparedness response
- Airport access
- All new bridges and underpasses are designed to convey 100-year flood event flows

Transportation Advisory Board

The Transportation Advisory Board (TAB) consists of five members appointed by City Council, each to five-year terms that meet monthly. The TAB advises City Council, Planning Board and city staff on transportation issues, reviews transportation community environmental assessments, reviews plans for capital improvements, reviews and recommends changes to the Transportation Master Plan and works with neighborhood groups, residents and staff on traffic mitigation issues

Planning and Development Services Comprehensive Planning Programs

The Planning and Development Services Comprehensive Planning is responsible for citywide and subcommunity and area planning. The Planning Department and portions of the Public Works Department together form Planning and Development Services (P&DS). P&DS is a service area that was formed to support its customers and the delivery of services. The P&DS Center provides customers with building and construction permits and applications, GIS mapping services, development review, inspections, licensing, zoning information, long range planning, and historic preservation.

Parks and Recreation Department

The Parks and Recreation Department and the Parks and Recreation Master Plan recognize the importance of undeveloped open land and natural parks in the city for quiet, passive recreation and hazard mitigation. Where park lands occur along the city's drainageways, the Stormwater and Flood Management Utility may cooperate with the Parks and Recreation Department and the Greenways Program to achieve open land/natural park objectives while promoting drainage and flood control objectives.

Working with the Boulder OEM, the City of Boulder Parks and Recreation Department completed emergency action plans for each recreation facility and program in 2009. This project was an action recommendation in the 2008 Multi-Hazard Mitigation Plan. These plans were developed with the assistance and input from staff at each facility and program. In addition, program supervisory staff attended training on emergency preparedness and hazard awareness, and each facility and program created an emergency plan that can be used by staff to inform park users to shelter-in-place or evacuate (including signage and instructions). Each plan discusses the appropriate actions to take during a flood and identifies possible evacuation sites (high ground).

Open Space and Mountain Parks Department

The Open Space and Mountain Parks Department operates in accordance with city charter provisions and missions, among which are to preserve and restore natural areas with associated unusual, spectacular, historically important, scientifically valuable, or rare examples of native flora and fauna; preserve water resources in their natural or traditional state, including wildlife habitats or fragile ecosystems; promote utilization of program lands for passive recreational use; preserve agricultural land uses and land suitable for agricultural production; and use lands wisely to prevent encroachment on floodplains. The Open Space and Mountain Parks Department, through area management planning, provides guidance and direction for management of specific areas, develops a framework for evaluating and incorporating appropriate uses of open space, prepares inventories and analyses of resources; provides opportunities for public participation, and coordinates resource management, protection, and planning with other city departments and public and private landowners.

Urban Forestry Department

The City's Urban Forestry Department maintains a healthy and safe urban forest, and preserves an extensive and diverse tree cover throughout the city. Responsibilities include:

- Public tree maintenance and planting programs, tree inventory
- Tree Safety Inspection Program (TSIP) and Integrated Pest Management (IPM)
- Commercial tree program
- Storm damage response
- Arborist licensing, education and outreach

Urban Forestry manages the Urban Forest Strategic Plan activities and response to hazards such as the Emerald Ash Borer invasion.

City Manager's Office – Resilience Program

Resilience is the ability of a community to prepare for and respond effectively to stress. Some of the stresses will come on suddenly, like the 2013 flood, wildfires, violence or illnesses. Others take their toll over time, such as economic hardship, social inequality, or the declining health of a community and its members. Resilience is a new way of thinking about the community in a holistic way that adds to and deepens the way we already plan for a sustainable future. Resilience is about anticipating the inevitable events that cause disruption and then developing the strategies to reduce their impacts to the greatest extent possible.

While resilience itself is not new, Boulder is one of the first 32 cities recently chosen to participate in the 100 Resilient Cities program. Pioneered by the Rockefeller Foundation, 100 Resilient Cities is the first organization to use resilience as a systematic framework, on a global scale, for actively managing and prioritizing city operations and activities. The program funds the City's Chief Resilience Officer and supports the City's Comprehensive Resilience Strategy. The City's "Resilient Boulder" program and "Resilient Together" outreach platform both provide communication and collaboration tools critical to the City's hazard mitigation and response capabilities.

Police Department

The Boulder Police Department (BPD) has adopted a policing philosophy that is built around the provision of service, as represented by proactive problem solving through the establishment of community partnerships, and safety, as represented by the aggressive application of modern law enforcement techniques. This philosophical shift from the traditional 911-driven, pure reactive approach to the delivery of police services emphasizes community-based, prevention-oriented policing. The issues and concerns in need of police attention emerge from ongoing discussion and interaction between the BPD and the community. The department defines its fundamental responsibilities as encompassing six general functions:

- Enforcing laws and preserving public safety and order
- Reducing crime and disorder through prevention and intervention
- Responding to community needs through partnerships and joint problem-solving
- Investigating and reporting serious and non-serious crimes for prosecution
- Providing information and service referrals
- Managing and administering BPD operations

The Boulder Police Department (BPD) Master Plan was originally developed in 1996 and revised in 2013. The BPD Master Plan is being updated to better reflect current and emerging trends such as an increase in community expectations and advances in technology and communications. The master plan is intended to guide BPD for the next 5 to 10 years in providing safety, education, enforcement and investigative services to the City of Boulder.

Fire-Rescue Department

The City of Boulder Fire–Rescue Department is responsible for the protection of life and property through fire prevention, education, fire suppression, and emergency medical and rescue services. The Fire–Rescue Department has a staff of 116, seven fire stations, and a budget of approximately $15.5 million to provide fire suppression, rescue, emergency medical care, fire prevention services, and public education for the population within Boulder's city limits. All addresses in the City of Boulder limits are within two miles of a fire station. The fire chief reports to the city manager and oversees the department's five divisions: Emergency Services, Fire Prevention, Training, Wildland, and Administration. Two permanent wildland fire positions including a wildland fire crew supervisor were added in 2012. This additional staffing was an action recommendation in the 2008 Multi-Hazard Mitigation Plan.

Boulder's firefighters do a lot more than fight fires. Every firefighter is a state certified emergency medical technician. Every engine crew is equipped with, and trained to operate, a cardiac defibrillator. The city's firefighters are also prepared to deal with flooding in a business or house, extricate someone from a vehicle accident, rescue people from a stalled elevator or a collapsed trench, and effectively deal with carbon monoxide alarms or tree branches on power lines. Many of Boulder's firefighters have advanced training in dive rescue, hazardous material spills, wildland firefighting, or fire safety education.

Boulder's firefighters also provide proactive services for the safety and well-being of the public. The engine crews and Fire Prevention Division inspect Boulder businesses to ensure they comply with the International Fire Code and Boulder Revised Code. The fire safety education team reaches virtually every elementary school student in the city during October, fire prevention month, through the school system. College students are taught fire safety through the Greek and Residence Assistants Fire Academies.

The Fire Prevention Division not only promotes fire safety and education, but also investigates fire, performs plan reviews for new or remodeled buildings, and performs building inspections to ensure compliance with the fire code. The department also has a training division that concentrates on recruit training, continuing education to the entire department, and emergency medical services training.

The Wildland Division was established in 1998 to help protect residents, visitors, and city lands from wildland fire. The response area of the division covers approximately 400 square miles. The division's purpose is to manage wildland fire activities on or threatening City of Boulder land. Another reason the division was established was to carry on and expand the prescribed fire program on city lands. To help accomplish this, the division assists the Open Space and Mountain Parks Department with their ecosystem management and forest health projects. The division educates the public on wildfire prevention, mitigation, and safety and provides training to city employees and local, state, and federal cooperators. The Public Safety Tax approved by voters in 1997 added seasonal personnel to respond to wildland fires occurring on and around Boulder's open lands. That crew is also available to conduct wildland fire mitigation, forest thinning, and prescribed burning.

The Fire–Rescue Department has seven fire stations strategically located around the city:

- Station One (Central Station)—2441 13th Street
- Station Two—2225 Baseline Road
- Station Three—1580 30th Street,
- Station Four—4100 Darley Avenue
- Station Five—4365 19th Street
- Station Six—5145 North 63rd Street
- Station Seven—1380 55th Street

Each station operates 24 hours per day, seven days per week and is equipped to respond to fire, medical, and other emergencies. Medical calls accounted for 62 percent of the total calls for service in 2011. The Fire–Rescue Department also participates in a countywide joint training center. The current facility is at 960 Lee Hill Road.

An update to the Fire and Emergency Medical Service Master Plan was adopted in June 2012. The master plan service standards are as follows:

- Emergency Services: Arrival of 1st unit dispatched to an emergency within 6 minutes 80% of the time. Arrival of all units dispatched to an emergency within 11 minutes 80% of the time.
- Hazardous Materials Team: Arrival of 1st unit dispatched to an emergency within 6 minutes 80% of the time. Arrival of all units dispatched to an emergency within 11 minutes 80% of the time.
- Wildland Coordination: Arrival of 1st unit dispatched to an emergency within 6 minutes 80% of the time. Arrival of all units dispatched to an emergency within 11 minutes 80% of the time.
- Dive Team: Arrival of 1st unit dispatched to an emergency within 6 minutes 80% of the time. Arrival of all units dispatched to an emergency within 11 minutes 80% of the time.

Traffic congestion and various traffic mitigation measures have impacted the department's ability to continue to meet the emergency response service standards. To ease the impact, the department activated traffic control devices that were installed at signaled intersections around the city. The department has also initiated an aggressive public education program funded by the Public Safety Tax of 1997. One purpose of the public education program is to reduce the demand for service by promoting a higher awareness of personal safety. As traffic congestion and the number of service calls increase, the addition of new fire stations will be necessary in areas where the response times are adversely impacted.

4.4.2 Hazards Management Capabilities of Other State and Regional Agencies

Colorado Water Conservation Board

The Colorado Water Conservation Board (CWCB) is an agency of the State of Colorado. The CWCB Flood Protection Program is directed to review and approve statewide floodplain studies and designations prior to adoption by local governments. The CWCB is also responsible for the coordination of the National Flood Insurance Program (NFIP) in Colorado and for providing assistance to local communities in meeting NFIP requirements. This includes CWCB prepared or partnered local floodplain studies. The CWCB has promulgated new floodplain rules and regulations that became effective on January 14, 2011. Increased protection for public health, safety and welfare in the state is the primary reason for updating Colorado's floodplain rules. The CWCB's rules aim to reduce flood losses through sound flood protection actions, which are implemented at the local level and supported by State and Federal programs. Key provisions of the new floodplain rules include: higher freeboard for structures, a 0.5-foot floodway and additional protection for "critical facilities" in the 100-year floodplain. The city supported the adoption of higher standards, and in fact was already enforcing a 6-inch floodway and a 2-ft freeboard criterion. The city is currently updating its floodplain ordinance to incorporate greater protection for critical facilities in the 500-year floodplain.

Urban Drainage and Flood Control District

The Urban Drainage and Flood Control District (UDFCD) was established by the Colorado legislature in 1969 to help local governments in the Denver metropolitan area with multi-jurisdictional drainage and flood control problems. The UDFCD covers 1,608 square miles and includes all or parts of 34 incorporated cities and towns, including the City of Boulder. There are about 1,600 miles of "major drainageways" that are defined as draining at least 1,000 acres. The population of the district is approximately 2.8 million.

The district provides services related to floodplain mapping; flood safety and early warning; new developments; and planning, design, construction and maintenance of watershed and stream improvements. The district helps local governments in maintaining and preserving floodways and floodplains in areas eligible for UDFCD maintenance. UDFCD maintenance is limited to facilities that are publicly owned or are in a public drainageway easement and are categorized into routine, restoration, and rehabilitation projects. Routine maintenance consists of scheduled mowings and trash and debris pickup on major drainageways during the growing season. It may also include small revegetation efforts and limited weed control. Restoration projects address local erosion problems, existing structure repair, detention pond restoration, tree thinning, removal of sediment deposits from flood control facilities, and revegetation work. Rehabilitation projects are major reconstruction efforts that would be included as capital improvement program projects in the City of Boulder. The district also assists with developing community flood warning capabilities, including implementation of early flood detection systems and providing early notifications concerning potential and imminent flood threats.

Colorado Division of Homeland Security and Emergency Management

The Colorado Office of Emergency Management (CO OEM) is responsible for the state's comprehensive emergency management program, which supports local and state agencies. Activities and services cover all aspects of emergency management. Assistance to local governments includes financial and technical assistance as well as training and exercise support. Services are made available through local emergency managers supported by CO OEM staff assigned to specific areas of the state. CO OEM also provides guidance and technical assistance on mitigation grant applications.

Colorado State Forest Service

The mission of the Colorado State Forest Service is to provide for the stewardship of forest resources and to reduce related risks to life, property, and the environment for the benefit of present and future generations. Its fire preparedness and response strategic priority is to provide leadership in wildland fire protection for state and private lands in Colorado and reduce wildfire-related loss of life, property, and critical resources.

Colorado Geological Survey

The Colorado Geological Survey is a state government agency within the Colorado Department of Natural Resources whose mission is to help reduce the impact of geologic hazards on the citizens of Colorado, to promote responsible economic development of mineral and energy resources, provide geologic insight into water resources, provide avalanche safety training and forecasting, and to provide geologic advice and information to a variety of constituencies. The Colorado Avalanche Information Center, located in Boulder, is also part of the Colorado Geological Survey.

Colorado Department of Water Resources – Office of State Engineer

The Colorado Division of Water Resources (DWR), also known as the Office of the State Engineer, administers water rights, issues water well permits, represents Colorado in interstate water compact proceedings, monitors streamflow and water use, approves construction and repair of dams and performs dam safety inspections, issues licenses for well drillers and assures the safe and proper construction of water wells, and maintains numerous databases of Colorado water information. As it relates to hazard mitigation it is the department's mission to ensure public safety through safe dams and properly permitted and constructed water wells.

The Dam Safety branch is responsible for the safety of all existing dams in the state of Colorado. The branch carries out two principal duties of the State Engineer: to determine the safe storage level of the reservoir dams in the state and to approve the plans and specifications for the construction and repair of Jurisdictional dams. Dam Safety engineers regularly inspect jurisdictional dams throughout the state.

Whenever there is a dam emergency, dam owners are requested to immediately follow their *Emergency Action Plan*, notify the local enforcement authority (ex. sheriff or 911), notify the Colorado Division of Emergency Management and notify the State of Colorado's Dam Safety Branch.

Colorado Department of Transportation

The Colorado Department of Transportation (CDOT) conducts planning and projects that relate to hazard mitigation. These include design of bridges to withstand scouring and convey flood flows in addition to rockfall hazard identification and mitigation along the State's highway system. CDOT employs message signs, road closure devices, and radio advisories to warn motorists of dangerous driving conditions and road closures due to severe weather or rockfall incidents. CDOT has developed a US 36 Traffic Incident Management Plan for the Boulder Turnpike.

4.4.3 Hazard-Related Policies, Regulations and Codes

The City of Boulder has several policies, regulations and codes that guide how the city manages development of hazard-prone areas. Many of these policies have multiple objectives. Those that are directly related to reducing losses to future development or the protection of critical facilities and/or vulnerable populations are summarized here.

Boulder Valley Comprehensive Plan

First adopted in 1978, the Boulder Valley Comprehensive Plan (BVCP) is a joint plan between the City of Boulder and Boulder County providing shared land use decision making in the Boulder Valley. The plan sets a course for the future growth and development of the city and the lands just outside the city's boundaries. The plan is adopted by four bodies: the City of Boulder Planning Board, the City Council, the County Planning Commission, and the Board of County Commissioners. The City and County jointly adopted the 2015 Major Update to the BVCP in August of 2017, which is the seventh major update. The updated plan includes guidance for resilience and sustainability, diversity of housing including for middle incomes, achieving greater community benefits, arts and culture, and other refreshed policies. The following is a summary of the core components of this plan:

- The BVCP policies guide decisions about growth, development, preservation, environmental protection, economic development, affordable housing, culture and the arts, neighborhood character, and transportation. The policies also inform decisions about the manner in which services are provided, such as police, fire, emergency medical services, water utilities, flood control, and human services.
- The BVCP Land Use Designation and Area I, II, III Maps define the desired land use pattern for the Boulder Valley regarding location, type, and intensity of development.

Boulder Valley Comprehensive Plan Policies

The general policies and principles that relate to mitigating the impacts of natural hazards are detailed below. These policies provide overarching direction for planning, development, and programs in the Boulder Valley.

General Policies

- Sustainability as a unifying framework to meet environmental, economic and social goals.
- Environmental stewardship and climate action.

Urban Design Linkages Policies

- **Urban Open Lands** (2.19)—Open lands within the fabric of the city provide recreational opportunities, transportation linkages, gathering places and density relief from the confines of the city as well as protection of the environmental quality of the urban environment. The city will promote and maintain an urban open lands system to serve the following functions: active and passive recreation, environmental protection, flood management, multimodal transportation, enhancement of community character and aesthetics.
- Boulder Creek, Tributaries and Ditches as Important Urban Design Features (2.20)—Boulder Creek, its tributaries and irrigation ditches will serve as unifying urban design features for the community. The city and County will support the preservation or reclamation of the creek corridors for natural ecosystems, wildlife habitat, and cultural resources; for recreation and bicycle and pedestrian transportation; to provide flood management; to improve air and water quality; and to provide a contrast to urban development. Path development will be sensitive to the ecology, terrain, and privacy of adjacent residents and surroundings.

Community Conservation Policies

- Preservation of Historic and Cultural Resources (2.24)—The city and county will identify, evaluate and protect buildings, structures, objects, districts, sites and natural features of historic, architectural, archaeological, or cultural significance with input from the community. The city and county will seek protection of significant resources through local designation when a proposal by the private sector is subject to discretionary development review.

Preserve and Enhance Biodiversity and Native Ecosystems Policies

- **Natural Ecosystems** (3.03)—The city and county will protect and restore significant native ecosystems on public and private lands through land use planning, development review, conservation easements, acquisition, and public land management practices. The protection and enhancement of biological diversity and habitat for federal endangered and threatened species and state, county, and local species of concern will be emphasized. Degraded habitat may be restored, and selected extirpated species may be reintroduced as a means of enhancing native flora and fauna in the Boulder Valley. (See policy 2.05 Open Space Preservation.)

- **Maintain and Restore Ecological Processes** (3.05)—Recognizing that ecological processes, such as wildfire and flooding, are integral **t**o the productivity and health of natural **eco**systems, the city and county will work to ensure that, when appropriate precautions have been taken for human safety and welfare, ecological processes will be maintained or mimicked in management of natural lands.
- **Wetland Protection** (3.06)—Natural and human-made wetlands are valuable for their ecological and, where appropriate, recreational functions, including their ability to enhance water and air quality. Wetlands also function as important wildlife habitat, especially for rare, threatened, and endangered plants and wildlife. The city and county will continue to develop programs to protect and enhance wetlands in the Boulder Valley. The city will strive for no net loss of wetlands by discouraging their destruction or requiring the creation and restoration of wetland in the rare cases when development is permitted and the filling of wetlands cannot be avoided.
- **Invasive Species Management** (3.07)—The city and county will promote efforts, both public and private, to prevent the introduction or culture of invasive plant and animal species and seek to control their spread. High priority will be given to managing invasive species that have, or potentially could have, a substantial impact on city and county resources.

Protect and Enhance the Quality of the Urban Environment Policies

- **Urban Environmental Quality** (3.10)—To the extent possible, the city and County will seek to protect the environmental quality of areas under significant human influence, such as agricultural and urban lands, and will balance human needs and public safety with environmental protection. The city will develop community-wide programs and standards for new development and redevelopment so that negative environmental impacts will be mitigated and overall environmental quality of the urban environment will not worsen and may improve.
- **Urban Forests** (3.11)—The city will support, promote and, in some cases regulate, the protection of healthy existing trees and the long-term health and vitality of the urban forest in the planning and design of public improvements and private development. The city will encourage overall species diversity, native and low water demand tree species where appropriate.
- **Water Conservation** (3.12)—The city and county will promote the conservation of water resources through water quality protection, public education, monitoring, and policies that promote appropriate water usage. The city will endeavor to minimize water waste and reduce water use during peak demand periods. New development and redevelopment designed to conserve water will be encouraged.

Protect Geologic Resources and Manage Natural Hazards Policies

- **Unique Geological Features** (3.14)—Due to its location at the interface of the Great Plains and the Rocky Mountains, Boulder Valley has a number of significant or unique geological and paleontological features. The city and county will attempt to protect these features from alteration or destruction through a variety of means, such as public acquisition, land use planning and regulation, and density transfer within a particular site.

- **Hazardous Areas** (3.16)—Hazardous areas that present danger to life and property from flood, forest fire, steep slopes, erosion, unstable soil, subsidence, or similar geological development constraints will be delineated, and development in such areas will be carefully controlled or prohibited.
- **Wildfire Protection and Management** (3.18)—The city and county will require on-site and off-site measures to guard against the danger of fire in developments adjacent to natural lands and consistent with forest and grassland ecosystem management principles and practices. Recognizing that fire is a widely accepted means of managing ecosystems, the city and county will integrate ecosystem management principles with wildfire hazard mitigation planning and urban design.
- **Preservation of Floodplains** (3.19)—Undeveloped floodplains will be preserved or restored where possible through public land acquisition of high hazard properties, private land dedication, and multiple program coordination. Comprehensive planning and management of floodplain lands will promote the preservation of natural and beneficial functions of floodplains whenever possible.
- **Flood Management** (3.20)—The city will protect the public and property from the devastating impacts of flooding in a timely and cost-effective manner while balancing community interests with public safety needs. The city will manage the potential for floods by implementing the following guiding principles: preserve floodplains, be prepared for floods, help people protect themselves from flood hazards, prevent unwise uses and adverse impacts in the floodplain, and seek to accommodate floods, not control them. The city will manage flood recovery by protecting critical facilities in the 500-year floodplain and implementing multi hazard mitigation and flood response and recovery plans.
- **Nonstructural Approach** (3.21)—The city will seek to preserve the natural and beneficial functions of floodplains by emphasizing and balancing the use of nonstructural measures with structural mitigation. Where drainageway improvements are proposed, a nonstructural approach should be applied wherever possible to preserve the natural values of local waterways while balancing private property interests and associated cost to the city.
- **Protection of High Hazard Areas** (3.22)—The city will prevent redevelopment of significantly flood-damaged properties in high hazard areas. The city will prepare a plan for property acquisition and other forms of mitigation for flood-damaged and undeveloped land in high hazard flood areas. Undeveloped high hazard flood areas will be retained in their natural state whenever possible. Compatible uses of riparian corridors, such as natural ecosystems, wildlife habitat and wetlands will be encouraged wherever appropriate. Trails or other open recreational facilities may be feasible in certain areas.
- **Larger Flooding Events** (3.23)—The city recognizes that floods larger than the 100-year event will occur resulting in greater risks and flood damage that will affect even improvements constructed with standard flood protection measures. The city will seek to better understand the impact of larger flood events and consider necessary floodplain management strategies including the protection of critical facilities.

Protect and Improve Water and Air Quality Policies

- **Protection of Water Quality** (3.24)—Water quality is a critical health, economic, and aesthetic concern. The city and county will protect, maintain, and improve water quality within the Boulder Creek watershed as a necessary component of existing ecosystems and as a critical resource for the human community. The city and county will seek to reduce point and nonpoint sources of pollutants protect and restore natural water system, and conserve water resources. Special emphasis will be placed on regional efforts such as watershed planning and priority will be placed on pollution prevention over treatment.
- **Water Resource Planning Acquisition** (3.25)—Water resource planning efforts will be regional in nature and incorporate the goals of water quality protection, and surface and ground water conservation. The city will continue to obtain additional municipal water supplies to insure adequate drinking water, maintain instream flows and preserve agricultural uses. The city will seek to minimize or mitigate the environmental, agricultural, and economic impacts to other jurisdictions in its acquisition of additional municipal water supply to further the goals of maintaining instream flows and preventing the permanent removal of land from agricultural production elsewhere in the state.
- **Drinking Water** (3.26)—The city and county will continually seek to improve the quality of drinking water and work with other water and land use interests as needed to assure the integrity and quality of its drinking water supplies. The city and county will employ a system-wide approach to protect drinking water quality from sources waters to the water treatment plant and throughout the water distribution system.
- **Minimum Flow Program** (3.27)—The city will pursue expansion of the existing in-stream flow program consistent with applicable law and manage stream flows to protect riparian and aquatic ecosystems within the Boulder Creek watershed.
- **Surface and Groundwater** (3.28)—Surface and groundwater resources will be managed to prevent their degradation and to protect and enhance aquatic, wetland and riparian ecosystems. Land use and development planning and public land management practices will consider the interdependency of surface and groundwater and potential impacts to these resources from pollutant sources, changes in hydrology, and dewatering activities.
- **Wastewater** (3.29)—The city will pursue sustainable wastewater treatment processes to achieve water quality improvements with greater energy efficiency and minimal chemical use. Pollution prevention and proactive maintenance strategies will be incorporated in wastewater collection system management. The county will discourage the installation of private on-site wastewater systems where municipal collection systems are available or where a potential pollution or health hazard would be created.
- **Protection of Air Quality** (3.30)—Air quality is a critical health, economic, and aesthetic concern. The city and county will seek to reduce stationary and mobile source emissions of pollutants. Special emphasis will be placed on local and regional efforts to reduce pollutants, which cause adverse health effects and impair visibility.

Community Health

- **Safety** (8.07)-The city will promote safety by fostering good neighborhood relations, building a sense of community pride and involvement, and promoting safe and attractive neighborhoods. The city and county will provide police, fire protection and emergency management services and preparedness education to ensure a safe community**.**

BVCP Action Plan

In September 2017, City Council approved the BVCP Action Plan and identified the following near-term items for focus in 2017 and 2018:

1. Prepare an Alpine-Balsam area plan, including coordination with Boulder County regarding the Iris and Broadway site.
2. Coordinate and plan for public engagement for CU South, including flood mitigation, open space planning, and site master planning toward an intergovernmental agreement and annexation.
3. Prepare Land Use Code amendments to address height modifications through site review (up to the City Charter 55-foot height limit) and address the affordable housing community benefit by July 2018.
4. Prepare incremental Land Use Code amendments for Accessory Dwelling Units (ADUs) to address barriers to creating new units and support affordable housing goals.
5. Initiate the Neighborhood Planning/Residential Infill Pilot project, including defining the project purpose and criteria for neighborhoods or other groups to apply and propose a project(s).
6. Initiate other Land Use Code Amendments to address Enhanced Community Benefit/Site Review, including some code maintenance updates from the on-going proposed code amendment list.

Fire Protection Considerations

The following seven philosophies provide general direction when establishing goals and objectives for fire protection in the City of Boulder:

- **Shared Responsibility for Fire Protection**—The city emphasizes private sector self-protection through code regulations and design incentives. Installation of automatic fire sprinkler systems is now required by ordinance for many uses.
- **Balance between Built-In Fire Protection and Public Fire Protection Service**—Municipal fire protection requires a balance between services provided by the city through fire stations, apparatus, and personnel and that provided by built-in automatic fire systems. Automatic systems offer a high degree of protection from fire originating in those protected properties. City-provided protection supplements the built-in systems and is designed to handle fires in

nonprotected buildings, outside fires, medical emergencies, and non-fire emergencies and events.

- **Generalist Theory of Operation**—The Fire–Rescue Department believes that each fire apparatus should have diverse equipment and that the firefighters should be generalists rather than specialists. Every front-line fire truck has firefighting and rescue equipment along with emergency medical supplies. Each firefighter must pass a comprehensive training program that supports that generalist approach. State of Colorado emergency medical technician certification is required, and every firefighter's training includes firefighting, hazardous materials response, and training for rescues involving vehicle accidents, fires, water, and ice incidents.
- **Basic Level of Emergency Medical Service**—The Fire–Rescue Department provides basic lifesaving services. The emergency medical care system in the city is a multi-tiered system involving Fire–Rescue, public/private partnership with a private ambulance service, and area hospitals, each providing a respectively higher degree of medical support.
- **Specialist Capabilities**—In addition to the general capabilities, the Fire–Rescue Department provides more specialized services:
  - The Dive Team responds to emergencies at the Boulder Reservoir, Boulder Creek, and other bodies of water within the city.
  - The Hazardous Materials Team responds to hazardous chemical releases, including chemical spills on manufacturing sites and during transport.
  - The Wildland Fire Team, with the help of additional seasonal wildland firefighters, responds to fires in open space and on the edges of the city, including the foothills.
  - The Public Education Team works with the department's fire-safety coordinator to provide public education in fire prevention.
- **Training**—The Fire–Rescue Department offers a wide variety of services to the citizens of Boulder. To maintain an adequate level of proficiency in many areas of emergency service, the department conducts extensive training in all service areas including firefighting, fire prevention, emergency medical care, hazardous materials, rescue, and public education. Joint training exercises are conducted with other county agencies.
- **Impact of Infill**—City fire stations are strategically located to meet the emergency response service standards. As population within service area increases, the number of calls for fire and emergency service will increase. When one fire response unit in a station exceeds 1,500 calls per year, additional apparatus and staffing needs to be provided.

The BVCP describes the following future activities and projects of the Fire-Rescue Department:

- **Anticipate and prepare for year-round wildfire risk** - Consider new codes for wildland interface and residential construction practices. Continue to focus on wildland fire planning, mitigation and protection, including more coordination with other city departments and regional partnerships with the Sheriff's Office and service providers. Continue to replace seasonal wildland fire crews with full-time employees.

- **Implement a plan to identify remaining wood roofs by the end of 2014**: One of the key wildfire mitigation polices enacted by the city is the passage of an ordinance banning wood roofs and requiring existing wood roofs to be replaced by 2014. The wood roof replacement ordinance has been implemented with nearly 100% compliance.
- **Apparatus Replacement**—The city is developing a planned fire truck replacement program.

Floodplain Regulations

The city has numerous codes and regulations in place governing floodplains. Some of the following descriptions are taken directly from the regulations and others are taken from existing plans and documents summarizing key regulatory elements of floodplain management including the 2004 Comprehensive Flood and Stormwater Utility Master Plan and Background Documents.

Significant work has been completed since that time and a major flood event in September 2013 has influenced the public's perceptions related to flooding. An updated Stormwater Master Plan was completed in 2017. An update to the Comprehensive Flood Plan will be initiated in 2018 to evaluate the following types of considerations:

- Climate change
- Floodplain, stormwater, water quality and groundwater regulations
- Floodplain mapping practices
- Prioritization of capital improvement projects

The Comprehensive Flood Plan update will include a public process to gather ideas and feedback from the community. The Urban Drainage and Flood Control District will also contribute funding and assistance.

Stormwater and Flood Management Utility (Boulder Revised Code—Title 11 Utilities and Airport: Chapter 5)

As previously discussed, the city has established and operates the Stormwater and Flood Management Utility pursuant to Title 11 Chapter 5 of the Boulder Revised Code. The purpose of this code section is to protect public health, safety, and welfare from damage associated with stormwater runoff and floods by requiring that property owners in the city pay for a share of the cost of the drainage facilities necessary to manage such stormwater and floods.

Also included in this section is the requirement to develop a master drainage plan for the city, based on engineering studies, that indicates the location of all city drainage facilities. The intent is to identify and alleviate present and future drainage and flooding problems in the city by means of presenting the general data and information essential in understanding the relationship between rainfall and storm runoff.

Regulations Governing the Floodplain (Boulder Revised Code—Title 9 Land Use Regulations: Chapter 3)

The city has had floodplain policies in place for over 50 years. During this time, the city has mapped 100-year floodplains to identify flood hazard areas and developed master plans to pursue mitigation of flood impacts.

The many critical environmental factors predominant in floodplains suggest that the approach to floodplain management should be oriented more toward preservation of floodplains and their beneficial environmental functions and less toward structural flood control measures. There is evidence that the city's floodplain policy is moving towards nonstructural flood mitigation measures as much as possible.

The floodplain is considered to include all land areas subject to inundation by floodwaters. The adopted regulatory floodplain is based on a predicted flood which has a 1 percent chance of being equaled or exceeded in any given year. This area is commonly called the 100-year floodplain. Development within the floodplain must include flood protection measures that mitigate the risk of property loss or damage resulting from a 100-year flood. Within the floodplain, the following zones are defined:

- **Conveyance Zone**— Also known as the floodway, this includes all areas in the floodplain that would be required for the passage or conveyance of the entire flood flow (measured in cubic feet per second) resulting from the encroachment (or blocking out) of the floodplain from the edges, allowing no greater than a maximum six-inch increase in the depth of flood waters. (The conveyance zone or floodway is usually a narrowed corridor within the floodplain.) This conveyance zone definition is more restrictive than that used by FEMA (but consistent with the new State of Colorado regulations), which allows a maximum one-foot increase in floodwater depth.
- **High Hazard Zone**—All areas in the floodplain where floodwater depth would equal or exceed four feet (or where the product number of the floodwater velocity (in feet per second) multiplied by the floodwater depth (measured in feet) would equal or exceed four). Because of life safety concerns, development in the high hazard zone is the most restricted.
- **Flood Fringe**—Those portions of the floodplain that are not in the conveyance zone or in the high hazard zone.

The city requires new development to be elevated or floodproofed 2 feet above the base, or 1% annual chance, flood event. This elevation is referred to as the 'flood protection elevation' in the Code. This concept of "freeboard" provides added protection for floods that exceed the base flood. Regulations that pertain to the entire floodplain include the following:

- A floodplain development permit must be acquired prior to any development within the floodplain.
- Floodproofing of buildings or structures must meet city standards.

- No hazardous materials may be stored at or below flood protection elevation with the exception of existing or replacement underground fuel storage tanks that are constructed to prevent discharge into floodwaters and that are adequately anchored against a flood.
- Parking areas may not be located in areas where flood depths exceed 18 inches.
- Rental properties in the floodplain must be posted with appropriate informational signs to warn tenants of flood hazards.
- Manufactured housing must be elevated on a permanent foundation so that the lowest floor is above the flood protection elevation, and the structure must be sufficiently anchored.
- New structures should be oriented with longitudinal axis parallel to the predicted direction of flow of floodwaters.
- Existing structures will be rehabilitated to conform with regulations when substantially expanded, enlarged, modified, or improved.
- New residential structures must be elevated so that the lowest floor is at or above the flood protection elevation.
- New nonresidential structures must be floodproofed or have the lowest finished floor elevated above the flood protection elevation.
- Any new structure must be adequately anchored, constructed of material resistant to flood damage, and designed and located so that electrical, heating and ventilation, plumbing, and air conditioning systems are not inundated.
- Fully enclosed areas that are subject to flooding must also allow for automatic equalization of flood forces by providing for entry and exit of floodwaters.

In addition to the regulations governing the floodplain, uses, structures, or developments in the conveyance zone that result in any rise in the elevation of the 100-year flood are prohibited. Proposed changes to the regulations in 2012 may allow an exception to this. Localized rises within flood channels or on specific properties may be permissible if all impacted property owners agree in writing to accept the rise and there is no adverse impact on any insurable structure or any other property. Construction of new, or expansion, enlargement, or substantial modification of existing structures intended for human occupancy in the high hazard zone, is not allowed.

Critical Facility and Mobile Population Ordinance

The city's Comprehensive Flood Study Master Plan (CFS MP, 2004) called for the development of 500-year protection standards for critical facilities in line with Federal guidance to ensure access to, use of and uninterrupted service for critical facilities such as fire and police stations, water and wastewater treatment facilities, utility infrastructure for water, sewer, gas, electric and communications, schools, day care and senior care facilities, hospitals, major roads and bridges, and hazardous material storage. The development of a critical facilities ordinance was identified as a mitigation action as part of the original development of this Multi-Hazard Mitigation Plan which was originally adopted in 2008. The action item outlined the need for the development and adoption of an ordinance that regulates new construction and improvements for critical facilities to the 500-year flood level to protect these facilities from flood losses and damages that could render them unusable during times of need.

In 2013, the City Council approved the Critical Facilities and Lodging Facilities Ordinance that went into effect in March 2014. The new ordinance expanded the regulation of mobile populations and the critical facility categories of essential service, at-risk population and hazardous materials facilities to areas encompassed by the 500-year floodplain.

In the 500-year floodplain:

- Substantial improvements or modifications to, or development of, new at-risk population and essential service facilities will be constructed so that the lowest floor of the entire building is protected to the level of the 500-year flood elevation plus one foot. Smaller building additions will also protect the new construction to that level.
- Existing hazardous materials buildings with modifications requiring a floodplain development permit or a building permit which exceeds 25 percent of the market value of the existing structure are required to secure the hazardous material from flooding within a 10 year implementation window. New hazardous material facilities would be required to secure the hazardous materials from flooding as a condition of the permit.

In the 500- and 100-year floodplains, emergency management plans will be required for:

- Critical facilities and mobile population facilities requiring building permits for new construction, development requiring a floodplain development permit, the addition of any floor area, or any building permit for a substantial improvement and must be developed as a condition of the permit.
- All other existing critical facility and mobile population facilities will be required to develop emergency management plans within a 10-year implementation window from the ordinance adoption.

Emergency management plans will include either shelter in place or evacuation plans. The most appropriate method of protection will be defined, and evacuation routes or sheltering locations will be posted in the building, similar to requirements for fire response. This requirement will ensure that necessary flood education and protection information is available during times of flooding.

Critical facilities and mobile population facilities will continue to be regulated within the area encompassed by the 100-year floodplain, consistent with other types of buildings, with the exception of the requirement to develop an emergency management plan. Existing 100-year regulations will remain in place and a revision of the definition of hazardous materials is included in the recommended ordinance. Existing critical and mobile population facilities can continue to operate in their current capacity.

Floodplain Development Permits (Boulder Revised Code—Title 9 Land Use Regulations: Chapter 3)

The city requires that a floodplain development permit be acquired for any development within the floodplain. The City Manager, through the Public Works Department, is responsible for review and approval or denial of floodplain development permits and the development of conditions of approval where appropriate. Developments that propose a change in a watercourse must be referred to the Planning Board for recommendation. Permit approvals for development in the conveyance or high hazard zone do not become effective for fourteen days following issuance and are subject to Planning Board review, public noticing, and appeal procedures.

The city assesses fees for the processing of floodplain development permits, variances, and flood map revisions. The city also coordinates its floodplain regulations with several other agencies, each of which regulate to the 100-year floodplain standard. These agencies include FEMA, the Colorado Water Conservation Board, the UDFCD, and Boulder County.

Floodplain development permit applications are reviewed by city staff within the Public Works Department, who provide public notice of the application if high hazard or conveyance zones are affected and make a recommendation of application approval, with or without conditions, or denial. Concerns considered in the review of a floodplain development permit application include compliance with regulations governing floodplains, conveyance zones, and high hazard areas; effects on drainage efficiency or capacity; whether the project will have an adverse environmental effect on the watercourse, including banks and streamside vegetation; effect of the project on adjacent, upstream, and downstream properties; the relationship of the project to the BVCP and applicable floodplain management programs; and whether the cumulative effects of the project with other existing and anticipated uses will increase flood heights.

Design and Construction Standards (Boulder Revised Code—Title 9 Land Use Regulations: Chapter 9)

The city's Design and Construction Standards (DCS) regulate the design and construction of public infrastructure, improvements, and landscaping within the city's public rights-of-way and public easements. The DCS requirements for stormwater management are primarily based on the UDFCD drainage criteria manuals. The updated DCS was adopted by City Council on October 17, 2000, with the passage of City of Boulder Ordinance No. 7088.

Stormwater issues related to land development and redevelopment are addressed through a variety of review processes coordinated by the Planning and Development Services workgroup. Most development and redevelopment projects are required to submit a stormwater report and plan prepared by a licensed professional engineer. The report and plan are required to address how the identified project will maintain historical runoff rates and mitigate water quality impacts. On-site detention storage is required for all developments other than individual single-family lots that are not part of a larger development where the runoff coefficient for the site is increased.

Natural Resource Protection Considerations

The City of Boulder has many regulations to protect the valuable resources within Boulder Valley. Taken directly from the regulations, highlights of these provisions are provided below.

Streams, Wetlands and Water Body Protection (Boulder Revised Code—Title 9 Land Use Regulations: Chapter 3)

The City of Boulder has adopted a streams, wetlands and water body protection ordinance to preserve, protect, and enhance streams, wetlands and water bodies by discouraging development activities in streams, wetlands, water bodies and adjacent areas. The ordinance establishes a goal of no net loss of wetland acreage and function by regulating activities in and around streams, wetlands and water bodies. These rules apply to all streams, wetlands and water bodies that are mapped within Boulder's city limits as well as all streams, wetlands and water bodies on city-owned land and all city activities affecting streams, wetlands or water bodies regardless of location.

City streams, wetlands and water body permits are required for projects that affect streams, wetlands, water bodies and associated buffer zones surrounding streams, wetlands and water bodies. The surrounding buffer zones vary in size based upon the functional classification of the stream, wetland and water body. Low functioning streams, wetlands and water bodies have a 25-foot outer buffer. High functioning streams, wetlands and water bodies have a 50-foot buffer area which consists of a 25-foot inner buffer and a 25-foot outer buffer. The regulations and permitting requirements are most restrictive for activities that directly impact streams, wetlands and water bodies and are the least restrictive for activities that only impact outer buffer areas. Maintenance of an existing public or private road, structure, or facility, including drainage facilities, water conveyance structures, dams, fences, or trails are permissible subject to the requirement of best management practices as identified in city Wetlands Protection Program Best Management Practices (May 1995). The maintenance activities may not materially change or enlarge any existing facility, structure, or road.

Protection of Trees and Plants (Boulder Revised Code—Title 6 Health, Safety, and Sanitation: Chapter 6)

The purpose of this chapter is to protect the public health, safety, and welfare by prescribing requirements for the protection of trees and plants within the city, including, without limitation, trees, shrubs, lawns, and all other landscaping. The City Council finds that all trees, plants, and other landscaping, located, standing, or growing within or upon city property, including, without limitation, any city-owned or city-controlled street, alley, rights-of-way, or other public place or city or mountain park, recreation area, or open space, belong to the city and are a community asset comprising a part of the public infrastructure. The City Council finds that the requirements of this chapter are necessary to ensure the continued protection, maintenance, replacement, and management of city-owned trees, plants, and other landscaping.

Building and Construction Considerations

The City of Boulder has adopted the 2012 International Code Council (ICC) codes, which went into effect on Jan. 31, 2014. The adopted building codes are:

- 2012 International Building Code
- 2012 International Residential Code
- 2012 International Fire Code
- 2012 International Mechanical Code
- 2012 International Plumbing Code
- 2012 International Fuel Gas Code
- 2012 National Electrical Code

Building Code (Boulder Revised Code—Title 10 Structures: Chapter 5)

The intent of the Building Code is to protect the public health and safety by regulating the construction, alteration, repair, wrecking, and moving of structures in the city. The City Council adopted the 2006 edition of the International Building Code and the 1997 edition of the Uniform Code for the Abatement of Dangerous Buildings with certain amendments and deletions found to be in the best interests of the residents of the city.

Elements of the International Building Code (IBC) relevant to natural hazards mitigation are described below.

Roofing (10-5-2(u))

All roof assemblies and roof coverings required to be listed by this section shall be tested in accordance with ASTM Standard E 108 or UL Standard 790. Class A roofs and the exceptions noted in IBC 1505.3 for Class B roofs as described in IBC chapter 15 are the only roof assemblies and roof coverings allowed to be installed on any new or existing building within the City of Boulder. Wood shakes, wood shingles, and wood roof covering materials are prohibited except as provided in Section 10-5-5, "Wood Roof Covering Materials Prohibited," for certain minimal repairs.

Wood Roof Covering Materials Prohibited (10-5-5)

No person shall install or cause to be installed any wood roof covering materials, including, without limitation, wood shakes or wood shingles. This prohibition includes wood roof covering materials with fire retardant treatments of any kind.

No person owning a building with wood roof covering materials shall fail to remove or cause to be removed from the building all wood roof covering materials before January 1, 2014, and to replace the removed roofing with approved roof covering materials that conform to the IBC as adopted, and no person shall thereafter take possession or ownership of a building with wood roof covering materials.

“Wood roof covering material” means an exterior surface material used as a top covering and made of wood. “Wood,” for the purposes of this definition, means any natural or composite material containing at least fifty percent wood by volume.

Snow Load (10-5-2(v))

The minimum roof snow load shall be thirty pounds per square foot, but the design roof load shall not be less than that determined by IBC Section 1607.

Wind Velocities (10-5-2(w))

In IBC Table 1609.3.1, the three-second gust wind speed for the city shall be 110 miles per hour.

Residential Building Code (Boulder Revised Code—Title 10 Structures: Chapter 5.5)

The purpose of this chapter is to protect the public health and safety by regulating the construction, alteration, repair, wrecking, and moving of residential structures in the city. The City Council adopted the 2012 edition of the International Residential Code with certain amendments found to be in the best interests of the city.

Elements of the International Residential Code (IRC) relevant to natural hazards mitigation are described below.

Climatic and Geographic Design (10-5.5-2(e))

The climatic and geographic design criteria applicable to IRC Table R301.2.1 are as follows:

- Roof snow load = thirty pounds per square foot
- Three second wind gust velocity = 110 miles per hour
- Seismic design category = B
- Weathering = severe
- Frost line depth = 32 inches
- Termite = slight
- Decay = none to slight
- Winter design temperature = 2 degrees Fahrenheit
- Ice shield underlayment = No

The building code does not specifically spell out seismic criteria for non-residential structures, specifically critical facilities. The design of critical facilities is based on criteria stated in the International Building Code and ASCE 7 Design Loads for Buildings and Other structures.

Roof Covering Materials (10-5.5-2(g))

All roof covering materials shall be listed as Class A or B as tested in accordance with UL Standard 790 or ASTM Standard E 108. Roof assemblies with covering of brick, masonry, slate, clay, or concrete roof tile; exposed concrete roof deck; ferrous or copper shingles or sheets; and metal sheets and shingles shall be considered Class A roof coverings.

Wood Shingles (10-5.5-2(h))

Wood shakes, wood shingles, and wood roof covering materials are prohibited except as provided in Section 10-5-5, “Wood Roof Covering Materials Prohibited” (see above).

Wood Shakes (10-5.5-2(i))

Wood shakes, wood shingles, and wood roof covering materials are prohibited except as provided in Section 10-5-5, “Wood Roof Covering Materials Prohibited” (see above).

Fire Prevention Code (Boulder Revised Code—Title 10 Structures: Chapter 8)

The purpose of this chapter is to protect public health and safety by regulating the use, condition, construction, alteration, and repair of property, structures, and occupancies in the city in order to prevent the ignition and spread of fire and risk of harm to persons or property from fire and other causes. The City Council adopted the 2012 edition of the International Fire Code with certain amendments, additions, and deletions found to be in the best interests of the city.

Elements of the International Fire Code amended by the city relevant to natural hazards mitigation are described below.

Accessible Private Drive (10-8-2(b.9))

“Accessible private drive” means a 20-foot unobstructed clear width with a 12-foot hard, all-weather, drivable surface that can support 40 tons on 10 wheels and has an SU 30 turning radius for the fire department’s fire apparatus.

Open Burning and Recreational Fires (10-8-2(b.10))

No person shall kindle or maintain outside of a habitable building any bonfire or burn or permit to be burned any trash, paper, rubbish, wastepaper, wood, weeds, brush, plants, or other combustible or flammable material anywhere within the city limits or anywhere on city property outside of the city limits, except when:

- The burning is in the course of an agricultural operation in the growing of crops as a gainful occupation and presents no fire hazard to other property in the vicinity;
- The burning is a smokeless flare or a safety flare used to indicate some danger to the public;

- The burning is a training fire conducted by the fire department or is a training fire conducted by another fire department or privately for industrial or commercial fire training purposes and approved in writing by the fire chief; or
- The burning is solely for fuels mitigation to alleviate wildland fire potential, or for weed abatement to assist restoration of native plants.

Mobile or portable type outdoor fire places are prohibited within the city limits or anywhere on city property outside of the city limits.

Historic Preservation (Boulder Revised Code—Title 9 Land Use Regulations: Chapter 11)

The purpose of this chapter is to promote the public health, safety, and welfare by protecting, enhancing, and perpetuating buildings, sites, and areas of the city reminiscent of past eras, events, and persons important in local, state, or national history or providing significant examples of architectural styles of the past. It is also the purpose of this chapter to develop and maintain appropriate settings and environments for such buildings, sites, and areas to enhance property values, stabilize neighborhoods, promote tourist trade and interest, and foster knowledge of the city's living heritage.

Historic Preservation Program and Ordinance

In the early 1970s, reacting to the demolition of a number of important buildings, concerned Boulder citizens initiated a grassroots effort to protect the city's historic resources. The resulting Boulder Historic Preservation Ordinance was the first such document in Colorado with the authority to designate and protect historic, architectural, or cultural resources considered valuable to the community as a whole. Many excellent examples of architecture from the turn-of-the twentieth century survive in these neighborhoods, in part, as a result of the city's adoption of the ordinance in 1974.

The purpose of this code is to protect, enhance, and perpetuate buildings, sites, and areas of the city reminiscent of past eras, events, and persons important in local, state, or national history or to provide significant examples of architectural styles of the past. The purpose of the code is also to develop and maintain appropriate settings and environments for such buildings, sites, and areas to enhance property values, stabilize neighborhoods, promote tourist trade and interest, and foster knowledge of the city's living heritage.

The code established the Landmarks Board charged with the responsibility of carrying out its provisions and goals. The code has four areas of focus:

- Designation of landmarks and historic districts
- Review and approval authority of proposed alterations to these buildings and to new construction or proposed demolition in these areas

- Review of applications for demolition or moving of non-landmarked buildings over 50 years old to prevent the loss of buildings that may have historical or architectural significance and to provide the time necessary to initiate designation or to consider alternatives for the building
- Requirement of prior approval of exterior changes to buildings or sites or proposed demolitions to preserve the historic integrity of individual landmarks and properties within historic districts

Urban Service Criteria and Standards

Also included in the BVCP, the Urban Service Standards set the benchmark for providing a full range of urban services in the Boulder Valley. These standards are intended to be minimum requirements or thresholds for facilities and services that must be delivered to existing or new urban development to be considered adequate. Included in the standards are criteria for stormwater and flood management as detailed below:

- Responsiveness to public objectives
  - Have personnel on call 24 hours per day for stormwater and flood emergencies
- Sufficiency of financing
  - Have revenue sources that are guaranteed so that revenues are available for stormwater and flood management related projects, materials, equipment, facilities, and personnel
  - Be organized to request and receive Urban Drainage and Flood Control District, state, and federal funds, if available, for projects, facilities, and equipment
- Operational effectiveness
  - Use annual budget for personnel, equipment, projects, facilities, and materials
  - Meet standards as exemplified by the Urban Drainage and Flood Control District
  - Adopt regulations consistent with FEMA
  - The following are standards for stormwater and flood management criteria for new urban development within the Boulder Valley:
    - Runoff analysis will be based upon proposed land use and will take into consideration all contributing runoff from areas outside the study area
    - Storm runoff will be determined by the Rational Method or the Colorado Urban Hydrograph Procedure
    - All local collection systems shall be designed to transport the following storm frequency:
      - Single-family residential—two-year storm
      - All other areas—five-year storm
    - The major drainageway system will be designed to transport the 100-year event or a modified standard in an approved plan
    - Storm runoff quantity greater than the “historical” amount will not be discharged into irrigation ditches without the approval of the flood regulatory authority or the appropriate irrigation ditch company
    - The type of pipe to be installed will be determined by the flood regulatory authority and will be based upon flows, site conditions, and maintenance requirements

  - All new urban development in the Boulder service area, which will be annexed, will be required to meet the intent of the adopted City of Boulder floodplain regulations.
  - Erosion and sedimentation control will be exercised
  - Detention storage requirements will be reviewed by the flood regulatory authority
- Proficiency of personnel
  - All flood control maintenance crews will be staffed by personnel trained and capable of operating the equipment necessary to maintain the stormwater and flood management system
- Location and adequacy of equipment and facilities
  - Provide essential equipment and vehicles for stormwater and flood management maintenance activities

4.4.4 Flood Mitigation Capabilities

This section describes the City of Boulder's flood program based primarily on the 2004 Comprehensive Flood and Stormwater Utility Master Plan, including the Background Materials to the Master Plan, and input from the HMPC.

Floodplain Management Program Background

The city's flood management program works to reduce flood hazards, adopt floodplain policies, map floodplains, develop master plans for floodplains, regulate floodplain activities, prepare for flood events, educate the public on floods and floodplains, and mitigate flood potential. The city's local guiding principles for flood management include:

- **Preserve floodplains** where possible to recognize the beneficial functions of floodplains for hazard reduction, water quality enhancement, wetland protection, wildlife habitat, riparian corridors, recreation, alternate modes travel, environmental relief, aesthetics, and greenway areas.
- **Be prepared for floods** by developing advanced floodplain mapping, detailed risk assessments, enhanced early warning systems, multiple emergency notification measures, understandable response plans, workable recovery plans, and ongoing storm monitoring.
- **Help people protect themselves from flood hazards** through public interaction and involvement, available flood information, community outreach and education, self-help measures, flood proofing options, affordable flood insurance, and emergency preparedness.
- **Prevent adverse impacts and unwise uses in the floodplain** through appropriate regulation and land use, open land preservation and acquisition, multi-objective planning, relocation or elimination of high hazard structures, prohibiting unacceptable encroachments, and establishing ongoing maintenance practices that preserve and enhance environmental functions.
- **Seek to accommodate floods, not control them**, through planned and monitored system maintenance, nonstructural flood proofing, opening non-containment corridors, overbank land

shaping to train flood waters, and limited structural (channelization) measures at constrained locations or where no alternatives are available.

The City of Boulder initiated its flood control program in the decade following the 1969 flood. That flood resulted in $5 million in damage to the city. During that time, the city adopted its first floodplain ordinance and first drainageway master plan. The floodplain ordinance, by requiring floodproofing of new buildings, was designed to ensure that new flooding problems would not be created. The master plan proposed improvements that would address future development and remedy existing problems. The ordinance regulated parcels that would be flooded during a 100-year flood, but enforcement was difficult due to the lack of floodplain delineation maps.

NFIP and CRS Program Participation

The city joined the NFIP on July 17, 1978, which allows private property owners to purchase affordable flood insurance and enables the community to retain its eligibility to receive certain federally backed monies and disaster relief funds. The city also participates in the NFIP's Community Rating System (CRS). The CRS is a voluntary program for NFIP-participating communities. It provides flood insurance discounts to policyholders in communities that provide extra measures of flood protection above the minimum NFIP requirements. The City of Boulder entered the CRS on October 1, 1992. Since 2007 the city has improved its CRS rating from a Class 8 to a Class 6 in 2012. Since 2012 the city improved its rating to a Class 5. The Class 5 rating will provide a 25 percent discount for flood insurance policyholders within a special flood hazard area (SFHA) and a 10 percent discount for those outside of an SFHA. With the Class 8 rating the discount was 10 percent and 5 percent, respectively. The city continues to work towards improving its CRS rating, with a goal of becoming a Class 4 community.

Floodplain Mapping Overview

To provide further direction on floodplain management in the city, numerous flood studies were conducted over the years on drainages throughout the County. In 1974, the city developed floodway and floodplain maps for flood-prone areas within the city.

Floodplain studies on various drainageways are an ongoing part of the city's floodplain management program. These studies, which may be approved by FEMA, include federally funded studies; studies developed by state, city, and regional public agencies; and technical studies generated by private interests as part of property annexation and land development efforts. These studies are conducted on entire drainages or limited stream sections depending on the scope of a study. Once approved and adopted by FEMA, they act to modify the regulatory floodplain of a given study area. The Background Information to the Comprehensive Stormwater and Flood Management Utility Master Plan provides a summary of flood studies conducted to date on Boulder's 15 major drainageways.

The City of Boulder has seven FEMA flood insurance rate maps (FIRMs) that cover the geographical extent of the city. As of December 2017, there had been 212 FEMA-approved letters of map changes for the seven FIRMs covering the City of Boulder. The city, through the GIS department, has been able to electronically incorporate all final map revisions into the original FIRM data. This HMP used the city's most current GIS flood layers to model the city's vulnerability to both the 100-year and 500-year floods. The city is part of the nationwide Flood Map Modernization effort, which has produced Digital Flood Insurance Rate Maps (DFIRMs) that will replace the older FIRMs. The National Flood Hazard Layer (NFHL) now incorporates LOMC/LOMA and LOMRs.

Flood Preparedness and Detection System

Flood preparedness is a critical element in the city's floodplain management program. The more prepared a community can be with pre-flood preparedness, ongoing monitoring, effective warning systems, trained response, and post-flood recovery, the better chance the risks of flooding may be managed.

During the peak flood season, the Urban Drainage and Flood Control District (UDFCD) contracts to have 24-hour meteorologist coverage for the Denver metro area. The UDFCD meteorologists forward daily forecasts to the city and the Boulder Office of Emergency Management (Boulder OEM). The UDFCD also operates and maintains a network of stream and rainfall gages in and around the city. This information provides real-time data that is monitored by city staff and the Boulder OEM during the flood season. In addition, the UDFCD emails daily forecasts and updates during severe weather, including the quantitative precipitation forecasts and storm tracks.

Due to the very short time frame that flooding can occur, there is often limited time available to provide adequate warning. This is particularly true for the city's smaller creek systems. In addition, thunderstorm cells can move and intensify very rapidly and often unpredictably. It is for these reasons that flood education, regulations and ordinances are critical components to the city's flood emergency preparedness program.

City of Boulder Flood Monitoring Cameras

The City of Boulder maintains cameras at Barker dam and at the lodge at Fourmile Creek. This allows for remote access during high water events. Conditions may be monitored from a safe distance.

Flood Awareness and Flood Safety Outreach

The city's annual flood education program elements include flood awareness advertisements in local newspapers, brochure inserts in April utility bills, and door hanger distribution to high risk properties. Ongoing but varying elements of the city's flood education program may include items such as targeted outreach to students, businesses or homeowners located in floodplains through the use of print material, public dialogue, etc.. In addition, the city maintains a wealth of flood-related information on a website located at www.boulderfloodinfo.net.

Gilbert White Memorial Flood Level Marker

The Gilbert White Memorial Flood Level Marker is an 18-foot tall LED-illuminated structure that shows the creek's 50-year, 100-year, 500-year and Big Thompson historic flood levels. The structure was installed in 2011 in Central Park near where the Broadway Avenue bridge crosses Boulder Creek. The structure was planned, designed and constructed by a committee of Gilbert's colleagues, friends and family, who also helped raise funds for the marker with private contributions and fundraising events. The marker was donated to the city and is maintained by the Parks and Recreation Department. A flood awareness interpretive display accompanies the memorial at the site.

"Flash Flood Alley" and "The Water's Edge"

The nonprofit Flood Safety Education Project, in coordination with local, state, and national partners, produced a series of highly detailed, interactive flood hazard maps and videos that explain the significant flash flood risks affecting decision makers, public safety personnel, and citizens of Boulder. These maps are GIS-based and use precisely crafted 3D views to display the 100-year and 500-year floodplains. A series of broadcast-quality videos were also produced that have aired on public access television.

The goal of this map/video project is twofold: 1) help increase awareness of the specifics of Boulder's worst flash flood zones and stream crossings (where people are most likely to die) and 2) the videos (12 short clips) explain what to do (and not do) before, during, and after a flood in and near these areas. Maps such as these can also be used to highlight other hazards and evacuation routes. A web-based version of this project can be accessed at www.floodsafety.com

Flood Mitigation Efforts Overview

The City of Boulder has taken many steps to reduce the threat from floods. The purchase of wetlands and open space not only helps preserve a unique way of life, it helps protect the community from the dangers of flooding. And, many of the flood mitigation efforts have benefits beyond keeping Boulder safe; they provide parks and trails, purify air, keep streams healthy, and make Boulder attractive.

- The city is active in the acquisition of open space and wetlands that give flood waters somewhere safe to go. Greenways provide wildlife habitat, trail systems, and flood protection.
- City requirements for tree planting help reduce the risk of urban flooding. Boulder's urban forest reduces stormwater runoff by approximately 12.2 million ft^3 per 2-inch storm event (enough water to fill Folsom Field, the university's football field several times).
- Floodplain regulations encourage safe development and may prohibit additional development in some areas.
- Flood mitigation master plans have been completed for most of the city's major drainageways.

- The city has purchased a number of structures in high hazard areas to be demolished or converted. The acquisition of structures creates park space and moves buildings out of danger.
- The city and County actively monitor local streams for flood danger. The city and County of Boulder Office of Emergency Management provides information about emergency preparation efforts.
- Pedestrian bridges in flood hazard areas are designed to break away in heavy flooding to minimize damage to the city's infrastructure.

Comprehensive Flood and Stormwater Utility Master Plan, 2004

The Comprehensive Flood and Stormwater Utility Master Plan provides a framework for evaluating, developing, and implementing various programs and activities in the utility. This plan replaced the 1989 Comprehensive Drainage Utility Master Plan. The plan's main objectives are to address flash flood hazards, stormwater quality, stormwater drainage, program integration and implementation, and financial considerations. The following summarizes the flood mitigation recommendations from the 2004 Comprehensive Flood and Stormwater Plan and other subsequent planning efforts and master planning studies.

Boulder Creek

Significant flood mitigation improvements to Boulder Creek were implemented as part of a joint use project with the Boulder Valley School District. Nine properties were purchased near Boulder High School and 13th Street. The structures were removed and the overbank area on the north side of the creek south of Arapahoe was excavated and graded to provide for additional flood conveyance and the construction of park and athletic fields. This work was completed in 1993. The following properties along Boulder Creek were also acquired and removed since 1989:

- City Tree House office structure on the south side of Boulder Creek east of the library
- Residence at 1234 18th Street along the north side of Boulder Creek
- 18-unit apartment complex at 299 Arapahoe just east of the Eben G. Fine Park site on the south side of Boulder Creek

Other flood control improvements that have been made along Boulder Creek since 1989 include the following:

- Eben G. Fine Park Stream Bank Restoration: Stream bank stabilization, erosion protection, habitat restoration, and recreation enhancements within Eben G. Fine Park between the northern sidewalk and Boulder Creek.
- Lower Arapahoe Avenue bridge structure replaced just east of Broadway
- 17th Street bridge replaced with a structure designed to pass 100-year flows
- Conveyance/detention storage improvements made along the creek through the University of Colorado's Research Park
- Railroad underpass structure at Cottonwood Grove

- Upper Arapahoe bridge structure replaced above Eben G. Fine Park
- 55th Street bridge replaced with a structure designed to pass 100-year flows
- Fixed concrete footbridge at Boulder High School replaced with a breakaway structure
- Broadway bridge over Boulder Creek replaced a structure designed to pass 100-year flows

The 2012 Boulder Creek Flood Mapping Study (BC FMS) updated the Boulder Creek Floodplain maps. It established floodplain boundaries, water surface elevations, conveyance zones and high hazard zones using current methodologies and will include improvements and changes along BC that have occurred since the maps were approved by FEMA in 1983. The BC FMS evaluates the floodplain from the area east of the confluence with Fourmile Canyon Creek, approximately three-quarters of a mile east of 61st Street, upstream to the mouth of Boulder Canyon west of Boulder's city limits. This model encompasses a stream reach length of 7 miles.

The 100- and 500-year floodplain, conveyance zone, and high hazard zone hazard boundaries have been updated and changed from the existing floodplain map. The changes to the hazard boundaries have caused some structures to be removed from the floodplain, conveyance and high hazard zones, while others have been identified as being newly located in these zones. The revised mapping provides the basis for floodplain land use regulation. A preliminary review of the final floodplain mapping indicated that there are 646 structures in the revised 100-year floodplain as compared to 680 structures in the previous 100-year floodplain.

The city's revised floodplain mapping was submitted to FEMA for review in the 4th quarter of 2012 and incorporated into FEMA's Digital Flood Insurance Rate Map.

Recognizing the value of protecting its own facilities from hazards, the Boulder Emergency Operations Center (EOC) was relocated in 2009 from a location within the Boulder Creek floodplain to a location on higher ground near the county airport. Other enhancements to the EOC have occurred because of the move.

South Boulder Creek

In 1996, the University of Colorado commissioned a flood study as part of its due-diligence review to purchase the 315-acre CU-Boulder South Campus. This study identified significant flood spills would impact east Boulder areas in what has subsequently been called the "West Valley Overflow" area.

In 1997, the city, Boulder County, the UDFCD and the Colorado Water Conservation Board, in cooperation with FEMA, commissioned another flood study (called the Taggart study) to verify the results of the CU study and to compare the results to the adopted floodplain mapping. Ultimately, the Taggart study was not approved and a new flood study, using more advanced hydraulic modeling and hydrology techniques, was commissioned by the city and the UDFCD. This study was performed by HDR Engineering and included a Climatology and Hydrology Report with reviews by an independent review panel, citizen advisory group and a hydrology advisory panel. The HDR Engineering study was completed in 2007 and resulted in a new flood map and formally identified the flood hazard that would impact the West Valley neighborhoods west of South Boulder Creek and north of US 36.

On April 17, 2007, City Council approved a motion authorizing the submittal of the flood study to FEMA. The flood mapping study was submitted in August 2007 and adopted late 2011. Prior to the mapping study, there were approximately 460 structures (with approximately 500 total dwelling units) in the 100-year floodplain. After being officially adopted by FEMA, there are now 700 structures (with a total of approximately 1,200 dwelling units) in the 100-year floodplain. Most structures within the existing regulatory mapping are also affected under the new study results; therefore, approximately 240 additional structures (with approximately 700 total dwelling units) were impacted. The majority of these structures are located within existing developed areas of the city within the West Valley area. A Risk Assessment completed in June 2009 estimated a 100-year event would result in $215 million in property damages.

The 2008 City of Boulder Multi-Hazard Mitigation Plan stated the need to prepare a master plan to evaluate flood mitigation alternatives for SBC as a high priority. The South Boulder Creek Flood Mitigation Planning Study began in early 2010 and was funded by the city and the UDFCD. A consulting team from CH2MHill was selected to perform the study. The study was focused on developing and evaluating alternatives designed to mitigate flood hazards affecting structures and areas within the current incorporated city limits, primarily within the West Valley area. A short list of project alternatives and an engineering recommendation were made and presented to the public, city boards and City Council. As a result, the Final South Boulder Creek Major Drainage Plan was adopted in August 2015.

Bear Canyon Creek

Significant flood mitigation improvements to Bear Canyon Creek have been implemented since 1989, including the following:

- Underpass and trail connections to CU main campus, Apache Trail, and Williams Village (1991)
- Trail reconstruction from Wellman Canal to Mohawk Drive (1992)
- Two underpasses, riparian habitat widening and restoration, wetland creation, landscaping, and trail reconstruction from Mohawk Drive to Gilpin Avenue (1993)
- Floodway improvements, two underpasses, and trail connections between Martin Drive and Moorhead (1994)
- Mohawk underpass and flood capacity improvements (1995)
- Gilpin underpass and flood control improvements (1997)
- Replacement of Broadway underpass, reconstruction of Anderson ditch crossing, and channel improvements (1999)
- Martin Park channel improvements to contain 100-year flows and storm sewer improvements including water quality pond construction (1999)

A flood mitigation master plan was completed for Bear Canyon Creek in 2016. Anticipated future projects are detailed in the document, include the following:

- Table Mesa Drive box culvert and separated grade crossing
- Foothills Parkway to Arapahoe drainageway and greenway improvements

Skunk Creek

The following projects were completed in the Skunk Creek drainage since 1989:

- The University of Colorado completed Skunk Creek stream channel reconstruction, flood control improvements, wetland and pond creation, water quality improvements, and trail construction from Foothills Parkway to Colorado Avenue in conjunction with the development of the CU Research Park (1991)
- Trail construction and wetlands creation from Colorado Avenue to Wellman Canal (1992)
- Underpasses beneath Baseline, U.S. Highway 36, and the U.S. Highway 36 on-ramp at Baseline (1995/1996)
- Developer constructed improvements from Colorado Avenue to Wellman Canal, including channel improvements, drop structure, and wetland creation (1996)
- Broadway pedestrian underpass increased channel capacity to 100-yr event and integrated a greenways trail segment. (2000)
- 27th Way pedestrian underpass increased channel capacity to 100-yr event and integrated a greenways trail segment. (2006)

Flood mitigation and property acquisition was considered in the community and environmental assessment process for the segment of Skunk Creek between Broadway and U.S. Highway 36, which was approved in 2001. However, flood mitigation work or property acquisition was not selected for implementation at the time. The City of Boulder has updated the floodplain mapping for Skunk Creek, Bluebell Canyon Creek, and King's Gulch. The updated mapping was approved by City Council on April 4, 2017.

Bluebell Canyon Creek/King's Gulch

No flood mitigation improvements or property acquisition along Bluebell Canyon Creek/King's Gulch have been initiated or planned.

Gregory Canyon Creek

Several flood mitigation improvements to Gregory Canyon Creek have been implemented since 1989, including the following:

- Replacement of culvert with a bridge driveway to Highlands School, near confluence with Boulder creek: The original culvert was constructed in 1970, and only conveyed 7cfs. Considering that this is the last culvert before Gregory Canyon Creek's confluence with

Boulder Creek, where attenuation will be at its highest, increasing capacity was a priority. Constructing a bridge at this location was determined to be the more cost-effective solution and would create an entrance to the historic Highlands School that reflects the history and character of Boulder. The bridge allows the creek to pass through in an open channel rather than a culvert and conveys 830 cfs. (2017)

- Construction of box culverts under Willowbrook Road (1996)
- Construction of rock drop structures in the creek bottom between University Avenue and Pleasant Street (1995)
- Replacement of an existing culvert crossing under Pleasant Street (1995)
- Reconstruction of a rock wall upstream of Pleasant Street (1995)
- Inlet improvements to the existing culvert under 7th Street (1995)
- Construction of rock drop structures between 7th Street and Pennsylvania Avenue (1995)
- Replacement of an existing culvert under Aurora Avenue and construction of associated rock drop structures, rock walls, and erosion protection upstream and downstream of Aurora Avenue (1995)

Additional property acquisition is planned along Gregory Canyon Creek as identified in the High Hazard Zone Property Acquisition Analysis (originally completed by Love & Associates in 1997 and updated by city staff in 2009). The city purchased a high hazard residential structure at 810 Marine St in 2012 and at 744 University St in 2017. The demolition of the Marine St property occurred in late 2012. There is also the potential for additional flood mitigation work along this drainageway.

The city commissioned two mini master plans to evaluate feasibility of mitigation measures along Gregory Canyon in 2010 and 2012. No feasible mitigation measures were identified for the 100-year floodplain other than opportunistically acquiring properties located in the high hazard zone.

Dry Creek

Flood mitigation improvements to Dry Creek, including the following, were implemented as part of the 55th Street roadway improvement project:

- Separating the crossing at the Wellman Canal
- Drainageway improvements upstream of the Wellman Canal to approximately Euclid Avenue
- Replacing a railroad bridge over the Dry Creek channel to meet 100-year flood carrying capacity (1998)

Additional flood mitigation measures were proposed in conjunction with the South Boulder Creek Flood Mitigation Plan recommended alternative.

Sunshine Canyon Creek

No flood mitigation improvements or property acquisition along Sunshine Canyon Creek have been initiated or planned.

Goose Creek

The following Phase II flood mitigation improvements for Goose Creek between Foothills Parkway and 30th Street were completed in 1995:

- Property acquisition
- Separated crossing of the Boulder and Left Hand and North Boulder Farmer's ditches
- Foothills Parkway to 30th Street channel and greenway improvements
- Box culvert and separated grade crossing at the Burlington and Santa Fe Railway
- Box culvert and separated grade crossing at 30th Street

Phase III flood mitigation improvements for Goose Creek between just west of 30th Street and just downstream of the Boulder White Rocks ditch were completed in 2002. This project included the following:

- Significant property acquisition
- Separated crossing of 28th Street
- 100-year channel and greenway improvements between just west of 30th Street to just downstream of the Boulder White Rocks ditch

Previously, no drainageway existed between downstream of the Boulder White Rocks ditch and 30th Street. The project created a drainageway through this area that removed numerous properties from the 100-year floodplain. The project also added a critical non-auto connection between the central area subcommunity and East Boulder, providing access to a major employment center, the Boulder Creek trail system, and what will eventually be the city's largest park. Several properties were acquired as part of the Phase III project:

- For the area between just west of 30th Street to 28th Street, the entire Fowler property was acquired under eminent domain proceedings. A portion of the Crouch and City Electric properties were also acquired based on a negotiated agreement.
- The Branding Iron Mobile Home Park was acquired under eminent domain proceedings, and a 1992 settlement agreement stipulated that the city complete the flood mitigation project on the west half of the mobile home park by December 31, 2000. A subsequent agreement extended this date, and the completion of the Phase III work fulfilled this requirement.
- For the area west of 28th Street, the Tebo/Chaknova property was acquired along with portions of the Chey Thuy and Credit Union properties.

The Goose Creek Phase IV project involves the area located within the Mapleton Mobile Home Park west to Folsom Avenue. The Phase IV project will include 100-year channel and greenway improvements through the mobile home park and separated crossing of the Boulder and White Rocks ditch.

To facilitate this project, the city purchased the Mapleton Mobile Home Park in 1998. The Phase IV project was completed in 2005. Other property acquisition along Goose Creek since 1989 includes a single-family residence at 1650 Alpine Street.

The city has contracted with ICON Engineering to develop updated floodplain maps for Upper Goose Creek and Twomile Canyon Creek. Hydraulic modeling of the project area and revised floodplain mapping was submitted to FEMA in 2013. There is potential for flood mitigation work upstream of Folsom Street following the remapping study.

Elmer's Twomile Creek

In 1994, the city identified the reach of Elmer's Twomile Creek behind the Willowbrook Townhomes just south of Glenwood Avenue for channel improvements to increase channel capacity, reduce perpetual maintenance activities, create wetland areas, and alleviate a persistent mosquito problem due to stagnant water in the channel. The city solicited the assistance of the UDFCD's Maintenance Program to complete this work in 1994. The work involved the cleaning and widening of the creek channel bottom, lining of one side of the channel with large boulders, installing river rock (cobbles) in the channel bottom, constructing a couple of rock drop structures, armoring banks around bends, and establishing some wetland areas just upstream of the improvements.

Greenway improvements between Goose Creek and Glenwood were completed in 2010. The project included separation of the creek from the Boulder and White Rock Ditch, channel improvements, a grade-separated crossing of Valmont Road, water quality improvements and extension of the multi-use path.

The Elmer's Twomile Creek Letter of Map Revision reflecting the project improvements was accepted by the Federal Emergency Management Agency (FEMA) and went into effect on September 7, 2011. The new mapping updates and replaces both the FEMA Flood Insurance Rate Map (FIRM) and the City of Boulder floodplain map.

Twomile Canyon Creek

The city has contracted with ICON Engineering to develop updated floodplain maps for Upper Goose Creek and Twomile Canyon Creek. Hydraulic modeling of the project area and revised floodplain mapping was submitted to FEMA in 2013. It is anticipated that a mitigation planning study will be completed following the remapping study.

Wonderland Creek

Flood mitigation improvements along Wonderland Creek since 1989 include:

- A box culvert with trail underpass at Broadway and drainageway improvements from 47th Street to Valmont
- A box culvert capable of passing the 100-year flood under Valmont Road was completed in 1992
- Construction of a 100-year capacity channel and multi-use path extension between Valmont Road and North Goose Creek

The city initiated a flood mapping study and flood mitigation master planning effort for both Wonderland Creek and Fourmile Canyon Creek in 2006. A letter of map revision for these two streams was approved by FEMA in November 2006, and the new floodplains became regulatory in late March 2007. The studies identified a previously unrecognized spill from Fourmile Canyon Creek to Wonderland Creek during storms that exceed the 50-year event. The spill begins near North Broadway and effectively doubles the 100-year flow in the downstream reaches of Wonderland Creek. The public process resulted in revisions to the study recommendations for a number of the stream reaches. City Council accepted a recommended flood mitigation plan for Wonderland Creek in November 2009. City staff documented the accepted recommendations in a final plan in 2011. The recommended improvements accepted by City Council in 2009 would greatly reduce the flood risk to numerous existing structures located along Wonderland Creek.

A Community Environmental Assessment Process (CEAP) Report was completed in 2010 that evaluated proposed flood mitigation improvements along Wonderland Creek from Foothills Parkway to 30th Street. This segment of Wonderland Creek has an extensive floodplain that includes numerous structures. The city developed a CEAP for the next upstream reach from the Diagonal Highway to Winding Trail in late 2012. The city has received federal funding for both of these stream reaches and construction began in 2015. The city with financial assistance from UDFCD purchased and deconstructed a single-family structure located in the High Hazard flood zone in 2010 (3115 Iris Avenue).

Fourmile Canyon Creek

Flood mitigation improvements along Fourmile Canyon Creek have included the following:

- Box culvert and separated grade crossing at Broadway (1995)
- Channel improvements and trail construction from Yellow Pine to Broadway (1998)
- Drainageway improvements associated with the Pleasant View Soccer Complex
- Acquired single-family residences at 1800 Violet and 2446 Sumac.

In 2006 the city initiated a flood mapping and mitigation study for Fourmile Canyon Creek and Wonderland Creek. A letter of map revision for these two streams was approved by FEMA in November 2006, and the new floodplains became regulatory in late March 2007. The studies identified a previously unrecognized spill from Fourmile Canyon Creek to Wonderland Creek during storms that exceed the 50-year event. The spill begins near North Broadway and effectively doubles the 100-year flow in the downstream reaches of Wonderland Creek. The public process resulted in revisions to the study recommendations for a number of the stream reaches. City staff documented the accepted recommendations in a final plan in 2011. During a 100-year storm event, flooding would prohibit safe vehicular access to Crest View Elementary School. In 2009, City Council stated the importance of mitigating flood conditions to allow safe vehicular access.

To accomplish this, channel improvements will be required at the crossings of Violet Avenue, Upland Avenue and 19th Streets along Fourmile Canyon Creek and at 19th Street along Wonderland Creek. Funding is shown in the Greenways and Flood Utilities 2013-2018 CIP for flood mitigation, a multi-use path connection and environmental restoration. The initial proposed project is for flood mitigation at 19th Street and Fourmile Canyon Creek. The city has completed a Community and Environmental Assessment Process (CEAP) to evaluate the social and environmental impacts of potential pedestrian, bicycle and vehicular access improvements for the area bound by 19th Street on the west, Upland Avenue on the north, 22nd Street on the east and Riverside Avenue on the south. The recommended flood improvement alternative is to replace the existing bridge at Fourmile Canyon Creek and 19th Street with box culverts sized to convey 100-year event flows. One of the box culverts would be used as a pedestrian and bicycle underpass. Final design is anticipated in 2013 with construction in 2014.

In fall of 2010 approximately 6,200 acres of land located west of the city burned. Approximately 20 percent of this area, known as the Fourmile Fire, is tributary to Fourmile Canyon Creek. Risk of flash flooding from the burn area will be elevated for the next 2-5 years. As a result, the UDFCD cleared debris and vegetation along Fourmile Canyon Creek upstream of Broadway in 2012. A new automated stream and rainfall gage was also installed in the tributary burn area in 2012.

Other improvements along Fourmile Canyon Creek include a private development located just east of Broadway. The project included channel improvements from Broadway to Violet Avenue and was completed in 2012 with partial city funding.

Viele Channel

Additional flood mitigation measures are proposed in conjunction with the South Boulder Creek Flood Mitigation Plan recommended alternative.

Stream, Wetland and Waterbody Protection Program

In February 1992, City Council adopted the following goal: "protect all wetlands in the Boulder Valley." This goal aims to ensure no net loss of wetland acreage or function. Since the city does not have the ability to protect all wetlands outside the city limits, at a minimum, significant wetlands outside the city and inside the Boulder Valley should be protected. The City of Boulder will be held to the standard of no net loss on city lands and for city projects both inside and outside the city limits. A wetland protection ordinance that requires a permit for certain activities in and around wetlands went into effect in 1993. This ordinance was revised in 2009. The implementation techniques listed below all contribute to the no net loss goal of the wetlands protection program:

- A local wetland permitting program

- Negotiated agreements with other governmental entities to protect wetlands
- Acquisition of significant wetlands
- Public education and technical assistance to encourage property owners to preserve, enhance, and restore wetlands through voluntary compliance
- Preservation, restoration, and enhancement of wetlands in conjunction with the development and maintenance of capital facilities
- Preservation, restoration, and enhancement of wetlands on city-owned or city-managed land.

4.4.5 Wildfire Mitigation Capabilities

Fire–Rescue Master Plan

The Fire–Rescue Master Plan, revised and adopted in June 2012, was developed to enhance the overall Fire–Rescue Program. The master plan was created through the cooperative efforts of Fire–Rescue Department members, staff from other city departments, and officials from emergency response agencies with which the department works. The Master Plan Committee identified several issues concerning service delivery, developed program goals and objectives, and identified recommendations to enhance the program. As of December 2017, the Plan is currently being updated to better reflect current and emerging trends.

Fire Training Center Relocation and Improvements

The Fire Department utilizes the Boulder Regional Fire Training Center, located on approximately ten acres of land east of the Boulder Reservoir, for much of its training activities. Opened in July 2010, under a cooperative agreement between the city and Boulder County, the center is operated today under an intergovernmental agreement between the city and the county. The site includes a 15,800-square-foot classroom/administration building, a training tower and a burn building. Specific features are designated for extrication training, propane fire scenarios, attic and garage fire simulations, rappelling practice, and a burn building that allows firefighters to experience actual fires that burn more cleanly and with less pollution than in older facilities. The center will give crews throughout Boulder County hands-on, realistic opportunities to train for emergencies close to the communities they serve. The facility is available to over 20 fire departments in Boulder County, enhancing their ability to respond effectively and safely.

A new wildland fire facility at the Fire Training Center site was completed in 2015.

City of Boulder Wildland Urban Interface Community Wildfire Protection Plan

The 2008 City of Boulder Community Wildfire Protection Plan (CWPP) is the result of a communitywide fire protection planning effort that included extensive field data gathering, compilation of existing fire suppression documents, a scientific analysis of the fire behavior potential of the study area, and collaboration with a variety of participants: homeowners, city officials, and the Colorado State Forest Service. A risk assessment estimated the risks and hazards associated with wildland fire in proximity to communities. In conjunction with values at risk, the assessment results were used to define areas of concern to assist with the prioritization of mitigation efforts. The plan offers solutions and mitigation recommendations to aid homeowners, land managers, and other interested parties in developing short- and long-term fuels and fire management plans. This project meets the requirements of the federal Healthy Forests Restoration Act (HFRA) of 2003 for community fire planning. The City is currently working to update the CWPP.

Boulder County Wildfire Mitigation Group

In the aftermath of the Black Tiger fire in 1989, which burned 44 homes and blackened over 2,000 acres of forested land in the western part of the County, just five miles from the City of Boulder, the Boulder County Wildfire Mitigation Group evolved. This group is headed by the Wildfire Mitigation Coordinator and consists of members from the County Land Use and Sheriff departments, the County's fire protection districts, the Colorado State Forest Service, the City of Boulder Fire–Rescue Department, the U.S. Forest Service, National Park Service, American Red Cross, representatives from the insurance, real estate and forest industry and private citizens. The group's mission is to discuss and coordinate actions that could help minimize loss of life and property from future wildfires. As part of their efforts, the GIS-based Wildfire Hazard Identification and Mitigation System (WHIMS) was developed to assess wildfire hazard using a hazard-rating model based upon wildfire behavior models and the expertise of wildfire behavior specialists.

City of Boulder Structure Protection Plan 2012

In 2012 the City of Boulder adopted the Structure Protection Plan. This document assists in the development of objectives, strategies, and tactics in protecting structures in—and immediately adjacent to—the municipal boundary of Boulder and provides guidance on ordering and placement of structure protection resources. It provides information graphically in order to provide information as quickly and methodically as possible with as little reading as possible. One of its key features is its modular design which facilitates the use of portions of the plan based on the fire location.

The plan divides the City of Boulder's wildland/urban interface into four zones: South, South Central, North Central, and North. These zones are based on topographic features and major road locations. The central dividing line is Boulder Canyon with two zones to the north and two to the south. Each zone contains three to four units. Within each unit, one to three tactical areas are defined with task assignments and resources required to accomplish those tasks.

The document is organized into sections based on four levels of resolution:

- **City-wide:** City-wide maps provide a broad overview of wildland/urban interface areas.
- **Zones:** Zone maps show the relationship of planning units to one another.
- **Units:** Planning unit maps provide depictions of structures, defensible features, and supervision.

- **Tactical:** Tactical maps provide detailed views of structures, defensible features, water sources, work assignments, suggested resources, and placement.

4.4.6 Multi-Hazard Mitigation Capabilities

Emergency Operations Plan Boulder County–City of Boulder

The 2014 Boulder Emergency Operations Plan (Boulder EOP) describes the structure and guidelines for managing a major emergency or disaster affecting Boulder. This plan is part of a larger system of inter-related plans at the local, state and federal levels. They are founded upon the National Response Framework (NRF) and the principles of the National Incident Management System (NIMS). The inter-related nature of the plans and incident management are designed to allow maximum coordination and cooperation between responders from all levels of government.

The EOP is designed in segments. The core document or Basic Plan (sometimes also referred to as the Basic Emergency Operations Plan - BEOP) describes the overall structure, assignment of responsibilities and general guidance for the overall emergency management program. The program includes activities related to mitigating the threat(s), preparing for the inevitable incident, response and recovery from an incident. The ESF Annexes contain the primary details of the Emergency Operations Plan. These annexes are function-specific guidelines for the coordination and the delivery of specific services. These annexes are developed by the affected organizations, and are to include agreements on policies and procedures for responding to specific requests. Each ESF Annex may also include a number of attachments, such as reference documents, resource lists, checklists and contact information for personnel. The EOC Support Annexes are specific guidelines for operating the EOC and the primary management positions within the EOC structure. These annexes include the EOC Operations Manual, the Policy Group Manual, the Planning Section Manual and the Logistics Section Manual.

Large Scale Incident Plan and Hazard-Specific Operational Support Annexes

The intent of the Large-Scale Incident Plan is to provide a common operational framework for initial response to an incident where multiple agencies and/or disciplines are involved. The Hazard-specific operational annexes provide field reference and resource material, and provide a scalable response framework appropriate to specific hazards. These annexes are currently being updated, and include the following hazards: Avalanche, Civil Unrest, Dam Failure, Explosion, Flood, Hazardous Materials Incident, Landslide, Pandemic Flu, Passenger Airliner Crash, Severe Winter Weather, Tornado, Train Incident, West Nile Virus, Wildland Fire, Windstorm, Subsidence, Drought, Earthquake, Extreme Temperatures, Severe Weather (lightning/hailstorm).

Boulder County Incident Management Team

This is an All Hazards Type 3 Incident Management Team (IMT) comprised of city employees, county employees, volunteer firefighters, and other private citizens. IMTs are "typed" according to the complexity of incidents they are capable of managing and are part of an incident command system. An IMT will provide the command and control infrastructure that is required to manage the logistical, fiscal, planning, operational, safety and community issues related to the incident/emergency. There are 5 types of IMTs, with Types 3-5 designated for standing teams at the local level. They manage incidents that extend into multiple operational periods and require a written Incident Action Plan (IAP). These incidents can include weather-related disasters such as a tornado, earthquake, or flood; a joint law enforcement operation; public health emergency; or a planned exercise or event. A Type 3 IMT may initially manage more complex incidents that later transition to a National Level IMT (Type 2 or Type 1). Its mission is to provide a qualified Type-3 Incident Management Team (IMT) as a mutual aid resource to fire departments and other entities in Boulder County for wildfires, emergency incidents and planned events of significance.

Boulder County Warning Systems

The city and County of Boulder have numerous types of warning systems in place to alert residents of potential and imminent danger from natural and manmade hazards. These systems are discussed below.

Emergency Outdoor Warning Sirens

The siren system is an all-hazard warning system used to alert citizens who are outdoors to potential danger. More than thirty outdoor warning sirens are in place across Boulder County. The sirens are located in Boulder, Longmont, Lafayette, Lyons, Eldorado Springs, Jamestown, Superior, Erie and the University of Colorado at Boulder. The sirens will broadcast a voice message immediately following the siren signal to inform the public of the situation and what actions should be taken.

The outdoor warning sirens are sounded only in the event of an emergency or during pre-announced tests. The sirens are activated through the Boulder County Sheriff’s Communications and Boulder Police and Fire Communications centers. During an actual emergency, the sirens will sound for five minutes. During a test, they will sound for two minutes. The same signal is used whether the emergency is a flood, tornado or other disaster. While the sirens have “voice over” capabilities, citizens are encouraged to tune to a local TV or radio station for further information when the sirens are sounded.

CU Lightning Detection and Warning System

The University of Colorado Boulder (CU) campus has a lightning warning system that detects the presence of electromagnetic fields that trigger lightning. The system does not need storms or strikes in the area to predict lightning and can predict first and “out of the blue” strikes. If lightning is predicted, the system will sound an alarm for about 30 seconds and activate a strobe light that will remain active until danger has passed. Once the siren blast stops, the light will continue to flash to indicate that unsafe conditions still exist. Once conditions improve, the all clear signal sounds. This consists of 3 shorter blasts of the siren and then the light will stop flashing (this cycle will repeat if conditions change again). Signage regarding the operation of the device is posted at each station. The six stations include Student Recreation Center, Williams Village Fields, Business Field, Kittredge Fields, Farrand Field and Franklin Field (operated as a strobe-only device; the light will begin to flash to indicate dangerous conditions exist and the light will cease to flash when conditions improve).

Emergency Warning and Evacuation System

The existing 911 database of telephone numbers and addresses is used in combination with detailed maps to help determine the geographic boundaries of an impacted area. The system is capable of making up to 1,200 calls per minute. It is designed to deliver recorded information to endangered people in advance of a disaster. Messages can be delivered in various languages. They can also be sent to pagers, cell phones and the Emergency Alert System.

Emergency Alert System

In January of 1997, the Federal Communications Commission (FCC) replaced the Emergency Broadcast System (EBS) with the Emergency Alert System (EAS). This digital system works with both new and established communications technologies, including satellite, broadcast, and cable systems. The EAS helps to make the disaster warning system more effective by emphasizing speed, reliability, and efficiency. It is designed to reduce property damage, injuries, and deaths resulting from natural and manmade disasters. There are eight Boulder County EAS stations according to the Denver Metro–Local Area 3 plan. The EAS can be activated locally by the emergency management director, Boulder County sheriff, and the manager of the Boulder Police and Fire Communications Center and Boulder County Sheriff's Communications Center.

NOAA Weather Radio All Hazards

NOAA Weather Radio All Hazards is a service of the National Oceanic and Atmospheric Administration (NOAA). It provides continuous broadcasts of the weather information directly from National Weather Service offices. Weather messages are repeated every four to six minutes and are routinely revised every two to three hours, or more frequently if needed. The broadcasts are tailored to weather information needs of people within the receiving area. During severe weather, National Weather Service forecasters can interrupt the routine weather broadcasts and substitute special advisory, watch and warning messages. Special weather radio receivers are available for purchase at local electronics stores. Although NOAA classifies coverage in Boulder as reliable, the signal may not be received in all canyon areas. The National Weather Service also emails messages to Boulder officials during severe events. The City was granted NOAA's StormReady designation in 2012.

Metropolitan Emergency Telephone System

The Metropolitan Emergency Telephone System (METS) is a specially designed telephone system for alerting law enforcement, other response agencies, and Denver media of emergency situations. METS is available in the Boulder Police and Fire Communications Center, and is sometimes used to receive information about emergency events around the Denver metro area. The Boulder Police and Fire Communications Center has the ability to instantly notify all Denver media of any life-threatening situations in Boulder County that can be immediately broadcast on all Denver radio and television stations, but this system is used infrequently.

National Warning System

The National Warning System consists of private line voice circuits. The detection systems of the North American Air Defense Command (NORAD), and other sources, provide the information from which NORAD commanders determine the probability or imminence of attack. At the present time, it is used mostly by the National Weather Service in Denver to disseminate weather-related warnings to warning points in Colorado.

Preparedness Checklists

The City of Boulder OEM website provides an emergency preparedness guide available for download, which has information for the public on planning and preparing for unexpected disasters and emergencies along with helpful checklists.

Drought Management

Source Water Master Plan

The city obtains its water from the Boulder Creek basin and from the western slope though the Colorado-Big Thompson and Windy Gap projects. Flows in the watershed basins supplying each source are highly variable from year to year. Because of this, the amount of water derived from each of Boulder's water sources and delivered into the municipal system also varies. These water rights are described in more detailed below.

- **Boulder Creek Basin Water Rights**—The city's water rights in the Boulder Creek basin include direct use and storage rights on Boulder Creek, Middle Boulder Creek and North Boulder Creek. Exchange rights allow the city to release water into Boulder Creek near 75th Street from Boulder and Baseline Reservoirs in exchange for increased diversion at the city's direct use and storage points on Middle and North Boulder Creeks. Most of the city's water rights are absolute. The city also has several conditional rights that are being developed for future use.
- **The Colorado-Big Thompson (CBT) Project**—Boulder receives western slope water at Boulder Reservoir from the CBT Project facilities. The city utilities own 21,015 CBT units out of a total of 310,000 units in the project. At present, CBT deliveries to Boulder can only be made from April through October of each year due to winter operating limitations on canals. Boulder uses CBT water for direct treatment at the Boulder Reservoir Water Treatment Plant, either diverted directly from the Boulder Feeder Canal or pumped out of Boulder Reservoir, and as a source of exchange water to increase water deliveries to the Betasso Water Treatment Plant and to meet some of its contractual delivery obligations to the Silver Lake Ditch.

- **The Windy Gap Project**—The Windy Gap Project delivers western slope water to municipal and industrial water users on the eastern slope through CBT facilities. The city has an allotment contract for 37 units out of a total of 480 units in the project. These units, when used in conjunction with storage space in Boulder and Barker Reservoirs and "borrowing" of CBT water, can deliver up to 3,700 acre-feet per year. Unlike much of the rest of Boulder's water, the Windy Gap water is fully consumable, meaning that the return flows (wastewater effluent and lawn watering return flow) from this source can be reused either for exchange back into Boulder's water system, for augmentation and replacement purposes, or for leasing to other downstream users.

Boulder's water supply system also includes many storage, conveyance, hydroelectric, and treatment facilities. The city owns approximately 7,200 acre-feet of reservoir storage in the North Boulder Creek watershed and 11,686 acre-feet of storage in Barker Reservoir on Middle Boulder Creek. Boulder also controls 8,500 acre-feet of storage in Boulder Reservoir. Boulder's two water treatment facilities are the Betasso plant, with approximately 45 million gallons per day of treatment capacity and the Boulder Reservoir plant at 16 million gallons per day. The city operates eight hydroelectric plants within the municipal water supply system. Four of these plants are located on raw water pipelines, and four are on treated water transmission pipelines. Electricity generated at these plants is sold to Xcel Energy.

Water provided by the city serves a variety of purposes ranging from those uses that require an assured supply, such as drinking water and firefighting, to those uses that can tolerate occasional restrictions, such as lawn irrigation and car washing. It is recognized that no municipal water supply can ever be 100 percent reliable against all risk factors and that the economic and environmental opportunity costs of reducing the risks of occasional water shortages are significant. The reliability standards for the city's municipal water supply that were adopted by City Council in 1989 are:

- For those water uses deemed essential to the maintenance of basic public health, safety, and welfare, such as indoor domestic, commercial, industrial uses, and firefighting uses, the city will make every effort to ensure reliability of supply against droughts with occurrence intervals of up to 1,000 years.
- For the increment of water use needed to provide continued viability of outdoor lawns and gardens, the city will make every effort to ensure reliability of supply against droughts with occurrence intervals of up to 100 years.
- For the increment of water needed to fully satisfy all municipal water needs, the city will make every effort to ensure reliability of supply against droughts with occurrence intervals of up to 20 years.

The Source Water Master Plan anticipates that the city will maintain a diversity of water supply sources (both eastern and western slope sources) to hedge against droughts and increase water supply reliability. In addition, the master plan identifies multiple-purpose uses for the city's municipal raw water supplies. In addition to municipal uses, the city's raw water supply has been used for maintaining streamflow and enhancing stream habitat in Boulder Creek and its tributaries and for leasing to downstream agricultural and recreational users.

Based on extensive modeling of the city's municipal water system and its water supply basins, it is believed that, assuming a continuation of historical hydrologic conditions and absent curtailment of Boulder's Colorado-Big Thompson (CBT) and Windy Gap project yields due to a Colorado River Compact Call, the city has sufficient raw water supply holdings to meet its reliability criteria while serving the projected water needs associated with expected development levels within the city's water service boundaries based on the current BVCP planning area. Future water needs were evaluated in the Raw Water Master Plan in 1989. The city's water demand forecasts have been updated several times since then based on more recent demographic and land use forecasts provided by the city's Planning and Development Services and changes in water use factors due to water conservation practices.

The reliability of Boulder's water supply system was most recently assessed as part of a study of the potential consequences of climate change on Boulder's water supply system, which combined paleohydrology with climate change projections to provide a robust statistical evaluation of the city's water supply system. Modeling in that study showed that the city's existing water supply system (including its present water rights portfolio) would be able to provide sufficient water to meet the city's reliability criteria at full buildout of the city's water supply service area in 12 of the 18 alternative climate change scenarios evaluated in that study. In the most severe scenario examined (which combined the greatest projected level of greenhouse gas emissions with a "dry" global climate model at 2070 conditions), voluntary use reductions or moderate use restrictions would be necessary in 8% to 16% of the years due to reduced supplies during drought. Severe use restrictions would be required in only two years out of 439 years when drought conditions would reduce water yields significantly. In only one year out of 439 years did water yields drop below the level of meeting essential indoor needs. A major caveat for this study was that the modeling assumed that there would be no curtailment of Boulder's CBT and Windy Gap project yields due to a Colorado River Compact Call.

The recently completed Source Water Master Plan has recommended an array of capital improvements and additional management studies of the of the city's water supply system.

With respect to the water distribution system, loss prevention capabilities include:

- Redundant pipelines, treatment facilities, storage tanks and pumping equipment to assure delivery of water based on a number of vulnerability scenarios.
- Facilities have been designed and constructed to resist the effects of ground movement, wildfire and in some cases floods.
- Redundant telecommunications facilities are available for system control purposes.

Wastewater Utility Master Plan

The Wastewater Utility Master Plan (WWUMP) is the overarching planning document that is intended to present key issues, programs, projects and associated budgets for the collection system, wastewater treatment plant and water quality programs. The WWUMP is supported by three primary planning documents for the Wastewater Utility: the Wastewater Collection System Master Plan (WWCSMP), the Wastewater Treatment Plant Master Plan (WWTPMP), and the Water Quality Strategic Plan (WQSP). Boulder's wastewater collection system and the 75th Street WWTP serve residences and businesses within the 26 square-mile Wastewater Utility Service Area (WUSA). Boulder's collection system currently serves a population of approximately 110,000 people and 101,000 employees associated with commercial and industrial business.

Loss prevention elements include:

- Wastewater treatment facility (WWTF) is protected by a flood levee designed with 3 feet of freeboard above the 100-year water surface elevation.
- Interceptor sewers have been encased in concrete at major drainageway crossings.
- The WWTF has two power feeds in case one is interrupted by a natural hazard such as lightning or wildfire.

Information Technology Master Plan and Continuity of Operations Plan

Information Technology based communications and applications are critical to disaster response and recovery efforts. The city Department of Information Technology has a Master Plan and Continuity of Operations (COOP) Plan. The COOP plan has been integrated into the WebEOC program so it can be readily accessed and updated when needed. The city has also housed redundant servers at the OEM outside of the 100-year floodplain.

Boulder County Climate Change Preparedness Plan

In 2011-2012 the City of Boulder jointly developed a climate change preparedness and adaptation plan with Boulder County. The planning project systematically considered the effects of projected climate changes and identified opportunities for adaptive planning efforts to address the challenges and opportunities posed by changing climate conditions in Boulder County. The plan identifies the potential impacts of climate change and explored the implications of these changes on four key sectors: water resources, emergency management, public health, and agriculture and natural resources. The planning process was designed such that the Plan itself can work in concert with the City of Boulder’s and Boulder County’s existing plans, processes, programs, and policies that currently, or could potentially, address climate-related issues. For example, current capabilities include those of the Office of Emergency Management, stormwater and floodplain management programs, Community Rating System (CRS) participation, hazard mitigation and emergency operations plans, and programs to improve forest health. The Plan emphasizes the need for additional disaster management planning, including long-term recovery plans and debris management plans. The plan also emphasizes the importance of the hazard mitigation plan and recommended incorporating climate change considerations into the hazard mitigation plan updates. By developing this plan through a collaborative process, the city and County has a better understanding of the impacts of climate change and how climate change may stress capabilities currently in place to manage flood and wildfire risk and other potential emergencies. The Plan was finalized in May 2012 serves as a resource for County and municipal planners as they integrate climate change as an aspect of ongoing planning efforts with the intent to help the city and Boulder County be more resilient to impacts of climate change. The plan is accessible on the Boulder County website.

West Nile Virus Mosquito Management Plan

The City of Boulder adopted the West Nile Virus Mosquito Management Plan in 2006 (formerly the West Nile Virus Vector Control Plan) in response to the public health threat of the virus. Species of mosquitoes from the genus *Culex* are able to carry and potentially transmit the West Nile Virus to humans.

Beginning in June of each year and continuing through September a baseline monitoring plan is implemented and lands owned or managed by the city are surveyed to evaluate the presence of these species. Areas that will be routinely surveyed include all known potential mosquito habitat areas found on city-owned lands within the city limits and on city-owned lands outside of the city limits.

These breeding sites are regularly monitored throughout the mosquito season and if the species of mosquito larvae that can transmit West Nile virus are found, the site is immediately treated with a larvicide. Adult mosquitoes are also monitored with a grid of traps throughout the city and samples from sentinel traps are tested for the presence of West Nile Virus. Control efforts during the larval stage are the most cost-effective and efficient means to eliminate mosquitoes at their source and, therefore, to most effectively reduce the risk of human infection. Measures to control mosquito larvae consist of treatment of breeding habitats with a bacterium that attacks the larvae. Control of the larvae limits the possible future need for nonbiological control of adult target mosquitoes, such as pesticide fogging or spraying.

5 MITIGATION STRATEGY

Requirement §201.6(c)(3): [The plan shall include] a mitigation strategy that provides the jurisdiction's blueprint for reducing the potential losses identified in the risk assessment, based on existing authorities, policies, programs and resources, and its ability to expand on and improve these existing tools.

This section describes the mitigation strategy process and mitigation action plan for the City of Boulder's Multi-Hazard Mitigation Plan. It explains how the City accomplished Phase 3 of FEMA’s 4-phase guidance—Develop the Mitigation Plan—and includes the following from the 10-step planning process:

- Planning Step 6: Set Goals
- Planning Step 7: Review Possible Activities
- Planning Step 8: Draft an Action Plan

5.1 Mitigation Strategy: Overview

The results of the planning process, the risk assessment, the goal setting, the identification of mitigation actions, and the hard work of the HMPC are captured in this mitigation strategy and mitigation action plan. As part of the 2018 plan update process, a comprehensive review and update of the mitigation strategy portion of the plan was conducted by the HMPC. Some of the goals and objectives from the 2012 plan were revisited, reaffirmed, and refined. The end result is a mitigation strategy that reflects the updated risk assessment, progress on mitigation actions, and the new priorities of this plan update. To support the updated goals, the mitigation actions from 2012 were reviewed and assessed for their value in reducing risk and vulnerability to the planning area from identified hazards and evaluated for their inclusion in this plan update (See Section 5.4.1). Section 5.2 below identifies the current goals and objectives of this plan update and Section 5.4.2 details the updated mitigation action plan.

5.2 Goals and Objectives

Requirement §201.6(c)(3)(i): [The hazard mitigation strategy shall include a] description of mitigation goals to reduce or avoid long-term vulnerabilities to the identified hazards.

Up to this point in the planning process, the Hazard Mitigation Planning Committee (HMPC) has organized resources, assessed natural hazards and risks, and documented mitigation capabilities. A profile of the County’s vulnerability to natural hazards resulted from this effort, which is documented in the preceding chapter. The resulting goals, objectives, and mitigation actions were developed based on this profile. The HMPC developed the new updated mitigation strategy based on a series of meetings and worksheets designed to achieve a collaborative mitigation planning effort, as described further in this section. The goals for this plan were developed by the HMPC based on the plan's risk assessment. This analysis of the risk assessment identified areas where improvements could be made and provided the framework for the HMPC to formulate planning goals and objectives and the mitigation strategy for the City of Boulder.

Goals were defined for the purpose of this mitigation plan as broad-based public policy statements that:

- Represent basic desires of the community;
- Encompass all aspects of community, public and private;
- Are nonspecific, in that they refer to the quality (not the quantity) of the outcome;
- Are future-oriented, in that they are achievable in the future; and
- Are time-independent, in that they are not scheduled events.

Goals are stated without regard for implementation, that is, implementation cost, schedule, and means are not considered. Goals are defined before considering how to accomplish them so that the goals are not dependent on the means of achievement. Goal statements form the basis for objectives and actions that will be used as means to achieve the goals. Objectives define strategies to attain the goals and are more specific and measurable.

Based upon the risk assessment review and goal setting process, the HMPC developed the following goals with several objectives and associated mitigation measures. These were revisited and validated by the HMPC during the 2018 HMP update process. There were some minor language changes to Goal 3 to incorporate resiliency, and there were some modifications to the objectives based on HMPC input. Objectives 2.1 and 3.2 below were either revised or added as part of the update process. These goals and objectives provide the direction for reducing future hazard-related losses within the City of Boulder.

Goal 1: Increase Community Awareness of Boulder's Vulnerability to Natural Hazards

- Objective 1.1: Inform and educate the community about the types of hazards the City of Boulder is exposed to, where they occur, and recommended responses

Goal 2: Reduce Vulnerability of People, Property, and the Environment to Natural Hazards

- Objective 2.1: Reduce impacts of hazards on residents and vulnerable populations in the community.
- Objective 2.2: Reduce impacts to critical facilities and services
- Objective 2.3: Reduce impacts to existing buildings and infrastructure to the extent possible
- Objective 2.4: Reduce impacts to future development and infrastructure to the extent possible
- Objective 2.5: Reduce impacts to the city's natural and historic resources
- Objective 2.6: Reduce impacts to public health

Goal 3: Increase Interagency Capabilities and Coordination to Reduce the Impacts of Natural Hazards and Increase Community Resiliency

- Objective 3.1: Continue to collaborate and coordinate with other agencies on planning, projects, hazard response, and funding opportunities.
- Objective 3.2: Minimize economic impacts of natural hazards.

5.3 Identification and Analysis of Mitigation Actions

Requirement §201.6(c)(3)(ii): [The mitigation strategy shall include a] section that identifies and analyzes a comprehensive range of specific mitigation actions and projects being considered to reduce the effects of each hazard, with particular emphasis on new and existing buildings and infrastructure.

In order to identify and select mitigation measures to support the mitigation goals, each hazard identified in Section 4.1: Identifying Hazards was evaluated. Once it was determined which hazards warranted the development of specific mitigation measures, the HMPC analyzed a set of viable mitigation alternatives that would support identified goals and objectives. Each HMPC member was provided with the following list of categories of mitigation measures, which originate from the Community Rating System:

- Prevention
- Property Protection
- Structural Projects
- Natural Resource Protection
- Emergency Services
- Public Information

The HMPC members were also provided with several lists of alternative multi-hazard mitigation actions for each of the above categories (See Appendix C). A facilitated discussion then took place to examine and analyze the alternatives. With an understanding of the alternatives, a brainstorming session was conducted to generate a list of preferred mitigation actions.

5.3.1 Prioritization Process

Once the mitigation actions were identified, the HMPC was provided with several decision-making tools, including FEMA's recommended prioritization criteria, STAPLEE sustainable disaster recovery criteria; Smart Growth principles; and others, to assist in deciding why one recommended action might be more important, more effective, or more likely to be implemented than another. STAPLEE stands for the following:

- Social: Does the measure treat people fairly? (e.g., different groups, different generations)
- Technical: Is the action technically feasible? Does it solve the problem?

- Administrative: Are there adequate staffing, funding, and other capabilities to implement the project?
- Political: Who are the stakeholders? Will there be adequate political and public support for the project?
- Legal: Does the jurisdiction have the legal authority to implement the action? Is it legal?
- Economic: Is the action cost-beneficial? Is there funding available? Will the action contribute to the local economy?
- Environmental: Does the action comply with environmental regulations? Will there be negative environmental consequences from the action?

In accordance with the DMA requirements, an emphasis was placed on the importance of a benefit-cost analysis in determining action priority. Other criteria used to assist in evaluating the benefit-cost of a mitigation action includes:

- Does the action address hazards or areas with the highest risk?
- Does the action protect lives?
- Does the action protect infrastructure, community assets or critical facilities?
- Does the action meet multiple objectives (Multiple Objective Management)?
- What will the action cost?
- What is the timing of available funding?

The mitigation categories, multi-hazard actions, and criteria are included in Appendix C: Mitigation Categories, Alternatives, and Selection Criteria.

With these criteria in mind, team members were asked to prioritize projects with the above criteria in mind. After determining the initial hierarchy of how the actions should be ranked through discussion at the HMPC meeting, team members further discussed their reasoning for the prioritization with side-bar meetings in follow-up to the meeting. This process provided the end priority for the new mitigation actions identified in 2017. The priority levels on existing mitigation actions continuing in the plan from 2012 were also revisited using this process, and in some cases revised with to reflect current priorities.

The process of identification and analysis of mitigation alternatives allowed the HMPC to come to consensus and to prioritize recommended mitigation actions. During the voting process, emphasis was placed on the importance of a benefit-cost review in determining project priority; however, this was not a quantitative analysis. After completing the prioritization exercise, some team members expressed concern that prioritizing all the actions as a group is not very effective, since many of the actions are department-specific. However, the team agreed that prioritizing the actions collectively enabled the actions to be ranked in order of relative importance and helped steer the development of additional actions that meet the more important objectives while eliminating some of the actions which did not garner much support.

Benefit-cost was also considered in greater detail in the development of the Mitigation Action Plan detailed below in Section 5.4. Specifically, each action developed for this plan contains a description of the problem and proposed project, the entity with primary responsibility for implementation, any other alternatives considered, a cost estimate, expected project benefits, potential funding sources, and a schedule for implementation. Development of these project details for each action led to the determination of a High, Medium, or Low priority for each.

Recognizing the limitations in prioritizing actions from multiple departments and the regulatory requirement to prioritize by benefit-cost to ensure cost-effectiveness, the HMPC decided to pursue: mitigation action strategy development and implementation according to the nature and extent of damages; the level of protection and benefits each action provides; political support; project cost; available funding; and individual jurisdiction and department priority.

This process drove the development of an updated, prioritized action plan for the City of Boulder. Cost-effectiveness will be considered in greater detail through performing benefit-cost project analyses when seeking FEMA mitigation grant funding for eligible actions associated with this plan.

5.4 Mitigation Action Plan

Requirement §201.6(c)(3)(iii): [The mitigation strategy section shall include] an action plan describing how the actions identified in section (c)(3)(ii) will be prioritized, implemented, and administered by the local jurisdiction. Prioritization shall include a special emphasis on the extent to which benefits are maximized according to a cost benefit review of the proposed projects and their associated costs.

This section outlines the development of the updated mitigation action plan. The action plan consists of the specific projects, or actions, designed to meet the plan's goals. Over time the implementation of these projects will be tracked as a measure of demonstrated progress on meeting the plan's goals.

5.4.1 Progress on Previous Mitigation Actions

During the 2018 update process the HMPC reviewed and evaluated the 2012 mitigation strategy to determine the status of the actions. The purpose of this was to measure progress by determining which actions were completed, and to revisit the remaining items to determine if they should be carried forward or removed from the plan. The 2012 mitigation strategy contained 33 separate mitigation actions. Of these actions, eight have been completed. Three of the actions from 2012 were determined to be similar to, and merged with, other actions in the revised action plan. The actions that have been completed are shown in Table 5.1. In general, the review shows that much progress has been made since 2012, and there has been a lot of successful mitigation projects completed since the original 2008 plan. Implementation of the actions has resulted in greater community awareness of Boulder’s vulnerability to natural hazards and reduced vulnerability for hazards such as flood. Several of these actions have increased the response capabilities of the city, and thus will help save lives in future incidents. Table 5.2 lists 15 actions from the 2012 plan being carried forward, as well as 10 new or revised mitigation actions. More detailed descriptions of those actions follow Table 5.2. Actions from 2012 that are not carried forward in this plan are summarized in Table 5.3.

Other actions have seen much progress and are close to completion. One example is the "Develop a Recovery Plan" action. Following the floods in September 2013. an After Action Report was developed and completed in 2015. The recovery plan is currently underway with completion scheduled for early 2018.

During the update and revision to the mitigation strategy the priority of the 2012 actions were revisited. Revised priorities are reflected in Table 5.2. Additionally, there were four actions that were removed since the 2012 plan. These actions are listed in Table 5.3 with notes explaining the reason for the deletion. An example of a removed action is "Implement a System of Automatic Vehicle Location for Police, Fire and Snow Removal Vehicles". This action was deleted during the 2018 update process due to lack of progress and diminished interest.

Table 5.1. Completed or Revised Mitigation Actions from 2012 Plan

Hazard(s)	Action Description	Status	Comments/Progress
Multi-Hazard	Preplan Prime Evacuation Points/Shelter Locations for Emergency Situations (fire, flood, snow, etc.)	Completed	Boulder OEM has worked with the Red Cross to verify shelter locations and Americans with Disabilities Act compliance. Shelter locations designated by the City Manager's Office include the North, South and East Boulder Rec Centers.
Multi-Hazard	Develop Recovery Plan	Nearly Complete	Following the September 2013 flood disaster, an After Action Report was developed and completed in 2015. The recovery plan is underway with completion scheduled for early 2018.
Multi-Hazard	Become a StormReady Designated Community	Completed	The City of Boulder and Boulder County were designated as StormReady in 2013.
Flood	Update Flood Preparedness Web Mapping Site	Completed	The city has reprogrammed the site using JavaScript, HTML5 and CSS. The updated Flood Preparedness website is now available on a desktop, tablet or mobile device.
Flood	Develop a Critical Facilities Floodplain Ordinance	Completed	The ordinance was approved on Oct. 1, 2013 and became effective on March 1, 2014.

Hazard(s)	Action Description	Status	Comments/Progress
Fire	Structure Protection Plan	Completed	The Structure Protection Plan was completed in 2012. This plan will be updated periodically as needed. As an additional safeguard for new structures built in the wildland fire area, the city adopted the International Wildland-Urban Interface Code (IWUIC) on Oct. 1, 2013. The effective date of the IWUIC was Jan. 31, 2014.
Fire	Construct New Wildland Fire Facility	Completed	The Wildland Fire Station (Station 8) was completed in August 2015 at a cost of $2.46 million.
Fire	Increase Boulder Wildland Fire Hazard Mitigation Crew Funding	Completed	In 2014, the city completed a three-year plan to upgrade six seasonal wildland firefighting positions to fulltime. Additionally, Public Works pays the Fire Department mitigation crew to perform specified wildland fire mitigation near or around Public Works facilities as needed. The need varies from year-to-year.
Flood	Implement Mitigation Plan for Fourmile Canyon Creek and Wonderland Creek	Revised	Action items pertaining to specific flood mitigation plans have been combined into one action item with broader implementation text.
Flood	Mitigate Flooding in South Boulder Creek Floodplain	Revised	Action items pertaining to specific flood mitigation plans have been combined into one action item with broader implementation text.
Fire	Implement Forest Ecosystem Management Plan	Revised	Combine with Parks and Open Space and Mountain Parks needs for conducting hazardous fuels reduction on city-owned open spaces.
Fire	Develop a Wildland Fire Mitigation Program for the Middle Boulder Creek Watershed	Revised	Text revised from developing plan to implementing plan and expanded to include other watersheds that supply water to the City of Boulder.

5.4.2 Continued Compliance with NFIP

Given the flood hazard and risk in the planning area, and recognizing the importance of the NFIP in mitigating flood losses, an emphasis will be placed on continued compliance with the NFIP by the City of Boulder. As of October 2016, City of Boulder was listed as a Class 5 CRS Community. As an NFIP and CRS participating community the city has and will continue to make every effort to remain in good standing with NFIP. This includes continuing to comply with the NFIP's standards for updating and adopting floodplain maps and maintaining and updating the floodplain zoning ordinance. There are several action items identified in Table 5.2 that address specifics related to NFIP continued compliance. Other details related to NFIP participation are discussed in the community capabilities in Section 4.4 of this plan and the flood vulnerability discussion in Section 4.3.

5.4.3 Updated Mitigation Action Plan

A summary of the action items is captured in Table 5.2, including a description of the action, priority, the year the action was first identified, the timeframe for implementation, what goals it the action is linked to, and the priority for the action. For each identified project a worksheet designed to capture additional details was filled out by the HMPC member or organization taking the lead on project implementation. These details include: project background, other alternatives considered, responsible entity, priority, cost, benefits (losses avoided), and potential funding. Actions that were identified in the 2008 or 2012 plan and carried forward in this plan update also have a description of progress to date. As the city is largely built out, many of these mitigation actions are intended to reduce impacts to existing development. Actions that protect future development from hazards, as required per the DMA 2000 regulations, are addressed by the city's continued compliance with the NFIP and CRS as well as through implementation of the Boulder Revised Code, Boulder Valley Comprehensive Plan and building code enforcement. See the discussion in Section 4.4 related to these existing policies and regulations.

It is important to note that the City of Boulder has numerous existing, detailed project descriptions (including structural flood hazard mitigation projects) in other planning documents, such as the Comprehensive Flood and Stormwater Utility Master Plan, various flood mitigation master plans, and capital improvement budgets and reports. These projects are considered to be part of this plan, and the details, to avoid duplication, should be referenced in their original source document. Many of these studies include more detailed alternatives analysis and benefit-cost analyses. The city also realizes that new project needs and priorities may arise as a result of a disaster or other circumstances and reserves the right to support these projects, as necessary, as long as they conform to the overall goals of this plan.

Table 5.2. City of Boulder Mitigation Action Plan Summary

	City of Boulder Action**	Responsible Office	Schedule	Status	Priority	Estimated Cost	Potential Funding	Link to Goals*
Multi-Hazard Actions								
1	Enhance critical facility data	Risk Management	Implemented annually or as funding becomes available	New 2018	Low	$10,000 initial + $3,000-$5,000/year	Staff time and City funds	2,3
2	Emergency back-up power	Facilities and Asset Management	2022	New 2018	High	$400,000 per building for generator; $75,000 per building for quick connect	City's General Fund Capital Fund	2
3	Hazard education	Boulder OEM, Fire, Police, CRS	Annually 2018-2022	New 2018	Medium	$10,000	Staff time and City funds	1,2,3
4	Increase outdoor and individual warning systems capacity available	Boulder Planning	2018	New 2018	High	$100,000	Public/private partnership	1
5	Outreach efforts associated with BoCo911Alert.com	Boulder OEM	2018-2020	Continuing	High	$10,000	Staff time and City funds	1
6	Develop updated city continuity of operations and emergency evacuation plans	CMO / Department heads	2018	Continuing	High	Staff time, $50k – 100k	Grants	1, 2, 3
7	Prepare pre-disaster FEMA forms	Boulder OEM	2013	Continuing	Low	Staff time	Staff time	1, 2, 3
8	Increase Public Awareness of Flood Risk and Safety Measures	Boulder OEM / Public Works	2018 and Annually	Continuing	High	Staff time	Staff time	1, 2, 3
9	Enhance outdoor warning system	Boulder OEM	2018-2020	Continuing	Low	$25,000 per siren, $250,000 total	City funds	1, 2
10	Maintain Urban Tree Canopy	City Parks and Recreation, Forestry Division	2018	Continuing	High	$200,000 city funds $520,000 other	City funds, grants, partnerships	2

	City of Boulder Action**	Responsible Office	Schedule	Status	Priority	Estimated Cost	Potential Funding	Link to Goals*
Flood Actions								
11	Implement Flood Mitigation Plans	City of Boulder Utilities Division	Implemented as funding becomes available	New 2018	High	+$100 million in mitigation projects	City of Boulder Stormwater fund, FEMA's Pre-Disaster Mitigation program	
12	Relocate fire station outside 100-year flood risk	FAM/Fire and Rescue	Begin in 2018	Continuing	Medium	$13 million	Grants, bonds, city funds	2
13	Prioritize flood hazards	Public Works	2018	Continuing	High	$50k - $100k	UDFCD, city funds	2
14	Update the Comprehensive Flood and Stormwater Master Plan	Public Works	2018	Continuing	High	$50k - $100k	UDFCD, city funds	2
15	Develop flood mitigation plans following mapping updates	Public Works	2020	Continuing	High	$100k - $150k	UDFCD, city funds	2
16	Acquire High Hazard Zone properties	Public Works	As properties become available	Continuing	Medium	Based on property value	UDFCD, city funds	2
17	Update city's floodplain maps	Public Works	Keep 10 yrs. current	Continuing	Medium	$100k - $150 k per study	UDFCD, city funds	1, 2
18	Implement a community assisted floodproofing program focusing on critical facilities	Public Works	January 1, 2019	Continuing	Low	Staff time / $50k annually	City funds	1, 2
Wildfire Actions								
19	Implement Wildland Fire Mitigation Program for Watersheds	City of Boulder Utilities Division	Pending funding	New Revised	Medium to High	$1 million	City of Boulder Water Resources Fund and the Colorado State Forest Service	2, 3
20	Wildland Fire Management Plan	OSMP/Fire	2018	New in 2018	Medium	$50 - $100K	Grant funding	1,2, 3
21	Update CWPP	OSMP/Fire	2019	New in 2018	Medium	$50,000	Grant funding	1,2, 3
22	Implement Community Wildfire Protection Plan	Boulder Fire, OSMP	Annually through 2022	Continuing	High	TBD by project	Grants, city funds	2

	City of Boulder Action**	Responsible Office	Schedule	Status	Priority	Estimated Cost	Potential Funding	Link to Goals*
23	Implement forest ecosystem management plan	OSMP	Annually through 2022	Continuing	High	$80k - $150 k annually	Grants, city funds	2
	Drought Actions							
24	Review city landscape codes for drought	Development Review	2013	Continuing	Medium	Staff time	Staff time	2
25	Update City's Drought Plan and Identify and Implement Priority Projects Identified in the Drought Plan	Public Works	2018-19	Continuing	High	$1.5 million+	Grants, city funds	1, 2, 3

Goal 1: Increase Community Awareness of Boulder's Vulnerability to Natural Hazards

Goal 2: Reduce Vulnerability of People, Property, and the Environment to Natural Hazards

Goal 3: Increase Interagency Capabilities and Coordination to Reduce the Impacts of Natural Hazards and Increase Community Resiliency

Table 5.3. Removed Actions from 2012 Plan

City of Boulder Action	Responsible Office	Reason for Removal
Implement automatic vehicle location system	Boulder OEM	No progress has been made on this activity since the 2012 plan. With little interest in continuing progress, this activity has been removed from the plan update.
Enhance Flood Warning System on Smaller Tributaries	Public Works	The intent of this action item was to install live feed video cameras on the drainageways in city limits. After further discussion with OEM staff, an enhanced rain gauge system higher in the watershed provides a higher degree of warning and emergency preparedness. The OEM is currently working with other agencies to install these gauges at appropriate locations.
Continue the City of Boulder West Nile Virus Mosquito Monitoring and Control Program	Public Health	The management plan has been successful. The West Nile Virus risk index has not reached levels to warrant further action or response. Continued monitoring and control is in place and considered a capability.
Implement the City's Forest Ecosystem Management Plan	OSMP	Open Space and Mountain Parks Department has completed more than 1,400 acres of forest restoration and fire mitigation work during the past 10 years. The department continues to fund an annual seasonal crew of eight people that is solely dedicated to the implementation of the city's Forest Ecosystem Management Plan. No additional resources are necessary, but there will be an ongoing budget item to support seasonal crews as a regular part of the OSMP operating budget.

Multi-Hazard Mitigation Actions

1. Enhance Critical Facility Data

Project Description/Background: The city's critical facility data is collected and organized in accordance with the critical facility ordinance. The data is not a comprehensive list of all critical facilities and infrastructure as established in FEMA guidelines. The data needs to be regularly updated and maintained to facilitate future updates to this plan and for use in other applications

Other Alternatives: None

Responsible Office: Risk Management

Priority (High, Medium, Low): Low

Cost Estimate: $10,000 initial + $3,000- $5,000/year update

Benefits (Avoided Losses): Map based critical facility data (in addition to facilities designated by city code) would allow the City risk management office to more quickly and effectively able to track and update critical facilities and develop more accurate representations of risk.

Potential Funding: Staff time and city funds

Schedule: Annual updates for current critical facilities data and as funding becomes available for enhancing data.

Status: New in 2018

2. Emergency Back-Up Power

Project Description/Background: Two of the city's critical and essential facilities do not have back-up power – the Municipal Building and the Main Library. The Municipal Building houses the City Manager Office, the City Attorney Office, Central Records, and City Council Chambers. The Main Library is a mass gathering location and provides key services and is an information hub for many Boulder citizens. The Main Library also houses the city's television services and studio. Both facilities lack emergency back-up power. Note, both facilities are located in the 100-year floodplain and surrounded by the high hazard and conveyance zones. Generators would likely have to be placed on the flat roofs.

Other Alternatives: A quick-connection for a large generator could provide a less expensive option for extended outages along with small UPS systems to key systems.

Responsible Office: Facilities and Asset Management

Priority (High, Medium, Low): High

Cost Estimate: $400,000 per building for generator; $75,000 per building for quick connect

Benefits (Avoided Losses): Key staff productivity losses due to power outages; loss of public access television; disruptions to City Council meetings, Planning Board meetings and other board and committee meetings held both at the Municipal Building and Main Library

Potential Funding: Compete with other needs in city's new General Fund Capital Fund; currently $400M identified as unfunded in city needs with a capital fund of $3.7 million in 2018

Schedule: by 2022

Status: New in 2018

3. Hazard Education

Project Description/Background: Considering the physical, social, and economic challenges of the 21st century, communities need to become more resilient. Resilient individuals, communities and cities are resourceful, adaptable, flexible, inclusive and integrated. Being resilient includes being aware of vulnerabilities, preparing for the future and having the ability to act quickly in an emergency. Being resilient also means having a strong network of people to reach out to and rely on. This project would promote hazard education through a collaborative network of community leaders, organizations, and government departments providing outreach and education to the public on resilience individually and at a community level. The City's participation in the CRS includes annual flood hazard awareness activities that can be leveraged into this multi-hazard hazard education project.

Other Alternatives: CERT programs and traditional push/pull models

Responsible Office: Office of Emergency Management, Fire, Police

Priority (High, Medium, Low): Medium

Cost Estimate: $10,000

Benefits (Avoided Losses): Increase in personal preparedness and community resiliency to decrease reliance of governmental assistance during disasters

Potential Funding: City funds, staff time

Schedule: Annually 2018-2022

Status: New in 2018

4. Increase Individual Warning Systems Capacity Available

Project Description/Background: All areas of city are not covered by sirens, which primarily are intended to warn people in the outdoors (see separate project to enhance outdoor sirens). This project would create a wireless mesh network to increase resiliency to outages and enhance warning systems capacity.

Other Alternatives: None

Responsible Office: Boulder Planning

Priority (High, Medium, Low): High

Cost Estimate: $100,000 initial estimate

Benefits (Avoided Losses): Increase resiliency of wireless network

Potential Funding: Public/Private Partnership

Schedule: 2018

Status: New in 2018

5. Outreach Efforts Associated with BoCo911Alert.com

Project Description/Background: Now that many families had stopped using telephone land lines efforts need to be made to ensure that emergency notifications can be sent to people potentially impacted by emergency situations. Public safety agencies throughout Boulder County are switching to a new emergency notification system which is accessible at BoCO911Alert.com. This system will allow residents of the county and all cities within the county to be notified of an emergency situation in a variety of ways, including on their cell phone, home and work phones and by text messaging and e-mail. This project would include outreach efforts to raise awareness about BoCO911Alert.com to increase the number of subscribers.

Other Alternatives: Emphasize radio or television communications instead.

Responsible Office: Boulder OEM

Priority (High, Medium, Low): High

Cost Estimate: $10,000

Benefits (Avoided Losses): Improved ability to notify the public of emergency situations. Potential for avoided deaths and injuries due to early warning notification.

Potential Funding: City funds

Schedule: 2018-2020

Status: Continuing – Not Started

6. Develop Updated City Continuity of Operations and Emergency Evacuation Plans

Project Description/Background: The city has outdated or incomplete plans for staff evacuation and continuity of operations following a disaster. These plans need to be updated / developed to ensure adequate safety and services.

Other Alternatives: Continue using the existing plans developed by individual departments for evacuations. Continuity of operations plans for the entire city have not been developed.

Responsible Office: City Manager's Office and Individual Department Heads.

Priority (High, Medium, Low): High

Cost Estimate: Dedicated staff time and $50,000 - $100,000 for consultant services support

Benefits (Avoided Losses): Potential city employee lives saved during an event; planning to continue basic services following a disaster and minimize disruptions.

Potential Funding: State Emergency Management Performance Grants, city funds

Schedule: Within the 5-year planning period

Status: Continuing

7. Prepare pre-disaster forms to facilitate public infrastructure mitigation through the FEMA public assistance program during post-disaster recovery

Project Description/Background: Following a disaster there is a 60 day filing time to complete project sheets to qualify for funding under the Public Assistance (PA) program within a Stafford Act (Presidential Disaster) Declaration. Having the critical infrastructure project sheets completed in advance and updated yearly ensures that the City of Boulder will qualify to the maximum benefit under a disaster declaration within reimbursement cost share guidelines. In addition, if mitigation projects are included in the assessment and written into the project sheets it will increase opportunities to apply mitigation projects into the recovery process. This project would entail assembling, in a pre-disaster environment, data for PA forms for infrastructure that would be expected to be impacted by; flood, fire, or technological hazards.

Other Alternatives: Wait until the disaster and hire consultants to complete the arduous process and hopefully complete the projects within the time frame allotted and to the detail required to maximize benefits.

Responsible Office: Boulder Office of Emergency Management

Priority (High, Medium, Low): Low

Cost Estimate: Staff time to create and maintain the project sheets and printing of project sheet plan.

Benefits (Avoided Losses): Having the critical infrastructure project sheets completed in advance and updated yearly ensures that the City of Boulder will qualify to the maximum benefit under a disaster declaration within reimbursement cost share guidelines.

Potential Funding: City staff time; FEMA PA funding following Presidential Disaster Declaration with 25% local cost share.

Schedule: As staff time becomes available

Status: Continuing

8. Increase Public Awareness of Flood Risk and Safety Measures

Project Description/Background: Increased public awareness of hazards in the city and county is a goal of this plan and a continuing action of the city and County of Boulder Office of Emergency Management. This project would continue and supplement existing outreach efforts with additional web-based information on hazards and personal preparedness measures.

Progress to Date: This action is ongoing.

The Boulder OEM launched a redesigned website in August 2010, which includes warning system information, hazard information, personal preparedness information and resources, and a downloadable emergency preparedness guide. In addition, Boulder OEM introduced a Facebook page, Twitter account and RSS feeds to increase outreach efforts and information flow to the public during an emergency.

The City of Boulder Public Works Department provides flood hazard information and safety preparedness updates on the website: www.boulderfloodinfo.net. Each year, city staff distributes flood awareness materials, organizes outreach booths and presents flood information to community members from various sectors. Activities can include online media, social media, print advertisements, presentations, education programs or utility bill inserts. The materials and activities include important flood safety messages and points users to the city website which includes more detailed information about flood plain maps and safety measures that should be taken pre, post and during a flood event. Each year, efforts have reached more than 100,000 public members.

Other Alternatives: No action

Responsible Office: Boulder Office of Emergency Management**;** City of Boulder Public Works Department

Priority (High, Medium, Low): High

Cost Estimate: Limited direct financial costs through use of existing staff time

Benefits (Avoided Losses): Benefits include reduced impacts to life and property as a result of a more hazard awareness and better prepared citizenry. A better prepared public will reduce the impacts on emergency services during hazard events.

Potential Funding: Grants (state), in-kind staff time

Schedule: Implemented annually

Status: Continuing; See Progress to Date notes

9. *Enhance Outdoor Emergency Warning System - add sirens to NW, East & SE areas of the City*

Project Description/Background: There are 11 outdoor warning sirens operating in the City of Boulder currently. The sirens should be evaluated for all risk placement to ensure coverage serves the identified hazard message capability of the system. For example, the sirens in sector 5 may need to be moved further west to increase coverage capability. The movement may require additional sirens towards the core of the city in the Northern corridor. In addition, to cover the entire city in outdoor warning sirens it possibly could require 6 additional sirens. Yearly verification of the functional status of all sirens is performed and the sirens are remotely tested once a month from April to August with silent testing weekly.

Progress to Date This action is in progress. A siren inventory has been verified to determine coverage gaps and determined approximate six locations where sirens should be installed; three sirens west of Broadway (one west of Lee Hill Road and Broadway, one west of Linden Avenue and Broadway, and one in the vicinity of Boulder Community Hospital); the neighborhood southeast of the intersection of Baseline Road and Foothills Parkway (near the East Boulder Recreation Center or Manhattan Middle School); the area around 55th Street and Valmont Road; and also the city properties in Gunbarrel, as there are no nearby sirens in that area at all. Sirens are intended for outdoor warning, so they don't necessarily need to be placed only in neighborhoods but anywhere the active Boulder citizens play outdoors.

Other Alternatives: Outdoor emergency warning systems typically involve audible mechanisms that may be heard over large areas. Fixed-location warning sirens are generally the most efficient systems for such coverage. Other alternatives for emergency warning could be human-intervention methods, such as loudspeaker systems affixed to moving vehicles and individual door-to-door contacts by emergency personnel. These human-intervention alternatives require time consuming dissemination and place people in harm's way during critical emergencies. Other alternatives include radio and telephone notifications that may not be effective for notifying larger area and outdoor recipients. No other alternative appears to offer an advantage for outdoor warning over an audible siren system.

Responsible Office: Boulder Office of Emergency Management, City of Boulder, Boulder Fire, Boulder Public Works

Priority (High, Medium, Low): Low

Cost Estimate: Estimated $45,000 per siren unit with a recommendation of at least 6 additional sirens citywide, total initial cost: $250,000

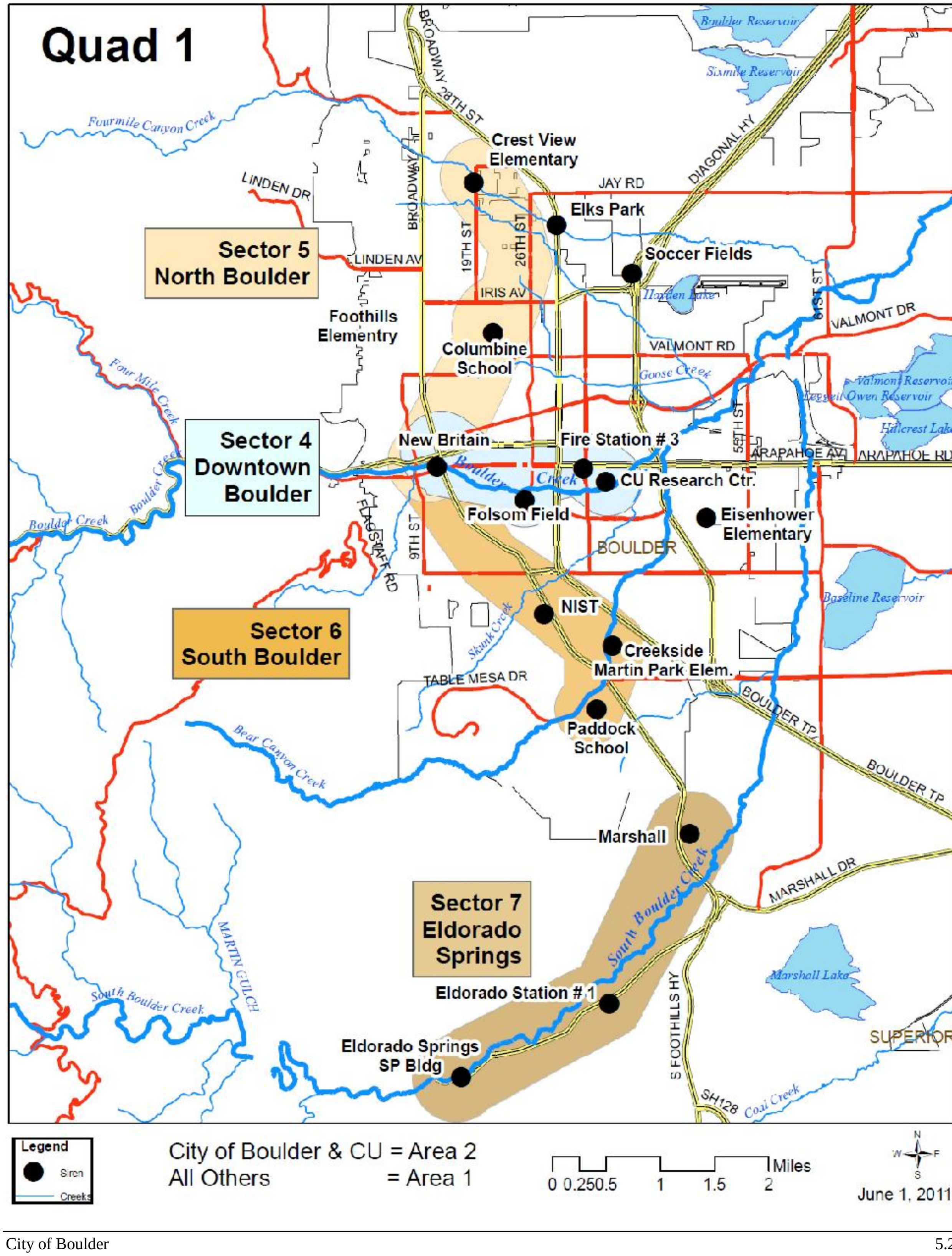
Benefits (Avoided Losses): Outdoor emergency warning sirens offer a notification system that can be implemented immediately by emergency operations in time of need. Warning sirens are recognized by the general population as a standard and accepted method of emergency notification. While multiple methods of emergency notification, including pagers, radio, television, reverse 911 calls, Internet, and cell phone listserv messaging, should be employed to reach all populations in the community, the outdoor emergency warning siren system offers the first line of defense in emergency preparedness. Having complete coverage ensures a standard of minimum alerting capability throughout the city.

Potential Funding: City of Boulder

Schedule: 2018-2020 with specific dates to be determined based on policy decision by city

Status: See Progress to Date

Figure 1.1. City of Boulder Siren Locations



10. Maintain Urban Tree Canopy

Target a 2:1 replacement ratio for the planting program and target species diversity such that no tree species comprises more than 10 percent of the current population (consistent with City of Boulder Environmental Management Audit 2001).

Project Description/Background: Boulder's urban forest provides nearly $5.2 million in annual environmental, economic, and social services to the community. These services include air quality improvements, energy savings, stormwater runoff reduction, atmospheric CO2 reduction, and aesthetic contributions to the social and economic health of the community. As UTC increases or decreases, so do the services provided. Maintaining the UTC is critical to ensuring the long term environmental and socio-economic services to the community.

The amount and distribution of leaf surface area, or the urban tree canopy (UTC), is the driving force behind the urban forest's ability to produce services for the community. The City of Boulder has an average UTC of approximately 16% based upon 2013 LiDAR imaging. However, only 25% of the UTC is under public jurisdiction; the remaining 75% is on private property.

The three largest threats to the Boulder UTC are:

1. Invasive insect and disease pests such as emerald ash borer (EAB),
2. Climate change (which can exacerbate insect populations) or individual severe weather events, and
3. Development.

Ash trees contribute more to the UTC on an individual tree basis than many other tree species as ash trees are large maturing, long-lived, and have large canopies. Emerald Ash Mar is now well established and causing mortality of approximately 12% of Boulder's trees (equal to approximately 25% of the UTC) over the next ten years. Implementing a strategy to maintain the urban tree canopy by preserving tree species other than Ash and planting replacement trees could prevent significant environmental, aesthetic and economic impact for decades to come.

Achieving a no-net-loss UTC goal will require enormous action and unprecedented levels of collaboration between public land managers, private landowners and planners working on how to respond and adapt to a changing climate and environment. Because 75% of the UTC is on private property, a partnership with the community is vital to achieve the UTC goal over the next 20 years. Forestry has a goal to plant 500 public trees annually on public property, but a minimum of 1300 trees must be planted on private property and existing trees preserved and maintained on both public and private property.

Progress to Date: Extensive public outreach has occurred to collect feedback to inform the Urban Forest Strategic Plan (UFSP). Potential action items for the UFSP include but are not limited to: establishment of a no-net-loss UTC goal for Boulder, updates to city codes and policies to better protect public and private trees to achieve the UTC goal, streamlined Forestry operations and increased funding to reach the desired community level of service for urban forest management, establishment of a partner non-profit urban forest foundation or “tree trust” to leverage additional financial and community support for the urban forest and the development of a community-led volunteer program focused on the UTC.

Other Alternatives: Continue current planting and pruning schedule

Responsible Office: Parks and Recreation Department, Forestry Division

Priority (High, Medium, Low): High

Cost Estimate: A partnership with the community is vital to achieve the UTC goal over the next 20 years. Forestry has a goal to plant 500 public trees annually on public property, but a minimum of 1300 trees must be planted on private property and existing trees preserved and maintained on both public and private property.

The cost would be shared between public and private property owners since 75% of the UTC is on private property. Costs include the purchase and planting of tree stock, the ongoing maintenance needed to ensure the health of these trees and for public education and outreach to encourage citizens to plant appropriate trees and preserve and maintain existing private trees.

The annual cost for Boulder Forestry to plant 500 trees into city parks and public street rights-of-way is approximately $200,000 and funding is currently divided among three sources: Forestry operations, emerald ash borer Capital Improvement Program (EAB CIP) and tree mitigation funding (received when public trees are removed per B.R.C. 6-6-7, Mitigation of Trees or Plants Removed or Destroyed). The EAB CIP is currently projected to last only through 2022 however and the mitigation received varies widely year to year, so a stable funding source is needed for the long term.

With Boulder Forestry planting 500 trees/year, the remaining gap of 1300 trees at an annual cost of $520,000 must come from other sources. The Parks and Recreation department has partnered with the National Arbor Day Foundation to give away tree seedlings to Boulder residents and Boulder Forestry annually provides 1200 seedlings to BVSD children. The department is also exploring other options to assist private property owners such as subsidized tree sales and development of a non-profit Tree Trust to accept private funding for tree planting and establishment efforts. The Urban Forestry Strategic Plan will also recommend a higher prioritization for tree preservation and increased tree planting through other public projects.

Benefits (Avoided Losses): Reduced stormwater runoff, reduced urban heat island effects.

Potential Funding: Parks and Recreation operational and CIP funding, Mitigation funds (received when public trees are removed per B.R.C. 6-6-7, Mitigation of Trees or Plants Removed or Destroyed), exploring options for development of non-profit Tree Trust to accept private funding

Schedule: Forestry staff developed an EAB Long Term Strategy to respond to the infestation within the city and potentially slow the spread throughout Boulder and to nearby communities. The strategy – including the development of a broader scope Urban Forest Strategic Plan (UFSP)– was discussed with City Council in Study Sessions in September 2015 and October 2017. The expected completion and adoption of the UFSP is planned for 2nd quarter 2018.

Status: See Progress to Date

Flood Mitigation Actions

11. Implement Flood Mitigation Plans

Project Description/Background: The city has a comprehensive flood management program for its 15 major drainageways that is designed to reduce the risks of flooding, minimize loss of life and property damage during a flood event, and support recovery following a major flood. As part of the flood management program, the city develops mitigation plans to evaluate opportunities to reduce flood risk. These mitigation plans analyze and recommend capital improvement projects along the 15 major drainageways in Boulder.

Other Alternatives: No action or maintain status quo.

Responsible Office: City of Boulder Utilities Division

Priority (High, Medium, Low): High

Cost Estimate: Over $100 million dollars of flood mitigation projects have been identified. Individual project costs vary.

Benefits (Avoided Losses): Flood mitigation projects would provide flood relief to several neighborhoods, businesses, and public buildings.

Potential Funding: City of Boulder Stormwater fund, FEMA's Pre-Disaster Mitigation program

Schedule: Flood mitigation master plans have been completed for most of the city's major drainageways. Projects will be implemented as funding becomes available.

Status: New in 2018

12. Relocate Fire Station out of 100-year Floodplain

Project Description/Background: Fire Station 3, located at the intersection of Arapahoe Avenue and 30th Street, has been identified in the Fire & Rescue Master Plan and capital improvement plan for relocation, because it is in the 100-year floodplain, it is not ideally placed for current and future emergency response time goals, and it has construction deficiencies in terms of community meeting space, energy efficiency standards, and physical space needs for apparatus re-deployment. Relocation will allow for better service delivery to parts of the city that are not currently within a four-minute response time (industry standard) of any of our fire stations. This station is a high priority due to its location in the flood plain, high energy use, and limited capacity. Relocation to a new facility will help the city achieve and maintain energy goals.

A new station will significantly improve response coverage to a rapidly growing portion of the city. In addition, the station will allow for existing fire response resources to be repositioned and increase the efficiency of department operations while allowing for a potentially increased scope of emergency medical service (EMS) delivery.

Learn more: www-static.bouldercolorado.gov/docs/fire-master-plan-1-201306031433.pdf

Other Alternative Continue the practice of relocating fire station personnel and vehicles during high flood potential times.

Responsible Office: Facilities and Asset Management / Fire and Rescue

Priority (High, Medium, Low): Medium

Cost Estimate: $17,000,000 – including cost of land purchase

Benefits (Avoided Losses): Loss in fire and emergency services capability at the city's busiest fire station when needed most. Avoided damages to building and contents.

Potential Funding: Bonds / Public-private partnership; FEMA PDM, FEMA post disaster HMGP or PA mitigation funds.

Schedule: In 2018, the city will work to secure a suitable property for the relocation of Fire Station #3 and begin site planning.

Status: Continuing, not completed

13. Flood Hazard Prioritization

Project Description/Background: The city prepares flood mitigation studies for creek systems. The flood master plans prioritize flood mitigation among each creek system. The city, however, has not conducted an evaluation to prioritize flood mitigation efforts city wide.

Other Alternatives: Continue to implement flood mitigation efforts as prioritized by creek system.

Responsible Office: Public Works Utilities Division

Priority (High, Medium, Low): High

Cost Estimate: $50,000 - $100,000

Benefits (Avoided Losses): Ability to implement the highest priority flood improvements based on a city-wide evaluation. The analysis will help justify public expenditures and secure grant funds.

Potential Funding: UDFCD, Public Works funding

Schedule: 2018

Status: Continuing, not completed.

14. Update the Comprehensive Flood and Stormwater Master Plan (CFS)

Project Description/Background: The city prepared a Comprehensive Flood and Stormwater Master Plan (CFS) in 2004. The plan provides a framework for evaluating, developing, and implementing programs and activities related to the city's flood management, stormwater quality and stormwater drainage problems. The plan is nearly eight years old and requires updating.

Other Alternatives: Continue to rely on the 2004 master plan.

Responsible Office: Public Works Utilities Division

Priority (High, Medium, Low): Medium

Cost Estimate: $50,000 - $100,000

Benefits (Avoided Losses): An updated master plan would provide current guidance for the city's programs related to flood management, stormwater quality and stormwater drainage.

Potential Funding: UDFCD, city funds

Schedule: 2018

Status: Continuing, not completed

15. Develop Flood Mitigation Plans After Flood Mapping Updates.

Project Description/Background: Develop major drainageway flood mitigation plans following floodplain mapping updates. Following the 2013 flood, the city accelerated its flood mitigation plan work program. Floodplain mitigation studies have been developed for Fourmile Canyon Creek, Wonderland Creek, South Boulder Creek, Boulder Creek, Gregory Canyon Creek and Bear Canyon Creek. A flood mitigation master plan is being developed for Twomile Canyon Creek, Upper Goose Creek, Skunk Creek, Bluebell Canyon Creek and King's Gulch. Flood mitigation plans have not been developed for Sunshine Creek and Boulder Slough.

Other Alternatives: Emphasize flood insurance and post flood mitigation efforts.

Responsible Office: Public works/Utilities

Priority (High, Medium, Low): High

Cost Estimate: $100,000 - $150,000 per study

Benefits (Avoided Losses): Constructed improvements provide direct relief from flooding with associated life safety enhancements and protection of the city's built infrastructure. The mitigation plan reports will result in an analysis of the preferred mitigation alternative.

Potential Funding: UDFCD, Public Works funds

Schedule: Complete remaining plans by 2020Following each flood mapping update

Status: Completed/Continuing

16. Acquire Properties in the High Hazard Flood Zone

Project Description/Background: Numerous structures are located in the City of Boulder's High Hazard Flood Zone where there exists the potential for risk to life and safety. In 1989, Boulder created a floodplain ordinance that prohibits new construction of structures intended for human occupancy in the high hazard zone. As part of this objective, community acquisition and removal of high hazard structures has been a key component of mitigating floodplain impacts in the city. The High Hazard Zone acquisition program has been in place for many years with funding by the flood management utility. Available funds are leveraged with matching funds from other organizations such as the Urban Drainage and Flood Control District, and purchases are made as high hazard properties become available on the market.

Progress to Date: The following properties have been acquired for the sole purpose of removing them from flood risk and not for the purpose of completing a drainageway improvement project:

- 299 Arapahoe
- 744 University Ave
- 810 Marine
- 1228 17th St.
- 1650 Alpine
- 1655 9th St.
- 1800 Violet
- 2150 Emerald
- 2400 Topaz
- 2435 Topaz
- 2446 Sumac
- 2490 Topaz
- 2650-2660 13th St.
- 3115 Iris
- 4018 26th St.

Other Alternatives: Acquire properties post-flood.

Responsible Office: City of Boulder Utilities Division

Priority (High, Medium, Low): Medium

Cost Estimate: $500,000 annually is programmed into the Stormwater and Flood Management Utility Fund for pre-flood property acquisitions.

Benefits (Avoided Losses): Would eliminate the most severe flood risks to human safety. Would also reduce the potential for flood-related damage to structures in the high hazard zone, which are subject to greater damage potential given the higher velocities and depths of flooding.

Potential Funding: Increased utility budgeting, federal matching funds, bonding, etc. FEMA PDM, FEMA post disaster HMGP funds. Flood Mitigation Assistance.

Schedule: List of highest priority High Hazard Zone structures has been developed and will be periodically updated with new mapping studies. Structures are purchased opportunistically.

Status: Completed/Continuing

17. Update City's Floodplain Mapping

Project Description/Background: The city recognizes that floodplain maps need to be periodically revised to incorporate changes in development, modeling techniques, and improved topographic data as well as LOMR information.

The city's goal is to keep all 14 tributaries to Boulder Creek current within a 10-year timeframe. The following table illustrates completed mapping studies:

Drainageway	Mapping Study
Bear Creek	1987
Sunshine Canyon Creek	1987
Fourmile Canyon Creek	2006
Wonderland Creek	2006
South Boulder Creek/Dry Creek	2008
Viele Channel	2008
Gregory Canyon Creek	2009
Elmers Twomile Creek	2011
Boulder Creek	2012
Goose/Twomile Canyon Creek	2015
Bluebell Canyon Creek	2017
Boulder Slough	2017
King's Gulch	2017
Skunk Creek	2017

Updates to floodplain mapping should include the development of depth grids which can be imported and used to refine loss estimation for benefit/cost analyses.

Other Alternatives: No action

Responsible Office: City of Boulder Utilities Division

Priority (High, Medium, Low): Medium

Cost Estimate: $100,000 - $150,000 per study

Benefits (Avoided Losses): More accurate flood hazard delineations provide for improved floodplain management, ordinance enforcement, public awareness and flood insurance determinations. Can also be used to refine flood risk modeling and target mitigation strategies.

Potential Funding: UDFCD, Public Works funds

Schedule: Currently updating Boulder Creek, Upper Goose, Skunk Creek, Boulder Slough, Kings Gulch, Bluebell Canyon Creek, and Two Mile Canyon Creek; trying to keep 10 years current.

Status: Completed/Continuing

18. Institute a Community Assisted Floodproofing Program Focusing on Critical Facilities

Project Description/Background: Evolving trends and philosophies in national and regional floodplain management have outlined alternative approaches and measures for addressing flood hazards in the future. These trends focus on the "wise use of the nation's floodplains" and "no adverse impacts." In an effort to allow possible development and flood mitigation flexibility that would avoid the need to implement publicly funded drainageway improvements to contain flood waters, the City of Boulder is interested in establishing opportunities to permit limited applications of floodproofing of critical facilities. City assistance under the program would involve development and adoption of local floodplain regulations to approve floodproofing applications for property owners to implement improvements to their facilities. The program would be consistent with nonstructural measures endorsed under the Comprehensive Flood and Stormwater Master Plan. This action would be focused on critical facilities in the floodplain.

Progress to Date: Floodproofing of residential structures does not eliminate or reduce the need to purchase flood insurance if located within the 100-year floodplain. The city is instead focusing on flood mitigation measures along high risk stream reaches. In 2012, the action was modified to apply only to critical facilities in the floodplain.

Other Alternatives: Other alternatives to mitigating flood damage potential to residential structures in shallow flooding areas involve continued application of structural drainageway improvements and assistance programs to elevate residential structures to meet standard FEMA requirements. Costs for these alternatives are far more expensive to implement and may not be justified with respect to benefits derived.

Responsible Office: City of Boulder Stormwater and Flood Management Utility

Priority (High, Medium, Low): Low

Cost Estimate: Administrative costs for ordinance adoption, $50,000 annual assistance funding

Benefits (Avoided Losses): A derived benefit avoids altering flood conditions as a result of structural improvements satisfying the "no adverse impact" philosophy.

Potential Funding: Increased utility budgeting

Schedule: January 1, 2019

Status: Completed/Continuing.

Wildfire Mitigation Actions

19. Implement Wildland Fire Mitigation Program for Watersheds

Project Description/Background: A wildfire within the city's water supply watersheds can increase erosion and sediment transport, reducing reservoir capacity and limiting water treatment options. In 2013, the city contracted with JW Associates, Inc. to perform a wildfire hazard and prioritization assessment for the smaller watersheds within the city's water supply system, incorporate water supply components and include opportunities and constraints to reducing wildfire hazard to the city's water supply. The analysis also helped to understand where sediment deposition or transport would most likely occur post-fire.

To minimize the potential for intense wildfires, tree thinning is recommended to reduce available hazardous fuel.

Progress to Date: This activity is ongoing as funding becomes available.

Other Alternatives: Rely on land managers/owners to individually mitigate fire hazards on their properties or implement post-fire mitigation of effects to water resources/facilities on an as-needed basis.

Responsible Office: City of Boulder Utilities Division

Priority (High, Medium, Low): Medium to High

Cost Estimate: $1,000,000

Benefits (Avoided Losses):

- Reduced loss of life and property.
- Reduced interruption of critical city water supplies and infrastructure.
- Reduced post-fire water facility clean-up and rehabilitation costs.
- Reduced long-term impacts to natural resources and economic value of Boulder's mountain backdrop.

Potential Funding: City of Boulder Water Resources Fund and the Colorado State Forest Service

Schedule: Pending funding.

Status: New in 2018

20. Wildland Fire Management Plan

Project Description/Background: The development of a Wildland Fire Management Plan is needed to increase resiliency to wildfires. The WFMP will provide initial guidance for wildfire decision making, accounting for values at risk, wildlife, vegetation, endangered species, cultural resources, etc.

Progress to Date: New in 2018

Other Alternatives: No action

Responsible Office: Open Space and Mountain Parks (OSMP)/Fire

Priority (High, Medium, Low): Medium

Cost Estimate: $50,000 - $100,000

Benefits (Avoided Losses): Loss of values at risk

Potential Funding: City funds, grants

Schedule: 2018

Status: New in 2018

21. Update the City of Boulder Community Wildfire Protection Plan

Project Description/Background: The City of Boulder Community Wildfire Protection Plan (CWPP) needs to be updated to reflect changes since 2007.

Progress to Date: None.

Other Alternatives: None

Responsible Office: Open Space and Mountain Parks (OSMP)/Fire

Priority (High, Medium, Low): Medium

Cost Estimate: $50,000

Benefits (Avoided Losses): Identify hazardous fuels and mitigation actions

Potential Funding: Grant funding

Schedule: 2019

Status: New in 2018

22. Implement the City's Community Wildfire Protection Plan

Project Description/Background: The City of Boulder is listed in the National Fire Plan as a community at high risk from wildfire. In 2007, the city worked with consultants to develop a Community Wildfire Protection Plan (CWPP) to address the wildfire threats to the community. The plan meets the requirements of the federal Healthy Forests Restoration Act and outlines steps the city can take to reduce and mitigate the threats of wildfire. The CWPP could be considered a parallel document to the city's Forest Ecosystem Management Plan (FEMP) in that the CWPP addresses areas within the city boundary, and the FEMP is focused on adjacent wildlands. The CWPP outlines steps the city and private property owners can take to both mitigate the threat of wildfire and increase public safety in the event of a wildfire. The plan makes recommendations for fuels modification projects, safety zones, evacuation routes, addressing, and ingress/egress routes. Funding for the plan development came from a combination of city departments and a matching state grant.

Progress to Date: This activity is ongoing.

Other Alternatives: Another alternative would be to rely fully on wildland management and implementation to decrease wildfire threat. The major drawback to this alternative is that it would not address the hazards within city limits and on private property. In the event of a fire in the wildland-urban interface, property could be lost and there would be an unnecessary risk to firefighters and the public.

Responsible Office: City of Boulder Fire–Rescue, City of Boulder Open Space and Mountain Parks

Priority (High, Medium, Low): High

Cost Estimate: Costs will vary depending on nature and magnitude of each project.

Benefits (Avoided Losses): The benefits from the implementation of this plan include decreased potential for wildfire, more consistent policies related to how a wildfire event is managed, education of the public in regard to wildfire and their responsibilities as property owners, and an increase in public preparedness and safety.

Potential Funding: City of Boulder Fire–Rescue, federal and state grants

Schedule: Ongoing with annual activities

Status: Continuing from 2012

23. Implement and Update the City's Forest Ecosystem Management Plan

Project Description/Background: The City of Boulder Open Space and Mountain Parks Department (OSMP) manages approximately 10,000 acres of forested land. Due to the land's close proximity to homes, dense forest conditions, and risks of fire ignition, the forests of Boulder fall within the high hazard category of the wildland-urban interface. In June of 1999, the City Council approved the Forest Ecosystem Management Plan (FEMP). The plan established a framework, policy guidelines, and management direction for forest ecosystem management on city lands. One of the FEMP's primary goals is to "reduce the wildfire risk to forest and human communities." Part of this objective includes forest thinning and prescriptive burning as key components in mitigating the threat of large scale wildfire. Forest treatments are to be completed on a steady basis under the plan. Funding for projects completed to date has come from the annual OSMP budget.

Progress to Date: This action is ongoing, and most of the recommendations in the CWPP have been implemented. OSMP, with the help of the city Fire Department- Wildland Fire Division has thinned close to 800 acres of forested city property and prescriptively burned over 200 acres. All of the projects conducted on city land have been in high hazard areas of the wildland-urban interface with the focus of improving ecological function and decreasing the risk of wildfire to public and private resources. Ongoing city monitoring has demonstrated the direct benefits of forest management on ecosystem health and wildfire risk.

In 2004, OSMP began hiring a four-person seasonal forest management crew to implement the FEMP. Funding is part of the annual OSMP operating budget and the primary focus of this crew is the implementation of the FEMP. The addition of this crew has allowed the city to thin, on average, 100 to 150 acres of city forests each year. The city also developed a Community Wildfire Protection Plan in 2007 for the portions of OSMP directly adjacent to the city. This plan, in conjunction with the FEMP, allows the city to apply for federal and state grant funding.

Forest management will continue to be an ongoing city priority and a focus of OSMP work planning. The city plans to update the FEMP in coming years, in order to adaptively manage Boulder's forests and efficiently place treatments on the landscape.

Other Alternatives: There are few other alternatives to mitigate the threat of wildfire given current forest conditions and the extent of the wildland-urban interface. An option may be to secure funding for restoration following a large scale wildfire event. The downside to this approach is that it is not preventative and places property and potentially lives at greater risk.

Responsible Office: City of Boulder Open Space and Mountain Parks

Priority (High, Medium, Low): High

Cost Estimate: $80,000-$150,000 annually

Benefits (Avoided Losses): Fire mitigation and forest restoration work has a direct impact on fuels and can immediately decrease the potential for wildfire. The work will mitigate the threat to properties owned by the city as well as property adjacent to open space areas. There is also an immediate ecological benefit in increased habitat and forest health.

Potential Funding: Increased City of Boulder Open Space and Mountain Parks and City of Boulder Fire–Rescue budgets, federal and state matching grants

Schedule: Ongoing, will require indefinite maintenance on annual basis

Status: Continuing, See Progress to Date above

Drought Mitigation Actions

24. Review City Landscape Codes for Drought

Project Description/Background: The Statewide Water Supply Initiative 2010 (http://cwcb.state.co.us/water-management/water-supply-planning/Documents/SWSI2010/SWSI2010.pdf) published by the Colorado Water Conservation Board in January 2011, recommended the following actions be taken by municipalities for landscape water use restrictions (residential and non-residential) including:

- Targeted audits for high demand landscape customers
- Landscape transformation of some high water requirement turf to low water requirement plantings
- Irrigation efficiency improvements

This project would review the current city codes related to landscaping and water conservation and recommend suggested improvements that may increase the resiliency of the city during times of drought.

Other Alternatives: Keep codes status quo.

Responsible Office: Water Conservation / Development Review

Priority (High, Medium, Low): Medium

Cost Estimate: Low, can be accomplished with staff resources

Benefits (Avoided Losses): Reduced losses to city landscaping during drought; water savings that can be used for other purposes during drought.

Potential Funding: Staff time

Schedule: 2019

Status: Continuing

25. Update City's Drought Plan and Identify and Implement Priority Projects Identified in the Drought Plan

Project Description/Background: The City of Boulder is subject to drought due to its location in a semiarid climate. City Council adopted a Drought Plan in 2003 to mitigate the effects of drought on the municipal water supply. The plan applies principles of water conservation and reliability criteria for the city's raw water system. The reliability criteria specify acceptable levels of frequency and amount of reduction in water availability due to drought for the various classifications of use. Water provided by the city serves multiple purposes ranging from critical uses that require an assured supply, such as water for drinking or firefighting, to uses that can tolerate occasional restrictions, such as outdoor irrigation or car washing. The Drought Plan provides guidance for recognizing droughts that will affect water supply availability and responding to these droughts. Strategies for responding to drought include increasing the water supply (e.g., eliminate leasing programs to farmers, lease water, trade water) and decreasing water demand (e.g. voluntary restrictions, mandatory restrictions). Each option presents its own unique issues and must be considered individually and with respect to drought severity.

Progress to Date: This action is in progress. The city is in the process of updating its water supply planning model, which will incorporate various future climate change scenarios. As part of the update, the city will evaluate whether the drought response strategies identified in the 2003 Drought Plan are appropriate to meet the city's reliability criteria. The city will update the drought plan to reflect the drought response strategies analysis and additional planning measures that may include a water demand reduction communications plan and the Water Efficiency Plan, which was completed in 2016.

Other Alternatives: Other alternatives to the actions included in the Drought Plan include imposing more severe water use restrictions than the adopted water reliability criteria and enhancing the water conservation program to reduce water use by more than the adopted 10 percent of 2000 levels by community build-out. Other options include acquiring additional senior water rights and constructing additional reservoir storage for water rights the city has developed. A less attractive option would be to develop municipal wells requiring extensive and costly augmentation plans. However, wells may not significantly increase the yield of the city's water supply system.

Responsible Office: City of Boulder Utilities Division, Water Resources Program

Priority (High, Medium, Low): High

Cost Estimate: Administrative costs, senior water rights acquisition (difficult to acquire but approximately $20,000 per acre-foot), $5-25 million for dam reconstruction

Benefits (Avoided Losses): Citizen response to most droughts will be voluntary water use restrictions. During more severe droughts, mandatory water use restrictions will be implemented to assure that water is available for the most essential water needs (such as indoor use, fire protection, health care) for all of the city’s water customers.

Potential Funding: Utility budget, increased utility budgeting, utility financial reserves, drought surcharges, and federal matching grants

Schedule: 2018-19

Status: Continuing

6 Plan Adoption

Requirement §201.6(c)(5): [The local hazard mitigation plan shall include] documentation that the plan has been formally approved by the governing body of the jurisdiction requesting approval of the plan (e.g., City Council, county commissioner, Tribal Council).

The purpose of formally adopting this plan is to secure buy-in from the City of Boulder, raise awareness of the plan, and formalize the plan's implementation. The adoption of this plan completes Planning Step 9 of the 10-step planning process: Adopt the Plan. The governing board for the City of Boulder, the Boulder City Council, has adopted this multi-hazard mitigation plan by passing a resolution. A copy of the generic resolution and the executed copy are included in Appendix A: Adoption Resolution. The plan was originally adopted on August 19, 2008. The plan was re-adopted by City Council on April 2, 2013 following the initial five-year update. Re-adoption occurred by City Council in 2018, following the 2017-18 update of the Plan.

7 PLAN IMPLEMENTATION AND MAINTENANCE

Requirement §201.6(c)(4):
[The plan maintenance process shall include a] section describing the method and schedule of monitoring, evaluating, and updating the mitigation plan within a five-year cycle.

Implementation and maintenance of the plan is critical to the overall success of hazard mitigation planning. This is Planning Step 10 of the 10-step planning process. This chapter provides an overview of the overall strategy for plan implementation and maintenance and outlines the method and schedule for monitoring, updating, and evaluating the plan. The chapter also discusses incorporating the plan into existing planning mechanisms and how to address continued public involvement.

7.1 Implementation

Implementation will be accomplished by adhering to the schedules identified for each mitigation action (see Chapter 5) and through pervasive efforts to network and highlight the multi-objective, win-win benefits of each project to the community and its stakeholders. These efforts include the routine actions of monitoring agendas, attending meetings, and promoting a safe, sustainable community. The three main components of implementation are:

- IMPLEMENT the action plan recommendations of this plan;
- UTILIZE existing rules, regulations, policies and procedures already in existence; and
- COMMUNICATE the hazard information collected and analyzed through this planning process so that the community better understands what can happen where, and what they can do themselves to be better prepared. Also, publicize the "success stories" that are achieved through the HMPC's ongoing efforts.

An important implementation mechanism that is highly effective and low-cost is incorporation of the hazard mitigation plan recommendations and their underlying principles into other city and county plans and mechanisms, such as the Comprehensive Flood and Stormwater Utility Master Plan and the Boulder Valley Comprehensive Plan. The city has and continues to implement policies and programs to reduce losses to life and property from natural hazards. This plan builds upon the momentum developed through previous and related planning efforts and mitigation programs and recommends implementing projects, where possible, through these other program mechanisms.

Mitigation is most successful when it is incorporated into the day-to-day functions and priorities of government and development. This integration is accomplished by constant, pervasive, and energetic efforts to network, identify, and highlight the multi-objective, win-win benefits to each program, the Boulder community, and its stakeholders. This effort is achieved through the routine actions of monitoring agendas, attending meetings, and promoting a safe, sustainable community. Additional mitigation strategies could include consistent and ongoing enforcement of existing policies and vigilant review of city and county programs for coordination and multi-objective opportunities.

Simultaneous to these efforts, it is important to maintain a constant monitoring of funding opportunities that can be leveraged to implement some of the more costly recommended actions. This will include creating and maintaining a bank of ideas on how any required local match requirements of state or federal grants can be met. When funding does become available, the HMPC will be in a position to capitalize on the opportunity. Funding opportunities to be monitored include special pre- and post-disaster funds, capital improvement budgeted funds, state or federal earmarked funds, and grant programs, including those that can serve or support multi-objective applications.

7.1.1 Role of Hazard Mitigation Planning Committee in Implementation and Maintenance

With re-adoption of this plan, the Hazard Mitigation Planning Committee (HMPC) will be tasked with plan implementation and maintenance. The HMPC, led by the City of Boulder Department of Public Works agrees to:

- Act as a forum for hazard mitigation issues;
- Disseminate hazard mitigation ideas and activities to all participants;
- Pursue the implementation of high-priority, low/no-cost recommended actions;
- Keep the concept of mitigation in the forefront of community decision making by identifying plan recommendations when other community goals, plans, and activities overlap, influence, or directly affect increased community vulnerability to disasters;
- Maintain a vigilant monitoring of multi-objective cost-share opportunities to help the community implement the plan’s recommended actions for which no current funding exists;
- Monitor and assist in implementation and update of this plan;
- Report on plan progress and recommended changes to the Boulder City Council; and
- Inform and solicit input from the public.

The HMPC will not have any powers over city staff; it will be purely an advisory body. Its primary duty is to see the plan successfully carried out and to report to the community governing board and the public on the status of plan implementation and mitigation opportunities for the city. Other duties include reviewing and promoting mitigation proposals, considering stakeholder concerns about hazard mitigation, passing concerns on to appropriate entities, and posting relevant information on the city website.

7.2 Maintenance and Monitoring

Plan maintenance implies an ongoing effort to monitor and evaluate plan implementation and to update the plan as progress, roadblocks, or changing circumstances are recognized.

7.2.1 Maintenance and Monitoring Schedule

In order to track progress and update the mitigation strategies identified in the action plan, the HMPC Group will revisit this plan at the following times or occurrences:

- Annually, to assess if projects have been completed;
- Following a significant hazard event;
- Following a disaster declaration;
- Any other time the MAC group sees it is prudent or necessary.

The City of Boulder Public Works Department is responsible for initiating this review and will consult with members of the HMPC. The review may occur in concert with CRS review and recertification. The suggested time frame for the annual review is in the spring, prior to flood and wildfire season. This will also position the city for grant and CRS review cycles that occur in the fall. A five-year written update to be submitted to the state and FEMA Region VIII, unless disaster or other circumstances (e.g., changing regulations) require a change to this schedule.

This plan will be updated, approved, and adopted within a five-year cycle as per Requirement §201.6(c)(4)(i) of the Disaster Mitigation Act of 2000. Efforts to begin the update should begin no later than June 2022. The City will monitor planning grant opportunities from the Colorado Division of Homeland Security and Emergency Management (DHSEM) and FEMA for funds to assist with the update. This may include submitting a Pre- Disaster Mitigation planning grant application. This grant should be submitted in 2021, as there is a three-year performance period to expend the funds, plus there is no guarantee that the grant will be awarded the when initially submitted. This allows time to resubmit the grant in subsequent years, if needed. Updates to this plan will follow the most current FEMA and DHSEM planning guidance. The first plan update is anticipated to be completed and reapproved by DHSEM and FEMA Region VIII by March 2023.

7.2.2 Maintenance Evaluation Process

Evaluation of progress can be achieved by monitoring changes in vulnerabilities identified in the plan. Changes in vulnerability can be identified by noting:

- Decreased vulnerability as a result of implementing recommended actions,
- Increased vulnerability as a result of failed or ineffective mitigation actions, and/or
- Increased vulnerability as a result of new development (and/or annexation).

The HMPC will use the following process to evaluate progress, note changes in vulnerability, and consider changes in priorities as a result of plan implementation:

- A representative from the responsible entity identified in each mitigation measure will be responsible for tracking and reporting to the HMPC when project status changes. The representative will provide input on whether the project as implemented meets the defined goals and objectives and is likely to be successful in reducing vulnerabilities.
- If the project does not meet identified goals and objectives, the HMPC will select alternative projects for implementation.
- New projects identified will require an individual assigned to be responsible for defining the project scope, implementing the project, monitoring success of the project.
- Projects that were not ranked high priority but were identified as potential mitigation strategies will be reviewed as well during the monitoring and update of this plan to determine feasibility of future implementation.
- Changes will be made to the plan to accommodate for projects that have failed or are not considered feasible after a review for their consistency with established criteria, the time frame, priorities, and/or funding resources.

Updates to this plan will follow the most current FEMA, DHSEM, and CRS planning guidance and consider the following:

- Consider changes in vulnerability due to project implementation,
- Document success stories where mitigation efforts have proven effective,
- Document areas where mitigation actions were not effective,
- Document any new hazards that may arise or were previously overlooked,
- Document hazard events and impacts that occurred within the five-year period,
- Incorporate new data or studies on hazards and risks,
- Incorporate new capabilities or changes in capabilities,
- Document continued public involvement
- Document changes to the planning process, which may include new or additional stakeholder involvement
- Incorporate growth and development-related changes to building inventories,
- Incorporate new project recommendations or changes in project prioritization,
- Include a public involvement process to receive public comment on the updated plan prior to submitting the updated plan to DHSEM/FEMA, and
- Include re-adoption by all participating entities following DHSEM/FEMA approval.

7.2.3 Incorporation into Existing Planning Mechanisms

The mitigation strategy in Section 5.3 Mitigation Strategy of this plan recommends using existing plans and/or programs to implement hazard mitigation in the city, where possible. This point is also emphasized previously in this chapter. Based on this plan's capability assessment, the city has and continues to implement policies and programs to reduce losses to life and property from natural hazards. This plan builds upon the momentum developed through previous and related planning efforts and mitigation programs and recommends implementing projects, where possible, through the following mechanisms:

- Flood Mitigation Master plans (see tie-in with related project in Chapter 5)
- Boulder Climate Preparedness Plan
- Boulder Climate Action Plan*
- City of Boulder Community Wildfire Protection Plan updates
- Boulder Recovery Plan (in development 2018)
- Boulder Revised Code*
- Boulder Valley Comprehensive Plan*
- Boulder County Hazard Mitigation Plan*
- City of Boulder Resilience Strategy
- Capital improvement plans and budgets*
- Comprehensive Flood and Stormwater Master Plan
- Facilities and Asset Management Master Plan
- Fire-Rescue Master Plan
- Forest Ecosystem Management plan
- Greenways Master Plan (2011)
- Green Infrastructure Strategic Plan (in development 2018)
- Source Water Master Plan
- Water Efficiency Plan
- Water Utility Master Plan
- Structure Protection Plan (2012)
- Transportation Master Plan (2014)
- Urban Forest Strategic Plan
- Other plans, regulations, and practices with a hazard mitigation or loss prevention element

*Indicates planning mechanism that mentions the 2012 Boulder Hazard Mitigation Plan

More information on these existing plans and planning mechanisms can be referenced in Section 4.4.

HMPC members involved in the updates to these mechanisms will be responsible for integrating the findings and recommendations of this plan with these other plans, as appropriate. Examples of where the 2012 Boulder Hazard Mitigation Plan was mentioned or cross-referenced are noted by an asterisk in the previous list of plans. For example, the city's capital improvement plan cites other plans where projects are recommended, such as this HMP. The mitigation plan can be considered as a "hub on the wheel" with spokes radiating out to other related planning mechanisms that will build from the information and recommendations contained herein.

7.2.4 Continued Public Involvement

Continued public involvement is also imperative to the overall success of the plan's implementation. The update process provides an opportunity to publicize success stories from the plan implementation and seek additional public comment. At least one public meeting or workshop to receive public input will be held during the next update period. When the HMPC reconvenes for the update, they will coordinate with all stakeholders participating in the planning process-including those that joined the committee since the planning process began-to update and revise the plan. The plan maintenance and update process will include continued public and stakeholder involvement and input through attendance at designated committee meetings, web postings, and press releases to local media. Public awareness of the plan and individual flood mitigation strategies could be developed each spring prior to the beginning of runoff and flood season. This can also occur in coordination with CRS public notification activities. The Public Participation Plan in Appendix F will serve as a continuing resource for future public involvement during plan updates.

APPENDIX A - ADOPTION RESOLUTION

RESOLUTION NO. 1230

A RESOLUTION BY THE CITY COUNCIL OF THE CITY OF BOULDER ADOPTING THE 2018 CITY OF BOULDER MULTI-HAZARD MITIGATION PLAN.

WHEREAS, THE CITY COUNCIL OF THE CITY OF BOULDER, COLORADO FINDS AND RECITES THE FOLLOWING FACTS RELATED TO THE ADOPTION OF THE BOULDER MULTI-HAZARD MITIGATION PLAN:

1. The City of Boulder recognizes the threat that natural hazards pose to people and property within our community.

2. Undertaking hazard mitigation actions will reduce the potential for harm to people and property from future hazard occurrences.

3. Congress passed the Disaster Mitigation Act of 2000 ("Disaster Mitigation Act") emphasizing the need for pre-disaster mitigation of potential hazards.

4. The Disaster Mitigation Act made available hazard mitigation grants to state and local governments.

5. An adopted Multi-Hazard Mitigation Plan is required as a condition of future funding for mitigation projects under multiple FEMA pre- and post-disaster mitigation grant programs.

6. The City of Boulder fully participated in the FEMA-prescribed mitigation planning process to prepare this Multi-Hazard Mitigation Plan.

7. The Colorado Office of Emergency Management and the Federal Emergency Management Agency Region VIII officials have reviewed the "City of Boulder Multi-Hazard Mitigation Plan," and approved it contingent upon this official adoption by the participating governing body.

8. The City of Boulder desires to comply with the requirements of the Disaster Mitigation Act and to augment its emergency planning efforts by formally adopting the Multi-Hazard Mitigation Plan for City of Boulder.

9. Adoption by the City Council for the City of Boulder demonstrates the jurisdictions commitment to fulfilling the mitigation goals and objectives outlined in this Multi-Hazard Mitigation Plan.

10. Adoption of this plan helps to coordinate the responsible agencies to carry out their responsibilities under the plan.

NOW, THEREFORE, BE IT RESOLVED BY THE CITY COUNCIL OF THE CITY OF BOULDER, COLORADO:

Section 1. The City of Boulder adopts the "2018 City of Boulder Multi-Hazard Mitigation Plan" as an official plan.

Section 2. The City Council orders the city manager to submit a copy of this resolution to the Colorado Office of Emergency Management and Federal Emergency Management Agency Region VIII officials to enable the plan's final approval.

APPROVED this 1st day of May 2018.

Mayor

ATTEST:

City Clerk

APPENDIX B - HMPC MEMBER LIST

Appendix B HMPC MEMBER LIST

CITY OF BOULDER					
Department	***Name***	***Title***	***Phone***	***Email***	**Address**
City Manager's Office	Greg Guibert	Chief Resiliency Officer	303-441-1924	GuibertG@bouldercolorado.gov	1300 Canyon Boulevard, Boulder CO, 80302
Finance	James Brown	Risk Manager	303-441-3075	brownj@bouldercolorado.gov	1720 13th St, Boulder CO, 80302
Fire-Rescue	David Lowrey	Batallion Chief	303-441-4356	LOWREYD@bouldercolorado.gov	3065 Center Green Dr, Boulder CO, 80301
Fire-Rescue	Brian Oliver	Wildfire Operations	303-441-1885	OliverB@bouldercolorado.gov	3065 Center Green Dr, Boulder CO, 80301
Parks and Recreation	Kathleen Alexander	Forester	303-441-3406	AlexanderK@bouldercolorado.gov	3198 Broadway, Boulder CO, 80304
Parks and Recreation	Ken Fisher	Forresty		FisherK@bouldercolorado.gov	3198 Broadway, Boulder CO, 80304
Parks and Recreation	Bryan Harding	Parks Planner	303-413-7228	HardingB@bouldercolorado.gov	3198 Broadway, Boulder CO, 80304
Parks and Recreation	Callie Hayden	Urban Parks Manager	303-441-3451	haydenc@bouldercolorado.gov	3198 Broadway, Boulder CO, 80304
Police Department	Jack Walker	Police Commander	303-441-4314	WALKERJ@bouldercolorado.gov	1805 33rd St, Boulder CO, 80301
Public Works	Kurt Bauer	Engineering Project Manager	303-441-4232	BauerK@bouldercolorado.gov	1739 Broadway, Boulder CO, 80302
Public Works	Ward Bauscher	Utilities Maintenance Manager	303-441-4199	BauscherW@bouldercolorado.gov	5050 East Pearl, Boulder CO, 80301
Public Works	Joe Castro	Facilities and Fleet Manager	303-441-3163	CastroJ@bouldercolorado.gov	1720 13th St, Boulder CO, 80302
Public Works	Kaaren Davis	Administrative Supervisor	303-441-3233	davisk@bouldercolorado.gov	1101 Arapahoe Ave, Boulder CO, 80302
Public Works	Kim Hutton	Water Resources Engineer	303-441-3115	Huttonk@bouldercolorado.gov	1739 Broadway, Boulder CO, 80302
Public Works	Gretchen King	Communications Specialist	303-441-3005	KingG@bouldercolorado.gov	1739 Broadway, Boulder CO, 80302
Public Works	MaryAnn Nason	Watershed Coordinator	303-413-7407	NasonM@bouldercolorado.gov	1739 Broadway, Boulder CO, 80302
Public Works	Annie Noble	Flood & Greenways Engineering Coordinator	303-441-3242	NobleA@bouldercolorado.gov	1739 Broadway, Boulder CO, 80302
Public Works	Gerrit Slatter	Transportation Engineering Manager	303-441-1978	SlatterG@bouldercolorado.gov	1101 Arapahoe Ave, Boulder CO, 80302
Public Works	Douglas Sullivan	Utilities Principal Engineer	303-441-3244	sullivand@bouldercolorado.gov	1739 Broadway, Boulder CO, 80302
Public Works	Chris Trice	Information Resources Manager	303-441-3298	Tricec@bouldercolorado.gov	3065 Center Green Dr, Boulder CO, 80301
Wildland Fire Mitigation	David Zader	Wildland & Fire Administrator	303-441-4353	ZaderD@bouldercolorado.gov	3065 Center Green Dr, Boulder CO, 80301
Stakeholders					
Boulder County Transportation	Dave Watson	Senior GIS Specialist	303-441-3900	dwatson@bouldercounty.org	2525 13th St, Boulder CO, 80304

Boulder County Transportation	Varda Blum	Floodplain Manager	303-441-3900	vblum@bouldercounty.org	2525 13th St, Boulder CO, 80304
Boulder Community Hospital	Chuck Merritt	Director		cmerritt@bch.org	1100 Balsam Ave, Boulder CO, 80304
BVSD	Rick Kellogg		303-447-1010	Richard.kellogg@bvsd.org	6500 Arapahoe Rd, Boulder CO, 80303
BVSD	Debbie Sedelmeier	Operations, Security and Environmental Services	303-447-1010	debbie.sedelmeier@bvsd.org	6500 Arapahoe Rd, Boulder CO, 80303
BVSD	Brendan Sullivan	Director of Safety, Security & Emergency Services	303-447-1010	brendan.sullivan@bvsd.org	6500 Arapahoe Rd, Boulder CO, 80303
CWCB	Stephanie Dibetitto	CAP Coordinator	303-866-3441	stephanie.dibetitto@state.co.us	1313 Shermat St, Denver CO, 80203
DHSEM	Mark Thompson	Mitigation Specialist	720-630-0770	markw.thompson@state.co.us	9195 E. Mineral Ave, Centennial CO, 80112
DHSEM	Patricia Gavelda	Program Manager	970-749-8280	patricia.gavelda@state.co.us	20591 US HWY 160, Durango CO, 81301
FEMA IIIV	Nicole Aimone	Lead Community Planner		nicole.aimone@fema.dhs.gov	
OEM	Mike Chard	Director	303-441-3653	ChardM@bouldercolorado.gov	3280 Airport Road, Boulder CO 80301
UDFCD	Jim Watt	Project Manager	303-455-6277	bseymour@udfcd.org	2480 W. 26th Ave, Suite 156-B, Denver CO 80211

APPENDIX C - MITIGATION CATEGORIES

Appendix C MITIGATION CATEGORIES

C.1 Categories of Mitigation Measures Considered

The following categories are based on the Community Rating System.

- Prevention
- Emergency Services
- Property Protection
- Natural Resource Protection
- Structural Projects
- Public Information

C.2 Alternative Mitigation Measures per Category

Prevention

Preventive measures are designed to keep the problem from occurring or getting worse. Their objective is to ensure that future development is not exposed to damage and does not increase damage to other properties.

- Planning
- Zoning
- Open space preservation
- Land development regulations
- Subdivision regulations
- Floodplain development regulations
- Stormwater management
- Fuels management, fire breaks
- Building codes
  - Firewise construction
- (also see Property Protection)

Emergency Services

Emergency services protect people during and after a disaster. A good emergency services program addresses all hazards. Measures include:

- Warning (floods, tornadoes, ice storms, hail storms, dam failures)
  - NOAA weather radio all hazards
  - Sirens
  - Reverse 911
- Evacuation and sheltering
- Communications
- Emergency planning
  - Activating the emergency operations room (emergency management)
  - Closing streets or bridges (police or public works)
  - Shutting off power to threatened areas (utility company)
  - Holding children at school/releasing children from school (school district)
  - Passing out sand and sandbags (public works)
  - Ordering an evacuation (mayor)
  - Opening evacuation shelters (red cross)
  - Monitoring water levels (engineering)
  - Security and other protection measures (police)
- Monitoring of conditions (dams)
- Critical facilities protection (buildings or locations vital to the response and recovery effort, such as police/fire stations, hospitals, sewage treatment plants/lift stations, power substations)
  - Buildings or locations that, if damaged, would create secondary disasters, such as hazardous materials facilities and nursing homes
  - Lifeline utilities protection
  - Health and safety maintenance

Property Protection

Property protection measures are used to modify buildings subject to damage rather than to keep the hazard away. A community may find these to be inexpensive measures because often they are implemented by or cost-shared with property owners. Many of the measures do not affect the appearance or use of a building, which makes them particularly appropriate for historical sites and landmarks.

- Retrofitting/disaster proofing
  - Floods
    - Wet/dry floodproofing (barriers, shields, backflow valves)
    - Relocation
    - Acquisition
  - Tornadoes
    - Safe rooms
    - Securing roofs and foundations with fasteners and tie-downs

    - Strengthening garage doors and other large openings
  - Drought
    - Improve water supply (transport/storage/conservation)
    - Remove moisture competitive plants (tamarisk/salt cedar)
    - Water restrictions/water saver sprinklers/appliances
    - Grazing on CRP lands (no overgrazing-see noxious weeds)
    - Create incentives to consolidate/connect water services
    - Recycled wastewater on golf courses
  - Earthquakes
    - Removing masonry overhangs, bracing, and other parts
    - Tying down appliances, water heaters, bookcases, and fragile furniture so they will not fall over during a quake.
    - Installing flexible utility connections that will not break during shaking (pipelines, too)
  - Wildland fire
    - Replacing building components with fireproof materials (roofing, screening)
    - Creating "defensible space"
    - Installing spark arrestors
    - Fuels modification
  - Noxious weeds/insects
    - Mowing
    - Spraying
    - Replacement planting
    - Stop overgrazing
    - Introduce natural predators
- Insurance

Natural Resource Protection

Natural resource protection activities are generally aimed at preserving (or in some cases restoring) natural areas. In so doing, these activities enable the naturally beneficial functions of floodplains and watersheds to be better realized. These natural and beneficial floodplain functions include the following:

- Storage of floodwaters
- Absorption of flood energy
- Reduction in flood scour
- Infiltration that absorbs overland flood flow
- Groundwater recharge
- Removal/filtering of excess nutrients, pollutants, and sediments from floodwaters
- Habitat for flora and fauna
- Recreational and aesthetic opportunities

Methods of protecting natural resources include:

- Erosion and sediment control
- Wetlands protection
- Riparian area/habitat protection
- Threatened and endangered species protection
- Fuels management
- Set-back regulations/buffers
- Best management practices-Best management practices ("BMPs") are measures that reduce nonpoint source pollutants that enter the waterways. Nonpoint source pollutants come from non-specific locations. Examples of nonpoint source pollutants are lawn fertilizers, pesticides, and other farm chemicals, animal wastes, oils from street surfaces and industrial areas and sediment from agriculture, construction, mining and forestry. These pollutants are washed off the ground's surface by stormwater and flushed into receiving storm sewers, ditches and streams. BMPs can be implemented during construction and as part of a project's design to permanently address nonpoint source pollutants. There are three general categories of BMPs:
  - Avoidance-Setting construction projects back from the stream.
  - Reduction-Preventing runoff that conveys sediment and other water-borne pollutants, such as planting proper vegetation and conservation tillage.
  - Cleanse-Stopping pollutants after they are en route to a stream, such as using grass drainageways that filter the water and retention and detention basins that let pollutants settle to the bottom before they are drained
- Dumping regulations
- Water use restrictions
- Weather modification
- Landscape management

Structural Projects

Structural projects have traditionally been used by communities to control flows and water surface elevations. Structural projects keep flood waters away from an area. They are usually designed by engineers and managed or maintained by public works staff. These measures are popular with many because they "stop" flooding problems. However, structural projects have several important shortcomings that need to be kept in mind when considering them for flood hazard mitigation:

They are expensive, sometimes requiring capital bond issues and/or cost sharing with Federal agencies, such as the U.S. Army Corps of Engineers or the Natural Resources Conservation Service.

- They disturb the land and disrupt natural water flows, often destroying habitats.

- They are built to a certain flood protection level that can be exceeded by a larger flood, causing extensive damage.
- They can create a false sense of security when people protected by a structure believe that no flood can ever reach them.
- They require regular maintenance to ensure that they continue to provide their design protection level.

Structural measures include:

- Detention/retention structures
- Erosion and sediment control
- Basins/low-head weirs
- Channel modifications
- Culvert resizing/replacement/maintenance
- Levees and floodwalls
- Fencing (for snow, sand, wind)
- Drainage system maintenance
- Reservoirs (for flood control, water storage, recreation, agriculture)
- Diversions
- Storm sewers

Public Information

A successful hazard mitigation program involves both the public and private sectors. Public information activities advise property owners, renters, businesses, and local officials about hazards and ways to protect people and property from these hazards. These activities can motivate people to take protection

- Hazard maps and data
- Outreach projects (mailings, media, web, speaker's bureau)
- Library resources
- Real estate disclosure
- Environmental education
- Technical assistance

C.3 Mitigation Alternative Selection Criteria

The following criteria were used to select and prioritize proposed mitigation measures:

STAPLE/E

- Social-Does the measure treat people fairly? (different groups, different generations)
- Technical-Will it work? (Does it solve the problem? Is it feasible?)
- Administrative-Do you have the capacity to implement and manage project?
- Political-Who are the stakeholders? Did they get to participate? Is there public support? Is political leadership willing to support?
- Legal-Does your organization have the authority to implement? Is it legal? Are there liability implications?
- Economic-Is it cost-beneficial? Is there funding? Does it contribute to the local economy or economic development?
- Environmental-Does it comply with environmental regulations?

Other

- Does the proposed action protect lives?
- Does the proposed action address hazards or areas with the highest risk?
- Does the proposed action protect critical facilities, infrastructure, or community assets?
- Does the proposed action meet multiple objectives (multi-objective management)?

Table C.1. Example Mitigation Actions Items by Category and Hazard

Alternative Mitigation Actions	Human Health hazards (Pan flu, West Nile)	Dam Failure	Floods	Land slides/ Land Subsidence /Soil hazards	Weather Extremes (hail, lightning, wind, temps, fog, drought)	Tornadoes and Earthquake	Wildfires	Winter Weather
PREVENTION								
Building codes and enforcement			■	■	■	■	■	■
Comprehensive Watershed Tax			■					
Density controls		■	■	■			■	
Design review standards			■	■		■	■	
Easements			■	■			■	
Environmental review standards			■	■		■	■	
Floodplain development regulations		■	■					
Hazard mapping		■	■	■			■	
Floodplain zoning		■	■					
Forest fire fuel reduction							■	
Housing/landlord codes					■			
Slide-prone area/grading/hillside development regulations				■			■	
Manufactured home guidelines/regulations		■	■		■	■		
Multi-Jurisdiction Cooperation within watershed		■	■					
Open space preservation		■	■	■			■	
Performance standards		■	■	■	■	■	■	■
Special use permits		■	■	■			■	
Stormwater management regulations			■					
Subdivision and development regulations		■	■	■		■	■	
Surge protectors and lightning protection					■			
Tree Management					■		■	■
Transfer of development rights			■	■			■	
Utility location				■	■			■

Alternative Mitigation Actions	Human Health hazards (Pan flu, West Nile)	Dam Failure	Floods	Land slides/ Land Subsidence /Soil hazards	Weather Extremes (hail, lightning, wind, temps, fog, drought)	Tornadoes and Earthquake	Wildfires	Winter Weather
PROPERTY PROTECTION								
Acquisition of hazard prone structures		■	■	■			■	
Construction of barriers around structures		■	■					
Elevation of structures		■	■					
Relocation out of hazard areas		■	■	■			■	
Non- structural improvements (safety film on windows, bookshelf anchoring, critical equipment bracing etc.)					■	■		
Structural retrofits (e.g., reinforcement, floodproofing, bracing, etc.)			■		■	■	■	■
PUBLIC EDUCATION AND AWARENESS								
Debris Control			■					
Flood Insurance		■	■					
Hazard information centers	■	■	■	■	■	■	■	■
Public education and outreach programs	■	■	■	■	■	■	■	■
Real estate disclosure		■	■	■	■	■	■	■
Crop Insurance					■	■		
NATURAL RESOURCE PROTECTION								
Best Management Practices (BMPs)	■		■	■	■		■	
Forest and vegetation management	■	■	■	■	■		■	■
Hydrological Monitoring	■	■	■	■	■			
Sediment and erosion control regulations		■	■	■				
Stream corridor restoration			■	■				
Stream dumping regulations			■					
Urban forestry and landscape management		■	■	■	■		■	■
Wetlands development regulations			■	■			■	

Alternative Mitigation Actions	Human Health hazards (Pan flu, West Nile)	Dam Failure	Floods	Land slides/ Land Subsidence /Soil hazards	Weather Extremes (hail, lightning, wind, temps, fog, drought)	Tornadoes and Earthquake	Wildfires	Winter Weather
EMERGENCY SERVICES								
Critical facilities protection		■	■	■	■	■	■	■
Emergency response services		■	■	■	■	■	■	■
Hazard threat recognition	■	■	■	■	■	■	■	■
Hazard warning systems (community sirens, NOAA weather radio)		■	■	■	■	■	■	■
Health and safety maintenance	■	■	■	■	■	■	■	■
Evacuation planning	■	■	■	■			■	
STRUCTURAL PROJECTS								
Channel maintenance			■					
Dams/reservoirs (including maintenance)		■	■					
Levees and floodwalls (including maintenance)			■					
Safe room/shelter					■	■		■
Snow fences								■
Water supply augmentation					■			
Post-disaster mitigation	■	■	■	■	■	■	■	■

APPENDIX D - REFERENCES

Appendix D REFERENCES

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Natural Hazard Mitigation Saves: An Independent Study to Assess the Future Savings from Mitigation Activities. National Institute of Building Science Multi-Hazard Mitigation Council. 2005.

Natural Hazard Mitigation Saves: 2017 Interim Report. National Institute of Building Science Multi-Hazard Mitigation Council 2018.

National Drought Mitigation Center.

National Lightning Safety Institute.

National Oceanic and Atmospheric Administration Climate Diagnostics Center.

National Oceanic and Atmospheric Administration Storm Prediction Center.

National Weather Service.

NOAA National Severe Weather Laboratory

NOAA Weather Radio All Hazards. National Weather Service.

PandemicFlu.gov. U.S. Department of Health & Human Services.

PERI Presidential Disaster Declaration Site.

Robert T. Stafford Disaster Relief and Emergency Act. Public Law 93-288, as amended, 42 U.S.C. 5121-5207. June 2007.

Rocky Mountain Area Predictive Services.

Spatial Hazard Events and Losses Database for the United States. University of South Carolina Hazards Research Lab.

State of Colorado Natural Hazards Mitigation Plan. Colorado Division of Homeland Security and Emergency Management. 2013.

National Center for Environmental Information database. (formerly National Climatic Data Center). National Oceanic and Atmospheric Administration

Tornado Fujita Damage Scale. Storm Prediction Center. 1971.

Understanding Your Risks: Identifying Hazards and Estimating Losses. Federal Emergency Management Agency. FEMA 386-2. 2001.

University Corporation for Atmospheric Research.

University of Colorado at Boulder ATOC Weather Lab.

Urban Drainage and Flood Control District.

U.S. Department of Agriculture Farm Service Agency.

U.S. Drought Monitor. University of Nebraska–Lincoln National Drought Mitigation Center.

U.S. Earthquake Information by State: Colorado. U.S. Geological Survey. Earthquake Hazards Program. Colorado. 2007.

U.S. Forest Service Wildland Fire Assessment System.

Volcanic Hazards Ash Dispersion Map. U.S. Geological Survey.

West Nile Virus Mosquito Management Plan. City of Boulder Office of Environmental Affairs. 2006.

Western Regional Climate Center.

Wind Chill Chart. National Weather Service. 2001.

Zoonotic Diseases. Colorado Department of Public Health and Environment. Disease Control and Environmental Epidemiology Division. 2007.

APPENDIX E - PLANNING PROCESS

John,
Regarding the plan see if you are able to upload it to this google drive:
https://drive.google.com/drive/folders/0BxANtS735MAbNXhBMlNiRlJlYWM?usp=sharing

If that doesn't work the mail would be preferred so I have it prior to the meeting.

I have attached some text that you can use to invite folks to the meeting via an email or letter from you. Feel free to edit. I recommend we get the notice out no later than February 23rd to give folks at least two weeks notice. If it goes out by email please CC me so I can have record for documentation purposes.

Here is a list of typical entities that should be involved at the local government level (County, town). I have attached a spreadsheet contact info template that can be used for identified contacts as we go through the process.   If you have something similar started we can work from that.
Suggested local government representation

- Planning and community development
- Emergency management
- Fire departments
- Floodplain administrators
- Administration
- Building department/code enforcement
- GIS
- Parks and recreation
- Public information office
- Public works
- Stormwater management
- Transportation (roads/bridges)
- Fire Districts

Other Public, Private, and Non-Profit Stakeholders typically include:

- CDOT
- CSFS
- USFS
- BLM
- Wildfire or watershed groups
- Agricultural organizations
- Local business and industry (if you have an LEPC this is a good way to connect with these groups)
- School districts
- Special districts
- Neighboring county emergency managers

CITY OF BOULDER MULTI-HAZARD MITIGATION PLAN

2017 UPDATE

KICKOFF MEETING

Thursday, June 8th, 2017
1:00 to 3:00 p.m.
City Council Chambers
1777 Broadway
Boulder, CO

- **Introductions**
- **Mitigation, Mitigation Planning, and the Disaster Mitigation Act Requirements**
- **The Role of the Hazard Mitigation Planning Committee**
- **Overview of the 2012 City of Boulder Multi- Hazard Mitigation Plan**
- **Objectives and Schedule for the Plan Update**
- **Review of Identified Hazards**
- **Implementation Success Stories**
- **Coordinating with Other Agencies, Related Planning Efforts, and Recent Studies**
- **Planning for Public Involvement**
- **Information Needs**
- **Questions and Answers/Adjourn**

City of Boulder Hazard Mitigation Planning Committee 2017 Update Kickoff Meeting 1720 14th Street Boulder, CO 6/8/2017 1:00-3:00pm

NAME	POSITION or Title	AGENCY	EMAIL	PHONE	Total Miles	Total Hours (including Travel)
✓ Carrie McCrea	GIS Manager	Amec Foster Wheeler	carrie.mccrea@amecfw.com	303-902-5229		
✓ Jess Fleck	Resilience Intern	City of Boulder	jessica.fleck@colorado.edu	8123193133		
MacKenzie Boli	Resilience Coordinator	City Managers off	bolim@bouldercolorado.gov	480-313-6542		
Callie Hayden	Urban Parks Mngr	COB Parks & Rec	haydenc@bouldercolorado.gov	x3451		
Ken Fisher	Forestry	COB P&R	FISHERK@BOULDR...	720 470 2899		
Mark Thompson	Mitigation Planner	DHSEM	markw.thompson@state.co.us	720-630-0770		
Jack Walker	Commander	Police	walkerj@ . gov	303-441-4314	4	16 min
Joe Castro	Fac. & Fleet Mgr	COB/Public Works	castroj@ boulder...	x3163		
Kurt Bauer	Eng Proj Mngr	Public Works	bauerk@bouldercolorado.gov	x4232		
Anne Noble	F/G Eng Coord.	Public Works	noblea@bouldercolorado.gov	3242		
Gerrit Slatter	Transportation Engineer	Public Works	slatterg@bouldercolorado.gov	X.1976		
Cynthia Swain	GIS Specialist	Boulder County	cswain@bouldercounty.org	303441-4416		1
Douglas Sullivan	Utilities Principal Engr	COB-PW	sullivand@bouldercolorado.gov	3/441-3244		
Brian Oliver	Wildfire Operations	COB - Fire-Rescue	oliverb@bouldercolorado.gov	3/441-1885	15	2.5

Meeting Room Cost____________________ Meeting Supplies (copies) Etc Cost__________________________

City of Boulder Hazard Mitigation Planning Committee 2017 Update Kickoff Meeting 1720 14th Street Boulder, CO 6/8/2017 1:00-3:00pm

NAME	POSITION or Title	AGENCY	EMAIL	PHONE	Total Miles	Total Hours (including Travel)
BRYAN HARDING	PARKS PLANNER	PARKS & REC	HARDINB@BOULDERCOLORADO.GOV	303.413.7228	2	2.25
Varda Blum	FP Manager	Boulder County	vblum@bouldercounty.org	720-564-2659		
Dave Watson	Sr. GIS Specialist	BC Trans	dwatson@bouldercounty.org	303 441-3550		
CHUCK MERRITT	DIRECTOR	BCH	cmerritt@bch.org	3)415-8368	2	.5
Gretchen King	Comms Specialist	City of Boulder	Kingg@bouldercolorado.gov			
MaryAnn Nason	H_2O shed Coord.	City of Boulder	nasonm@bouldercolorado.gov		7	2
Greg Guibert	CRO	COB	guibertg@bouldercolorado.gov			1
MIKE Chard	DIRECTOR OEM	BOEM	mchard@bouldercounty.org	3-565-7878	4	.75
Stephanie DiBetitto	CAP Coord.	CWCB	stephanie.dibetitto@state.co.us	303-866-3441	60	1.5
DAVE ZADER	WILDLAND FIRE ADMINISTRATOR	FIRE	ZADERD@BOULDERCOLORADO.GOV	303 249 4896	164	4.5 * FROM MEETING IN SOUTH CO

Meeting Room Cost____________________ Meeting Supplies (copies) Etc Cost__________________________

Summary of the City of Boulder Multi-Hazard Mitigation Plan Update Kick-Off and Hazard Identification Review Meeting

1:00 to 3:00 pm
June 8, 2017
City Council Chambers
1777 Broadway, Boulder, CO

Introductions and Opening Remarks

Welcoming remarks and an introduction to the hazard mitigation plan were presented by Christin Shepherd from the City of Boulder Public Utilities Department. Christin asked everyone around the room to introduce themselves. Twenty-four persons representing a mix of City agencies and stakeholders were present and documented on sign-in sheets. City departments included several Department of Public Works divisions including: Utilities, Facilities & Fleet, and Transportation. Other departments included Parks and Recreation, Communication, Fire, Police, and the City Manager's Office including Resilient Boulder. Stakeholders present included representatives from the Colorado Water Conservation Board, Colorado Department of Homeland and Emergency Management, Boulder Community Hospital, and Boulder County. Project team members from Amec Foster Wheeler (AmecFW), the consulting firm hired to facilitate the planning process and to develop the updated Plan, were also present. Supporting documents were provided as handouts including an agenda, plan section and analysis summary, and hazard identification table.

Mitigation, Disaster Mitigation Act (DMA) Requirements, and the Planning Process

A PowerPoint presentation was presented by Jeff Brislawn, the project manager from AmecFW. The presentation described the objectives and goals for the Multi-Hazard Mitigation Plan Update and the ten-step planning process that will be followed. The plan is intended to identify hazards, assets at risk, and ways to reduce impacts through long-term, sustainable mitigation projects. The plan will also maintain eligibility for FEMA mitigation grant funding. Mark Thompson from DHSEM spoke to the group regarding types of projects eligible for FEMA funding and provided examples from other communities that have received Hazard Mitigation Grant Program or Pre-Disaster Mitigation (PDM) Grant Program funds. Jeff also noted that FEMA has recently provided PDM funding for 'climate resilient' mitigation activities that can include green infrastructure for stormwater and flood mitigation and groundwater recharge as a drought mitigation action.

The Role of the Hazard Mitigation Planning Committee (HMPC)

This meeting is the first meeting of the City of Boulder Hazard Mitigation Planning Committee (HMPC) during the update process. Participation in the planning process will include:

- Attending and participating in the HMPC meetings,
- Providing available data requested by the HMPC coordinator or Amec Foster Wheeler's project manager,
- Providing or updating hazard profiles and vulnerability details specific to the City,
- Developing or updating the local mitigation strategies (action items and progress to date, such as the relocation of the EOC),
- Advertising and assisting with the public input process,
- Reviewing and commenting on plan drafts, and
- Coordinating formal re-adoption of the updated plan.

This plan will also be developed to conform to Community Rating System (CRS) planning requirements. This program rewards communities that go above and beyond implementing the minimum National Flood Insurance Program (NFIP) standards by providing discounts on flood insurance rates. The HMPC may be further subdivided into working groups such as a steering committee, technical committee, and public involvement committee. Partly for CRS purposes, a steering committee consisting of a mix of City and non-city stakeholders was developed to help strategize public outreach during the 2012 update.

Overview of the 2012 City of Boulder Multi Hazard Mitigation Plan

Jeff Brislawn talked about the existing plan originally developed in 2006 and 2007 and approved by FEMA in 2008; the plan went through a comprehensive five-year update in 2012. The plan is being updated again in accordance with the five-year update requirement of the Disaster Mitigation Act of 2000 (DMA). Mr. Brislawn pointed out some of the hazards data in the plan, the goals of the plan, and referred to some of the mitigation action strategies identified in the 2012 plan. Christin noted that many of the mitigation actions identified in the plan have been completed or in progress. The progress on implementation of these strategies will be assessed and documented during the update process.

Discussion of Objectives and Schedule for the Plan Update

Goals of the process were discussed that included:

- Update the City's Multi-Hazard Mitigation Plan per the DMA and CRS requirements
- Update the risk assessment to reflect current hazards, risk and vulnerability
- Update the City's mitigation strategies as appropriate
- Document progress and success stories

The plan update will be developed over the next seven months, with two more meetings of the HMPC. Amec Foster Wheeler will be drafting the updated risk assessment in the next couple of months, with input from the HMPC. The first draft for HMPC review is targeted for November 2017, and a public review draft in December. A final draft for State and FEMA review is targeted to be completed by late December. The final approved plan should be ready for adoption by February/March 2018. The next meeting of the HMPC is targeted for late August, with exact dates to be determined (TBD). A handout provided outlined the major sections of the plan and the key elements that will be updated through the process.

Review of Identified Hazards

Based on hazards from the 2012 plan, the list of potential natural hazards was reviewed. The focus is on natural hazards, since manmade hazards are not required by DMA 2000 regulations and often are dealt with through separate planning mechanisms. However, some human health and related hazards were included in the 2012 plan. For the City of Boulder, the hazards currently in the plan include:

- Avalanche
- Dam Failure
- Drought
- Earthquakes
- Floods
- Human Health Hazards
  - Pandemic Flu
  - West Nile Virus
- Landslides and Rockfalls
- Severe Weather
  - Extreme Temperatures
  - Fog
  - Hailstorm
  - Heavy Rains
  - Lightning
  - Tornadoes
  - Windstorms
- Soil Hazards
  - Expansive Soils
  - Land Subsidence
- Volcanoes
- Winter Storms
- Wildfire

These hazards were compared to the hazards list in the 2013 State of Colorado Hazard Mitigation Plan. In general, the HMPC felt that the list was comprehensive and should be maintained as such in the updated plan. Insect-infected trees were discussed as a growing concern due to Emerald Ash Borer and Mountain Pine Beetle impacts which result in trees more susceptible to severe weather and wildfire. A severe temperature drop in 2014 also resulted in tree mortality within the urban forest. Hazards with the urban forest will be noted in as consequences of severe weather, wildfire, and winter storm hazards, if not already. Utility impacts were also noted as consequences of flood and wildfire. Erosion and deposition were significant during the 2012 flood and rain event.

Jeff Brislawn asked HMPC members to review specific hazard chapters and comment on how they could be enhanced or updated with:

- Historic incidents
- Incident logs
- Public perception
- Scientific studies
- Other plans and reports (e.g., flood and drainage studies, CWPPs)
- Recent disasters

A discussion of recent studies of hazards in other documents and reports performed by or for the City followed. Recent studies included:

- Incident Logs from Boulder OEM
- Recovery Framework
- Flood Recovery data
- Damage Assessment Plan and Debris Management plans (ask Chris Meschuck)
- City Resiliency Strategy
- NIST report on 2013 floods
- Structural Protection Plan (Fire Department)

Coordination with Other Plans

Integration with Other Plans

Jeff asked the group if the Boulder HMP had been cross-referenced in any other planning efforts in the past five years, or if opportunities might exist to do so in the future.

A discussion on coordination with other plans/policies and hazard information sources occurred, and the following were suggested by the HMPC that may already have cross-references to the HMP:

- City Community Wildfire Protection Plan (CWPP)
- Boulder Valley Comprehensive Plan
- Boulder Emergency Operations Plan
- City of Boulder Drought Plan
- City of Boulder Urban Forestry Master Plan
- City of Boulder Resilience Strategy

Recent or related plans in development that may have opportunities to potentially cross reference the mitigation plan included:

- City of Boulder Recovery Plan – currently in development
- The City CWPP will be updated next year
- Urban Forestry Strategic Plan update
- Volunteer Strategic Plan

Planning for Continued Public and Stakeholder Involvement

Public meetings will be part of the planning process. The update process will include 2 meetings in locations to be determined. The first was held as part of a Utilities Department open house event. The next meeting will be held later in the process when the public review draft becomes available.

Some additional ideas for further outreach and public feedback included using social media methods to disseminate and receive information; "piggy backing" plan update meetings on other public hearings, events, etc. Specific suggestions included:

- Boulder Valley School District parent email group (utilized in 2012)
- Social Media such as the Boulder OEM Facebook page or 'Nextdoor'
- Boulder Resilience Team has about 10-15 upcoming events that include outreach to targeted groups and workshops, including the National Night Out in August.
- The Boulder 'Resilient Together' website: Resilienttogether.org which includes digital public engagement capabilities through a partnership with a local firm.
- BOCO Strong – trainings and workshops

Data Collection Needs and Next steps

Amec Foster Wheeler will begin updating the Risk Assessment based on current GIS databases and research of noted documents and hazard information sources. An email group will be used to communicate with the HMPC on upcoming meetings and events. Jeff encouraged the group to email Christin Shepherd or himself the related information discussed that may inform the plan update process.

Adjourn

The meeting adjourned at 2:40pm.

Summary prepared by Jeff Brislawn, Amec Foster Wheeler

Jeff.brislawn@amecfw.com
303-820-4654
1942 Broadway, Suite 314
Boulder, CO 80302

From: Shepherd, Christin <ShepherdC2@bouldercolorado.gov>
Sent: Thursday, June 22, 2017 10:54 AM
To: Noble, Annie; Oliver, Brian; Harding, Bryan; Hayden, Callie; cmerritt@bch.org; cswain@bouldercounty.org; dwatson@bouldercounty.org; Zader, David; Sullivan, Douglas; Slatter, Gerrit; Guibert, Greg; King, Gretchen; Walker, Jack; jessica.fleck@colorado.edu; Castro, Joe; Fisher, Ken; Bauer, Kurt; markw.thompson@state.co.us; Nason, MaryAnn; Chard, Mike; stephanie.dibetitto@state.co.us; vblum@bouldercounty.org; bseymour@udfcd.org; Bauscher, Ward; Davis, Kaaren; Lowrey, David; patricia.gavelda@state.co.us; Trice, Chris; Walsh, Noreen; Brislawn, Jeff P; McCrea, Carrie V
Cc: Boli, Mackenzie
Subject: Multi-Hazard Mitigation Plan - Closed Group Invitation

Hello MHMP Group Members!

Thank you for your participation in the plan update thus far. The full update process is now underway!

In an effort to streamline communication and share resources across departments and agencies, we will be utilizing an online platform called Resilient Together which will house all of our electronic communication (email), documents, meeting dates and summaries, and discussions.

To continue to participate, **please register for the platform (http://www.resilienttogether.org/users/sign_up) no later than Friday, July 7**, using the same email account you are receiving this email at. Registering will take 30-60 seconds and your information will not be used for any other purposes than the MHMP closed group.

On Monday, July 10, Resilient Together will email you with information on how to access the invite-only page where all things related to the plan update will be housed. **Please register on the platform to receive this and future emails about the plan update by Friday, July 7.**

If you have any questions at all about the Resilient Together platform, how to register, or have any issues with the registration process, please contact Mackenzie Boli (Community Resilience Coordinator) at bolim@bouldercolorado.gov.

Thank you again for your continued efforts to make Boulder a more hazard prepared and resilient city ~

Christin Shepherd, P.E., CFM
Civil Engineer II

City of Boulder
Public Works

O: 303-441-1889
shepherdc2@bouldercolorado.gov

Public Works/Utilities
1739 Broadway | Boulder, CO 80302
Bouldercolorado.gov

City of Boulder Hazard Mitigation Plan Update 2017

Overall Hazard Significance Summary Table September 14, 2017 DRAFT

Significance based on a combination of Geographic Extent, Potential Magnitude/Severity and Probability as defined below. Ratings based on or interpolated from existing Hazard Mitigation Plans and 2017 HIRA update.

Hazard	Geographic Extent	Probability of Future Occurrences	Magnitude/ Severity	Significance
Avalanche	Limited	Unlikely	Negligible	Low
Dam Failure	Significant	Unlikely	Catastrophic	High
Drought	Extensive	Likely	Critical	High
Earthquakes	Significant	Occasional	Limited	Medium
Floods	Significant	Occasional	Catastrophic	High
Human Health Hazards:				
Pandemic Flu	Extensive	Occasional	Critical	High
West Nile Virus	Extensive	Likely	Negligible	Low
Landslides & Rockfalls	Limited	Occasional	Negligible	Low
Severe Weather:				
Extreme Temperatures	Extensive	Highly Likely	Negligible	Low
Fog	Significant	Unlikely	Negligible	Low
Hailstorms	Extensive	Likely	Limited	Medium
Thunderstorms	Extensive	Highly Likely	Limited	Low
Lightning	Extensive	Highly Likely	Limited	Medium
Tornadoes	Limited	Occasional	Negligible	Low
Windstorms	Extensive	Highly Likely	Limited	Medium
Soil Hazards:				
Expansive Soils	No Data	No Data	No Data	Low
Land Subsidence	No Data	No Data	No Data	Low
Volcanoes	Limited	Unlikely	Negligible	Low
Wildfire	Limited	Likely	Critical	High
Winter Storms	Extensive	Highly Likely	Critical	Medium

Geographic Extent
Limited: Less than 10% of planning area
Significant: 10-50% of planning area
Extensive: 50-100% of planning area

Probability of Future Occurrences
Highly Likely: Near 100% chance of occurrence in next year, or happens every year.
Likely: Between 10 and 100% chance of occurrence in next year, or has a recurrence interval of 10 years or less.
Occasional: Between 1 and 10% chance of occurrence in the next year, or has a recurrence interval of 11 to 100 years.
Unlikely: Less than 1% chance of occurrence in next 100 years, or has a recurrence interval of greater than every 100 years.

Magnitude/Severity
Catastrophic—More than 50 percent of property severely damaged; shutdown of facilities for more than 30 days; and/or multiple deaths
Critical—25-50 percent of property severely damaged; shutdown of facilities for at least two weeks; and/or injuries and/or illnesses result in permanent disability
Limited—10-25 percent of property severely damaged; shutdown of facilities for more than a week; and/or injuries/illnesses treatable do not result in permanent disability
Negligible—Less than 10 percent of property severely damaged, shutdown of facilities and services for less than 24 hours; and/or injuries/illnesses treatable with first aid

Significance
Low: minimal potential impact
Medium: moderate potential impact
High: widespread potential impact

Goals and Objectives

Goals were defined for the purpose of this mitigation plan as broad-based public policy statements that:

- Represent basic desires of the community;
- Encompass all aspects of community, public and private;
- Are nonspecific, in that they refer to the quality (not the quantity) of the outcome;
- Are future-oriented, in that they are achievable in the future; and
- Are time-independent, in that they are not scheduled events.

Goals are stated without regard for implementation, that is, implementation cost, schedule, and means are not considered. Goals are defined before considering how to accomplish them so that the goals are not dependent on the means of achievement. Goal statements form the basis for objectives and actions that will be used as means to achieve the goals. Objectives define strategies to attain the goals and are more specific and measurable.

Team members were given the list of goals from the 2008 plan to consider. The HMPC was instructed that they could use, combine, or revise the statements they were provided or develop new ones on their own, keeping the risk assessment in mind. It was decided by the HMPC that the three previous goals were still legitimate, but some of the objectives needed revision. Planning goals remained the same, but the objectives were modified to better suit the 2012 plan update.

Based upon the risk assessment review and goal setting process, the HMPC developed the following goals with several objectives and associated mitigation measures. These goals and objectives provide the direction for reducing future hazard-related losses within the City of Boulder.

Goal 1: Increase Community Awareness of Boulder's Vulnerability to Natural Hazards

Objective 1.1: Inform and educate the community about the types of hazards the City of Boulder is exposed to, where they occur, and recommended responses

Goal 2: Reduce Vulnerability of People, Property, and the Environment to Natural Hazards

Objective 2.1: Provide mechanisms to enhance life safety
Objective 2.2: Reduce impacts to critical facilities and services
Objective 2.3: Reduce impacts to existing buildings and infrastructure to the extent possible
Objective 2.4: Reduce impacts to future development and infrastructure to the extent possible
Objective 2.5: Reduce impacts to the city's natural and historic resources
Objective 2.6: Reduce impacts to public health

Goal 3: Increase Interagency Capabilities and Coordination to Reduce the Impacts of Natural Hazards

Objective 3.1: Continue to collaborate and coordinate with other agencies on planning, projects, hazard response, and funding opportunities.

**This text is from Section 5.2 (around page 248) of the 2012 MHMP*

CITY OF BOULDER MULTI-HAZARD MITIGATION PLAN

2017 UPDATE

RISK ASSESSMENT and GOALS UPDATE MEETING

Monday, September 18, 2017
1:00 to 4:00 p.m.
City Council Chambers
1777 Broadway
Boulder, CO

- **Introductions 1-1:10**
- **Review of the Planning Process 1:10-1:15**
- **Review of Identified Hazards 1:15-1:25**
- **Vulnerability Assessment Update Highlights by Hazard 1:25-2:45**
- **Break 2:45-3:00**
- **Capability Assessment Review 3:00-3:15**
- **Reviewing and Updating Plan Goals and Objectives 3:15-3:45**
- **Public Involvement Update 3:45-3:50**
- **Information Needs/Next Steps/Q&A/Adjourn 3:50-4:00**

City of Boulder Hazard Mitigation Planning Committee 2017 Update Risk and Goals Meeting 1720 14th Street Boulder, CO 9/18/2017 1:00-4:00pm

NAME	POSITION or Title	AGENCY	EMAIL	PHONE	Total Miles	Total Hours (including Travel)
Mark Thompson	Mit Planner	DHSEM	mark.thompson@state.co.us	720 630 0770	—	—
JAMES BROWN	RISK MGR	CITY OF BOULDER	BROWNJE@BOULDERCOLORADO.GOV	303-441-3070	—	—
KURT BAUER	Public Works	COB	bauerk@ ..	x4232	—	—
Anne Noble	FT GW ENG COORD.	COB		3242		
Nicole Aimone	Community Planner	FEMA	nicole.aimone@fema.dhs.gov		—	
CHUCK MERRITT	DIRECTOR	BCH	cmerritt@bch.org	3)415.8368	—	—
Gerrit Slatter	Principal Engineer	COB	slatterg@ ..	441-1978	—	—
ROB PRICE	ASS. SUPERINTENDENT OF OPERATIONS	BVSD	ROB.PRICE@BVSD.ORG	970-214-0110		
Jack Walker	Police Command	BPD	walkerj	720 [illegible]		
[illegible] Kellogg	MANAGER	BVSD	rick.kellogg@bvsd.org	7205619180		
BRENDAN SULLIVAN	DIRECTOR	BVSD	BRENDAN.SULLIVAN@BVSD.ORG	720 561-5756		
MIKE CHARD	EDOM	EDOM	michael.chard@boulder [illegible]	3 585 7898	6	3
Mackenzie Boli	community resilience coordinator	COB	bolim@bouldercolorado.gov	480-313-6542		
Katie Jefferis	volunteer	COB	katieljefferis@gmail.com	+447876456-092	—	—
Joe Castro	Public Works	COB	castroj@bouldercolorado.gov	303 441-3163	—	—
Dave Lowrey	Chief Fire Marshal	Fire	lowreyd@bouldercolorado.gov	303 441 4356	—	—

Meeting Room Cost__________________ Meeting Supplies (copies) Etc Cost____________________

City of Boulder Hazard Mitigation Planning Committee 2017 Update Risk and Goals Meeting 1720 14th Street Boulder, CO 9/18/2017 1:00-4:00pm

NAME	POSITION or Title	AGENCY	EMAIL	PHONE	Total Miles	Total Hours (including Travel)
BROOKE WATKINS	Community Resilience Coordinator	Boulder CMO	watkinsb@bouldercolorado.gov	—	—	—
DAVE ZADER	WILDLAND FIRE ADMINISTRATOR	BFD	ZADERD@BOULDERCOLORADO.GOV	303 249 4896 303 441 4353	—	—
Madi Pluss	Mitigation Planner	AMEC FW	madeleine.pluss@amecfw			
Carrie McCrea	GIS Analyst	AmecFW	carrie.mccrea@amecfw.com	303-902-5229		
Mack Chambers	GIS Specialist	AMEC FW	mack.chambers@amecfw.com		—	—
Jeff Brislawn	Project Manager	Amec FW	Jeff.brislawn@amecfw.com	303-704-5506	—	—

Meeting Room Cost___________________ Meeting Supplies (copies) Etc Cost_________________________

Summary of the City of Boulder
Multi-Jurisdictional Hazard Mitigation Plan Update
Risk Assessment and Goals Meeting

September 18, 2017
1:00 PM – 4:00 PM
City Council Chambers, 1777 Broadway
Boulder, CO

Introductions and Opening Remarks

Christin Shepherd of the City of Boulder began the meeting with welcoming remarks. Jeff Brislawn of Amec Foster Wheeler, the consulting firm hired to facilitate the plan development process, gave a brief overview of the meeting agenda and facilitated the meeting. Twenty two persons were present and documented on a sign in sheet.

Review of Mitigation, Disaster Mitigation Act (DMA) Requirements, and the Planning Process

Following introductions, a PowerPoint presentation was presented by Jeff Brislawn. Jeff reviewed the planning process being followed and discussed the project status.

Risk Assessment Presentation and Discussion

Jeff outlined the general risk assessment requirements before beginning a detailed discussion of each hazard. He presented highlights on each hazard included in the updated risk assessment chapter of the plan. Refer to the meeting PowerPoint presentation for specific details on each hazard and a handout summarizing hazard significance.

Additional insight and details were learned during the risk assessment conversation among participants. Highlights of the discussion are noted by hazard in the table below.

Hazard or Topic	**Meeting Discussion**
Avalanche	• Little to minimal risk. No comment
Dam Failure	• The spillway releases worked properly during the 2013 floods. However, HMPC members are concerned about the volume of water released.
Drought	• No comment
Earthquake	• No comment
Flood	• Two-Mile Creek experienced the most severe flooding. New plan should integrate the risk assessment from the 2015 Upper Goose Creek and Two-Mile Canyon Creek Floodplain mapping study.

Hazard or Topic	Meeting Discussion
	• Current project is underway to evaluate certain pedestrian bridges and walkways in the Boulder parks system. • Discussion on DFIRM limitations, provokes the question of other available studies. DFIRM is not completely reflective of actual events and conditions of the planning area. • Suggestion to do a flood risk assessment on the 10-year flood event to identify the highest risk buildings. • HMPC members mentioned an analysis of bridges that includes a color coding system based on the degree of flood hazard. Consider integrating findings into plan.
Human Health Hazards: Pandemic Flu	• A question was raised regarding if this should be kept a 'high' significance hazard. It was suggested to followup with County Public Health.
Human Health Hazards: West Nile Virus	• No comment
Landslide, Debris Flow, Rockfall	• New debris flow mapping was presented, post 2013 flooding. No comment
Severe Weather: Extreme Temperatures Fog Hailstorm Thunderstorm Lightning Tornado Windstorm	• Several sub-hazards of Severe Weather were discussed. No comment
Soil Hazards: Expansive Soils	• No comment
Soil Hazards: Land Subsidence	• No comment
Volcano	• No comment
Wildfire	• Open Space and Mountain Parks has information on fuels treatment sites, past and proposed.
Winter Storms	• No comment
Other	• Air quality standards— A question about if this is an identified hazard and how related discussion be incorporated into the plan. Jeff noted that typically this issue is not addressed as a hazard in local mitigation plans, but could be an outcome or impact of other hazards such as wildfires or implications of climate change. A representative from FEMA suggested this could be discussed in relation to development trends.
Capabilities	• Carrie McCrea from Amec Foster Wheeler noted highlights of the capability assessment update. • Resilient Together website and survey was presented. Representatives from the organization outlined objectives, and discussed how the HMP could incorporate resilience concepts. • Other repated plans included integration with City/County Climate Change Preparedness Plan • City's Structure Protection Plan was noted • BV Comp Plan – Need to check to see if HMP is referenced within.

Plan Goals Update

The HMPC reviewed the goals and objectives from the previous plan to see if they were still relevant or needed updating. In general, the group thought was they were still valid. The primary focus of discussion was around the level of specificity in some of the Objectives language. Additionally, members of the HMPC were interested in the wording of objective 2.1 and the ambiguity of “life safety”. A suggestion was made to potentially combine objectives 2.3 and 2.4. The HMPC also wanted to integrate more language related to resilience, as well as social vulnerability and consideration for special needs populations. Another suggestion was to note minimizing economic impacts. Jeff will revise per the suggestions and the group will revisit the goals for finalization at the beginning of the next meeting.

Mitigation Action Strategy update needs

Jeff noted that the mitigation action strategy update will be the focus of the next planning meeting. This will be an opportunity to reflect on progress made on implementation of actions, and develop new actions to include in the updated plan. Jeff will work with Christin on the status of actions and may be reaching out to other departments for information.

Update on Public Involvement Activities/public meeting.

Boulder’s Community Resilience Coordinator provided an update on a public survey developed for the planning effort. She noted that the public survey had 12 responses thus far that were collected at a community resilience forum. The survey will be available until October 30 and will be advertised further in the coming weeks. Jeff will share the details of the responses prior to the next meeting. Additionally, the planning process and objectives of hazard mitigation have been endorsed by the local media, specifically Channel 8.

Plan Timeline/Next steps

The next and final HMPC planning meeting will be November 2nd from 1-4. The purpose of this meeting is to develop mitigation actions for the plan. A calendar update will be sent out to save the date. The meeting materials will also be shared electronically, including the presentation and handouts.

The meeting adjourned at 3:30.

CITY OF BOULDER MULTI-HAZARD MITIGATION PLAN

2017 UPDATE

MITIGATION STRATEGY MEETING

Thursday, November 2nd, 2017
1:00 to 4:00 p.m.
City Council Chambers
1777 Broadway
Boulder, CO

- **Introductions**
- **Review of the Planning Process and HIRA Recap**
- **Public survey results**
- **Finalizing Updated Goals**
- **Review of possible mitigation activities and alternatives**
- **Discuss criteria for mitigation action selection and prioritization**
- **Review of progress on existing actions in the plan**
- **Brainstorming Session: Development of new mitigation actions (group process)**
- **Prioritize mitigation actions (group process)**
- **Discuss plan implementation and maintenance**
- **Discuss next steps/Questions and Answers/Adjourn**

Summary of the City of Boulder Mitigation Strategy Meeting
2017 Hazard Mitigation Plan Update

November 2, 2017
1:00 – 3:30 PM
City Council Chambers
1777 Broadway, Boulder, CO

Introduction and Opening Remarks

Jeff Brislawn, project manager with Amec Foster Wheeler, initiated the meeting with a discussion of the agenda for the afternoon. Jeff asked everyone around the room to introduce themselves; 10 persons from various City, County, and State departments were in attendance and documented on a sign in sheet. Stakeholders included the CO Division of Homeland Security and Emergency Management, Boulder Emergency Management, Boulder Fire Department, and Boulder Public Works. Handout materials were provided.

Jeff presented the PowerPoint slide deck that outlined the meeting agenda and topics.

Review of the Planning Process

Jeff reviewed the planning process that has taken place so far. The process is currently in Phase III – Develop a Mitigation Plan and this meeting is the last formally facilitated meeting of the Hazard Mitigation Planning Committee (HMPC). Jeff also reviewed the findings of the process up to the point of the meeting, including the draft hazard identification and risk assessment. Jeff also noted the results of the online-public survey that was generated by Boulder's Resilient Together. Amongst other results, the primary findings of the survey relate to the public's belief on what is considered the highest natural threat to the community, as well as the perception of who should be responsible for hazard mitigation. There were twenty responses to the survey, despite broad efforts to advertise it. After reviewing the data, the group discussed how the survey could be more effective and various strategies to increase public involvement and gather more responses. One of the HMPC members mentioned that a survey was conducted in 2013 after the floods and received a significant amount of public input, which could be integrated in the planning process for the 2017 update. In follow-up to the discussion the potential for extending and re-advertising the survey will be explored.

Plan Goals

Jeff reviewed the broad mitigation goals with some modifications that were suggested at the previous meeting. The group felt that they looked reasonable. The revised goals and objectives that will be included in the updated plan for review by the HMPC, during which there will be opportunity for final review and comment.

Review of Possible Mitigation Activities and Alternatives

Jeff presented information on typical mitigation activities and alternatives and referred to handouts with further details and guidance. Jeff reviewed ideas for possible mitigation activities and alternatives based on the risk assessment. Jeff outlined potential project criteria and action requirements, including the requirements of the Disaster Mitigation Act of 2000. Each hazard must have at least one true mitigation action (not preparedness) pertaining to them. The group was provided a handout with a matrix of typical mitigation alternatives organized by Community Rating System categories for the hazards identified in the plan. Another reference document titled “Mitigation Ideas” developed by FEMA was suggested at the meeting, which can be found online at: https://www.fema.gov/media-library/assets/documents/30627

This reference discusses the common alternatives and best practices for mitigation by hazard.

Action Prioritization

The group was provided with a decision-making tools to consider when prioritizing the actions. This including FEMA’s recommended criteria, STAPLE/E (which considers social, technical, administrative, political, legal, economic, and environmental constraints and benefits). Other criteria used to recommend what actions might be more important, more effective, or more likely to be implemented than another included:

- Does action protect lives?
- Does action address hazards or areas with the highest risk?
- Does action protect critical facilities, infrastructure or community assets?
- Does action meet multiple objectives (Multiple Objective Management)?

Actions continuing from the 2012 plan will need to be reviewed for relative priority (high, medium, low). Any new actions developed will also need a relative prioritization based on these criteria.

Review of progress on 2012 Plan actions and identification of new actions

Jeff provided a handout with the mitigation action table from the 2012 plan. Each of the 33 actions from the 2012 plan was discussed with the group. Christin has been soliciting input on whether the action had been completed and if not reasons why. Some actions were determined to still be relevant and should continue in the updated plan. Others were recommended to be deleted; some progress details were still outstanding. Action priorities were revisited and modified in some cases. Completed and deleted actions will be moved to separate tables in the updated plan. The continuing, deferred and new actions will be grouped together in an updated action strategy table.

When discussing success stories from mitigation actions identified in the 2012 plan, a representative from the Fire Department mentioned that the Sunshine Fire in April 2017 utilized the structure protection plan that was prioritized in 2012. Another HMPC member commented on the deletion of the West Nile Management Plan, which resulted in a discussion of its relevancy. It was decided that associated actions be deleted, however, the Plan will be discussed in the capabilities section of the 2017 Hazard Mitigation Plan as an ongoing activity.

A number of proposed new action items were presented to the HMPC that were identified during the plan update process. These originated from previous meetings or discussion, or were suggested by Amec Foster Wheeler for consideration. HMPC members were given the opportunity to remark on the proposed new action items, before contributing additional ideas. The comments are described in the bullets below:

- There is no need to update the 2008 Community Wildfire Protection Plan because, Boulder Fire indicated that they are currently working on a city-wide fire management plan for open space, which is more comprehensive than a CWPP.
- The actions regarding “water quality” and “shallow groundwater regulations” were removed after further discussion
- There are already generators at the fire and police stations in the City of Boulder and there is no room to store extra generators. Therefore, any associated action items should be deleted.
- Add “parks and recreation natural lands” to the action item regarding prescribed burns in Boulder OSMP, and change ‘prescribed burns’ to ‘hazardous fuels reduction’, which is a more encompassing term frequently used by FEMA.
- South Boulder Creek and Boulder Canyon already have drainage studies with flood matrices. There are other streams that are not covered.
- Rather than stream gauges, additional rain gauges may be more effective for the City of Boulder’s flood mitigation and preparedness due to the relatively small size of watersheds.
- Flood mitigation actions should be more encompassing, rather than identifying specific watersheds/drainages.

After Jeff passed out 3x5 sticky notes for participants to specify new mitigation actions. The participants placed these on a large flip chart for further discussion. Each action was given an initial prioritization based on discussion with the group. The strategies are listed below:

- Regularly updated and Enhanced Critical Facility data – Priority Low – James Brown/Christin Shepherd – PW Utilities
- City of Boulder Fire Management Plan – Priority Medium – OSMP/Fire Dept.
- Prescribed Burns on Opens Space and Mountain Parks and other natural lands properties – Priority High – Chris Wanner
- Implementation of Flood Mitigation Plans (Gregory, South Boulder Creek, Two Mile/Goose, and Bear Canyon) - Priority High - Christin Shepherd – PW Utilities
- Hazard education through “Better Together Program” – Priority Medium – Boulder OEM
- Enhance Wireless Communications Mesh Network – Priority High – Boulder OEM
- Green Infrastructure Strategy Plan – Priority/applicability TBD
- Enhanced warning systems for flooding from dam releases - Priority/applicability TBD

Next Steps

Jeff provided a new action worksheet for participants to flush out the details of proposed actions. Some of the worksheets were filled out during the meeting, and Jeff invited the participants to continue to fill out sheets if more ideas emerged later. New action worksheets are due November 17th. These will be compiled by Jeff into the mitigation action table and shared with the committee for further refinement and prioritization when the draft plan is made available for review, which is targeted for early December. The goal is to finalize the plan for submittal to FEMA by mid-February.

The meeting adjourned at 3:30 PM.

City of Boulder Hazard Mitigation Planning Committee 2017 Update Mitigation Strategy Meeting 1720 14th Street Boulder, CO 11/3/2017 1:00-4:00pm

NAME	POSITION or Title	AGENCY	EMAIL	PHONE	Total Miles	Total Hours (including Travel)
Mark Thompson	Mitigation Planner	DHSEM	markw.thompson@state.co.us	720-630-0770	—	—
Christin Shepherd	Civil Engineer II	COB	shepherdc2@bouldercolorado.gov	(303) 441-1889	—	—
Mary Ann Nason	Flood Watershed Supervisor	COB	nasonm@bouldercolorado.gov	3-413-7407	14	5
BRYAN HARDING	PARKS PLANNER PARKS & RECREATION	PARKS & REC.	HARDINGB@BOULDERCOLORADO.GOV	3.413.7228	4	3.25
Anne Noble	Flood/Greenways Coordinator	COB	noblea@bouldercolorado.gov		—	—
KURT BAUER	PW Eng. Prjt Mngr	COB	Bauerk@	4232	—	—
Gretchen King	Comms Specialist	COB	Kingg@bouldercolorado.gov	3005	—	—
DAVE ZADER	WILDLAND FIRE ADMINISTRATOR	COBFD	ZADERD@BOULDERCOLORADO.GOV	3032494896	30	4
Dave Lowrey	Chief Fire Marshal	COBFD	lowreyd@bouldercolorado.gov	x4356	—	—
Madi Pluss	AMEC Planner	AMECFW	madeleinepluss@woodplc	303.807.7142	30	—

Meeting Room Cost____________________ Meeting Supplies (copies) Etc Cost__________________________

City of Boulder
Hazard Identification and Risk Assessment
Public Survey April 2017

The City of Boulder is updating its hazard identification and action plans as a basis for further hazard mitigation projects and resilient land use planning. Please take this short survey to provide input into the process:

1. Please rank your perception of the city's hazards with 1 = low, 2 = moderate and 3 = high:

- [1] Avalanche
- [3] Dam Failure
- [3] Drought
- [2] Earthquake
- [3] Extreme Heat and Cold
- [3] Flood – including erosion/deposition
- [3] Hail
- [3] Health Hazards
- [3] Landslide/Rockfall/Mud Flow
- [3] Lightning
- [3] Snow/Ice
- [3] Soil Hazards (expansion and subsidence)
- [2] Tornado
- [3] Wildfire
- [3] Wind

2. Please rank your preferred method of notification of a significant natural hazard event with 1 = least effective, 2 = somewhat effective and 3 = most effective:

Radio	1	E mail	2
Television	1	Sirens	3
Text Message	3	Phone Message	2

Other (describe): Highway Message Boards |2|

3. What would help you be more prepared for a significant natural hazard event?

List of emergency preparedness ideas/items

4. I am age:

18-25 [ ] 26-35 [ ] 36-45 [X] 46-55 [ ] 56-older [ ]

City of Boulder
Hazard Identification and Risk Assessment
Public Survey April 2017

5. Do you have information on specific hazard issues/problem areas that you would like the planning committee to consider? Note the area of town to which it applies.

6. Please comment on any other pre-disaster strategies that the planning committee should consider for reducing future losses caused by natural disasters.

7. Would you like to get involved? Please provide your email if you would like to be added to our distribution list for upcoming planning process activities.

____

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1. Please rank your perception of the city's hazards with 1 = low, 2 = moderate and 3 = high:

1	Avalanche	3	Landslide/Rockfall/Mud Flow
1	Dam Failure	3	Lightning
3	Drought	3	Snow/Ice
1	Earthquake	2	Soil Hazards (expansion and subsidence)
1	Extreme Heat and Cold	2	Tornado
3	Flood – including erosion/deposition	3	Wildfire
2	Hail	3	Wind
2	Health Hazards		

2. Please rank your preferred method of notification of a significant natural hazard event with 1 = least effective, 2 = somewhat effective and 3 = most effective:

Radio	1	E mail	3
Television	3	Sirens	1
Text Message	3	Phone Message	3

Other (describe):

3. What would help you be more prepared for a significant natural hazard event?

4. I am age:

18-25 ☐ 26-35 ☐ 36-45 ☐ 46-55 ☐ 56-older ☒

City of Boulder
Hazard Identification and Risk Assessment
Public Survey April 2017

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1. Please rank your perception of the city's hazards with 1 = low, 2 = moderate and 3 = high:

3	Avalanche	2	Landslide/Rockfall/Mud Flow
2	Dam Failure	2	Lightning
3	Drought	2	Snow/Ice
1	Earthquake	2	Soil Hazards (expansion and subsidence)
2	Extreme Heat and Cold	1	Tornado
2	Flood – including erosion/deposition	3	Wildfire
2	Hail	2	Wind
2	Health Hazards		

2. Please rank your preferred method of notification of a significant natural hazard event with 1 = least effective, 2 = somewhat effective and 3 = most effective:

Radio	1	E mail	2
Television	1	Sirens	2
Text Message	3	Phone Message	1
Other (describe):			

3. What would help you be more prepared for a significant natural hazard event?

if children learn about the risks in school and bring the info home to family.

4. I am age:

18-25 ☐ 26-35 ☐ 36-45 ☐ 46-55 ☒ 56-older ☐

City of Boulder
Hazard Identification and Risk Assessment
Public Survey April 2017

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1. Please rank your perception of the city's hazards with 1 = low, 2 = moderate and 3 = high:

	Avalanche		Landslide/Rockfall/Mud Flow
	Dam Failure		Lightning
2	Drought		Snow/Ice
	Earthquake	4	Soil Hazards (expansion and subsidence)
	Extreme Heat and Cold		Tornado
1	Flood – including erosion/deposition	3	Wildfire
~~1~~	Hail		Wind
	Health Hazards		

2. Please rank your preferred method of notification of a significant natural hazard event with 1 = least effective, 2 = somewhat effective and 3 = most effective:

Radio		E mail	
Television		Sirens	
Text Message		Phone Message	
Other (describe):			

3. What would help you be more prepared for a significant natural hazard event?

CONTINUE FLOOD MITIGATION & H_2O CONSERVATION AS PART OF DROUGHT PLAN

4. I am age:

18-25 [ ] 26-35 [ ] 36-45 [ ] 46-55 [ ] 56-older [X]

City of Boulder
Hazard Identification and Risk Assessment
Public Survey April 2017

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1. Please rank your perception of the city's hazards with 1 = low, 2 = moderate and 3 = high:
↳ DON'T YOU KNOW?? :)

1	Avalanche	1	Landslide/Rockfall/Mud Flow
	Dam Failure	2	Lightning
2	Drought		Snow/Ice
1	Earthquake	2	Soil Hazards (expansion and subsidence)
	Extreme Heat and Cold	1	Tornado
3	Flood – including erosion/deposition	3	Wildfire
2	Hail	3	Wind
	Health Hazards		

2. Please rank your preferred method of notification of a significant natural hazard event with 1 = least effective, 2 = somewhat effective and 3 = most effective:

Radio		E mail	1
Television		Sirens	3
Text Message		Phone Message	2+
Other (describe):			

3. What would help you be more prepared for a significant natural hazard event?

PRE KNOWLEDGE OF EVAC ROUTES & CONTINGENCIES, SHELTERS.
NOAA WEATHER/ALERT RADIO'S ARE GREAT.
HIGHLY RECOMMENDED FOR FOLKS ESP. IF LOCAL EMERGENCY BROADCASTS COULD BE ADDED ON A SIDE-BAND. OTHERWISE BROADBAND SCANNERS TO LISTEN IN ON EMER. SVCS.

4. I am age:

18-25 [ ] 26-35 [ ] 36-45 [ ] 46-55 [ ] 56-older [X]

WHAT ABOUT OFFERING A "NETWORK-APPLIANCE" ALERT/UPDATE SYSTEM FOR HOUSEHOLDS & INSTITUTIONS.

City of Boulder
Hazard Identification and Risk Assessment
Public Survey April 2017

5. Do you have information on specific hazard issues/problem areas that you would like the planning committee to consider? Note the area of town to which it applies.

6. Please comment on any other pre-disaster strategies that the planning committee should consider for reducing future losses caused by natural disasters.

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~~SPIRITBI~~ SPIRITPICO@GMAIL.COM

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1	Dam Failure	2	Lightning
2	Drought	1	Snow/Ice
1	Earthquake	1	Soil Hazards (expansion and subsidence)
1	Extreme Heat and Cold	1 ~~4~~	Tornado
4 2	Flood – including erosion/deposition	3 ~~4~~	Wildfire
1	Hail	3 ~~2~~	Wind
2	Health Hazards		

2. Please rank your preferred method of notification of a significant natural hazard event with 1 = least effective, 2 = somewhat effective and 3 = most effective:

Radio	☐	E mail	☑
Television	☐	Sirens	☐
Text Message	☑	Phone Message	☐
Other (describe):			

3. What would help you be more prepared for a significant natural hazard event?

4. I am age:

18-25 ☐ 26-35 ☒ 36-45 ☐ 46-55 ☐ 56-older ☐

City of Boulder
Hazard Identification and Risk Assessment
Public Survey April 2017

5. Do you have information on specific hazard issues/problem areas that you would like the planning committee to consider? Note the area of town to which it applies.

not at this time.

6. Please comment on any other pre-disaster strategies that the planning committee should consider for reducing future losses caused by natural disasters.

—

7. Would you like to get involved? Please provide your email if you would like to be added to our distribution list for upcoming planning process activities.

no thanks

Report for Multi-Hazard Mitigation Plan Questionnaire

Response Counts

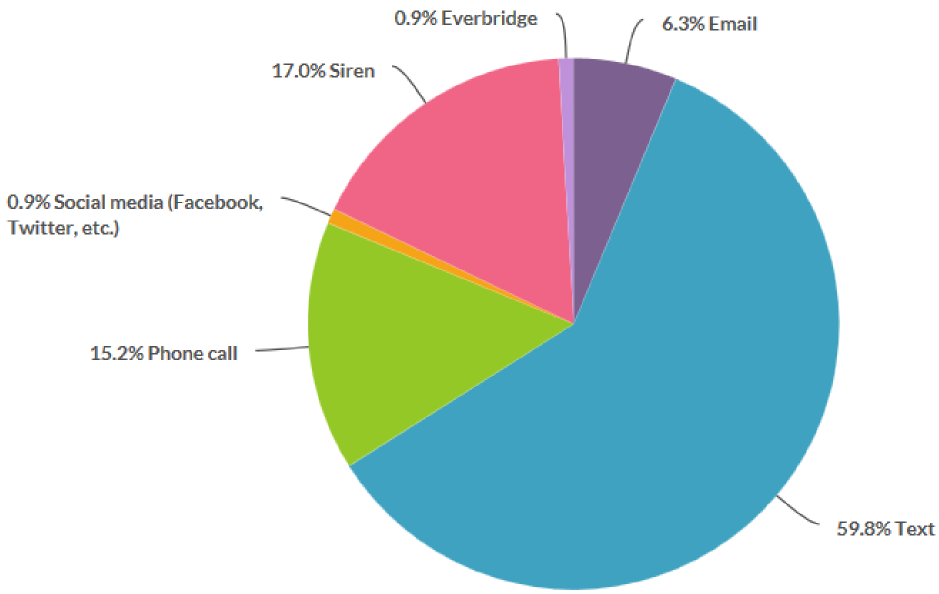
Completion Rate:	**99.1%**	
	Complete	111
	Partial	1
		Totals: 112

1. What do you consider the three greatest natural threats to Boulder? Please rank from top to bottom.

Item	Overall Rank	Rank Distribution	Score	No. of Rankings
Wildfire	1		1,458	92
Flood (including erosion/deposition)	2		1,409	87
Drought	3		816	55
Climate Change	4		729	50
Wind	5		481	36
Extreme Heat and Cold	6		299	27
Snow and Ice	7		281	26
Hail	8		279	23
Dam Failure	9		274	25
Emerald Ash Borer/Invasive Species	10		270	26
Health Hazards	11		259	25
Lightening	12		173	19
Tornado	13		144	21
Landslide/Rockfall	14		131	20
Soil Hazards	15		102	18
Earthquake	16		84	19
Avalanche	17		43	18

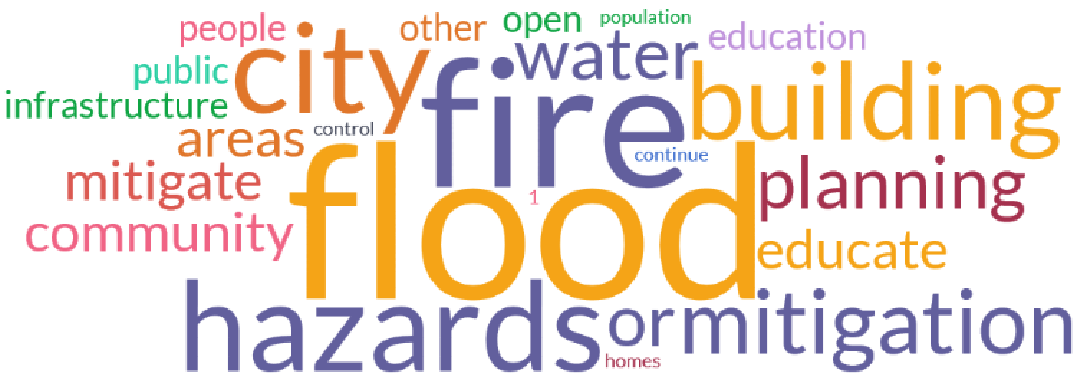
Lowest Rank — Highest Rank

2. How would you prefer to be notified of an emergency?



Value	Percent	Responses
Email	6.3%	7
Text	59.8%	67
Phone call	15.2%	17
Social media (Facebook, Twitter, etc.)	0.9%	1
Siren	17.0%	19
Everbridge	0.9%	1
		Totals: 112

3. How could the city reduce risk associated with natural hazards?



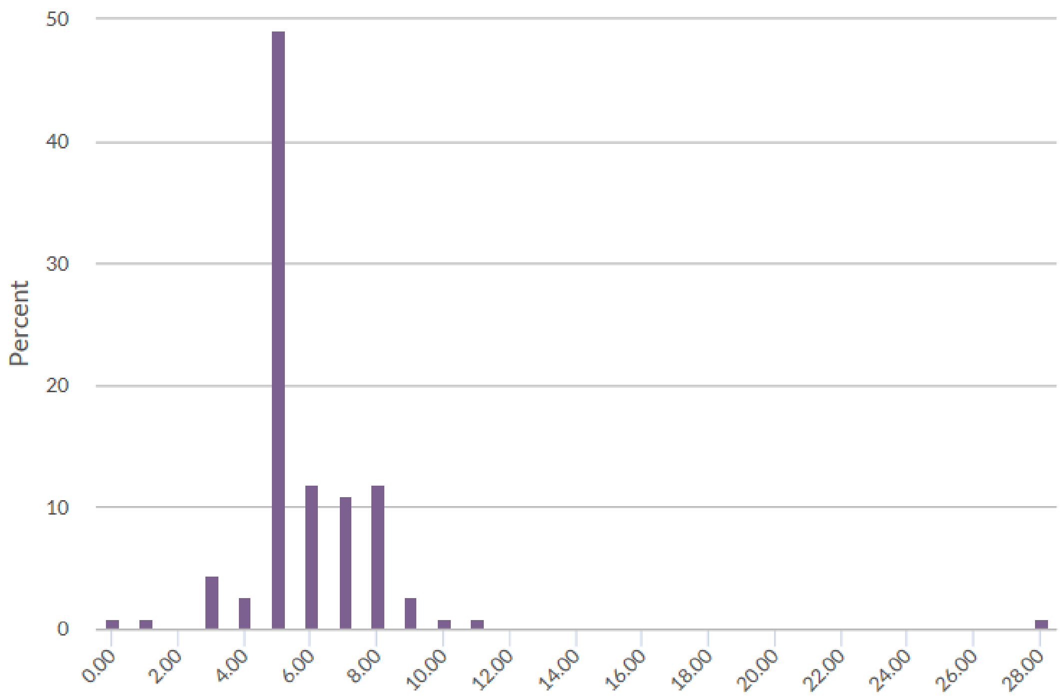
Hide Responses

ResponseID	Response
1	through land management designations
2	More communications to the public to better understand natural hazard mitigation and what they can do about it.
3	fire trucks ready and mutual aid agreements
4	long term planning
5	Enable registration of cell phones to receive Reverse 911 calls (via Smart911 or similar).
6	Keep up excellent flood control program.
7	preparedness planning by individual, neighborhood, and community
8	Keep folks informed about potential threats and mitigation actions.
9	Changes for flood mitigation. Don't allow building in the flood plane. Make sure Flood amounts of water will flow UNDER 36.
10	Educate us, the public, about prevention as well as dealing with hazards when they arrive.

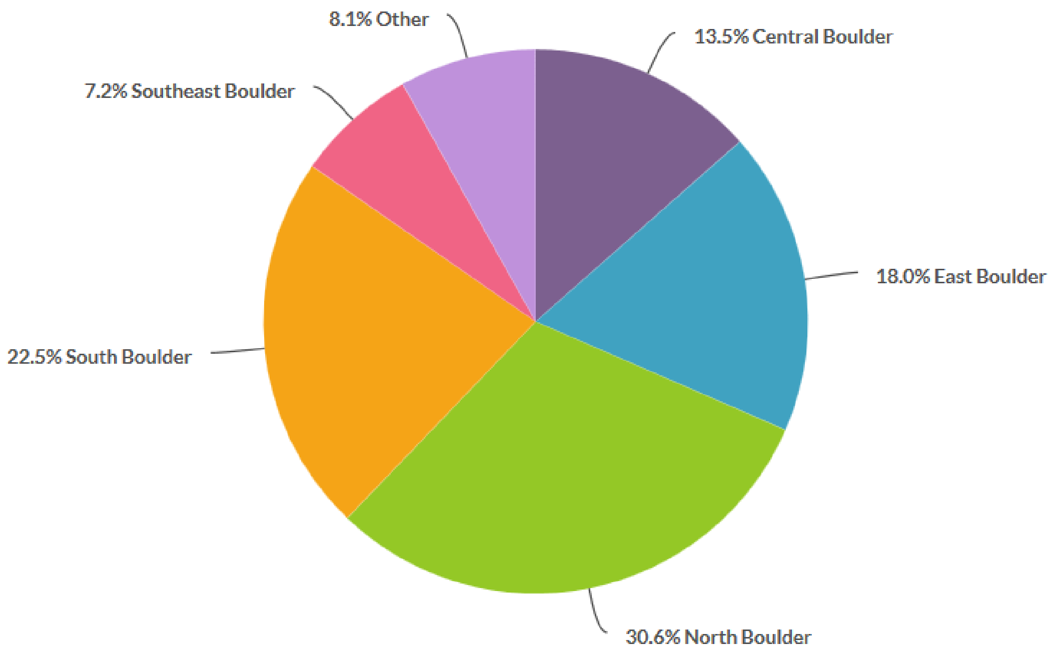
11	(1) Assess the probability and impact of various hazards (2) Prioritize the likely and "ruinous" hazards (3) Provide tax incentives for people to prepare and reduce their risk of exposure to high priority and ruinous hazards
12	1. Not allow any more homes in nearby mountains; institute policy of no rebuilding in same area after a fire. 2. Comprehensive flood plain planning; consider 500-year floods now 50-year floods
13	Preparation and awareness both within government and for city residents, continued investment in land use and planning to mitigate/avoid exposure, increased cross-sectoral and cross-jurisdictional communication, coordination and networking to respond to and recover from anticipated and unanticipated events.
17	mandate brush/leaf clean up, better/more street sweeping
20	Stop spending money on useless art projects and spend more on snow plowing and clearing
21	planning, communicating,
22	not allow building/development on open areas that naturally allow for water retention and infiltration
23	Better stormwater management, good emergency communications, keeping up with prescribed burns and other fuel management, secure and diversify our water supply
24	Ban smoking and fireworks
25	Education, simulation training, recommend actions to mitigate the hazard, modify infrastructure to mitigate the hazard

Previous Page Next Page

4. On a scale from 1 to 10, what do you think is the responsibility of community members, opposed to the responsibility of government, for reducing risk to natural disasters? (1 being only community members responsibility, 10 being only government responsibility)



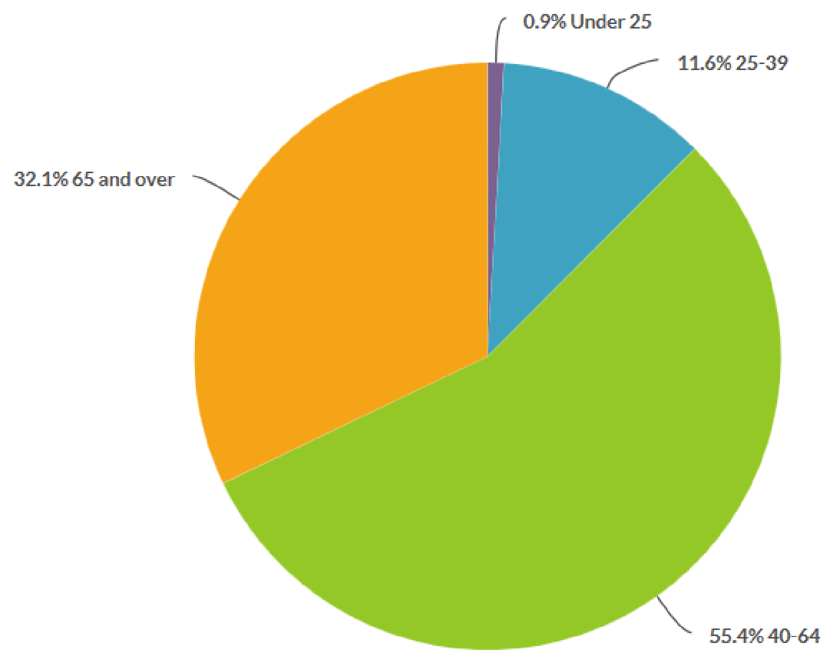
5. What community do you live in?



Value		Percent	Responses
Central Boulder		13.5%	15
East Boulder		18.0%	20
North Boulder		30.6%	34
South Boulder		22.5%	25
Southeast Boulder		7.2%	8
Other		8.1%	9

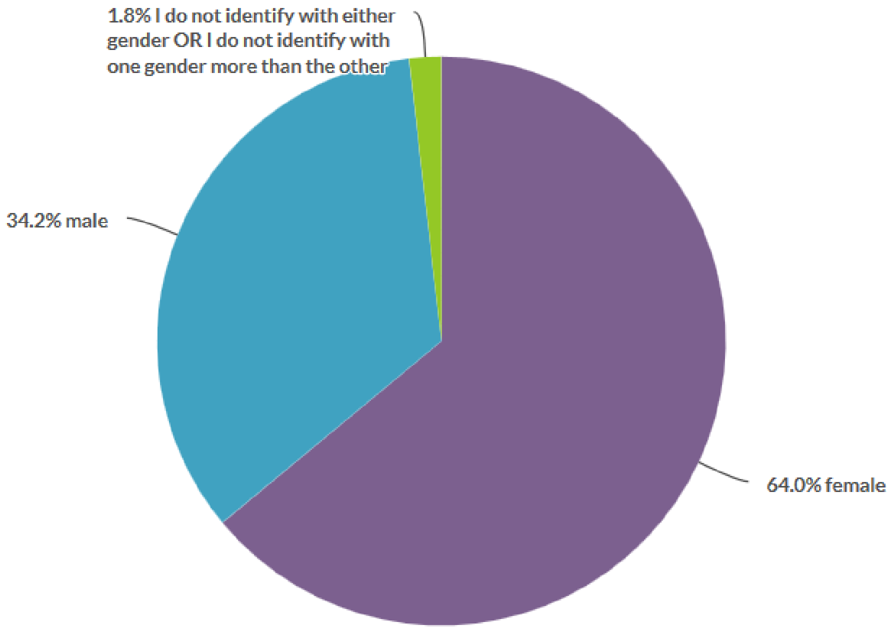
Totals: 111

6. What is your age range?



Value		Percent	Responses
Under 25		0.9%	1
25-39		11.6%	13
40-64		55.4%	62
65 and over		32.1%	36
			Totals: 112

7. What gender do you mostly identify with?



Value	Percent	Responses
female	64.0%	71
male	34.2%	38
I do not identify with either gender OR I do not identify with one gender more than the other	1.8%	2
		Totals: 111

This is a report for "Multi-Hazard Mitigation Plan Questionnaire" (Survey #3997593)

Survive. Adapt. Thrive.

BETTER TOGETHER: A SERIES OF WORKSHOPS ON DISASTER RESPONSE & COMMUNITY RESILIENCE

Are you ready to help yourself, your family and your neighbors the next time there's an emergency? Be the solution to a lack of disaster preparedness in Boulder by joining us for this free workshop series.

AUG. 16, AUG. 23 & AUG. 30
6:00 to 8:30 p.m. @ Boulder Jewish Community Center
6007 Oreg Ave., Boulder, CO 80303

FOR MORE INFORMATION AND TO REGISTER,VISIT **RESILIENTTOGETHER.ORG**

RESILIENT BOULDER

CITY OF BOULDER

Boulder County

You're Invited!
City of Boulder Flood Information Open House

Join City of Boulder staff to learn how the city's flood management program is reducing the community's flood risk and what you can do to help.

When: Wednesday, April 12, 2017 | 5:30 to 7 p.m.
Where: Boulder High School Library | 1604 Arapahoe Ave.

Information on the following topics will be provided:

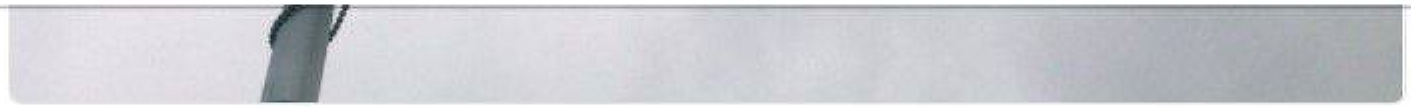
- Floodplain Management Program
- Emergency Management Planning
- Multi-Hazard Mitigation
- Mitigation Planning - current projects include: Fourmile Canyon Creek, Upper Goose and Twomile Canyon Creek, Skunk Creek / Bluebell Canyon Creek/King's Gulch
- Capital Improvement Projects - current projects include: Gregory Canyon Creek, S. Boulder Creek, and Wonderland Creek
- Water Quality
- Home Preparedness
- Critical Facilities Ordinance Requirements

In addition, staff is seeking input from the community on mitigation opportunities for Upper Goose, Twomile Canyon Creek, and Skunk Creek / Bluebell Canyon Creek / King's Gulch.

Know Your Risk | Plan for Your Risk | Mitigate Your Risk
For additional information please visit: www.boulderfloodinfo.net

City of Boulder

Department of Public Works
Utilities Division
P.O. Box 791
Boulder, CO 80306-0791



1 2 14

City of Boulder @bouldercolorado · Feb 5

The city's draft Multi-Hazard Mitigation Plan is available for review and comment. Tell us what you think! ow.ly/Y99T30idGr9

1 2

City of Boulder @bouldercolorado · Feb 5

Wildlife is everywhere in #Boulder -- even your patio sometimes. This bobcat looks mighty relaxed in these photos by @HafaRamon.

Multi-Hazard Mitigation Plan 5-Year Update

Thank you for completing our Community Input Survey!

We are reviewing your input and updating the hazard mitigation plan.

Come back in January to review the changes and provide additional feedback!

Interested in helping to plan and prepare for natural hazards? This year, the City of Boulder is updating its 5-Year Multi-Hazard Mitigation Plan. By providing feedback on the plan update, you are helping to make Boulder a safer place for everyone. Your participation helps emergency managers understand what the community's priorities are, and your feedback will be incorporated into the plan update. Additionally, by participating, property owners in Boulder could be eligible to receive discounted flood insurance premiums through the National Flood Insurance Program's **Community Rating System**, and ensures that the city is eligible for federal grants.

What do you think?

What do you think would best reduce Boulder's vulnerability to natural hazards?

- Residents who are stocked up for an emergency
- Informed residents
- Reinforced infrastructure
- Better emergency messaging
- More connections between neighbors

View Results

Submit

The goals for the 2017 update are:

- **Increase community awareness** of Boulder's vulnerability to natural hazards
- **Reduce vulnerability** of people, property and environment to natural hazards
- **Reduce the impacts of natural hazards** by increasing inter-agency capabilities and coordination

COMMUNITY INPUT

All unpublished Surveytool item are shown as "Draft". Only admins will be able to see it in the preview mode.

Community Input

Draft

Thank you for weighing in on this important topic.

What is your first and last name? *

Please limit answer to 255 characters

255

What do you consider to be the greatest natural threat to Boulder? *

Choose an option ▾

What do you consider to be the second greatest natural threat to Boulder? *

Choose an option ▾

What do you consider to be the third greatest natural threat to Boulder? *

Choose an option ▾

How would you prefer to be notified of an emergency near your home, work or school?

Timeline for Plan Update

Community Input (Round 1)

In **August**, residents in the City of Boulder are invited to share input about which natural hazards are most worrisome, how you prefer to be contacted in the event of an emergency, and any ideas you have for mitigating/preparing for disasters.

Review Feedback & Update Plan (Round 1)

In **October**, staff will review input from residents to inform the update and prioritize tasks.

Community Input (Round 2)

In **January 2018**, residents are invited to review plan changes and provide additional feedback before the plan is finalized.

Review Feedback & Update Plan (Round 2)

In **early 2018**, staff will once again review ideas brought forward by our community and make any necessary changes to the plan update.

Final Draft to State/FEMA

In **early 2018**, the Colorado Department of Public Safety and the Federal Emergency Management Agency will review

Are you signed up for emergency alerts? If not, visit https://member.everbridge.net/index/453003085612231#/signup to get signed up.

How could the city reduce risk associated with natural hazards?

On a scale from 1 to 10, what do you think is the responsibility of community members, opposed to the responsibility of government, for reducing risk to natural disasters? (1 being only community members responsibility, 10 being only government responsibility) *

- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10

How much time did you spend learning about the Multi-Hazard Mitigation Plan and filling out this survey? *

Please limit answer to 255 characters

255

Cancel Submit

the plan and provide feedback.

Local Adoption

In **mid 2018**, the plan will be presented to City Council for local adoption.

Document Library

Multi-Hazard Mitigation Plan 2012 (23.2 MB) (pdf)

more..

Resilience Value

The Multi-Hazard Mitigation Plan (MHMP) helps the city mitigate and prepare for a **shock**, or a sudden, acute event that threatens the city, and addresses some of our natural **stressors**, or underlying challenges that weaken the fabric of our city on a day-to-day or cyclical basis. The MHMP is one of many ways we are building resilience, or ability to adapt and thrive, in Boulder. To learn more, check out the City of Boulder Resilience Strategy.

Project Manager

Christin Shepherd

Civil Engineer II, PE, CFM
City of Boulder

Email shepherdc2@bouldercolorado.gov

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4

City of Boulder @bouldercolorado · Feb 7

The city's draft Multi-Hazard Mitigation Plan is available for review and comment. Tell us what you think! ow.ly/tZIB30ig7YY

1 2

City of Boulder @bouldercolorado · Feb 7

The majestic Flatirons peak out from the clouds. 📷: primal_flow via Instagram.

10:49 AM
2/14/2018

MULTI-HAZARD MITIGATION PLAN - 2018 UPDATE

The City of Boulder is updating its Multi-Hazard Mitigation Plan. Keeping the plan current helps the city to be better prepared for natural hazards, provides the opportunity to apply for federal grants and allows property owners to be eligible to receive discounted flood insurance premiums through the National Flood Insurance Program's (NFIP) Community Rating System (CRS).

The goals for this update include increasing community awareness, reducing vulnerability of people, property and environment to natural hazards, and reducing the imact of natural hazards on our community.

The DRAFT Plan is ready for review!

Please read the* DRAFT 2018 Multi-Hazard Mitigation Plan *and provide your feedback.

Please share any comments on the draft plan below

APPENDIX F - PUBLIC PARTICIPATION PLAN

City of Boulder Multi-Hazard Mitigation Plan Update

Appendix F
Public Participation Plan

2017-2018

Purposes of the Public Participation Plan

The basic purpose for a public participation plan (PPP) is to provide for a meaningful process through which the City of Boulder and its citizens, public officials, and stakeholder groups may effectively participate in the update of the City of Boulder Multi-Hazard Mitigation Plan. This plan will be developed based upon the understanding that citizens and groups are the source of tremendous creativity, and that their creativity and input will produce better planning decisions. The emphasis is to recognize every citizen's right to participate in the process of making local government decisions.

A wide variety of public participation methods, representing distinct purposes, will be employed to provide for broad public participation. These purposes of public participation are as follows:

- **Public Awareness –** to share information and to promote awareness of planning process, including ways the public can participate
- **Public Education –** to educate citizens and help them make more informed choices
- **Public Input –** to provide citizens and groups with opportunities to inject ideas into the planning process
- **Public Interaction –** to exchange views and ideas as a means of reaching consensus
- **Public Partnership –** to involve citizens in the decision making process

Objectives of the Public Participation Plan

1. Recognizing that there are many levels of public participation, to provide for an effective mix of participation opportunities that include the above bulleted purposes.

2. Recognizing that not everyone participates in the same way or at the same time, to include a mix of participation strategies that provides for a broad and diverse set of participation opportunities that considers the diversity of the planning area.

3. Recognizing the City of Boulder's history of past public participation with planning projects, the Hazard Mitigation Planning Committee will continue to provide the public with opportunities to review, clarify, and update previously generated information, as well as generate new policies, goals, objectives, and information.

4. To build public support for, and ultimately ownership of, the City of Boulder Multi-Hazard Mitigation Plan.

Local Government Public Outreach/Involvement Responsibilities

The requirements related to public involvement in hazard mitigation plans according to the Disaster Mitigation Act of 2000 are listed below:

Requirement §201.6(b): *In order to develop a more comprehensive approach to reducing the effects of natural disasters, the planning process* ***shall*** *include:*

(1) An opportunity for the public to comment on the plan during the drafting stage and prior to plan approval;

(2) An opportunity for neighboring communities, local and regional agencies involved in hazard mitigation activities, and agencies that have the authority to regulate development, as well as businesses, academia and other private and non-profit interests to be involved in the planning process; and
(3) Review and incorporation, if appropriate, of existing plans, studies, reports, and technical information.

Requirement §201.6(c)(1): *[The plan **shall** document] the planning process used to develop the plan, including how it was prepared, who was involved in the process, and how the public was involved.*

Requirement §201.6(c)(4)(iii): *[The plan maintenance process **shall** include a] discussion on how the community will continue public participation in the plan maintenance process.*

The Community Rating System (CRS) also has public involvement requirements. At a minimum there must be an opportunity for the public to comment on the plan during the plan development and before plan approval. Members of the public may be part of the HMPC or part of a separate committee. For CRS credit, the term "public" includes residents, businesses, property owners, and tenants in the floodplain and other known hazard areas as well as other stakeholders in the community, such as developers and contractors, civic groups, environmental organizations, academia, non-profit organizations, major employers, and staff from other governmental agencies, such as a drainage district, housing authority, Natural Resources Conservation Service, or the National Weather Service. In addition to meeting the intent of CRS Activity 510, Item 2 (a) Planning Committee that includes members of the public, this committee membership could also include that created for the Program for Public Information (PPI) in Activity 330, which provides outreach advising people of the flood hazard, the availability of flood insurance, and/or flood protection methods.

To meet DMA and CRS requirements as well as the goals of the Public Participation Plan, the city is expected to engage in various public outreach and feedback efforts, which can include:

- Assist in distributing press releases and information to local media
- Share public input/comment with the HMPC
- Document and report on progress/activities related to public involvement
- Review public input for incorporation in plan, as appropriate
- Assist with advertising and holding public workshops
- Announcing the planning effort at other public and civic meetings, or holding additional public meetings, if desired.
- Announce how the plan can be accessed d**u**ring the public review period. This can include providing links from the City's website to the project website, or providing hardcopy of the plan in a public location such as a municipal building.
- Follow the recommendations for continued public involvement as designated in the implementation chapter of the hazard mitigation plan.

The following public participation steps and specific activities are outlined in conjunction with the hazard mitigation planning steps to demonstrate how they are linked in the process. This PPP is a document that will be utilized and updated during plan update processes, and serve to document the efforts made to involve the public during each plan update.

City of Boulder Multi-Hazard Mitigation Plan Update
Public Participation Plan – 2017-18

Timeframe	Mitigation and CRS Flood Mitigation Planning Steps	Public Participation Steps/Ideas	Specific Activities/Actions
April – July 2017	1. Getting Organized 2. Plan for public involvement 3. Coordinate with other departments and agencies	• Build public awareness through media channels • Outreach through other groups, Private, Non-Profit. Non-governmental organizations • Possible public groups include: Local media, Chamber of Commerce, Downtown Business, Inc., RTD, State Parks, Department of Commerce Labs, Boulder Valley School District – parent email group • The Boulder 'Resilient Together' website: Resilienttogether.org which includes digital public engagement capabilities through a partnership with a local firm. • BOCO Strong – trainings and workshops	• Hazard Mitigation Planning Committee formed • A public workshop was held on April 12, 2017 by the Utilities Flood Department that showcased all flood projects together in one open house. It was also utilized as an opportunity to educate the public on the MHMP. Questionnaires distributed and 6 were collected. • Invite to kickoff meeting extended to Boulder County, DHSEM, CWCB, Boulder Valley School District, Boulder Community Hospital and Urban Drainage and Flood Control District; several attended meeting on June 8th at the City of Boulder City Council Chambers. • Developed and displayed content on the hazard mitigation plan update project website on www.Resilienttogether.org • Group invitation sent to HMPC about login to www.Resilienttogether.org to serve as collaboration tool.
August-November 2017	4. Identify the hazards 5. Assess the risks	• Provide survey and materials at meetings • Share public input with HMPC • Cooperative review of public input • Announce workshops • Build contact list of interested citizens based on survey to inform of future activities	• Resilient Together representatives helped coordinate a range of public involvement activities, including press releases, Channel 8 News video clip, website postings, and the collection of public comments from a survey developed specifically for the plan update. • A Resilient Together public workshop in October discussed the plan and gathered input into the public survey. • Additional outreach on public survey • Collection and compilation of survey results

December 2017 – February 2018	6. Set planning goals 7. Review mitigation alternatives 8. Draft an action plan 9. Adopt the plan 10. Implement the plan, evaluate its worth, and revise as needed	• Outreach through Water Resource Advisory Board • Place draft plan online and advertise public comment period • Encourage public review of final draft	• Announcement of upcoming public workshop through various media channels • Develop links from City website to project website, encourage review and comment on draft plan. • Developed online form so public could leave comments • Presentation at City Council meeting during adoption

APPENDIX G - CRITICAL FACILITIES

Aggregate	Facility Type	Facility SubType	Name	Address	Prone to Floodway Flooding	1% Annual Chance Flood Prone	0.2% Annual Chance Flood Prone	Zone X Protected by Levee	Prone to High Hazard Flooding	Prone to 10 Year Flooding	Prone to Barker Dam Inundation	Prone to Gross Dam Inundation	Area of Fire Conern	Source
At-Risk Population	Congregate Care	Child Care	Bixby School School-Age Child Care	4760 Table Mesa DR								Yes		CDPHE
At-Risk Population	Congregate Care	Child Care	Blue Sky Kindergarten	3046 11th ST										CDPHE
At-Risk Population	Congregate Care	Child Care	Boulder Bilingual Childcare, Inc.	2700 29th ST							Yes			CDPHE
At-Risk Population	Congregate Care	Child Care	Boulder County Head Start	2675 Mapleton AVE							Yes			CDPHE
At-Risk Population	Congregate Care	Child Care	Boulder County Head Start	2845 Wilderness PL			Yes				Yes			CDPHE
At-Risk Population	Congregate Care	Child Care	Boulder Day Nursery	1518 Spruce ST							Yes			CDPHE
At-Risk Population	Congregate Care	Child Care	Boulder Journey School	1919 Yarmouth AVE										CDPHE
At-Risk Population	Congregate Care	Child Care	Boulder Montessori School	3300 Redstone RD										CDPHE
At-Risk Population	Congregate Care	Child Care	Boulder Parks And Recreation	4655 Hanover AVE										CDPHE
At-Risk Population	Congregate Care	Child Care	Boulder Waldorf Kindergarten	4072 19th ST			Yes							CDPHE
At-Risk Population	Congregate Care	Child Care	Bvsd Community Montessori Sac	805 Gillaspie DR										CDPHE
At-Risk Population	Congregate Care	Child Care	Cherryvale Day Camp	6007 Oreg AVE										CDPHE
At-Risk Population	Congregate Care	Child Care	Child Learning Center	2501 Kittredge LOOP										CDPHE
At-Risk Population	Congregate Care	Child Care	Children's Creative Learning Center	3050 34th ST										CDPHE
At-Risk Population	Congregate Care	Child Care	City Of Boulder Parks And Recs East	5660 Sioux DR								Yes		CDPHE
At-Risk Population	Congregate Care	Child Care	City Of Boulder Parks And Recs North	3170 Broadway			Yes							CDPHE

Aggregate	Facility Type	Facility SubType	Name	Address	Prone to Floodway Flooding	1% Annual Chance Flood Prone	0.2% Annual Chance Flood Prone	Zone X Protected by Levee	Prone to High Hazard Flooding	Prone to 10 Year Flooding	Prone to Barker Dam Inundation	Prone to Gross Dam Inundation	Area of Fire Conern	Source
At-Risk Population	Congregate Care	Child Care	City Of Boulder Parks And Recs South	1360 GILLASPIE										CDPHE
At-Risk Population	Congregate Care	Child Care	Commerce Children's Center	325 Broadway Bldg 26										CDPHE
At-Risk Population	Congregate Care	Child Care	Donna Hamann	1286 Sumac AVE			Yes							CDPHE
At-Risk Population	Congregate Care	Child Care	Dream Makers	1345 28TH ST	Yes	Yes			Yes		Yes			CDPHE
At-Risk Population	Congregate Care	Child Care	Elm Tree Preschool	2575 Glenwood DR										CDPHE
At-Risk Population	Congregate Care	Child Care	Emma Bellera	3195 E Aurora AVE		Yes								CDPHE
At-Risk Population	Congregate Care	Child Care	Fabienne Geer	1481 Toby LN		Yes				Yes		Yes		CDPHE
At-Risk Population	Congregate Care	Child Care	Family Learning Center Inc	3164 34th ST										CDPHE
At-Risk Population	Congregate Care	Child Care	Friends' School	5441 Pennsylvania AVE			Yes					Yes		CDPHE
At-Risk Population	Congregate Care	Child Care	Friend's School Aftercare Program	5465 Pennsylvania AVE		Yes						Yes		CDPHE
At-Risk Population	Congregate Care	Child Care	Gwen Thelen	710 35th ST										CDPHE
At-Risk Population	Congregate Care	Child Care	Homestar Child Development Center	3280 Dartmouth AVE			Yes							CDPHE
At-Risk Population	Congregate Care	Child Care	Hong Wang	4795 Mckinley DR								Yes		CDPHE
At-Risk Population	Congregate Care	Child Care	Horizons K8 School	4545 Sioux DR								Yes		CDPHE
At-Risk Population	Congregate Care	Child Care	Iris Center	3198 Broadway			Yes							CDPHE
At-Risk Population	Congregate Care	Child Care	Jarrow Montessori School	3900 Orange CT										CDPHE
At-Risk Population	Congregate Care	Child Care	Jay & Rose Phillips Ecc @ The Boulder Jcc	6007 Oreg AVE										CDPHE

Aggregate	Facility Type	Facility SubType	Name	Address	Prone to Floodway Flooding	1% Annual Chance Flood Prone	0.2% Annual Chance Flood Prone	Zone X Protected by Levee	Prone to High Hazard Flooding	Prone to 10 Year Flooding	Prone to Barker Dam Inundation	Prone to Gross Dam Inundation	Area of Fire Conern	Source
At-Risk Population	Congregate Care	Child Care	Judy Robinson	4497 Grinnell AVE										CDPHE
At-Risk Population	Congregate Care	Child Care	Juliet Galltier	855 34th ST										CDPHE
At-Risk Population	Congregate Care	Child Care	Kiera Schuler	1885 Upland AVE	Yes	Yes			Yes	Yes				CDPHE
At-Risk Population	Congregate Care	Child Care	Mapleton Montessori School	3121 29th ST										CDPHE
At-Risk Population	Congregate Care	Child Care	Meadowlark Preschool	2650 Table Mesa DR									High	CDPHE
At-Risk Population	Congregate Care	Child Care	Miss Catherines Creative Learning Ctr	6525 Gunpark DR 340										CDPHE
At-Risk Population	Congregate Care	Child Care	Miss Catherine's Infant Center	5280 Spine RD # 104										CDPHE
At-Risk Population	Congregate Care	Child Care	Mount Hope Lutheran Day Care	1345 S. Broadway										City of Boulder
At-Risk Population	Congregate Care	Child Care	Mt Calvary Rainbow Child Care Center	3485 Stanford CT										CDPHE
At-Risk Population	Congregate Care	Child Care	Mt Zion Lutheran Preschool	1680 Balsam AVE										CDPHE
At-Risk Population	Congregate Care	Child Care	Off Broadway Preschool Of Fine Arts	1235 Pine ST							Yes			CDPHE
At-Risk Population	Congregate Care	Child Care	Patience Montessori	3600 Hazelwood CT		Yes								CDPHE
At-Risk Population	Congregate Care	Child Care	Rocky Mountain Day Camp	2205 Norwood AVE										CDPHE
At-Risk Population	Congregate Care	Child Care	Sacred Heart Of Jesus Preschool	1317 Mapleton AVE										CDPHE
At-Risk Population	Congregate Care	Child Care	Shining Mountain Waldorf School	999 Violet AVE										CDPHE
At-Risk Population	Congregate Care	Child Care	Snow Lion School, Inc	2580 Iris AVE			Yes							CDPHE
At-Risk Population	Congregate Care	Child Care	Sunflower Preschool	3340 Dartmouth AVE			Yes							CDPHE
At-Risk Population	Congregate Care	Child Care	Sunrise Early Learning Center	4215 Grinnell AVE										CDPHE

Aggregate	Facility Type	Facility SubType	Name	Address	Prone to Floodway Flooding	1% Annual Chance Flood Prone	0.2% Annual Chance Flood Prone	Zone X Protected by Levee	Prone to High Hazard Flooding	Prone to 10 Year Flooding	Prone to Barker Dam Inundation	Prone to Gross Dam Inundation	Area of Fire Conern	Source
At-Risk Population	Congregate Care	Child Care	Sunshine House Montessori School, Inc.	745 College AVE										CDPHE
At-Risk Population	Congregate Care	Child Care	The Cottage School	805 30th ST		Yes								CDPHE
At-Risk Population	Congregate Care	Child Care	The Cottage School North	1301 North ST										CDPHE
At-Risk Population	Congregate Care	Child Care	The Elm Tree	1330 Alpine AVE										CDPHE
At-Risk Population	Congregate Care	Child Care	Tiny Minders Daycare & Preschool North	3735 Iris AVE										CDPHE
At-Risk Population	Congregate Care	Child Care	Tiny Minders Daycare Preschool	3685 3695 Martin DR			Yes							CDPHE
At-Risk Population	Congregate Care	Child Care	Univ Co Fmly Hsng Childrens Ctr	2202 Arapahoe		Yes					Yes			CDPHE
At-Risk Population	Congregate Care	Child Care	Virginia Sarmiento	735 Mohawk DR								Yes		CDPHE
At-Risk Population	Congregate Care	Child Care	Wendy Grunthal	3964 Fuller CT										CDPHE
At-Risk Population	Congregate Care	Child Care	Ymca Bv Mapleton Branch	2850 Mapleton AVE			Yes				Yes			CDPHE
At-Risk Population	Congregate Care	Child Care	Ymca Of Bldr Valley @ Bear Creek Elementary	2500 Table Mesa DR									High	CDPHE
At-Risk Population	Congregate Care	Child Care	Ymca Of Bldr Valley @ Creekside At Martin	3740 Martin Park DR										CDPHE
At-Risk Population	Congregate Care	Child Care	Ymca Of Bldr Valley @ Eisenhower Elementary	1220 Eisenhower DR								Yes		CDPHE
At-Risk Population	Congregate Care	Child Care	Ymca Of Bldr Valley @ Flatirons Elementary	1150 7th ST										CDPHE
At-Risk Population	Congregate Care	Child Care	Ymca Of Bldr Valley @ Manhattan Middle Sch	290 Manhattan DR								Yes		CDPHE
At-Risk Population	Congregate Care	Child Care	Ymca Of Bldr Valley @ Mesa Elementary	1575 Lehigh										CDPHE

Aggregate	Facility Type	Facility SubType	Name	Address	Prone to Floodway Flooding	1% Annual Chance Flood Prone	0.2% Annual Chance Flood Prone	Zone X Protected by Levee	Prone to High Hazard Flooding	Prone to 10 Year Flooding	Prone to Barker Dam Inundation	Prone to Gross Dam Inundation	Area of Fire Conern	Source
At-Risk Population	Congregate Care	Child Care	Ymca Of Bldr Valley @ University Hills	956 16th ST										CDPHE
At-Risk Population	Congregate Care	Child Care	Ymca Of Bldr Valley @ Whittier Elementary	2008 Pine ST							Yes			CDPHE
At-Risk Population	Congregate Care	Child Care	Ymca Of Bldr Valley Crestview Elementary	1897 Sumac										CDPHE
At-Risk Population	Congregate Care	Child Care	Ymca Of Bldr Valley Foothill Elementary	1001 Hawthorn AVE			Yes							CDPHE
At-Risk Population	Congregate Care	Child Care	Ymca Of Bldr Valley High Peaks & Bcsis	3995 Aurora AVE										CDPHE
At-Risk Population	Congregate Care	Child Care	Ywca Of Boulder County Children's Alley	2222 14th ST										CDPHE
At-Risk Population	Congregate Care	Licensed Home Day Care	Amber Lahti	740 Morgan DR			Yes					Yes		CDPHE
At-Risk Population	Congregate Care	Licensed Home Day Care	Barbara Mcgregor	3535 Eastman AVE			Yes							CDPHE
At-Risk Population	Congregate Care	Licensed Home Day Care	Ellie Willis	3111 Westwood CT										CDPHE
At-Risk Population	Congregate Care	Licensed Home Day Care	Julie Zacharias	3640 Buckeye CT										CDPHE
At-Risk Population	Congregate Care	Licensed Home Day Care	Marie-Pierre Nicoletti	4700 Sioux DR								Yes		CDPHE
At-Risk Population	Congregate Care	Licensed Home Day Care	Rita Batiste	805 Orman DR								Yes		CDPHE
At-Risk Population	Residential Care	Group Home	Bob And Judy Charles Smart Home	1806 IRIS AVENUE		Yes								CDPHE
At-Risk Population	Residential Care	Group Home	Foothills Group Home	4500 7TH STREET										CDPHE

Aggregate	Facility Type	Facility SubType	Name	Address	Prone to Floodway Flooding	1% Annual Chance Flood Prone	0.2% Annual Chance Flood Prone	Zone X Protected by Levee	Prone to High Hazard Flooding	Prone to 10 Year Flooding	Prone to Barker Dam Inundation	Prone to Gross Dam Inundation	Area of Fire Conern	Source
At-Risk Population	Residential Care	Group Home	Manhattan Apartments	435 MANHATTAN DR			Yes					Yes		CDPHE
At-Risk Population	Residential Care	Senior Care	Academy At Bella Vista, The	2762 BELLA VISTA LANE										CDPHE
At-Risk Population	Residential Care	Senior Care	Anam Chara	1795 Quince St.										City of Boulder
At-Risk Population	Residential Care	Senior Care	Balsam House	2818 - 2820 13TH STREET										CDPHE
At-Risk Population	Residential Care	Senior Care	Boulder Housing Partners	4800 N. Broadway										City of Boulder
At-Risk Population	Residential Care	Senior Care	Boulder Manor	4685 Baseline Rd.								Yes		City of Boulder
At-Risk Population	Residential Care	Senior Care	Boulder Meridian	801 Gillaspie										City of Boulder
At-Risk Population	Residential Care	Senior Care	Brookdale Boulder Creek	3375 34th St.	Yes	Yes								City of Boulder
At-Risk Population	Residential Care	Senior Care	Brookdale North Boulder	3350 30th St.			Yes							City of Boulder
At-Risk Population	Residential Care	Senior Care	Care Link, Inc	3434 47TH STREET SUITE 100										CDPHE
At-Risk Population	Residential Care	Senior Care	Center For People With Disabilities	1675 RANGE ST								Yes		CDPHE
At-Risk Population	Residential Care	Senior Care	Dunn Memorial Housing	4805 Baseline Rd.								Yes		City of Boulder
At-Risk Population	Residential Care	Senior Care	Frasier Meadows	350 Ponca Place								Yes		City of Boulder
At-Risk Population	Residential Care	Senior Care	Frasier Meadows	4950 Thunderbird Dr		Yes						Yes		City of Boulder
At-Risk Population	Residential Care	Senior Care	Golden West Senior Residence	1055 Adams Circle										City of Boulder
At-Risk Population	Residential Care	Senior Care	Manor Care	2800 Palo Parkway										City of Boulder
At-Risk Population	Residential Care	Senior Care	Mary Sandoe House	1244 Gillaspie										City of Boulder
At-Risk Population	Residential Care	Senior Care	Mesa Vista Of Boulder	2121 Mesa Drive										City of Boulder

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At-Risk Population	Residential Care	Senior Care	Morningstar Of Boulder	575 TANTRA DRIVE										CDPHE
At-Risk Population	Residential Care	Senior Care	Presbyterian Manor	1050 Arapahoe Ave.			Yes			Yes	Yes			City of Boulder
At-Risk Population	Residential Care	Senior Care	Shawnee Gardens	4755 Shawnee Place								Yes		City of Boulder
At-Risk Population	Residential Care	Senior Care	Sunrise Assisted Living	3955 28th St.										City of Boulder
At-Risk Population	Residential Care	Senior Care	The Academy	970 Aurora Ave.										City of Boulder
At-Risk Population	Residential Care	Senior Care	The Carillon At Boulder Creek	2525 Taft Dr.		Yes					Yes			City of Boulder
At-Risk Population	Residential Care	Senior Care	Warner House	2833 N BROADWAY										CDPHE
At-Risk Population	School	Middle School	Casey Middle School	1301 HIGH STREET										CDPHE
At-Risk Population	School	Middle School	Centennial Middle School	2205 NORWOOD AVENUE										CDPHE
At-Risk Population	School	Middle School	Halcyon School (Special Education)	3100 BUCKNELL COURT										CDPHE
At-Risk Population	School	Middle School	Manhattan Middle School Of The Arts And Academics	290 MANHATTAN DRIVE								Yes		CDPHE
At-Risk Population	School	Middle School	Southern Hills Middle School	1500 KNOX DRIVE										CDPHE
At-Risk Population	School	Middle School	Summit Middle Charter School	4655 HANOVER AVENUE										CDPHE
At-Risk Population	School	Middle School	Watershed School	1661 ALPINE AVE										CDPHE
At-Risk Population	School	Preschool	Alaya Preschool	3340 19TH STREET										CDPHE
At-Risk Population	School	Preschool	Boulder Waldorf Kindergarten	4072 NORTH 19TH STREET			Yes							CDPHE
At-Risk Population	School	Preschool	Bvsd Columbine Preschool	3130 Repplier DR										CDPHE

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At-Risk Population	School	Preschool	Bvsd Preschool At Aurora 7 High Peaks Bcsis	3995 E Aurora AVE										CDPHE
At-Risk Population	School	Preschool	Bvsd Preschool At Creekside	3740 Martin DR										CDPHE
At-Risk Population	School	Preschool	Bvsd Preschool At University Hill	956 16th ST										CDPHE
At-Risk Population	School	Preschool	Children's Ally Ywca Boulder	2222 14TH STREET							Yes			CDPHE
At-Risk Population	School	Preschool	Children's Creative Learning Center	3050 34TH STREET										CDPHE
At-Risk Population	School	Preschool	Childrens House Preschool	3370 IRIS WALK COURT										CDPHE
At-Risk Population	School	Preschool	First Presbyterian Preschool Of Boulder	1820 15th ST			Yes				Yes			CDPHE
At-Risk Population	School	Preschool	Harmony Preschool	3990 15TH STREET										CDPHE
At-Risk Population	School	Preschool	Mapleton Early Childhood Center	840 MAPLETON AVENUE										CDPHE
At-Risk Population	School	Preschool	Mapleton Montessori School	3121 29TH STREET										CDPHE
At-Risk Population	School	Preschool	Mountain View Preschool	355 Ponca PL								Yes		CDPHE
At-Risk Population	School	Preschool	Mt Zion Lutheran Church & Preschool	1680 BALSAM AVENUE										CDPHE
At-Risk Population	School	Preschool	New Horizons Cooperative Preschool	1825 Upland AVE			Yes							CDPHE
At-Risk Population	School	Preschool	Rainbow Center	3485 STANFORD CT										CDPHE
At-Risk Population	School	Preschool	Rally Sport	2727 29th ST			Yes				Yes			CDPHE
At-Risk Population	School	Preschool	Sunshine House	745 COLLEGE AVENUE										CDPHE
At-Risk Population	School	Preschool	The Acorn School For Early Childhood Development	2845 WILDERNESS PLACE			Yes				Yes			CDPHE

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At-Risk Population	School	Primary School	Bear Creek Elementary School	2500 TABLE MESA DRIVE									High	CDPHE
At-Risk Population	School	Primary School	Bixby School	4760 TABLE MESA DRIVE								Yes		CDPHE
At-Risk Population	School	Primary School	Boulder Community School/Integrated Studies	3995 EAST AURORA AVENUE										CDPHE
At-Risk Population	School	Primary School	Boulder Country Day School	4820 NAUTILUS COURT NORTH										CDPHE
At-Risk Population	School	Primary School	Columbine Elementary School	3130 REPPLIER DRIVE			Yes							CDPHE
At-Risk Population	School	Primary School	Community Montessori School	805 GILLASPIE DR										CDPHE
At-Risk Population	School	Primary School	Creekside Elementary School At Martin Park	3740 MARTIN DRIVE										CDPHE
At-Risk Population	School	Primary School	Crest View Elementary School	1897 SUMAC AVENUE										CDPHE
At-Risk Population	School	Primary School	Eisenhower Elementary School	1220 EISENHOWER DRIVE								Yes		CDPHE
At-Risk Population	School	Primary School	Flatirons Elementary School	1150 7TH STREET										CDPHE
At-Risk Population	School	Primary School	Foothill Elementary School	1001 HAWTHORNE AVENUE			Yes							CDPHE
At-Risk Population	School	Primary School	Friends' School	5465 PENNSYLVANIA AVENUE		Yes						Yes		CDPHE
At-Risk Population	School	Primary School	High Peaks Elementary School	3995 EAST AURORA AVENUE										CDPHE
At-Risk Population	School	Primary School	Horizons K-8 School	4545 SIOUX DRIVE								Yes		CDPHE
At-Risk Population	School	Primary School	Mesa Elementary School	1575 LEHIGH STREET										CDPHE
At-Risk Population	School	Primary School	Sacred Heart Of Jesus School	1317 MAPLETON AVENUE										CDPHE

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At-Risk Population	School	Primary School	University Hill Elementary School	956 16TH STREET										CDPHE
At-Risk Population	School	Primary School	Whittier Elementary School	2008 PINE STREET							Yes			CDPHE
At-Risk Population	School	Secondary School	Boulder High School	1604 ARAPAHOE AVENUE		Yes					Yes			CDPHE
At-Risk Population	School	Secondary School	Boulder Prep Charter High School	5075 CHAPARRAL COURT #1										CDPHE
At-Risk Population	School	Secondary School	Fairview High School	1515 GREENBRIAR BOULEVARD										CDPHE
At-Risk Population	School	Secondary School	New Vista High School	700 20TH STREET										CDPHE
At-Risk Population	School	Secondary School	September School	1902 WALNUT STREET			Yes				Yes			CDPHE
At-Risk Population	School	Secondary School	Tara Performing Arts High School	4180 NINETEENTH STREET										CDPHE
At-Risk Population	Senior Center		East Senior Center	5660 Sioux Drive								Yes		City of Boulder
At-Risk Population	Senior Center		West Senior Center	909 Arapahoe							Yes			City of Boulder
Essential Services	Air Transportation	Airport	Boulder Municipal Airport	3300 Airport Road										City of Boulder
Essential Services	Communication	Emergency Siren	Columbine School	Floral Dr. & Repplier St.										Boulder OEM
Essential Services	Communication	Emergency Siren	County Jail	3200 Airport Rd										Boulder OEM
Essential Services	Communication	Emergency Siren	Creekside/Martin Park Elem.	3740 Martin Drive										Boulder OEM
Essential Services	Communication	Emergency Siren	Crest View Elementary	1897 Sumac										Boulder OEM
Essential Services	Communication	Emergency Siren	Cu Research Ctr.	3300 Marine St.	Yes	Yes			Yes		Yes			Boulder OEM
Essential Services	Communication	Emergency Siren	Eisenhower Elementary	1220 Eisenhower Drive								Yes		Boulder OEM

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Essential Services	Communication	Emergency Siren	Elks Park	3975 28th St		Yes				Yes				Boulder OEM
Essential Services	Communication	Emergency Siren	Fire Station # 3	1580 30th Street	Yes	Yes			Yes		Yes			Boulder OEM
Essential Services	Communication	Emergency Siren	Fire Station 6											Boulder OEM
Essential Services	Communication	Emergency Siren	Folsom Field	CU Stadium										Boulder OEM
Essential Services	Communication	Emergency Siren	Foothills Elementry				Yes							Boulder OEM
Essential Services	Communication	Emergency Siren	Manhattan School	290 Manhattan Dr								Yes		Boulder OEM
Essential Services	Communication	Emergency Siren	New Britain Building	1101 Arapahoe Ave.	Yes	Yes			Yes		Yes			Boulder OEM
Essential Services	Communication	Emergency Siren	Nist	325 Broadway										Boulder OEM
Essential Services	Communication	Emergency Siren	Paddock School	Gillespie Dr. & Armer Dr.										Boulder OEM
Essential Services	Communication	Emergency Siren	Vectra Bank Building	1375 Walnut St.							Yes			Boulder OEM
Essential Services	Communication	TV Broadcasting	Rocky Mountain Public Broadcasting Network, Inc.	0 30th Street										HIFLD
Essential Services	Emergency Medical Facility	Ambulance Service	American Medical Response	3800 Pearl St			Yes				Yes			CDPHE
Essential Services	Emergency Medical Facility	Hospital	Boulder Community Foothills	4747 Arapahoe Av							Yes	Yes		City of Boulder
Essential Services	Emergency Medical Facility	Hospital	Tru Community Care	1100 BALSAM AVE, 2N										City of Boulder
Essential Services	Emergency Medical Facility	Hospital	Wardenberg Health Center	18th St & Broadway on CU Campus										City of Boulder
Essential Services	Emergency Medical Facility	Urgent Care	Boulder Medical Center, P C	2750 BROADWAY		Yes				Yes				CDPHE
Essential Services	Emergency Medical Facility	Urgent Care/Birth Center	Birth Center Of Boulder, Llc The	2800 FOLSOM STREET										CDPHE
Essential Services	Emergency Medical Facility	Urgent Care/Surgery	Avista Surgery Center	2525 4TH ST, STE #201										CDPHE

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Essential Services	Emergency Medical Facility	Urgent Care/Surgery	Boulder Surgery Center	4740 PEARL PARKWAY SUITE 100			Yes				Yes			CDPHE
Essential Services	Emergency Medical Facility	Urgent Care/Surgery	Foothills Surgery Center Llc	4743 ARAPAHOE AVE SUITE 101							Yes	Yes		CDPHE
Essential Services	Government Building	City Data Center	Emergency Operations Center	3280 Airport Rd.										City of Boulder
Essential Services	Government Building	City Data Center	Public Safety Building	1805 33rd St.			Yes				Yes			City of Boulder
Essential Services	Government Building	City Manager's Office	Municipal Building	1777 Broadway	Yes	Yes					Yes			City of Boulder
Essential Services	Government Building	County Commissioner	County Courthouse	1325 Pearl St							Yes			City of Boulder
Essential Services	Government Building	Court	County Courthouse	1325 Pearl St							Yes			City of Boulder
Essential Services	Government Building	Court	Justice Center	1777 6th Street				Yes			Yes			City of Boulder
Essential Services	Government Building	Equipment Center	Fleet Services	5100 Pearl Parkway			Yes				Yes	Yes		City of Boulder
Essential Services	Government Building	Finance Division	Finance	1720 14th St		Yes					Yes			City of Boulder
Essential Services	Government Building	IT Department	Center Green	3065 Center Green Dr			Yes							City of Boulder
Essential Services	Government Building	Jail	County Jail	3200 Airport Rd										Boulder OEM
Essential Services	Government Building	Maintenance Center	Municipal Services Center	5050 Pearl St			Yes				Yes	Yes		City of Boulder
Essential Services	Government Building	Permanent Records	Carnegie Library	1125 Pine St										City of Boulder
Essential Services	Government Building	Permanent Records	Main Library	1001 Arapahoe Ave		Yes					Yes			City of Boulder
Essential Services	Government Building	Permitting and Inspection	Park Central Building	1739 Broadway	Yes	Yes			Yes	Yes	Yes			City of Boulder
Essential Services	Government Building	Transportation Division	New Britain Building	1101 Arapahoe Ave.	Yes	Yes			Yes		Yes			City of Boulder
Essential Services	Government Building	Utilities Division	Park Central Building	1739 Broadway	Yes	Yes			Yes	Yes	Yes			City of Boulder

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Essential Services	Public Safety Facility	Emergency Operation Center	Cu Police	1070 Regent Dr										City of Boulder
Essential Services	Public Safety Facility	Emergency Operation Center	Emergency Operations Center	3280 Airport Rd.										City of Boulder
Essential Services	Public Safety Facility	Fire Station	Fire Station Five	4365 19th St.			Yes							City of Boulder
Essential Services	Public Safety Facility	Fire Station	Fire Station Four	4100 Darley Ave.										City of Boulder
Essential Services	Public Safety Facility	Fire Station	Fire Station One	2441 13th St.										City of Boulder
Essential Services	Public Safety Facility	Fire Station	Fire Station Seven	1380 55th Ave.			Yes					Yes		City of Boulder
Essential Services	Public Safety Facility	Fire Station	Fire Station Six	5145 63rd St.										City of Boulder
Essential Services	Public Safety Facility	Fire Station	Fire Station Three	1585 30th St.	Yes	Yes			Yes		Yes			City of Boulder
Essential Services	Public Safety Facility	Fire Station	Fire Station Two	2225 Baseline Rd.										City of Boulder
Essential Services	Public Safety Facility	Fire Station	Wildland Fire Cache	6075 Reservoir Rd.										City of Boulder
Essential Services	Public Safety Facility	Police Station	Boulde County Sheriff	5600 FLATIRON PK			Yes				Yes	Yes		City of Boulder
Essential Services	Public Safety Facility	Police Station	Cu Police	1070 Regent Dr										City of Boulder
Essential Services	Public Safety Facility	Police Station	Pearl St. Substation	1500 Pearl St			Yes				Yes			City of Boulder
Essential Services	Public Safety Facility	Police Station	Public Safety Building	1805 33rd St.			Yes				Yes			City of Boulder
Essential Services	Public Safety Facility	Police Station	University Hill Substation	1310 College Av										City of Boulder
Essential Services	Public Utility	Electric Substation	Gunbarrel	6300 Diagonal HW										HIFLD
Essential Services	Public Utility	Electric Substation	Xcel Boulder Terminal	2500 28th St			Yes				Yes			HIFLD
Essential Services	Public Utility	Electric Substation	Xcel Ncar Substation	1245 Wildwood Rd										HIFLD

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Essential Services	Public Utility	Electric Substation	Xcel Sunshine Substation	151 Mapleton Av										HIFLD
Essential Services	Public Utility	Natural Gas Power	University Of Colorado	18TH ST AND COLORADO										HIFLD
Essential Services	Public Utility	Pump	Cherryvale Pump Station									Yes		City of Boulder
Essential Services	Public Utility	Pump	Diagonal Aka IBM Lift Station											City of Boulder
Essential Services	Public Utility	Pump	Iris Pump Station											City of Boulder
Essential Services	Public Utility	Water Tank	Chautauqua Water Tank											City of Boulder
Essential Services	Public Utility	Water Tank	Devils Thumb Water Tank											City of Boulder
Essential Services	Public Utility	Water Tank	Kohler Water Tank										High	City of Boulder
Essential Services	Public Utility	Water Tank	Maxwell Water Tank										Moderate	City of Boulder
Essential Services	Public Utility	Water Treatment Plant	Boulder Reservior Aka 63rd Water Treatment Plant											City of Boulder
Essential Services	Shelter		City Of Boulder Parks And Recs East	5660 Sioux DR								Yes		Boulder OEM
Essential Services	Shelter		City Of Boulder Parks And Recs North	3170 Broadway			Yes							Boulder OEM
Essential Services	Shelter		City Of Boulder Parks And Recs South	1360 GILLASPIE										Boulder OEM
Essential Services	Shelter		Ymca Bv Mapleton Branch	2850 Mapleton AVE			Yes				Yes			Boulder OEM
Hazardous Material	Hazardous Waste Biennial Reporter		Array Biopharma Inc	3200 WALNUT ST			Yes				Yes			EPA
Hazardous Material	HAZARDOUS WASTE BIENNIAL REPORTER		Equilon Enterpises Llc Dba Shell Oil	1480 CANYON BLVD		Yes					Yes			EPA

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Hazardous Material	Hazardous Waste Biennial Reporter		Osi Pharmaceuticals Incorporated	2860 WILDERNESS PLACE SUITE 200			Yes				Yes			EPA
Hazardous Material	Hazardous Waste Biennial Reporter		Sirna Therapeutics, Inc.	2950 WILDERNESS PL			Yes				Yes			EPA
Hazardous Material	Hazardous Waste Biennial Reporter		Target Store T0064	2800 PEARL ST			Yes				Yes			EPA
Hazardous Material	Hazardous Waste Biennial Reporter		University Of Co Boulder-East Campus	30TH AVE & MARINE STREET		Yes					Yes			EPA
Hazardous Material	Hazardous Waste Biennial Reporter		University Of Colorado	1000 REGENT DRIVE										EPA
Hazardous Material	Hazardous Waste Large Quantity Generator		Vac-Tec Systems	2590 CENTRAL AVE			Yes	Yes			Yes	Yes		EPA
Hazardous Material	Hazardous Waste Small Quantity Generator		Advanced Thin Films Inc	5733 CENTRAL AVE				Yes			Yes	Yes		EPA
Hazardous Material	Hazardous Waste Small Quantity Generator		Alpine Research Optics Llc	6810 WINCHESTER CIR										EPA
Hazardous Material	Hazardous Waste Small Quantity Generator		Boulder Community Hospital Foothills Campus	4747 ARAPAHOE AVE							Yes	Yes		EPA
Hazardous Material	Hazardous Waste Small Quantity Generator		Home Depot - 1546	1600 29TH ST			Yes				Yes			EPA
Hazardous Material	Hazardous Waste Small		Research Electro Optics Inc	1855 SOUTH 57TH COURT				Yes			Yes	Yes		EPA

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	Quantity Generator													
Hazardous Material	Hazardous Waste Small Quantity Generator		Sherwin-Williams #1638	3130 VALMONT RD							Yes			EPA
Hazardous Material	Hazardous Waste Small Quantity Generator		Transgenomic Incorporated	6200 LOOKOUT ROAD										EPA
Hazardous Material	Toxic Release Inventory		Amgen Inc	5550 AIRPORT BOULEVARD										EPA
Hazardous Material	Toxic Release Inventory		Ball Aerospace & Technologies Corp	1600 COMMERCE STREET							Yes	Yes		EPA
Hazardous Material	Toxic Release Inventory		Circuit Images Inc	3155 BLUFF STREET			Yes				Yes			EPA
Hazardous Material	Toxic Release Inventory		Corden Pharma Colorado Inc	2075 N 55 ST		Yes		Yes		Yes	Yes	Yes		EPA
Hazardous Material	Toxic Release Inventory		Design Fabricators Inc	6930 WINCHESTER CIRCLE										EPA
Hazardous Material	Toxic Release Inventory		Dieterich Standard Inc	5601 NORTH 71ST STREET										EPA
Hazardous Material	Toxic Release Inventory		Graphic Packaging Corp Boulder Div	3825 WALNUT STREET			Yes				Yes			EPA
Hazardous Material	Toxic Release Inventory		Hauser Chemical Research Inc	4747 PEARL ST 4			Yes				Yes			EPA
Hazardous Material	Toxic Release Inventory		Hauser Inc	4750 NAUTILUS COURT SOUTH										EPA
Hazardous Material	Toxic Release Inventory		Hospira Boulder Inc	4884 STERLING DR							Yes			EPA
Hazardous Material	Toxic Release Inventory		Inb: Paxis Pharmaceuticals	5555 AIRPORT BOULEVARD SUITE 200										EPA
Hazardous Material	Toxic Release Inventory		Jay Medical Ltd	4745 WALNUT STREET			Yes				Yes			EPA
Hazardous Material	Toxic Release Inventory		Kryptonics Inc.	5660 CENTRAL AVE.			Yes	Yes			Yes	Yes		EPA

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Hazardous Material	Toxic Release Inventory		Lexmark International Inc	6555 MONARCH RD.										EPA
Hazardous Material	Toxic Release Inventory		Martin Marietta Valmont Ready Mix	5959 VALMONT DR.								Yes		EPA
Hazardous Material	Toxic Release Inventory		Micro Motion Inc.	7070 WINCHESTER CIRCLE										EPA
Hazardous Material	Toxic Release Inventory		Mks Instruments Inc Hps Pro Ducts Div	5330 STERLING DRIVE							Yes	Yes		EPA
Hazardous Material	Toxic Release Inventory		Napro Biotherapeutics Inc	6304 SPINE ROAD UNIT A										EPA
Hazardous Material	Toxic Release Inventory		Proligo L.L.C.	4699 NAUTILUS COURT SOUTH SUITE B502										EPA
Hazardous Material	Toxic Release Inventory		Sae Circuits Colorado Inc	4820 63RD STREET SUITE 100										EPA
Hazardous Material	Toxic Release Inventory		Sae Circuits Colorado Inc	4820 63RD STREET SUITE 100										EPA
Hazardous Material	Toxic Release Inventory		Spectralink Corp	5755 CENTRAL AVE				Yes			Yes	Yes		EPA
Hazardous Material	Toxic Release Inventory		Tecnetics Inc	6287 ARAPAHOE ROAD										EPA
Hazardous Material	Toxic Release Inventory		Tyco Healthcare Group Lp	5920 LONGBOW DRIVE										EPA
Essential Services	Communication	Emergency Siren	Marshall	1180 S. Marshall Rd	Yes	Yes			Yes	Yes		Yes		Boulder OEM
Essential Services	Public Utility	Electric Substation	Leggett	1800 63rd St										HIFLD
Essential Services	Public Utility	Electric Substation	Tap206428	1800 63rd St										HIFLD
Essential Services	Public Utility	Electric Substation	Valmont	1800 63rd St										HIFLD
Essential Services	Public Utility	Electric Substation	Xcel Energy	2451 63th St.										HIFLD

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Essential Services	Public Utility	Electric Substation	Xcel Leggett Substation	1900 63rd St										HIFLD
Essential Services	Public Utility	Natural Gas Power	Valmont Combustion Turbine Project	1800 N 63RD										HIFLD
Essential Services	Public Utility	Solar Power	City Of Boulder Wwtp	4049 75TH STREET		Yes					Yes	Yes		HIFLD
Essential Services	Public Utility	Steam and Coal Power	Valmont	1800 N 63RD										HIFLD
Essential Services	Public Utility	Wastewater Treatment Plant	75th Steet Wastewater Treatment Plant	4049 N 75TH ST							Yes	Yes		City of Boulder
Essential Services	Public Utility	Water Tank	Booton Water Tank											City of Boulder
Essential Services	Public Utility	Water Treatment Plant	Betasso Water Treatment Plant											City of Boulder
Hazardous Material	Toxic Release Inventory		Brooks Automation Inc Granville Phillips Product	6450 DRY CREEK PARKWAY										EPA
Hazardous Material	Toxic Release Inventory		International Business Machines Ibm	6300 DIAGONAL HIGHWAY										EPA
Hazardous Material	Toxic Release Inventory		Martin Marietta Valmont Ready Mix	5959 VALMONT DR.								Yes		EPA
Hazardous Material	Toxic Release Inventory		Public Service Co Of Colorado Valmont Station	1800 63RD ST										EPA
At-Risk Population	Congregate Care	Child Care	Active Boulder Kids, Llc	5001 Pennsylvania AVE								Yes		CDPHE
At-Risk Population	Congregate Care	Child Care	Avid4 Adventure	5680 Valmont RD UNIT 4	Yes	Yes			Yes		Yes	Yes		CDPHE
At-Risk Population	Congregate Care	Child Care	Countryside Montessori Preschool	5524 Baseline RD		Yes						Yes	Low	CDPHE
At-Risk Population	Congregate Care	Child Care	Ymca Of Boulder Valley @ Platt Middle	6096 BASELINE RD										CDPHE

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At-Risk Population	School	District Office	Boulder Valley Re 2	6500 ARAPAHOE ROAD										CDPHE
At-Risk Population	School	Preschool	Countryside Montessori School	5524 BASELINE ROAD		Yes						Yes	Low	CDPHE
Essential Services	Communication	Emergency Siren	Soccer Fields	4600 BLK Kalmia Ave										Boulder OEM
Essential Services	Public Utility	Electric Substation	Xcel Substation	5001 75th St										HIFLD

Source: City of Boulder Public Works Utilities; Hazard Analysis by Amec Foster Wheeler