2022 – 2027 BOULDER HAZARD MITIGATION PLAN

Abstract

Boulder County experiences natural hazards frequently and the Boulder Hazard Mitigation Plan provides detailed information about each hazard. The plan also contains information by community about hazards, risk, and vulnerabilities along with mitigation strategies and projects.

Boulder OEM

mchard@bouldercounty.org

Table of Contents

1.0 Introduction 1-1
1.1 Purpose 1-1
1.2 Background and Scope 1-1
1.3 Boulder County Hazard Mitigation Update Report 2017-2020 1-2
1.4 City of Boulder County Hazard Mitigation Update Report 2019 1-2
1.5 Climate Change and Equity Considerations in the County Hazard Mitigation Plan Update 2021-2022 1-3
1.5.1 Social, Ecological, Technological Systems (SETS) Framework 1-10
2.0 Community Profile 2-1
2.1 Geography and Climate 2-1
2.2 Population 2-1
2.3 History 2-2
2.4 Economy 2-2
3.0 Planning Process 3-1
3.1 Planning Process 3-1
3.1.1 Importance of This Plan 3-1
3.1.2 Outcome of the Planning Process 3-1
3.1.3 Hazard Mitigation Planning Committee 3-1
3.2 Multi-Jurisdictional Participation 3-2
3.3 The 10 Step Planning Process-201.6(C) (1): 3-3
3.3.1 Phase 1: Organize Resources 3-4
3.3.2 Phase 2 Assess Risk 3-13
3.3.3 Phase 3 Develop the Mitigation Plan 3-13
3.3.4 Phase 4 Implementation of the Plan 3-14
4.0 Risk Assessment 4-1
4.1 Hazard Identification 4-2
4.1.1 Disaster Declaration History 4-3
4.2 Climate, Social, Ecological Considerations 4-6
4.2.1 Climate Change 4-6
4.2.2 Social and Ecological Considerations 4-8
4.3 Hazard Profiles 4-9
4.3.1 Air Quality 4-12

4.3.2 Avalanche 4-15
4.3.3 Communicable / Zoonotic Disease Outbreak 4-17
4.3.4 Dam and Levee Failure 4-22
4.3.5 Drought 4-28
4.3.6 Earthquake 4-35
4.3.7 Expansive Soils 4-39
4.3.8 Extreme Temperatures 4-43
4.3.9 Flood 4-48
4.3.10 Hailstorm 4-61
4.3.11 Landslide/Mud and Debris Flow/Rockfall 4-65
4.3.12 Lightning 4-70
4.3.13 Subsidence 4-77
4.3.14 Tornado 4-81
4.3.15 Wildfire 4-85
4.3.16 Windstorm 4-93
4.3.17 Winter Storms (Severe) 4-100
4.4 Vulnerability Assessment 4-107
4.4.1 Methodology 4-107
4.4.2 Critical Facilities 4-108
4.4.3 Community Assets 4-110
4.4.4 Social Systems 4-110
4.4.5 Community Services 4-114
4.4.6 Future Development 4-115
4.4.7 Economy 4-116
4.4.8 Ecological Systems 4-118
4.4.9 Technological Systems 4-125
4.4.10 Growth and Development Trends 4-130
4.4.11 Sets Vulnerability Mitigation Opportunities 4-132
4.5 Estimating Potential Losses 4-132
4.5.1 Air Quality 4-132
4.5.2 Dam and Levee Failure 4-132
4.5.3 Drought 4-135
4.5.4 Earthquake 4-136
4.5.5 Extreme Temperatures 4-139
4.5.6 Flood 4-139

4.5.7 Landslide/Debris Flow/Rockfall 4-146
4.5.8 Lightning 4-147
4.5.9 Communicable and Zoonotic Diseases 4-147
4.5.10 Subsidence 4-148
4.5.11 Tornado 4-149
4.5.12 Wildfire 4-150
4.5.13 Windstorm 4-154
4.5.14 Winter Storms (Severe) 4-154

5.0 Mitigation Strategy 5-1
5.1 Goals and Objectives 5-1
5.1.1 City of Boulder Hazard Mitigation Goals 5-3
5.2 Identification and Analysis of Mitigation Actions 5-3
5.3 Progress on Mitigation Actions 5-3
5.4 Prioritization Process 5-3
5.5 Mitigation Action Plan 5-4

6.0 Plan Adoption 6-1

7.0 Plan Implementation and Maintenance 7-1
7.1 Role of Hazard Mitigation Planning Committee in Implementation and Maintenance §201.6(d)(3) 7-1
7.2 Maintenance/Monitoring§201.6(C)(4)(Ii) 7-2
7.2.1 Maintenance/Monitoring Schedule 7-2
7.2.2 List of Communities Adopting Boulder County's Plan Monitoring & Maintenance Schedule 7-2
7.2.3 Maintenance Evaluation Process 7-3
7.2.4 Incorporation into Existing Planning Mechanisms §201.6(C)(3) 7-4
7.2.5 Continued Public Involvement 7-4

Annexes:
A Boulder County
B City of Boulder
C City of Lafayette
D City of Longmont
E City of Louisville
F Town of Erie
G Town of Lyons
H Town of Nederland
I Town of Superior

J Four Mile Fire Protection District

Appendices

Appendix A Kick-off Meeting Documentation
Appendix B: Meeting 2 Documentation, Goals and Community Engagement
Appendix C: Meeting 3 Documentation, Review Goals Revisions, Public Survey Results, Mitigation Strategy
Appendix D: Meeting 4 Documentation, Developing Mitigation Actions
Appendix E: Meeting 5 Documentation, Plan Finalization
Appendix F: Posting of HMP on Website and Community Engagement
Appendix G1: HMP Project Status Reports 2017-2018
Appendix G2: HMP Project Status Reports 2019
Appendix G3: HMP Project Status Report 2020

1.0 Introduction

1.1 Purpose

In 2008 the Boulder Office of Emergency Management (OEM), together with the communities of Erie, Jamestown, Lafayette, Longmont, Louisville, Lyons, Superior, Ward, and the Boulder Valley and St. Vrain School Districts, prepared the first Boulder County Multi-Hazard Mitigation Plan to better protect people and property from the hazards that threaten our County. By completing the plan, our County became eligible for certain federal disaster assistance including the Federal Emergency Management Agency's (FEMA) Hazard Mitigation Grant Program and the Pre-Disaster Mitigation program. Our County also earned credits for the National Flood Insurance Program's Community Rating System.

In 2016 Boulder County received approval from FEMA and established another 5-year hazard mitigation plan and program. The organizations participating in the 2016-2022 Boulder County Hazard Mitigation Plan participated in yearly updates and accomplished significant and steady progress on projects. The Board of County Commissioners reviewed yearly updates and approved the Hazard Mitigation Program Progress summary as provided each year by the Boulder OEM.

The 2016 Hazard Mitigation Plan built off the 2008 plan's mitigation goals and continued project planning within that framework. In the 2022 Hazard Mitigation Plan there are new goals created from a community desire to refresh the plan's goals and create a new framework and direction within this planning effort and projects to address hazards.

The update of the 2016 Hazard Mitigation Plan began in 2019 and included most planning partners from the 2016 planning team with new members from departments within the municipalities represented. The planning process had a renewed vigor and vitality from previous planning efforts. The planning group placed an emphasis on significantly updating the mitigation goals, assessing the effects of climate change on hazards, vulnerabilities and risk.

As with any civic effort, the process to revise and update our hazard mitigation plan works best when it is as inclusive as possible. The OEM reached out to stakeholders, partners, and residents to educate, inform, and generate unprecedented levels of participation. In 2016, Boulder County Office of Emergency Management (BOEM) launched a virtual planning process using social media to broaden the dialogue to include those members of our communities that in the past have been underrepresented in the planning process. This activity was continued in the 2022 plan and a community survey was utilized to incorporate community input.

Through an inclusive revision process focused on the mitigation goals of our communities we have developed a revised plan that will help enable our communities to protect their critical facilities, reduce their liability exposure, minimize the impact and disruption caused by hazards, and reduce the costs of disaster response and recovery.

1.2 Background and Scope

Our communities within Boulder County are very familiar with the threats of fire and flood. Yet we face other hazards as well, including tornadoes, drought, hailstorms, and even earthquakes. Each hazard threatens in some way our economy, our property, and our lives. The good news is that we are not powerless against these threats. Through mitigation, we can reduce or even eliminate much of the damage caused by the hazards we face.

FEMA defines hazard mitigation as any sustained action taken to reduce or eliminate long-term risk to human life and property from a hazard. A Congressional study found that, on average, each dollar spent on mitigation saves $6 in future losses. Even more importantly, those savings pale in comparison to the lives we can save through mitigation.

This revised and updated plan improves upon the 2008 & 2016 plan and identifies new opportunities and strategies to reduce vulnerabilities and increase resiliency and sustainability in our communities. Boulder County's Multi-Hazard Mitigation Plan is a multi-jurisdictional plan that geographically covers everything within Boulder County's jurisdictional boundaries. Unincorporated Boulder County, the municipalities of Boulder, Erie, Lafayette, Longmont, Louisville, Lyons, Nederland, and Superior, along with the Four Mile Fire Protection District participated in the planning process and are seeking FEMA approval of this plan.

This plan continues to meet the requirements of the Disaster Mitigation Act of 2000 (PL 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) and finalized on October 31, 2007. By meeting these requirements, the County and participating jurisdictions will remain eligible for federal disaster assistance and hazard mitigation funding under the Robert T. Stafford Disaster Relief and Emergency Act (PL 93-288). Access to these resources will be critical to enabling residents of Boulder County to mitigate against and recover from disaster.

The goals of the mitigation plan are summarized here and detailed further in Chapter 5.

Goal 1: Reduce the Loss of Life and Personal Injuries from Hazard Events

Goal 2: Reduce Impacts of Hazard Events on Property, Critical Facilities/Infrastructure, and the Environment

Goal 3: Strengthen Intergovernmental Coordination, Communication, and Capabilities Regarding Mitigating Hazard Impacts

Goal 4: Improve Public Awareness and Preparedness Regarding Hazard Vulnerability and Mitigation

Goal 5: Address Hazard Identification in the Context of Climate Change

1.3 Boulder County Hazard Mitigation Update Report 2017-2020

For credit under the Community Rating System, this report must be distributed to the media and be made available to the public. Notification of the availability of the report will be sent to the media that cover Boulder County via a press release. Copies of this report and the 2016 Plan Update are available for review at the Boulder OEM or on the website (BoulderOEM.com).

The original hazard mitigation planning process was managed by the Boulder OEM and included representatives from communities throughout Boulder County, non-profit agencies, Boulder County departments, members from the Colorado Division of Homeland Security and Emergency Management's Mitigation Section and FEMA Region 8. The plan was adopted officially on April 4, 2016 and covers the following communities, Boulder County; the Cities of Longmont and Louisville; the Towns of Erie, Gold Hill, Jamestown, Lyons, Nederland, and Superior; and the Fire Protection Districts of Fourmile and Sunshine. The update process occurred in 2020-2022.

Tables with implementation status of county projects from the 2017-2020 report can be found in Appendices E, F & G. Status updates for each jurisdiction's mitigation projects can be found in each of the jurisdictional annexes.

1.4 City of Boulder County Hazard Mitigation Update Report 2019

For credit under the Community Rating System, this report must be distributed to the media and be made available to the public. Notification of the availability of the report will be sent to the media that cover the City of Boulder via a press release. Copies of this report and the 2018 Plan Update are available for review at the Boulder OEM or on the website (BoulderOEM.com).

The original hazard mitigation planning process was managed by The City of Boulder Public Works Department and included representatives from communities throughout the City of Boulder, Boulder County, non-profit agencies, Boulder County departments, members from the Colorado Division of Homeland Security and Emergency Management's Mitigation Section and FEMA Region 8. The plan was adopted officially in March 2018 and the plan will expire in 2023. Currently, the plan is being integrated with the Boulder County Hazard Mitigation Plan update process to increase whole community mitigation projects. The update process is being managed by the Boulder OEM and it will be submitted to FEMA for adoption in 2022.

1.5 Climate Change and Equity Considerations in the County Hazard Mitigation Plan Update 2021-2022

The Boulder County 2021-2022 Hazard Mitigation Plan update is focused on shifting from a reactive structure to a more proactive approach. Boulder County recognizes that climate change is real and that our planet is rapidly warming at a pace never experienced by humans. We can no longer use past hazard events as a good indicator for future hazard impacts. Although there is value in using our previous data and assessing trend lines, the County has made a commitment to integrating climate change into the 2021-2026 HMP.

Boulder County also recognizes that hazards do not impact members of our community equally. We recognize that the root causes of climate change, environmental injustice, and racial inequity are the same and are due to colonization and extraction of natural and human resources to the benefit of a few. In order to effectively reduce vulnerability of people, property, and the environment, we must acknowledge the true history of our country and identify solutions that prioritize the needs of the most marginalized.

Finally, Boulder County understands that humans are part of the ecosystem and that we are deeply connected to and reliant on the natural environment. For decades we have neglected to respect the environment and that has led to air, water and soil quality issues and environmental degradation.

In the 2021 Hazard Mitigation Plan Update, Boulder County will continue to use the successful structure and strategies identified in our 2016 plan and incorporate climate change, social equity and ecological considerations into the risk assessment and mitigation strategies. Additionally, we will restructure elements of the plan to ensure connectivity to other implementation partners for a more holistic and proactive approach. This includes structure inclusive of social, ecological, and technological/infrastructure actions.

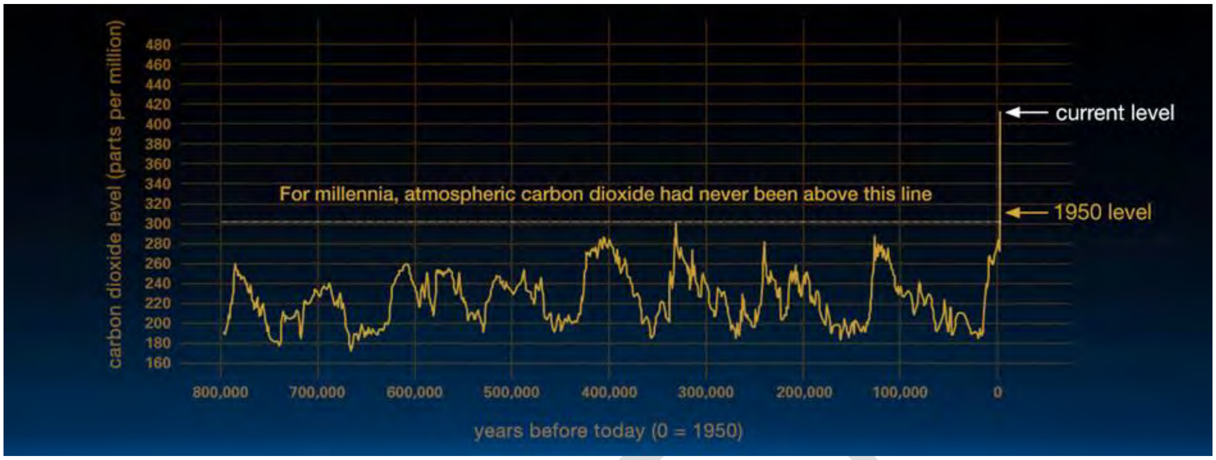
Climate Change

Global Context

The Earth is warming at an unprecedented rate. Since 1880, the global average surface temperature has increased by two degrees Fahrenheit (NASA). Increasing air and ocean temperatures affect the planet's weather and climate systems leading to increases in extreme weather events and natural disasters. Although the planet has been through several cycles of heating and cooling, human activities that increase carbon dioxide and other emissions into the atmosphere have led to record warming over the past 40 years, and with it, record-setting extreme weather events. All but one of the 16 hottest years in NASA's 134-year record have occurred since the year 2000.

To date, scientists have been able to document precipitation (rain and snowfall) variability globally, with increased average precipitation in some areas contrasting severe drought in other areas; ice sheets and mountain glaciers melting which reduces the Earth's ability to reflect sunlight; shifts in wildlife habitats including altered migration patterns, the loss of several species, and the thriving of disease carriers such as mosquitoes and ticks (NASA).

Figure 1-1 Global Carbon Dioxide Levels over Time



Climate.nasa.gov. This graph, based on the comparison of atmospheric samples contained in ice cores and more recent direct measurements, provides evidence that atmospheric CO2 has increased since the Industrial Revolution. (Credit: Luthi, D., et al. 2008; Etheridge, D.M., et al. 2010; Vostok ice core data/J.R. Petit et al.; NOAA Mauna Loa CO2 record.)

The Intergovernmental Panel on Climate Change (IPCC) is made up of over 1300 scientists from around the world. Utilizing best available data, these scientists believe average global temperatures will continue to rise between 2.5- and 10-degrees Fahrenheit by the end of this century (IPCC). Impacts from a two-degree rise have already led to increased extreme heat days, precipitation variability, bigger hurricanes and storm events, increased likelihood of wildfires, and sea level rise. If trends continue, there will be catastrophic impacts to the economic, social and environmental systems we all rely on.

National Context

The Fourth National Climate Assessment (NCA4) states that in the coming decades the United States will experience "high temperature extremes, heavy precipitation events, and high tide flooding events along the U.S. coastline," among other effects. With these changes will also come "more frequent and intense extreme weather and climate-related events, as well as changes in average climate conditions". As experienced and observed in recent years, these extreme hazard events disrupt lives and local economies, strain social services, damage infrastructure, and cause harm to ecosystems. Effects of climate change are impacting our communities today. Daily stresses are compounded when one or more of these climate-related impacts occurs.

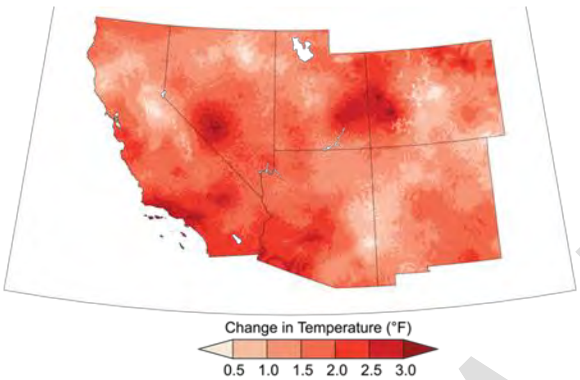
Recent trends in annual average temperature variability will not only persist but also accelerate in the coming decades. According to NCA4, "annual average temperature over the contiguous United States has increased by 1.2°F for the period 1986-2016 relative to 1901-1960". In the future, the annual average temperature of the contiguous United States is expected to increase by about twice as much (2.5°F) by 2050, as compared to the average from 1976-2005, and even larger increases are expected to occur by the end of the 21st century.

Daily extreme temperatures are also expected to increase, with the largest increases effecting the coldest temperatures of the year, especially in the northern half of the country. Changes in the warmest daily temperatures of the year will be more uniform across the contiguous United States. However, overall average temperatures will continue to increase leading to more frequent and intense heatwave and extreme heat events. In addition to temperature changes, heavy precipitation events are also likely to continue increasing in frequency and intensity leading to more flash flooding.

Regional Context

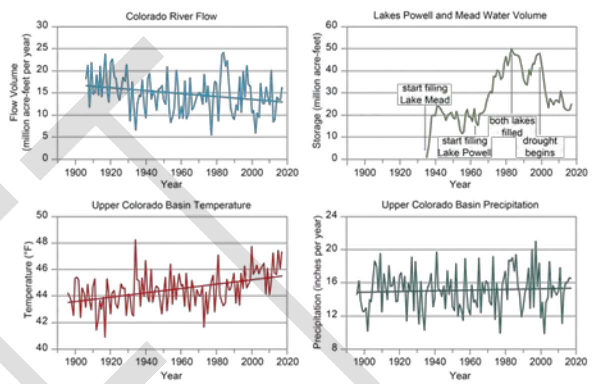
The southwest is incredibly vulnerable to the impacts from climate change. The region is made up of an assortment of ecosystems ranging from coastal land and deserts to mountains and high elevation forests. Even with a variety of ecosystems, the region is collectively experiencing rapid changes in average temperatures and precipitation variability.

Figure 1-2 Change in Temperature in the Southwest



Source: NCA 2018 Chapter 25

Figure 1-3 Drought Impacts in the Southwest



Source: PRISM Climate

Group, Oregon State University

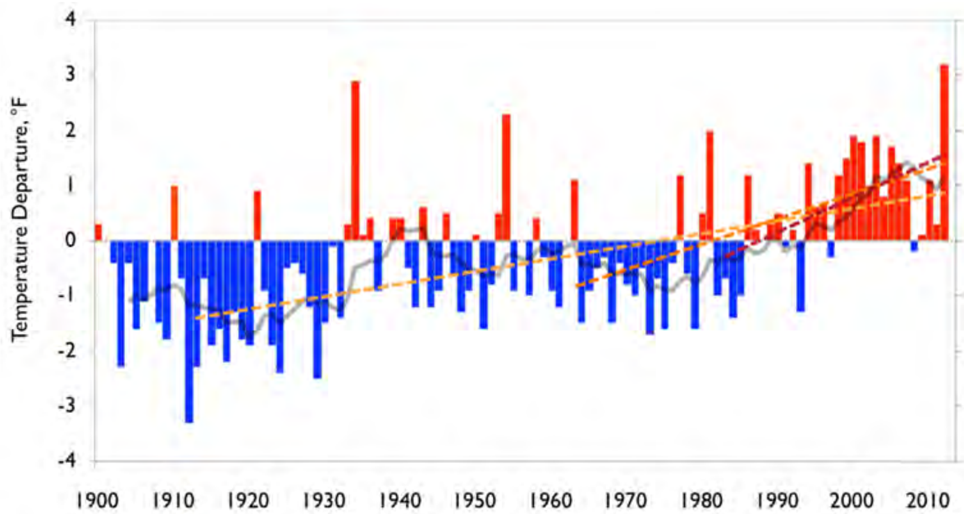
The climate of the Intermountain West is mimicking trends seen at the global and national scale. Over the past 30 years, the average temperature in the Intermountain West has increased by nearly two degrees Fahrenheit; a rapid pace that is unlike other periods of warming. This region is expected to continue warming. Similar to global and national projections, the Intermountain West is projected to warm by 2 to 6.5 degrees by mid-century (WWA).

Local Context

Climate models for Colorado show potential for both increased and decreased precipitation, but models are in overall agreement that the hottest recorded summer temperatures in the state will become the new normal; spring snowpack will decrease between 5% and 20%; and streamflows will decrease by up to 30% by 2050 (WWA 2018). In Boulder County, climate data show that the number of 95-degree days has already doubled from 5 to 11 between 2000-2017. Projections indicate that this number will grow to 38 days above 95 degrees by 2050, and 70 days above 95 degrees by the end of the century (Rocky Mountain Climate Organization 2016). Climate change models exhibit a much wider variation in projecting precipitation events, but the models agree that the number of large or heavy storms, with precipitation over ½ inch, will increase in both quantity and intensity. Storms creating over 1" of precipitation are likely to increase by 50% by the end of the century (Rocky Mountain Climate Organization 2016). While the mountains will see an increase in large storm events, there will also likely be a reduction in overall precipitation at high elevations, including up to a 5% reduction in precipitation during the summer months by the end of the century (Rocky Mountain Climate Organization 2016).

Accompanying the changes in temperature, the number of drought months will nearly double compared to their historic occurrence, and drought events will be classed as "severe" and "extreme" according to the Palmer Drought Severity Index (Resilient Analytics 2018). The combination of increased drought and higher temperatures will further reduce moisture availability within soils, making drought impacts on vegetation more severe and impacting road and infrastructure foundations (Resilient Analytics 2018). Water availability in Boulder County will be impacted by the earlier snow melt, 5%-20% reduction in snowpack, and 30% reduction in stream flow that is projected for the state as a whole by the end of the century (WWA 2018).

Figure 1-4 Colorado Statewide Annual Temperature 1900-2012



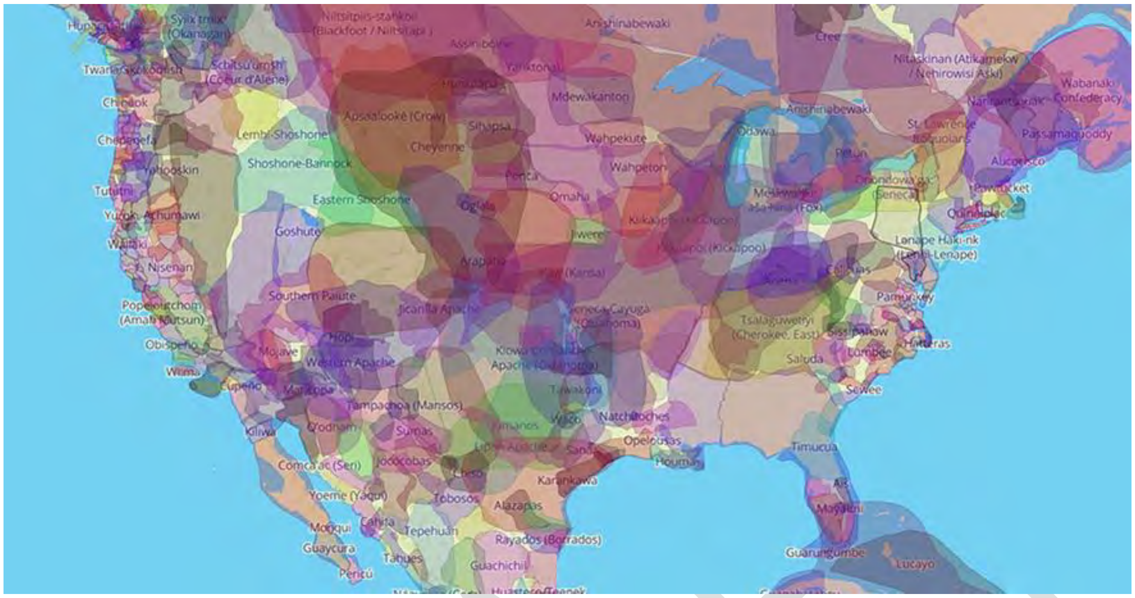
Source: NOAA/National Centers for Environmental Information (NCEI)

Social Equity

Black Indigenous People of Color (BIPOC), immigrants and low-income people, known as frontline communities, have intentionally been made more vulnerable to the impacts of natural hazards and climate change due to decades of prejudice policies and practices, inequitable power distribution and withholding of assets and resources. Institutionalized racism, theft of land and water rights, and class bias began with colonization of the United States and have been foundational pillars that continue to create deep divisions within the country. Unjust systems have created higher levels of poverty and limited access to jobs, resources, transportation, and education for frontline communities.

Prior to colonization by White Europeans in the 15th century, the lands occupied by the United States were home to many Indigenous Tribes and intricate and productive ecosystems that were intertwined with human livelihoods. Despite the rich history of Native Americans, they have also been subject to intense violence, persecution, and swindling at the hands of White colonizers, which has resulted in massive disparities in income, land and home ownership in addition to inequities in basic public health, bodily safety, and civil rights. Much of the current land possession within the United States, state boundaries, city plans, housing developments, and land rights are implicitly records of White supremacy and that preserve the assets and historical records of White populations at the expense of the rights of native peoples. Native Americans are now one of the populations most vulnerable to climate change due to higher exposure to hazard impacts and lower adaptive capacity due to historical and current disenfranchisement. Over the period of colonization in the United States, Tribes have been forcibly restricted to lands with limited resources and struggled to have rights of ownership recognized by state and federal governments. The impacts of this on communities are exacerbated by climate change as sovereign lands of many Tribes are becoming increasingly dry, and the scant water rights afforded to Indigenous Americans are insufficient for their needs.

Figure 1-5 Map Showing the Various Boundaries of Indigenous American Tribes in What is Now the United States



In addition to the disenfranchisement of Native Americans, practices such as "redlining," where the Federal Housing Authority refused to insure mortgages in and around Black neighborhoods, have created massive income inequalities between races, and continue to segregate communities of color into areas with more pollution, less economic opportunity, and higher rates of incarceration. Redlining is an example of the deep entrenchment of racism and racist policies within federal, state, and local governments that historic prejudice and bias have created and still uphold today. These government funded "Jim Crow" policies that barred Black and other people of color from the opportunities, facilities, and cultural institutions of White America, have made race the single greatest disparity in terms of economic and educational achievement, public health, and all other components of social systems within the current United States. Though most segregation laws have been technically removed, in practice many of their impacts still remain, and continue to affect BIPOC across the country. Laws that discriminate specifically against Black people have been replaced by less overtly racist policies such as revitalization and civic improvement efforts; many of which serve to displace entire Black communities from affordable housing. The resulting neighborhoods are upgraded and improved or gentrified for White families that can afford higher rents and home prices. Other so-called public safety policies such as stop and frisk and stand your ground laws are aimed directly at BIPOC and immigrant communities. This over policing has resulted in the mass incarceration of Black people, especially Black men. Today in the United States, one out of every three Black boys will be sentenced to prison in their lifetime, compared with one out of six for Latinos, and one out of 17 for White boys (NAACP 2020). These racist policies are directly responsible for generational cycles of poverty, lost economic and educational opportunities, and severe disparities in mental and physical health between races in the United States.

Home Ownership, Insurance, and Reinsurance

In addition to marginalizing and stifling the growth of communities of color, the practice of redlining and its continued effects have exacerbated the impact of hazards, reduced resource access, and ensured highly finite and fragile mechanisms of resilience within BIPOC communities. The impacts of systemic racism within the housing market are so stark, that Black homeownership has lagged far behind White homeownership for decades. Estimates on the overall equity gap that these policies contribute to indicate that it would take Black families over 200 years to accumulate the same amount of wealth that White people possess, and this disparity is only increased by the impacts of natural hazards. In Houston after Hurricane Harvey, reporting found that White, wealthier homeowners were provided with more resources for recovery than Black, poor families. This pattern holds true across the United States, whereby the wealthy, and the White get more federal aid after a disaster, while minorities and the poor, receive less (NPR 2019). The cycle of poverty increased by homeownership policies is also visible on Native American reservations, where the lack of addresses on homes that are legible to White bureaucracy has prevented distribution of aid for years. A series of flooding events on the Oglala Sioux Pine Ridge reservation from 2015 forward showcased the haphazard approach that FEMA had in distributing aid to Native American Tribes, as assistance was distributed only in piecemeal fashion because of the burden of proof laid on homeowners for deeds to their homes and maintenance reports. In subsequent years, including 2019, no disaster declaration was granted to the Tribe even though major disaster declarations were given to neighboring states.

This lack of bureaucratic recognition and stifling of aid distribution contributes to ongoing poverty and increased income disparities during recovery. Other ways in which income disparities are exacerbated and inhibit community recovery include lack of insurance for BIPOC and low-income communities. Data on damage estimates and disaster impact is created through insurance reporting. For underinsured communities, lack of reporting means lack of recognition in recovery resources and may result in exclusion from rebuilding and resilience efforts.

Local Context

The communities of Boulder County live with highly differentiated risk exposure due to the diverse influences of geography, culture, economic opportunity, and racial and social inequities. These different groups exhibit various capacities to respond to and recover from hazard impacts. Racial inequities in Boulder County are reflective of the history of Colorado as a whole, in that White majorities were created and maintained rather than happened naturally. Early disputes over Black voting rights in the 1860s sparked racial tensions, with Congress bypassing White voters in the territory to grant Black residents suffrage before admitting Colorado to the Union (Newsum 2017). In the early 1900s, the African American population in Denver created a thriving community known as the "Harlem of the West," but the power of the local branch of the Ku Klux Klan meant that the population was restricted within certain neighborhoods in Denver (Newsum 2017). If Black homeowners moved outside of the area, they were threatened with violence, including drive by bombings. Because of the racist restrictions on Black activities and incipient violence, eventually the thriving neighborhood of Five Points lost its entertainment venues and economic viability (Newsum 2017).

The largest non-White group in Boulder County is the Latinx population, which makes up approximately 14% of the County residents (TRENDS 2019). There is a long history of Latinx residents in the area, as many arrived in the 1920s and 30s to farm sugarbeets and mine coal, coming north from Trinidad, Colorado to follow economic opportunity (McIntosh 2016). Throughout the 1900s the Ku Klux Klan tormented people of color in Boulder County, ensuring that Latinx populations only lived in certain areas in the eastern part of the County (TRENDS 2019). More subtly, environmental racism has a long history in Boulder County, where the myth of untouched, virgin open space has been used to romanticize the history of Native Americans in the area, and to restrict the availability of affordable housing (Hickcox 2007). This trend continues through 2020, as residents of the County are least willing to donate to causes that will benefit minorities, immigrants, and refugees (TRENDS 2019). The impacts of systemic racism can be seen in the chronic disparities between Whites and non-Whites in Boulder County. For the Latinx population, this means a higher occurrence of health issues such as diabetes, and child obesity compared to Whites as well as comprising 37% of COVID-19 cases and 48% of COVID-19 deaths (POS 2020); a 86% graduation rate after four years in high school compared to a 93% graduation rate for Whites in Boulder Valley School District (TRENDS 2019); and a median income level of $46,388 for Latinx vs $75,802 for Whites (POS 2020).

Income levels impact recovery from all disasters, but the effects of institutional racism have been also seen in problems with Latinx access to resources after the 2013 floods, and in lack of warning systems in Spanish. There are a number of ongoing efforts to combat the impacts of racism within Boulder County government, but this plan acknowledges that existing inequities increase hazard vulnerabilities for people of color. Other areas of significant vulnerability in Boulder County include the 60% of the population over 65 that has a mental or physical disability, the 27% of residents that do not earn enough to cover basic needs, and the lack of affordable housing that increases commute times and places heavy reliance on working roadways, such as the 50,000 people that commute into the City of Boulder to work every day (TRENDS 2019). Problems with underinsurance are prevalent throughout the mountain communities, as many homeowners do not have enough to cover their wildfire risk. In manufactured home parks, and for monolingual Spanish speakers, recovery in Boulder County has been made more difficult by lack of access to resources and the lack of comprehensive data collection on needs and culturally appropriate disaster preparedness. These gaps in services indicate a need for a more robustly supported cultural broker network and the creation of community-led after action reports that will assist in improving and adjusting mitigation plans and actions.

Ecological

Natural hazards are part of geophysical processes that are constantly at work across the Earth. Movements of tectonic plates, alterations in water availability, precipitation, wind, lightning, etc. are all-natural processes that both create and destroy natural resources. Human activities have affected landscape processes and resource availability for millennia. Throughout North America, this has included indigenous practices of prescribed burns in forests and grasslands, rotational agriculture, hunting, and fishing, etc. With colonization of the United States, exploitation of natural resources and disruption to natural systems accelerated, and practices such as overlogging of forests, fire suppression, cattle ranching, and mining reduced the availability and resiliency of intact ecological systems. These exploitative practices have at times increased the occurrence and severity of hazards, including events such as the Peshtigo fire in 1871. No impact, however, has caused so much disruption as climate change, which has accelerated rapidly since the beginning of the Industrial Revolution around 1750. The advent of fossil fuel powered machines has been shown to have begun warming parts of the world as early as 1830. The increase in greenhouse gas emissions and warming global temperatures are disrupting ecological systems on both large and small scale. Coupled with increased development, clear cutting of forests, and the destruction of habitat around the world and throughout the United States, including for continued oil and gas development, the world is staring at an ecological crisis. This includes rapid temperature swings that stress plant life and reduce soil health; loss of ocean current strength with an accompanying collapse of aquatic food chains; loss of pollinators that would maintain viability of crops and flowering plant life; and many other damaging consequences that threaten human life as well as the robustness of the built environment.

Ecological systems provide the foundation for human technologies and community construction, and ecological health is a fundamental driver of human life and economic viability. Nationally, the United States is unprepared for the ecological impacts of climate change on nearly all points. The hazards that arise from geophysical processes will become more extreme and more difficult to predict as climate change effects increase in strength. Natural resources will become scarcer, and economic sectors that are entirely dependent on the environment, such as tourism, will provide less income and fewer jobs. Climate change will also disrupt supply chains, transportation systems, and trade networks. These economic impacts in addition to hazard impacts will increase strain on government resources and reduce community capacities for resilience and recovery.

Boulder County's ecological systems are diverse and cover a wide range of ecotones as the County topography rises quickly from the plains to alpine environments. Straddling this transition zone, Boulder County includes shortgrass prairie environments as well as alpine tundra, subalpine and montane forests, with lodgepole pine, and mixed Ponderosa and Douglas fir forests as well as pockets of quaking aspen. The foothills display mountain mahogany shrublands while grasslands, wetlands, and riparian areas are scattered throughout the rest of the County. Boulder County exhibits the most condensed transition from plains to mountains of all the Front Range communities in Colorado, with only 15 miles of transition between the two environments (CNHP 2008). This increases the landslide risk for certain parts of the County, but also creates a large diversity of plant and animal species. The mountains in Boulder County include some of the oldest rock in Colorado, with Precambrian elements that date from 1,800-900 million years ago. Intricate fault lines and magma intrusions weave throughout these formations, and the uplift of the Rocky Mountains injected them with mineral rich ore that enticed White settlers into the area and contributed to a long tradition of extractive mining in the area.

Besides precious metals, the ecological systems in Boulder County have provided resources to the Indigenous Tribes in the area, agricultural viability for early farmers, and now power a large tourism industry that includes hiking, camping, leaf watching, cycling, and skiing.

1.5.1 Social, Ecological, Technological Systems (SETS) Framework

Natural hazards such as earthquakes, winter storms, wildfires, and even zoonotic diseases do not impact one jurisdiction, community or sector in isolation. Hazard impacts are wide ranging and felt at many scales, and response and recovery take many forms and require a variety of resources. Recognizing the diverse nature of hazard impacts across human, natural, and built environments, this document uses a social, ecological, and technological systems (SETs) framework to explore interconnections and identify co-existing risks and vulnerabilities within these systems. This framework is based on the understanding that past efforts to harden infrastructure and create robust systems have depended on an ability to control or prevent any level of disruption on infrastructure/technological systems from hazards. With increasing volatility from climate change and the inability to predict hazard occurrence or scales of return with confidence, hardening infrastructure and relying on engineered control has become maladaptive. In situations where technology is considered as the only system, engineered solutions can lock communities into fragile infrastructure design that cannot adapt to new hazards and risks. A glaring example of this is Houston. As the city has massively increased the amount of impervious surface coverage without regard for ecological systems, FEMA floodplain maps failed to account for 75% of insured losses between the years 1999 and 2009.

In order to increase system flexibility, adaptive capacity, and long-term solutions creation, the SETs framework considers the intertwined nature of human, natural environment, and infrastructure systems. Examining the impacts that these systems have on one another and the ways in which they interact leads to increased ability to meet the demands of changing climate and increasing hazard impacts. This document uses the SETs framework throughout Section 4.0 in order to better analyze hazard profiles and functionally address the risks and vulnerabilities that community members, ecological systems, and the built environment have and will experience within Boulder County. For each hazard profile, consideration of social, ecological, and technological systems is included in each hazard profile. Likewise, vulnerability and risk assessments consider how interactions between these systems result in increased risk for certain populations.

2.0 Community Profile

2.1 Geography and Climate

Our unique geography and climate help shape the hazards we face in Boulder County. We live in environments ranging from the rolling prairies in the eastern part of the County to the rugged mountains and alpine forests in the western regions. We live at elevations climbing from 5,000 feet on the high plains to more than 12,000 feet at the Continental Divide which forms our western border.

Our climate is as varied as our topography. In winter we endure frequent snowstorms and temperatures as low as minus 30 degrees Fahrenheit. But, as those of us who live here know snow today does not mean temperatures in the 60s tomorrow. With gusts of 120 miles per hour or more, we also experience some of the strongest winds in the continental United States. Summer typically brings us temperatures reaching the upper 90s and low levels of humidity. We receive an average of 18.17 inches of moisture each year which means that we enjoy at least some sunshine most days.

2.2 Population

At the 2010 census our County had a population of 294,571. According to the State Demography Office, population estimates as of 2020 for Boulder County is 330,860 residents. Below are additional population statistics from the 2020 U.S. Census.

Table 2-1 Boulder County Population by Jurisdiction

Jurisdiction	2020 Population
Unincorporated Boulder County	43,368
City of Boulder	108,860
Town of Erie	12,791
Town of Jamestown	255
City of Lafayette	30,377
City of Longmont	97,833
City of Louisville	21,171
Town of Lyons	2,202
Town of Nederland	1,481
Town of Superior	13,099
Town of Ward	129

Source: Colorado State Demography Office U.S. Census Bureau 2020 Census

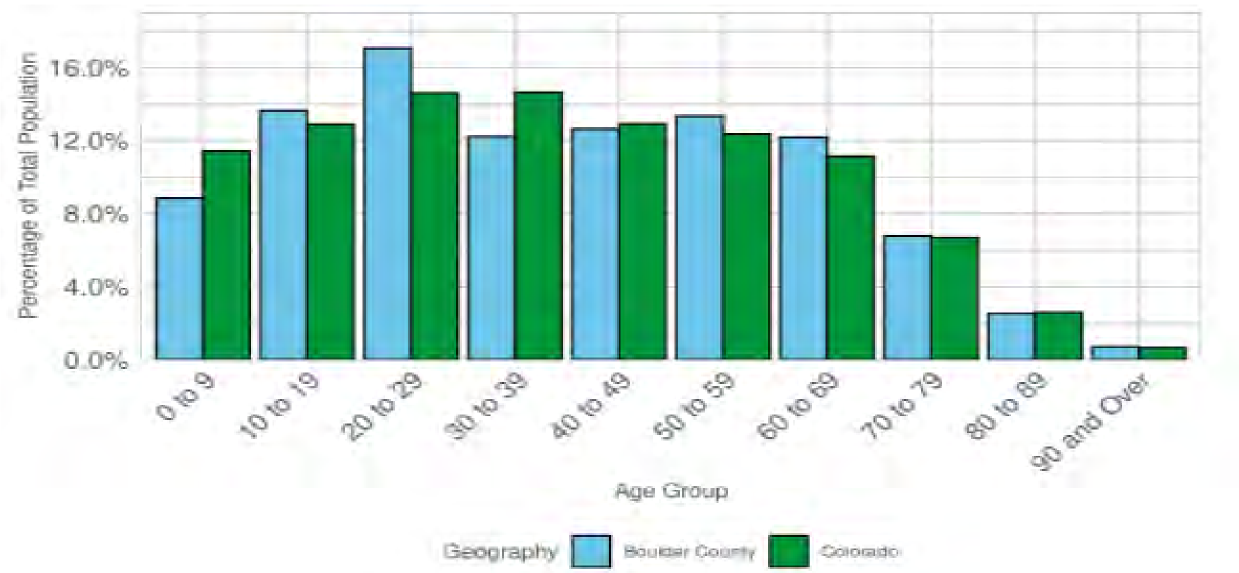
Table 2-2 Boulder County Population by Race

Race	2020 Census	% of total county population
White	261,253	79
African American	4,378	1.3
Asian	18,069	5.5
American Indian/Alaska Native	1,577	0.5

Race	2020 Census	% of total county population
Hispanic/Latino Origin	45,583	13.8.6

Source: Colorado State Demography Office U.S. Census Bureau 2020 Census

Figure 2-1 Boulder County Population by Age Compared to State of Colorado



Source: Colorado State Demography Office, U.S. Census Bureau 2020 Census

2.3 History

Native Americans were the first inhabitants of the area that would become Boulder County. The Southern Arapahoe Tribe had a village here and the Utes, Cheyenne, Comanche, and Sioux also frequented the area.

Gold seekers established the first non-native settlement in 1858. Boulder became an important supply base for miners working in the mountains. At the creation of the Colorado Territory in 1861, Boulder County was one of the 17 original counties represented in the first territorial assembly. In 1873 the railroad connected Boulder to Denver as well as eastern locations to the mining camps to the west. In 1874 Boulder became the home of the University of Colorado spurring more growth.

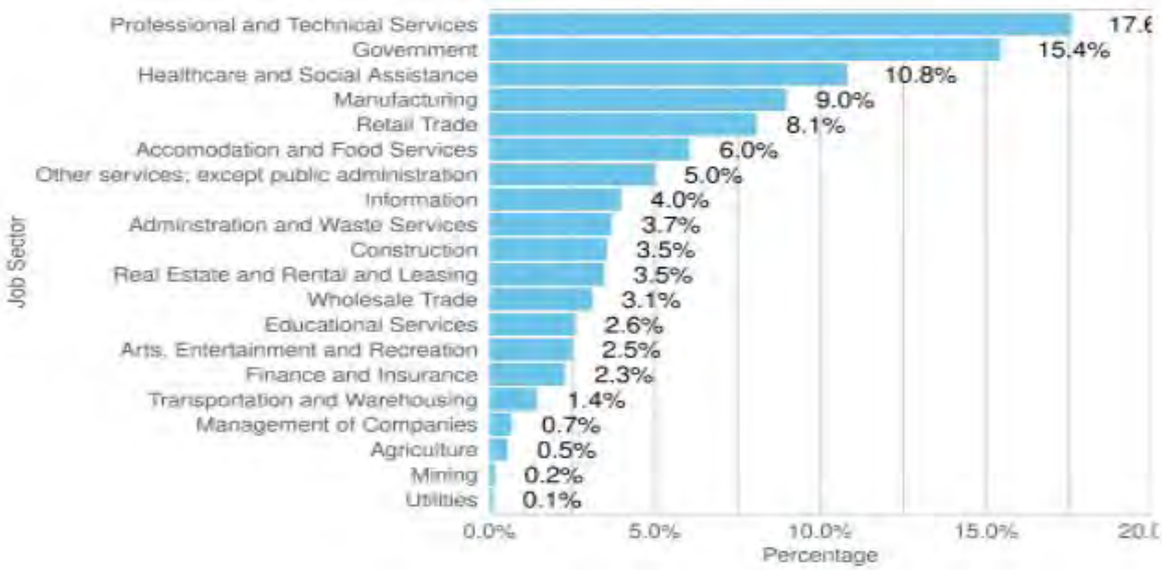
Throughout the 20th century the University and a boom in tourism would continue to drive and shape the development of our area and attract new industries such as the National Bureau of Standards (now the National Institute of Standards and Technology) which located here in 1952.

The hazards of flood and fire have been a part of the history of our County. In 1894 a flood destroyed every bridge in Boulder Canyon and covered the flood plain in 8 feet of water. In 1913 a flood destroyed roads and cutoff the community of Jamestown for two weeks. In 1941 the St. Vrain creek flooded causing damage to homes, businesses, and farms. Notable recent wildfires include the Black Tiger Fire of 1989, the Old Stage fire in 1990, the Overland fire of 2003, Fourmile fire of 2010, the Cal-Wood Fire of 2020 and the Marshall Fire of 2021.

2.4 Economy

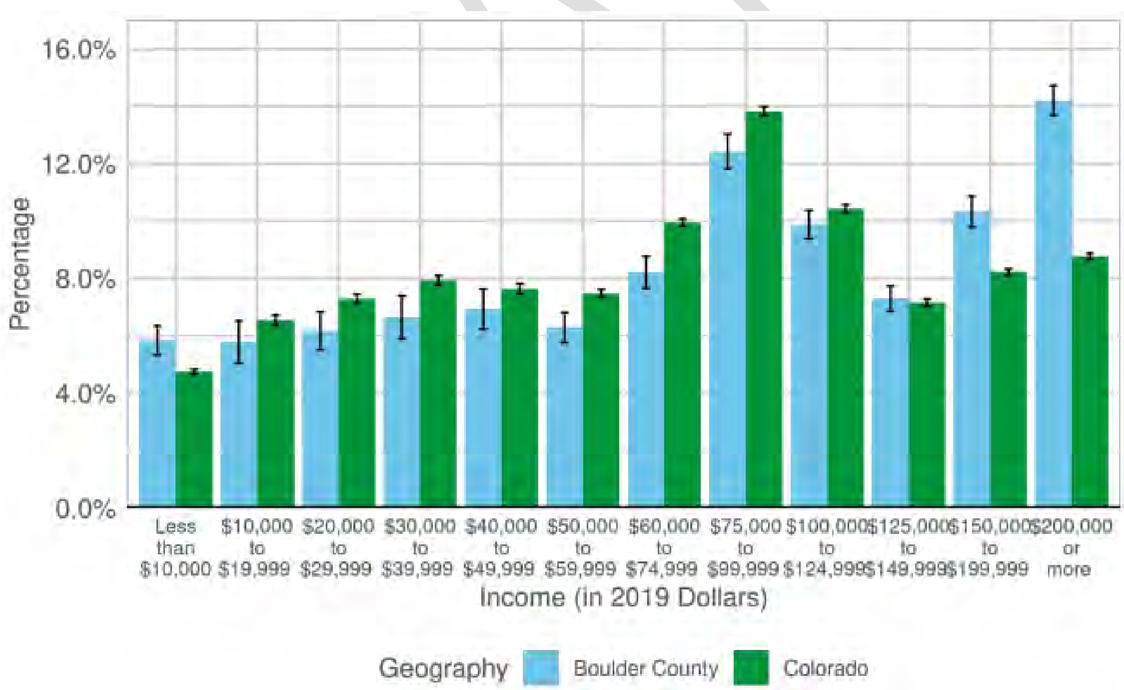
According to the U.S. Census Bureau's 2019 American Community Survey most of Boulder County's labor force is employed in the professional, scientific, and management, and administrative and waste management services industry. The median household income in our County is $83,019. The per capita income is $46,826.

Figure 2-2 Boulder County Employment by Industry



Source: Colorado State Demography Office, U.S. Census Bureau, 2015-2019 American Community Survey

Figure 2-3 Boulder County Household Income Distribution Compared to Colorado



Source: Colorado State Demography Office, U.S. Census Bureau, 2015-2019 American Community Survey

3.0 Planning Process

3.1 Planning Process

44 CFR 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.

As a requirement under the Disaster Mitigation Act of 2000, local jurisdictions are responsible for revising their Hazard Mitigation Plans every five years. This plan is an update to the County's 2016 – 2022 Hazard Mitigation Plan that was approved in April 2016 under this requirement. All sections of the plan were analyzed and revised where appropriate as part of the update process. At the time of the update a global pandemic and significant wildfires (2020 Cal-Wood and the 2021 Marshall Fire) occurred disrupting the update of the 2016-2021 plan. One challenge was the ability to hold community meetings as part of the plan. Social media and interactive periods of public comment were made during this update. The opportunity to comment on the plan spanned many months rather than one or two meetings as sponsored in a traditional planning effort.

Wood Environment & Infrastructure Solutions, Inc (Wood) was procured following in the fall of 2021 to assist with finalizing the plan update and address initial review comments from the Colorado Department of Homeland Security and Emergency Management (DHSEM).

3.1.1 Importance of This Plan

Being a participant in the hazard mitigation planning process qualifies communities and some organizations to apply for pre- disaster and post- disaster mitigation grant funding for projects that decrease or remove the impacts of natural hazards. In addition, having an approved plan assists in qualifying for recovery programs, relief assistance and public assistance under a federal disaster declaration.

3.1.2 Outcome of the Planning Process

A Hazard Mitigation Plan should bring together a community to identify hazards, assess the risks and develop pre- and post-disaster mitigation programs. The previous Boulder County Hazard Mitigation Plan received approval by FEMA in 2016. That plan was designed with a life span of 5 years. The Boulder County Natural Hazards Mitigation Planning process of 2021-2022 is fulfilling the required update to that plan and is expected to receive approval by FEMA in 2022.

This plan builds off previous planning efforts, including the original plan in 2008 and the 2016 update and is aligned with the Disaster Mitigation Act (DMA) planning regulations.

FEMA requires local mitigation planning to meet the intent of regulation 44 CFR §201.6 to qualify for the above-mentioned programs. In accordance with the regulation, the updating of this plan includes the following activities (1) planning process overview, (2) hazard identification and risk assessment, (3) mitigation strategy, (4) plan review, evaluation and implementation, and (5) plan adoption.

3.1.3 Hazard Mitigation Planning Committee

A multi-jurisdictional Hazard Mitigation Planning Committee (HMPC) guided the development of the plan. The HMPC is comprised of staff members with broad areas of expertise from the municipalities included in the plan as well as other public stakeholders. Please see Table 3-1for a list of the members of the HMPC.

3.2 Multi-Jurisdictional Participation

44 CFR Requirement §201.6(B)(2): multi-jurisdictional plans may be accepted, as appropriate, as long as each jurisdiction has participated in the process and has officially adopted the plan.

The planning regulations and guidance of the DMA of 2000 stress that each local government seeking FEMA approval of its mitigation plan must participate in the planning effort in the following ways:

- Participate in the process as part of the HMPC
- 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

Table 3-1 Multi-Hazard Mitigation Planning Committee

Committee Members	Representative 1	Representative 2
Boulder County Assessor	Cynthia Braddock	
Boulder County Attorney	Melanie Lewis	Melanie Lewsis
Boulder County BOCC	Jana Peterson	Michelle Krezek
Boulder County Community Services	Joycelyn Fankhauser	
Boulder County Firefighter's Association	Chris O'Brien	
Boulder County GIS	Mark Mullane	
Boulder County Community Planning	Dale Case	Jim Webster
Boulder County OEM	Mike Chard	Andrew Notbohm
Boulder County Parks and Open Space	Stefan Reinold	
Boulder County Public Works	Mike Thomas	
Boulder County Community Planning and Resiliency	Stacey Proctor	Virginia Gazzetti
	Kelly Watson	
Boulder County Public Health	Joe Malinowski	Chris Campbell
Boulder Mountain Fire	John Benson	
Boulder Rural Fire Department	Greg Schmann	
Boulder Valley School District	Mike Cuskelly	Rob Price
City of Boulder	Kate Dunlap	Christin Shepherd
	Bret KenCairn	
City of Boulder Public Works	Joe Taddeucci	Ed Stafford
Colorado Dam Safety	Bill McCormick	Kallie Bauer
City of Lafayette	Jeff Arthur	Brian Rasipagla
City of Louisville	Dave Hayes	Megan Davis
		Emily Hogan
City of Longmont	Shannon McVaney	Monica Bortolini
	Peter Gibbons	

Committee Members	Representative 1	Representative 2
Colorado Division of Homeland Security & Emergency Management	Mark Thompson	Patricia Gavelda
FEMA	Nicole Aimone	
Four Mile Fire Protection District	Bret Gibson	Maya MacHamer
Mile High Flood District	Kevin Stewart	
National Weather Service	Greg Hansen	Treste Huse
Town of Erie	Kim Stewart	
Town of Lyons	Victoria Simonsen	
Town of Nederland	Miranda Fisher	
St. Vrain Valley School District	Richard Pebbles	
Town of Superior	Matt Magley	
University of Colorado	Garry Dejong	Deon Phenning

For the HMPC, "participation" meant:

Attending and participating in the HMPC meetings, providing available data as requested by the HMPC members, reviewing and providing comments on the plan drafts, Advertising, coordinating, and participating in the public input process, and coordinating the formal adoption of the plan by the governing boards.

Boulder County's Multi-Hazard Mitigation Plan is a multi-jurisdictional plan that geographically covers everything within Boulder County's jurisdictional boundaries. Unincorporated Boulder County, the municipalities of Boulder, Erie, Lafayette, Longmont, Louisville, Lyons, Nederland, and Superior, along with Four Mile Fire Protection District participated in the planning process and are seeking FEMA approval of this plan. The City of Boulder was previously covered by its own separate multi-hazard mitigation plan but decided to join the County plan in the 2020-2022 planning process. The municipalities of Jamestown, Ward, and Gold Hill and the Sunshine and Lefthand fire protection districts opted not to participate in the 2020-2022 plan update process due to limited resources.

3.3 The 10 Step Planning Process-201.6(C) (1):

The Boulder OEM established the planning process for the update of this plan using FEMA's associated guidance information. This 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

This four-phase process also contains the more detailed 10-step planning process used for FEMA's CRS and Flood Mitigation Assistance programs. Thus, the process used for this plan meets the requirements of six major programs: FEMA's Hazard Mitigation Assistance Grant Program, Building Resilient Environments (BRIC), CRS, Flood Mitigation Assistance Program, and new flood control projects authorized by the U.S. Army Corps of Engineers. The County and cities of Longmont and Louisville all participate in the CRS and have earned planning credits from the development of this plan and by continuing in the update process.

Table 3-2 shows how the modified 10-step process fits into FEMA's four-phase process.

Table 3-2 FEMA's 4-Phase Process and the 10-Step CRS Process Used to Develop Boulder County's Local Hazard Mitigation Plan

FEMA's 4-Phase DMA Process	Modified 10-Step CRS Process
1) Organize Resources	
201.6(c)(1)	**1) Organize the Planning Effort**
201.6(b)(1)	**2) Involve the Public**
201.6(b)(2) and (3)	**3) Coordinate with Other Departments and Agencies**
2) Assess Risks	
201.6(c)(2)(i)	**4) Identify the Hazards**
201.6(c)(2)(ii)	**5) Assess the Risks**
3) Develop the Mitigation Plan	
201.6(c)(3)(i)	**6) Set Goals**
201.6(c)(3)(ii)	**7) Review Possible Activities**
201.6(c)(3)(iii)	**8) Draft an Action Plan**
4) Implement the Plan and Monitor Progress	
201.6(c)(5)	**9) Adopt the Plan**
201.6(c)(4)	**10) Implement, Evaluate, and Revise the Plan**

3.3.1 Phase 1: Organize Resources

Step 1: Organize the Planning Effort

The Boulder OEM established the framework and organization for the development of this plan update. OEM identified the key county, municipal, and other local government and initial stakeholder representatives. Letters were mailed to invite them to participate as a member of the HMPC and to attend a kick-off meeting. Table 3-3 lists the County departments and municipalities that participated on the HMPC and assisted in the development of the plan.

Table 3-3 Boulder County Hazard Mitigation Planning Committee Framework

Boulder County	City of Boulder	Municipalities	Districts
Emergency Management	OSMP	Erie	Boulder County Fire Chiefs Assoc.
Sheriff	Fire Dept.	Jamestown	Boulder Fire Chiefs Assoc.
Community Planning	Utilities	Lafayette	Four Mile Fire Protection District
Assessor's Office	City Manager	Longmont	
Building	Open Space and Mountain Parks	Louisville	
Commissioners' Office		Lyons	
Public Health		Superior	
Information Technology/GIS			
Public Works			
Parks and Open Space			

A list of all HMPC representatives is included in Table 3-1.

During the planning process, the HMPC communicated with a combination of face-to-face meetings, phone interviews, email correspondence, and an ftp (file transfer protocol) site. Four planning meetings with the HMPC were held during the plan's development between April 2019 and December 2021. The meeting schedule and topics are listed in the following table. The sign-in sheets and agendas for each of the meetings are on file with Boulder OEM.

Table 3-4 Schedule of HMPC Meetings & Events

HMPC Meeting	Meeting Topic	Meeting Date
1	Introduction to Natural Hazard Mitigation Plan (NHMP) Planning/Kick-off Meeting Overall Plan Goals, Hazard analysis	April 12, 2019
2	Social media blitz begins	November 2019
3	Hazard Mitigation Goal Setting	July 15, 2019
4	Hazard Mitigation engagement and update meeting	February 19, 2020
5	Hazards, Risk & Vulnerability assessment, review mitigation strategies and community capabilities	July 12, 2020
6	HMP Draft Version 1 completed and sent through social media outlets to stakeholders and the community	September 9, 2020
7	Posted to Website and remained for public viewing and comment	September 10, 2020
8	Call for mitigation projects and community profiles with stakeholders	September 11, 2020
9	HMP Draft Version 2 completed and sent through social media outlets to stakeholders and the community	October 10,2020
10	HMP Draft final version completed and sent through social media outlets to stakeholders and the community	October 31, 2020
11	Community Website Virtual Engagement	November 12, 2020
12	Final Draft Established on BOEM Website	January 28, 2021
13	Submitted to CO DHSEM for review and begin addressing comments from state.	March 2021
14	Procure consultants Wood to help address DHSEM comments and resubmit to state.	December 2021
15	HMP Participant follow up/plan finalization meeting to complete DHSEM required revisions.	December 13, 2021
16	Resubmitted to State for Review	April 2022
17	FEMA Submittal	April 2022
18	Submit for Final Approval From FEMA	May-June 2022

Step 2: Public Involvement & Community Engagement

44 CFR Requirement 201.6(b): 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.

FEMA requires community engagement in the process in order for the plan to be approved. The requirements set forth by FEMA are found in the requirements of §201.6(b) and §201.6(c). 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 non-profit interests to be involved in the planning process;
3) Partners and stakeholders' engagement in developing and implementing mitigation strategies is critical to successful plan adoption and operational application of mitigation projects;
4) Opportunities for community engagement throughout the planning process using social media outlets and tools; and
5) [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.

Our engagement of the community has been our strength. This process began with the kick-off meeting and continued throughout the entire process in one form or another. Community engagement initially began with social media, press releases and scheduled meetings. Each community participating in the Natural Hazards Mitigation Plan had a responsibility to carry the message and engage their community in the process. The Boulder OEM created and will maintain social media sites, programs and community group facilitation as needed.

On March 11, 2020 just as community meetings were being scheduled the COVID-19 Pandemic hit the world. Since that time public gatherings have been challenging as Public Health Orders have prohibited public gatherings. Boulder OEM utilized social media to conduct community risk analysis and review versions of the plan. The feedback was incorporated into the plan changes as each version was published.

Public Survey Results

In late 2019 a public survey was conducted and launched on the Boulder OEM website and Facebook page. Over 1700 views occurred and 334 residents took the survey. The survey contains 13 questions designed to identify communities represented, identify the most significant hazards and gain insight about what the community has done to prepare and wants done to mitigate hazards.

The majority of respondents in the survey had not participated the 2016 hazard mitigation planning efforts (Yes 18% No 82% in 2008 & Yes 12 % and No 88%). All questions that solicited responses used "Word Cloud" formatting to represent the range and weight of responses. The following results summarize the data collected over the three-month period of time.

The number of people taking the survey by community.

City of Boulder	37.01%	124
Town of Erie	5.67%	19
Town of Jamestown	0.00%	0
City of Lafayette	7.16%	24
City of Longmont	31.34%	105
City of Louisville	5.67%	19
Town of Lyons	2.39%	8
Town of Nederland	4.48%	15
Town of Superior	3.58%	12
Town of Ward	0.90%	3
Allenspark	0.30%	1
Caribou	0.30%	1
Coal Creek	0.60%	2
Eldora	0.90%	3
Eldorado Springs	0.60%	2
Gold Hill	1.49%	5
Gunbarrel	2.09%	7
Hygiene	0.90%	3
Niwot	2.69%	9
Unincorporated Boulder County	18.21%	61

The survey results identifying the most concerning hazards in Boulder County were Wildfire, Flood and drought. Severe weather related to hail and winter storm also were significantly represented but, in the comments, stressors and human-caused or technological hazards were also represented.

Avalanche	0.37%	1
Dam and Levee Failure	10.45%	28
Drought	35.07%	94
Earthquake	1.87%	5
Expansive Soils	4.10%	11
Extreme Temperatures	10.07%	27
Flood	58.96%	158
Hailstorm	21.64%	58
Landslide/Mud and Debris Flow/Rockfall	10.82%	29
Lightening	5.22%	14
Pandemic Flu	14.55%	39
Severe Winter Storm	32.46%	87
Subsidence	1.12%	3
Tornado	7.09%	19
West Nile Virus	10.82%	29
Wildfire	56.34%	151
Windstorm	19.03%	51

What additional hazards do you believe the Hazard Mitigation Planning Committee should consider?

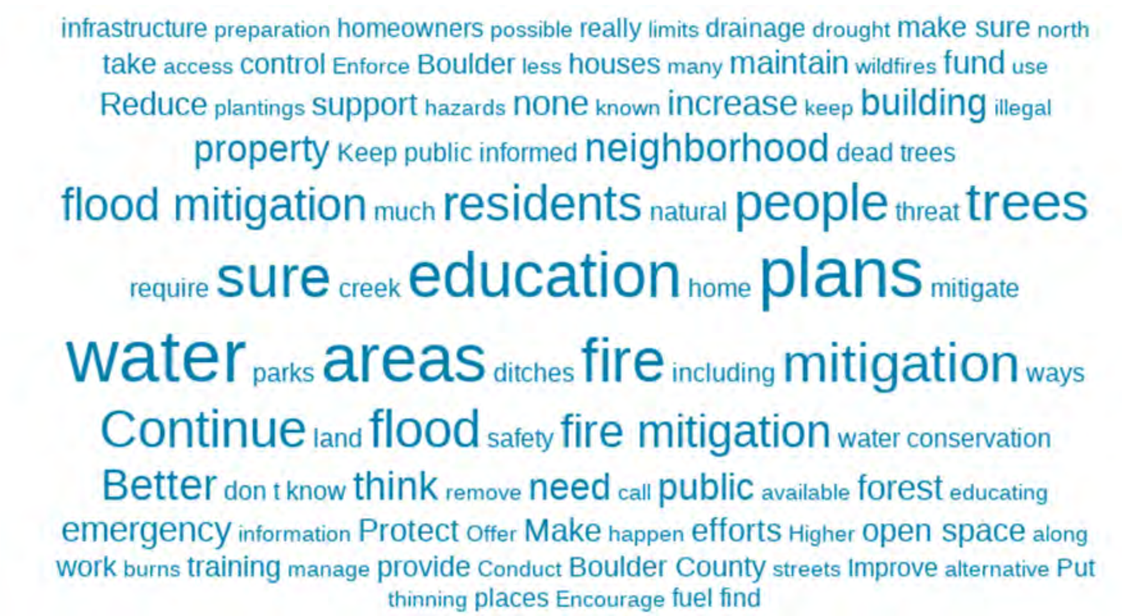
Of all the hazards you have identified which do you consider to be the greatest threat to you and your community?

If the greatest threat to you and your community occurred in your neighborhood today, what would be the likely impact to you and your family?

If you answered YES to Question 10, please describe the actions you or your community have taken to reduce or eliminate the impact of this hazard?

What actions do you believe your local government or Boulder County can take to help reduce or eliminate the impact of these hazards?

Are there any other comments, questions, or concerns you would like the Hazard Mitigation Planning Committee to consider?



Step 3 Coordinate with other Departments and Agencies

Neighboring Jurisdictions: The Boulder Hazard Mitigation Plan was sent to Jefferson County Office of Emergency Management, Larimer County Office of Emergency Management, Gilpin County Emergency Management, Broomfield County and Weld County Emergency Management for comments and feedback.

Agency Involvement and other government stakeholders: At each of the planned meetings invitations were sent out to all sectors of the community. Government, non-profit, private sector and academia were directly targeted or open sourced to attend the meetings. Meetings were communicated via email, social media and traditional media postings. The following agencies were invited to be involved in the plan update process:

- Boulder County Firefighter’s Association
- Colorado Division of Homeland Security & Emergency Management
- Denver Water
- FEMA
- Mile High Flood District
- National Weather Service
- Boulder Valley School District
- St. Vrain School District
- University of Colorado

Additional agencies invited to comment on the plan include Colorado Division of Fire Prevention and Control, CDOT and the Colorado Water Conservation Board.

Incorporating plans and studies: Numerous data sources were used in the development of this plan. Existing studies from the Mile High Flood District, weather models from the National Weather Service (NWS) and FEMA flood plain studies also were used. The Boulder Valley Comprehensive plan and the Boulder Climate Adaptation plan were also consulted. Refer to Table 3-5 for a high-level summary of key plans, studies and reports reviewed and incorporated where applicable.

Table 3-5 Summary of Review of Key Plans, Studies, and Reports

Plan, Study, Report Name	How Plan informed LHMP
Boulder Valley Comprehensive Plan (2020)	Provided background information on the county including some information related to jurisdictions. Informed the Community Profile in Chapter 1 and the jurisdictional annexes.
Boulder County Comprehensive Plan (2018)	Informed the Boulder County Annex, capability assessment
Boulder Climate Adaptation Plan	Informed the risk assessment and the City of Boulder annex, capability assessment
Mile High Flood District studies	Informed the flood section of the risk assessment in the base plan and in the applicable annexes.
National Weather Service weather models	Informed the Community Profile, Geography and Climate section and the weather related hazards in the risk assessment
Boulder County Hazard Mitigation Plan (2016)	Informed the updated risk assessment.
City of Boulder Hazard Mitigation Plan (2018)	Informed the updated risk assessment and portions of the City of Boulder annex (vulnerability assessment and mitigation actions)
Colorado State Hazard Mitigation Plan (2018)	Informed the HIRA (Chapter 3) with risk information specific to Boulder County and hazard profile information for each of the hazards.
Colorado State Demography Office. 2020 Census Data	Informed the Community Profile and each of the incorporated jurisdictional annexes.
Census Bureau American Community Survey 2015-2019 estimates	Informed the Community Profile and each of the incorporated jurisdictional annexes.
Boulder County Flood Insurance Study (2019)	Reviewed for information on past floods and flood problems to inform risk assessment (Chapter 3) Utilized Digital Flood Insurance Rate Maps to update maps and flood risk assessment in Chapter 3.
Boulder County Community Wildfire Protection Plan (2011)	Informed the hazard profile and vulnerability assessment for the Wildfire section and in the jurisdictional annexes.
Colorado State Forest Service - 2018 Report of The Health of Colorado's Forests	Informed the pest infestation, specifically to forest pests hazard profile and risk assessment. Provided background information on successful wildfire mitigation before the Buffalo Mountain Fire.
History of Colorado Avalanche Accidents 1859-2006	Informed the avalanche hazard profile in Chapter 3 risk assessment.
Colorado State Drought Response and Mitigation Plan (2018)	Informed the drought hazard profile and vulnerability assessment in Chapter 3 risk assessment.
Colorado Department of Labor and Employment 2019 data	Informed the Economic Assets sections of the jurisdictional annexes
Colorado Water Conservation Board – Colorado Water Availability Study (2018)	Informed the drought hazard vulnerability assessment in Chapter 3 risk assessment.
Boulder County Land Use and Development Code	Informed the County's capabilities assessment.

Plan, Study, Report Name	How Plan informed LHMP
City of Lafayette Community Profile (2018)	Informed the discussion on economic assets and top employers in the City of Lafayette annex.
Colorado State Register of Historic Properties	Informed the community profiles of the jurisdictional annexes. Each annex has a table of historic properties listed in the register.
City of Lafayette Register of Historic Places	Informed the Historic and Cultural Resources section of the City of Lafayette annex.
2013 Technical Update to the Lafayette Comprehensive Plan	Informed the capability assessment of the City of Lafayette annex.
City of Longmont Sustainability Plan (2016)	Informed the City of Longmont's annex, capability assessment section.
City of Longmont Land Development Code Update (2018)	
Envision Longmont Multimodal and Comprehensive Plan (2016)	
Longmont Open Space Master Plan (2018)	
Longmont Wildlife Management Plan (2019)	
City of Longmont Emergency Operations Plan (2020)	
Town of Erie Comprehensive Plan (2015)	Informed the community profile, capability assessment, and vulnerability assessment of the Town of Erie Annex.
City of Louisville Comprehensive Plan (2013)	Informed Economic Assets and Capability assessment sections of the Louisville annex
Louisville Municipal Code	Informed the City of Louisville's annex, capability assessment section.
Denver Regional Council of Governments Nederland profile	Informed Economic Assets section of the Nederland annex
Town of Nederland Comprehensive Plan (2013)	Informed Natural, Cultural, and Historic resources section of the Nederland annex
OnTheMap Census Bureau	Informed Economic Assets section of the Nederland annex
Town of Superior Comprehensive Plan with 2012 Amendment	Informed the Town of Superior annex, capability assessment section.
Superior Municipal Code and Superior Development Code	
Coal Creek and Rock Creek Master Drainageway Plan (2014)	
Weld County HMP (2021)	Used to cross reference capability assessment for Town of Erie
Lyons Land Use and Management Plan for Deed Restricted Buy-Out Properties (2017)	Informed Town of Lyons annex
Lyons HIRA (2017)	Informed vulnerability assessment for Town of Lyons annex

Plan Visibility: Throughout the planning process various versions or drafts of the plan were authored. With each version the plan was sent out to the participating agencies for feedback and approval. Community members were also allowed to publicly comment on the draft versions.

3.3.2 Phase 2 Assess Risk

Step 4 Identify Hazards

During the kick-off meeting, the HMPC discussed past events, impacts, and future probability for each of the hazards required by FEMA for consideration in a local hazard mitigation plan. A profile of each hazard was then developed with the help of County- GIS staff in developing GIS layers to display the information. The HMPC discussed the rankings as determined by the scores associated with each of the factors, i.e., occurrences, probability of future occurrences, magnitude and severity. The committee concurred with the scoring and the ratings of hazards as either high, medium, or low hazards. The committee then determined the areas affected by the top three hazards and GIS mapped out the areas using a subjective boundary.

Step 5 Assess Risks

After profiling the hazards that could impact Boulder County, the Boulder OEM staff collected information to describe the likely impacts of future hazard events in the participating jurisdictions. This step involved two parts: a vulnerability assessment and a capability assessment.

The vulnerability assessment involves an inventory of assets at risk to natural hazards and in particular wildfires, flooding, and rock fall/landslides. These assets included total number and value of structures; critical facilities and infrastructure; natural, historic and cultural assets; and economic assets. Boulder OEM staff supported the efforts of each community to complete a detailed analysis for the revision of the plan. The analysis was used to determine the proportion of value of buildings in the hazard areas that were identified by the HMPC or community planning effort. The County GIS system was used by first selecting parcels from the assessor's data that have their center within the City or Town limits and then making a sub-selection of parcels that have their center within the defined hazard area. Structure value is based on the actual value of improvements.

A similar process was completed for each jurisdiction to understand the affected population. This analysis used census tract data. The capability assessment consists of identifying the existing mitigation capabilities of participating jurisdictions. This includes government programs, policies, regulations, ordinances, and plans that mitigate or could be used to mitigate risk to disasters. Participating jurisdictions collected information on their regulatory, personnel, fiscal, and technical capabilities as well as ongoing initiatives related to interagency coordination and public outreach.

3.3.3 Phase 3 Develop the Mitigation Plan

Step 6 Set Goals

On April 12, 2019, the kick-off meeting occurred and one of the meeting objectives was to set the goals of the new HMP effort. A multi-agency group selected four goals as defined in Section 5.0 of the plan.

- **Goal 1:** reduce the loss of life and personal injuries from hazard events
- **Goal 2:** Reduce impacts of hazard events on property, critical facilities / infrastructure, and the environment
- **Goal 3:** Strengthen Intergovernmental coordination, communication and capabilities in regard to mitigation hazard impacts
- **Goal 4:** Improve public awareness regarding hazard vulnerability and mitigation

Step 7 Review Possible Activities

At the third committee meeting, the HMPC identified and prioritized mitigation actions. The HMPC conducted a brainstorming session in which each committee member identified at least one mitigation action to address each of the plan's goals. IN addition, each community was asked to complete a capabilities worksheet for any additional mitigation actions throughout the remaining planning process.

As with each priority, there is a responsible agency to ensure the project is completed. The HMPC identified the responsible agency for implementing each action. The responsible agency then completed the Mitigation Project Description Worksheet. These worksheets allow the HMPC to document background information, ideas for implementation, alternatives, responsible agency, partners, potential funding, cost estimates, benefits, and timeline for each identified action. Alternatives, responsible agency, partners, potential funding, cost estimates, benefits, and timeline for each identified action.

Step 8: Draft the Plan

A draft of the revised Boulder County Multi-Hazard Mitigation Plan was developed by the Boulder OEM staff and submitted to the HMPC for internal review. Once the committee's comments were incorporated, a complete draft of the plan was made available online for review and comment by the public and other agencies and interested stakeholders. The review period was from September 2020 to February 2021. Public comments were integrated into a final draft for submittal to the Colorado OEM and FEMA Region VIII.

3.3.4 Phase 4 Implementation of the Plan

Step 9 Adopt the Plan

To implement the plan, the governing bodies of each participating jurisdiction adopted the plan with a formal resolution. Scanned copies of resolutions of adoption are included in the appendices of the plan.

Step 10: Implement, Evaluate, and Revise the Plan

The HMPC developed and agreed upon on overall strategy for plan implementation and for monitoring and maintaining the plan over time. This strategy is further described in the plan implementation section.

4.0 Risk Assessment

Requirement §201.6(c) (2): [The plan shall include] A risk assessment that provides 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.

The traditional risk assessment process identifies and profiles relevant hazards and assesses the exposure of lives, property, and infrastructure to these hazards. Boulder County's process builds off the traditional risk assessment and improves our understanding of risk by integrating social equity considerations and projected impacts due to climate change. Expanding the information considered in the risk assessment allows for a better understanding of the County's role in creating disenfranchised communities through prejudice policies and practices and connecting that information to why a community's potential risk to natural hazards is currently higher and will continue to be worse as impacts from climate change increase the frequency and intensity of natural hazard events. This more comprehensive risk assessment provides a framework for developing and prioritizing mitigation actions that take inequities into account while also reducing risk from future hazard events by integrating the best available science and considering trend lines.

The following sections are organized to align with the methodology and four-step process described in the FEMA publication Understanding Your Risks—Identifying Hazards and Estimating Losses. However, Boulder County recognizes the need to integrate social and ecological elements into this plan to better assess risk holistically and proactively address systems connectivity. The following sections will also build off that guidance to ensure social, ecological and infrastructure elements are considered and incorporated.

1) Hazard Identification identifies the hazards that threaten the planning area and describes why some hazards have been omitted from further consideration.
2) Hazard Profiles discusses the threat to the planning area and describes previous occurrences of hazard events. Profiles include increased frequency and intensity of hazard events and integrates anticipated impacts utilizing the best climate science to determine the likelihood of future occurrences. Social, ecological and infrastructure considerations will all be included in the profiles.
3) Identify Community Assets and Analyze Risk will build off the hazard profiles and identify which social, ecological and technical/infrastructure assets and systems are at risk.
4) Vulnerability Assessment assesses the County's total exposure to natural hazards, considering assets at risk, critical facilities, disenfranchised communities, human health discrepancies and ecosystem services and evaluates where risks vary by jurisdiction within the planning area accounting for future development trends. Preventing disaster losses and improving human quality of life in Boulder County requires a more comprehensive approach to understanding the natural hazards that pose a risk to our communities. The following terms will be utilized throughout the Plan and are critical to understand and consider when designing mitigation strategies.

- **Hazard:** An event or physical condition that has the potential to cause fatalities, injuries, property damage, infrastructure damage, agricultural loss, damage to the environment, interruption of business, or other types of harm or loss (FEMA 1997, xxi).
- **Risk:** The probability of a specific hazards occurrence and its consequences including the impact to people, facilities, services and structures.
- **Vulnerability:** FEMA defines vulnerability as the susceptibility of people, property, industry, resources, ecosystems, or historical buildings and artifacts to the negative impact of a disaster. According to the Centers for Disease Control and Prevention (CDC), social vulnerability refers to the

potential negative effects on communities caused by external stresses on human health. For the purposes of this document, vulnerability is the inability of people, assets, resources, ecosystems, organizations, industry or businesses to withstand adverse impacts from natural or human-caused disasters, or disease outbreaks including social, economic and environmental impacts and intersections.

- **Climate Change:** changes in average weather conditions that persist over multiple decades or longer. This includes increases and decreases in temperature, as well as shifts in precipitation, changing risk of certain types of severe weather events and changes to other features of the climate system (NCA, 2018).
- **Social Equity:** Policy Link defines equity as "just and fair inclusion into a society in which all can participate, prosper, and reach their full potential. Unlocking the promise of the nation by unleashing the promise in us all." Social equity includes all people having what we need to survive or succeed including access to opportunity, networks, resources, and supports—based on where we are and where we want to go. Equitable policies actively mitigate the disproportionate harm faced by certain communities.
- **Discrimination:** The unequal allocation of goods, resources, and services, and the limitation of access to full participation in society based on individual membership in a particular social group; reinforced by law, policy, and cultural norms that allow for differential treatment on the basis of identity.

4.1 Hazard Identification

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.

This risk assessment evaluates risk by considering probability and likelihood of a hazard event occurring, exposure of people, property and infrastructure to the hazard, and the cascading consequences of that exposure. Historically, the HMPC used a "multi-hazard" approach for the 2008 HMP. They agreed upon a list of hazards that could affect Boulder County by using existing hazards data, plans from participating jurisdictions, and input gained through planning and public meetings. In 2013, the HMPC determined that the updated mitigation planning process would focus on natural hazards. They then reviewed the hazard events that have occurred since 2007, and developed a list of hazards, listed alphabetically to be included in the HMP. For this update, the Multi-Hazard Mitigation Planning Team (MHMPC) reviewed the 2013 list of hazards and felt that the hazard profile list is appropriate and recommended no changes. However, the MHMPC concluded that climate change needs to be incorporated into the 2021 plan and thus, air quality has been added as a hazard and climate change considerations will be integrated throughout the risk assessment. Additionally, to address climate change it was determined that the County must consider social equity and ecological impacts. Thus, we have added social considerations and ecological considerations to the assessment of each hazard.

For this risk assessment, hazards evaluated include those that have already occurred historically or have the potential to cause significant social, ecological and/or infrastructural losses in the future. Historical hazards data from FEMA, the Colorado DHSEM (including the 2018-2023 Colorado Hazard Mitigation Plan), the National Oceanic and Atmospheric Administration, the Spatial Hazard Events and Losses Database for the United States (SHELDUS), the Colorado Geological Survey (CGS), the Colorado Dam Safety Branch (DSB), the United States Geological Survey (USGS) and many other sources were examined to assess the significance of these hazards to the planning area. Additionally, social data was assessed from the Centers for Disease Control and Prevention (CDC) Social Vulnerability Index (SVI), Boulder County Cultural Brokers Resilience Program, Boulder Community Foundation's Trends Report, Colorado Department of Public Health and Environment, Boulder County Regional Housing Partnership, Boulder County Mobility for All

Needs Assessment and Action Plan, Census and American Community Survey Data, and Headwater Economics Neighborhoods at Risk.

The historical data, potential for catastrophic impacts to humans and the systems they rely on, and the probability and potential of future occurrences were all utilized to determine the list of hazards, listed alphabetically to be included in the Natural Hazard Mitigation Plan.

1) Air Quality
2) Avalanche
3) Communicable/Zoonotic Disease Outbreak*
4) Dam and Levee Failure
5) Drought
6) Earthquake
7) Expansive Soils
8) Extreme Heat
9) Flood
10) Hailstorm
11) Landslide/Mud and Debris Flow/Rockfall
12) Lightning
13) Subsidence
14) Tornado
15) Wildfire
16) Windstorm
17) Winter Storm (Severe)

** This includes Pandemic Flu and West Nile Virus. The World Health Organization (WHO) states "there is much evidence of associations between climatic conditions and infectious diseases…. changes in infectious disease transmission patterns are a likely major consequence of climate change." Thus, Communicable/Zoonotic Disease Outbreak falls within the list of hazards that are connected to nature and influenced by climate change.*

. In 2019 the Multi-Hazard Mitigation Planning Committee (MHMPC) reviewed the hazards and felt that the hazard profile list is appropriate however, the MHMPC concluded that climate change needs to be incorporated into the 2021 plan and thus, the addition of air quality as a hazard is listed above. Additionally, the team added climate change as a consideration for determining hazard significance.

Table 4-1 provides overall hazard significance based on geographic extent, probability of occurrence and the likely magnitude and severity of the hazard. The significance ratings are based on data from the hazard analysis in the following sections in addition to input from all the participating jurisdictions. Only the more significant hazards (high or medium) have a more detailed hazard profile and are analyzed further in the Vulnerability Assessment section (to the extent possible). Note that the significance of the hazard may vary from jurisdiction to jurisdiction (see the Jurisdictional Annexes for notes on how the significance varies for each jurisdiction). Some modifications were made to the original HMPC input based on the results of this risk assessment.

Table 4-1 Boulder County Hazards Significance Identification Worksheet

Hazard	Geographic Extent	Probability/ Frequency	Magnitude/ Severity	Increased Threat (Climate Change)	Overall Significance
Air Quality	Extensive	Highly Likely	Critical	Moderate	Medium
Avalanche	Limited	Highly Likely	Limited	Low	Low
Communicable Disease	Extensive	Occasional*	Critical	Substantial	Medium

Hazard	Geographic Extent	Probability/ Frequency	Magnitude/ Severity	Increased Threat (Climate Change)	Overall Significance
Dam and Levee Failure	Significant	Unlikely	Catastrophic	Moderate	High
Drought	Extensive	Likely	Catastrophic	Substantial	High
Earthquake	Extensive	Occasional	Catastrophic	Low	Medium
Expansive Soils	Significant	Highly Likely	Limited	Substantial	Low
Extreme Heat	Extensive	Likely	Critical	Severe	Low
Flood	Significant	Highly Likely	Critical	Severe	High
Hailstorm	Extensive	Likely	Limited	Moderate	Limited
Landslide	Limited	Occasional	Limited	Substantial	High
Lightning	Extensive	Likely	Limited	Moderate	Medium
Subsidence	Significant	Likely	Limited	Moderate	Medium
Tornado	Significant	Likely	Limited	Low	Medium
Wildfire	Significant	Highly Likely	Critical	Severe	High
Windstorm	Extensive	Highly Likely	Critical	Moderate	High
Winter Storm (Severe)	Extensive	Highly Likely	Catastrophic	Substantial	High

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

Increase Threat from Climate Change
- Low- unlikely to become more of a threat due to climate change.
- Moderate – possibly will become more of a threat due to climate change.
- Substantial- likely to become more of a threat due to climate change.

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.

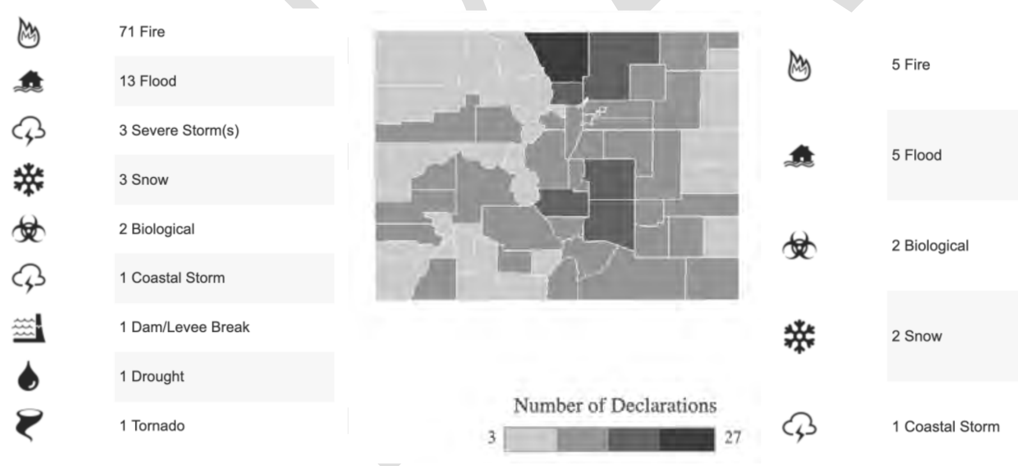
Hazard	Geographic Extent	Probability/ Frequency	Magnitude/ Severity	Increased Threat (Climate Change)	Overall Significance
• Severe- highly likely to become more of a threat due to climate change		• Negligible—Less than 10 percent of property severely damaged, shutdown of facilities and services for 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			

**Based on occurring anywhere in the United States*

4.1.1 Disaster Declaration History

Identification of hazards to consider and address in this plan are based on previous plans and on research of past events that triggered federal and/or state emergency or disaster declarations. When the local government's capacity has been surpassed, a state disaster declaration may be issued, allowing for the provision of state assistance. The Robert T. Stafford Disaster Relief and Emergency Assistance Act, 42 U.S.C. §§ 5121-5206, was enacted in 1988 to address when a disaster is so severe that both the local and state governments' capacities are exceeded. When a federal emergency or disaster declaration is issued, this allows for the provision of federal assistance. The disaster assistance that is granted through either of these declarations is supplemental and sequential.

Figure 4-1 Number of Disaster Declarations for the State of Colorado since 1953

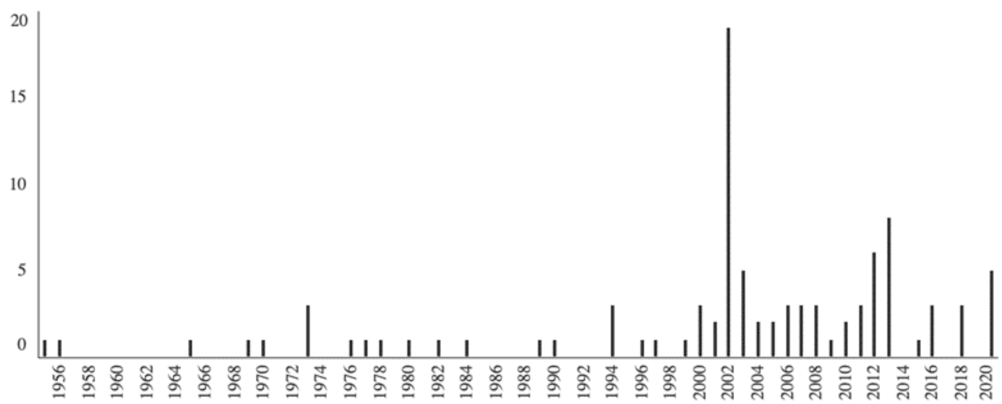


Source: FEMA

The figure above is a graphical representation of FEMA recognized federal disaster and emergency declarations that have occurred in Colorado since 1953. The numbers represented on the right are specific to Boulder County. Note that the unusual coastal storm consideration was related to evacuations related to Hurricane Katrina in 2005.

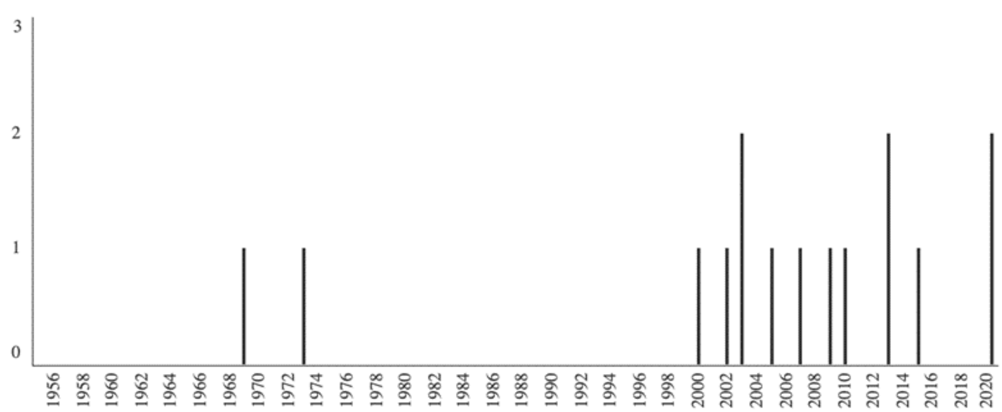
Above the state level, there are a few agencies which can authorize a disaster declaration. The federal government may issue a disaster declaration through the FEMA, the U.S. Department of Agriculture (USDA), and/or the Small Business Administration (SBA). As a side note, FEMA also issues emergency declarations. These are different from 'disaster declarations' in that they are more limited in scope and without the long-term federal recovery programs. It is the quantity and types of damage that are the determining factors between an 'emergency declaration' vs. a 'disaster declaration'.

Figure 4-2 Disaster Declarations for the State of Colorado since 1953 by Year



Source: FEMA

Figure 4-3 Disaster Declarations for Boulder County since 1953 by Year



Source: FEMA

A USDA declaration will result in the implementation of the Emergency Loan Program through the Farm Services Agency. This program enables eligible farmers and ranchers in the affected county as well as contiguous counties to apply for low interest loans. A USDA declaration will automatically follow a major disaster declaration for counties designated major disaster areas. Counties that are contiguous to the declared counties, including those that are across state lines will also qualify for benefits. As part of an agreement with the USDA, the SBA offers low interest loans for eligible businesses that suffer economic losses. These loans are referred to as Economic Injury Disaster Loans. Businesses in Counties who received a disaster declaration and those contiguous to them may apply.

Table 4-2 provides information on natural disasters declared in Boulder County between 1953 and December 2021.

Table 4-2 Boulder County Disaster and Emergency Declarations, 1953-2021

Year of Declaration	Type of Declaration	Disaster Type
1969	Federal	Severe Storms and Flooding
1973	Federal	Heavy Rains, Snowmelt, Flooding
1989	Local	Wildfire
1990	Local	Wildfire
1994	Local	Flooding
1995	State	Flooding
1998	Local	Wildfire
2000	USDA Federal	Drought Wildfire- Eldorado Fire
2001	State	Severe Weather
2002	Federal USDA	Wildfire Drought
2003	Federal Federal	Snow Wildfire- Overland Fire
2005	Federal	Hurricane Katrina Evacuation
2006	USDA Federal	Heat, High Winds, Ongoing Drought Snow
2007	Federal	Snow
2009	Federal	Wildfire- Olde Stage Fire
2010	Federal	Wildfire
2011	Local	Flooding
2012	Federal	Wildfire
2013	Federal	Flood
2015	Federal	Severe Storms, Tornadoes, Flooding, Landslides, and Mudslides
2016	Federal	Wildfire
2017	Federal	Wildfire
2020	Federal	Pandemic- COVID-19 Pandemic

Year of Declaration	Type of Declaration	Disaster Type
2020	Federal	Wildfire
2021	Federal	Wildfire
2021	Federal	Wildfires and Straight-Line Winds

Source: 2018-2023 Colorado Hazard Mitigation Plan; FEMA, PERI Presidential Disaster Declaration Site. U.S. Department of Agriculture

Hazards Not Included

Other hazards were discussed by the MHPC, but ultimately not included in this plan. Thunderstorm is not identified as an individual hazard, but thunderstorms are recognized for their role in the flood, lightning, and windstorm hazards, and is addressed accordingly in those hazard profiles. Erosion/deposition had not been identified previously for inclusion. However, after the September 2013 rain and flood events it is important to recognize the unique and different impacts these phenomena present. Further mitigation efforts and planning will need to occur and should be included in future updates to this plan. Fog, and volcanoes were considered but removed from the list due to minor occurrences and/or impacts. Coastal erosion, coastal storm, hurricane, and tsunami were excluded because they are not experienced in Boulder County.

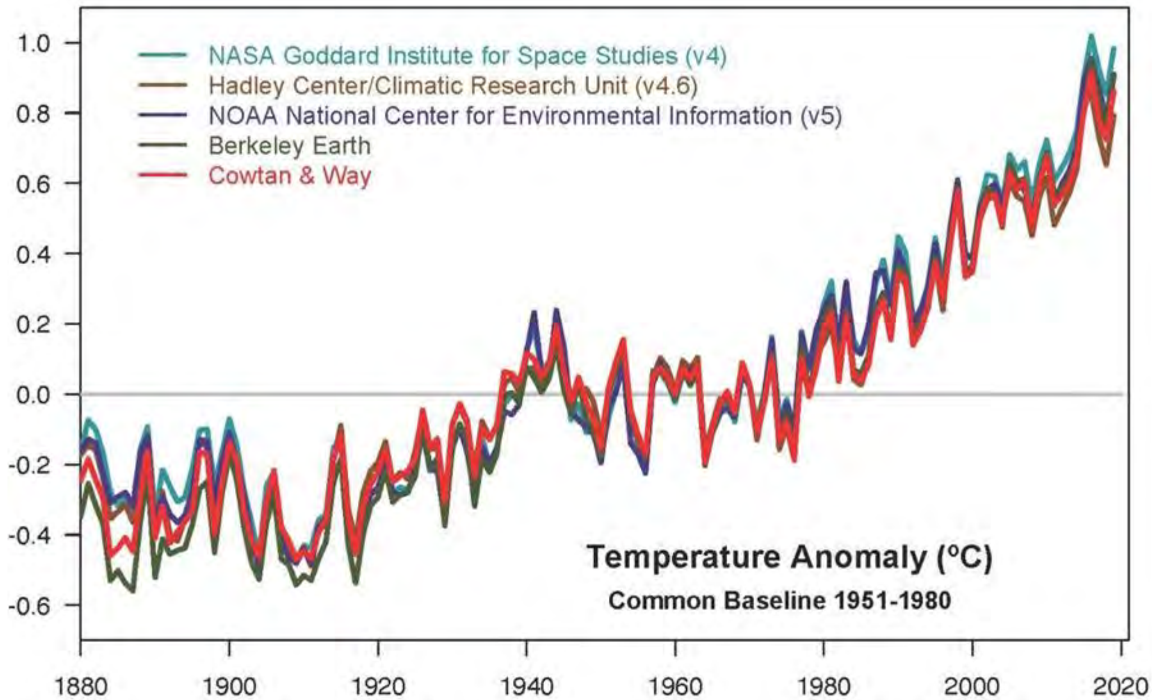
4.2 Climate, Social, Ecological Considerations

4.2.1 Climate Change

Climate change is real. Evidence from direct measurements of ocean and air temperatures unequivocally demonstrates that the Earth's climate is rapidly warming due to human activities. In fact, the Earth is warming faster today than ever before in recorded history. Climate refers to patterns of weather that includes variations in precipitation, wind, temperature, and humidity. Weather refers to short-term changes in the atmosphere whereas climate refers to averages over a longer period of time. Scientists believe that global temperatures will continue to rise for decades to come due to irreversible consequences from human action.

Climate change exacerbates existing vulnerabilities while generating new risks. Changes in global climate patterns are already having visible impacts on social, ecological and technical systems in Colorado. The State is and will continue to experience more intense and frequent hazard events leading to increased loss of life, ecosystem services, and vulnerabilities. As population increases, these losses will be further magnified along with severe economic disruption.

Figure 4-4 Scientific Consensus: Earth's Climate is Warming



Temperature data showing rapid warming in the past few decades, the latest data going up to 2019. According to NASA data, 2016 was the warmest year since 1880, continuing a long-term trend of rising global temperatures. The 10 warmest years in the 140-year record all have occurred since 2005, with the six warmest years being the six most recent years. Credit: NASA/NOAA

The U.S. Global Change Research Program (USGCRP) is the national authority on climate change in the United States. In 2018, the USGCRP released the Fourth National Climate Assessment (NCA4) which confirms that climate change is impacting every region of the United States and provides peer reviewed data and information about how impacts are expected to become worst as average global temperatures continue to rise. The report breaks the country into regions in which Colorado is part of the southwest region.

The southwest region is one of the quickest warming areas in the nation, greater than the global average. Over the past 30 years, there has been a 2°F increase in average surface temperatures which, despite the regions variable weather, is unprecedented. Warmer temperatures are expected to increase summer temperatures more than winter temperatures leading to increased risk of heat stress, outbreaks of infectious disease, water supply issues and infrastructure failure.

Over the past 40 years, Colorado had a tremendous increase in natural disasters making it the number one state in the country in the rate of increase for natural disruptions. The rapid increase in average temperatures has already begun to increase the number of natural hazard events such as wildfires, drought and heavy precipitation. Higher temperatures impact soil, water and air quality leading to direct impacts on human health, livestock, crop yields and wildlife. Additionally, climate impacts effect population groups differently. BIPOC, age-advanced, youth, and less able-bodied people are impacted disproportionately due to the combination of prejudice systems and structures with more frequent and intense hazard events.

The following information comes from NASA's Global Climate Change, Vital Signs of the Planet website and provides a brief summary of expected impacts from climate change in this area. According to NASA, the southwest region will experience increased heat, drought and insect outbreaks along with increased wildfires, declining water supplies, reduced agricultural yields and more severe flooding. Less winter and spring precipitation is projected in the southwest however, precipitation patterns are likely to change leading to more intense precipitation events and increasing unpredictability. Summer temperatures will continue to rise exacerbating heat waves, reducing soil moisture, increasing disease outbreaks and wildfires while also leading to more human health impacts.

4.2.2 Social and Ecological Considerations

Social Considerations

Communities of Color, specifically BIPOC, are disproportionately impacted by climate change due to centuries of discriminatory policies and practices. The United States is founded on extraction of people and natural resources to enable the seeds of capitalism to grow. Race is the nation's greatest disparity. When assessing vulnerability, it is critical to assess impacts of racism and prejudice against BIPOC communities first and to integrate a targeted universalism approach to solutions.

Other vulnerable people include children, the elderly, those with health conditions and lower income; however, in all of these categories, race is still the greatest disparity and BIPOC people have lower capacity to anticipate, accommodate and cope with hazard events. Hazard events intensify existing social stressors such as lack of access to resources and transportation, lack of affordable housing, living paycheck-to-paycheck, economic hardship, health issues, etc.

Boulder County recognizes the need to take a 'targeted universalism' approach to hazard mitigation by ensuring that resources, capacity, and action are prioritized in BIPOC communities with high vulnerability and risk. This approach will ensure that those with the most need are recognized, heard and valued while also improving human health, infrastructure and quality of life. This aligns with recent guidelines developed by FEMA including the FEMA guide on expanding mitigation and making the equity connection identified 13 population groups that are likely to be disproportionately impacted by natural disasters. These groups include:

- People of Color
- Tribal and First Nation communities
- Underserved communities with a low socioeconomic status
- Women
- Members of the lesbian, gay, bisexual, transgender, and queer persons (LGBTQ+) community
- Individuals experiencing homelessness or displacement
- Rural communities
- Elderly and youth populations
- Populations with limited English proficiency
- Service workers and migrant laborers
- Populations with limited cognitive or physical abilities
- Institutionalized populations such as those in prisons and nursing homes
- Renters

FEMA moves on to acknowledge the negative impacts of government policies that make it harder for BIPOC and low-income people to prepare for, anticipate, withstand, and recovery from hazard impacts. Centuries of discrimination (which still exists today) have led to inequitable impacts leading to higher incidences of heart disease, respiratory illness, high blood pressure, diabetes and other health issues that when combined with lack of access to resources and support led to higher likelihood of impact from natural hazards.

Ecological Considerations

Ecological dimensions are the elements of nonhuman nature that connect throughout the County. They include elements such as tree growth, soil formation, habitat formation, and hydrologic processes. All elements of the natural environment are subject to a range of impacts from climate change, including an inability to adapt to the rapid fluctuations in temperature and extreme changes to the hydrologic cycle.

Alterations to ecological systems will make hazard events less predictable and may increase hazard impacts.

Extreme hazard events will increase damage to property and infrastructure while also disrupting productivity and accessibility. Boulder County's economy is highly dependent on the health and resources generated by ecological systems and disruptions to the natural environment will have repercussions for all sectors, from agriculture to technology. In addition to local impacts, climate change is a global issue and hazard events will impact global and national systems with repercussions for supply chains and businesses with operations outside of county borders. As average global temperatures continue to rise, Boulder County must proactively anticipate these disruptions and build adaptability into hazard mitigation projects and strategies.

4.3 Hazard Profiles

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. 32

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. The description shall include an overall summary of each hazard and its impact on the community.

The hazards identified in the Hazard Identification section are profiled individually in this section. Much of the profile information came from the same sources used to initially identify the hazards however additional sources were utilized when developing the climate change, social equity and ecological sections. Those sources are cited throughout the document.

Profile Methodology

Each hazard is profiled in a similar format that is described below.

- Hazard Description

This subsection gives a generic description of the hazard and associated problems, followed by details on the hazard specific to Boulder County.

- Geographic Extent

This subsection discusses which areas of the County are most likely to be affected by a hazard event. For clarification, 'planning area' refers to Boulder County.

- **Limited:** Less than 10 percent of planning area
- **Significant**: 10-50 percent of planning area
- **Extensive:** 50-100 percent of planning area

Previous Occurrences

This subsection contains information on historic incidents, including impacts where known. The extent or location of the hazard within or near the Boulder County planning area is also included here. Information for the previous occurrences of these hazards was provided by the HMPC along with information from other data sources.

Probability of Future Occurrences

The frequency of past events is used in this subsection to gauge the likelihood of future occurrences. Based on historical data, the likelihood of future occurrences is categorized into one of 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

The frequency, or chance of occurrence, was calculated where possible based on existing data. Frequency 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. Example: Three droughts over a 30-year period equates to 10 percent chance of that hazard occurring in any given year.

Magnitude/Severity

This subsection summarizes the magnitude and severity of a hazard event based largely on previous occurrences and specific aspects of risk as it relates to the planning area. Magnitude and severity are classified in the following manner:

- **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

Increase Threat from Climate Change

The IPCC states that "warming of the climate system in unequivocal, and since the 1950's, many of the observed changes are unprecedented over decades to millennia. The atmosphere and oceans have warmed, the amounts of snow and ice have diminished, and sea level has risen." Human emissions of greenhouse gases trap heat near the surface of the Earth leading to increase in average global surface temperatures. This subsection summarizes the likelihood of a hazard becoming an increased threat due to climate change.

- **Low:** unlikely to become more of a threat due to climate change
- **Moderate:** possibly will become more of a threat due to climate change
- **Substantial:** likely to become more of a threat due to climate change
- **Severe:** highly likely to become more of a threat due to climate change

Overall Hazard Significance

Overall vulnerability and potential impact of each hazard is summarized in this subsection, based on probability of future occurrence, magnitude of previous occurrences, and assessments of public safety risk and threat to property and infrastructure.

Social Considerations

Hazards do not impact all people equally. Climate change is a result of extraction, extraction of natural resources but also of people. The United States is built on the acceptability of extracting from Black and Indigenous people for the benefit of White male landowners including theft of land, slavery, and genocide. BIPOC have faced centuries of racism and discrimination that has been institutionalized into policies and practices at all levels of government and into our economic system. Social considerations are critical when assessing hazard impacts and identifying mitigation strategies that acknowledge inequities and shift towards a targeted universalism approach.

Ecological Considerations

The ecosystems that benefit human quality of life are the same systems that are being impacted by climate change. Elements like clean air and water have benefits for crop pollination, fishing, hunting, tourism and human health. Ecological considerations are critical when assessing hazards and determining mitigation strategies. The entire web of life and the inner connectivity and interactions are important to understand and evaluate in order to design solutions that will be sustainable and able to withstand increased frequency and intensity of natural hazards. Within this hazard assessment, ecological connectivity and opportunities will be evaluated to ensure more holistic mitigation strategies are prioritized.

4.3.1 Air Quality

Hazard	Geographic Extent	Probability/ Frequency	Magnitude/ Severity	Increased Threat (Climate Change)	Overall Significance
Air Quality	Extensive	Highly Likely	Critical	Moderate	Medium

Description

Air quality is a measure of how polluted or clean the air is. It is critical to human health, agriculture, and vegetation and is impacted by weather, climate and human activities. Ground-level ozone and particulate matter (PM) are two very common air pollutants that negatively impact human health and ecological systems. Unlike the protective ozone in the upper stratosphere, ground-level ozone is formed in the atmosphere and is impacted by emissions from human actions, ecological systems such as forests, and weather conditions. Ozone pollution is a serious hazard for the Denver Metro/North Front Range region and the nine air quality monitors in the region often exceed Environmental Protection Agency (EPA) air quality standards.

Poor air quality can have significant social, ecological, and economic impacts. Although impacts to human health are most documented, poor air quality can also have negative effects on vegetation, crops, and forests leading to loss of environmental and economic benefits. Colorado's complex topography and variable weather patterns can significantly impact differences in air quality from point to point.

Air quality is measured by air quality monitors and the Air Quality Index (AQI) which is a system utilized to warn the public when there are dangerous levels of air pollution. The AQI categorizes air pollution into five levels based on a scale of 0 to 500. Each level is provided with an associated color to make it easier to communicate poor air quality days with the public.

Air Quality Index	Value	Ozone	Particulate Matter
Good	0-50	No major concerns.	No major concerns.
Moderate	51-100	Unusually sensitive individuals may experience respiratory symptoms.	Respiratory symptoms possible in unusually sensitive individuals, possible aggravation of heart or lung disease in people with cardiopulmonary disease and older adults.
Unhealthy for Sensitive Groups	101-150	Increasing likelihood of respiratory symptoms and breathing discomfort in active children and adults and people with lung disease, such as asthma.	Increasing likelihood of respiratory symptoms in sensitive individuals, aggravation of heart or lung disease and premature mortality in people with cardiopulmonary disease and older adults.
Unhealthy	151-200	Greater likelihood of respiratory symptoms and breathing difficulty in active children and adults and people with lung disease, such as asthma; possible respiratory effects in general population.	Increased aggravation of heart or lung disease and premature mortality in people with cardiopulmonary disease and older adults; increased respiratory effects in general population.
Very Unhealthy	201-300	Increasingly severe symptoms and impaired breathing likely in active children and adults and people with lung disease, such as asthma; increasing	Significant aggravation of heart or lung disease and premature mortality in people with cardiopulmonary disease and older adults; significant

Air Quality Index	Value	Ozone	Particulate Matter
		likelihood of respiratory effects in general population.	increase in respiratory effects in general population.
Hazardous	301-500	Severe respiratory effects and impaired breathing likely in children and adults and people with lung disease, such as asthma; increasingly severe respiratory effects likely in general population.	Serious aggravation of heart or lung disease and premature mortality in people with cardiopulmonary disease and older adults; serious risk of respiratory effects in general population.

Table based on information from the American Lung Association AQI and Colorado Department of Public Health and Environment

Although indoor air quality is critical to human health and it is important to consider when developing housing, building and floodplain policies and codes, the specific elements around indoor air quality are outside the scope of the HMP and will only be referenced as having co-benefits in the mitigation strategies identified in Section 5.0.

Social Considerations

According to the Colorado Health Institute, every two years more people than the entire population of Colorado are prematurely killed globally due to effects of air pollution. Air pollution impacts BIPOC members of the community disproportionately due to discriminatory policies that lead to "undesirable uses" such as processing plants, industrial sites, highways and other high polluters being located in BIPOC communities. Decades of exposure to pollution creates adverse impacts to human health and can lead to respiratory illness, asthma, premature death, lost wages for outdoor workers and more school days missed for young people.

People with increased vulnerability are even at risk from short-term changes in air quality. Data shows that when air pollution levels increase, so do health issues such as respiratory illnesses, strokes, and heart attacks, having negative impacts on emergency services, emergency rooms and healthcare facilities. Air quality also interacts and exacerbates other hazards such as zoonotic diseases. A study by Harvard University was able to document higher death rates from COVID-19 occurred in areas where people live with long-term air pollution issues.

Geographic Extent

A combination of unique topography, geography and weather increase Boulder County's vulnerability to air quality. Ozone levels are highest in dense urban areas such as the Front Range and when there is considerable sunlight and warm temperatures. Ground-level ozone pollution and PM come from neighboring states and surrounding counties making it difficult to effectively decrease without regional collaboration. Generally, Boulder County experiences the same poor air quality as the entire nine-county North Front Range and when the region experiences very unhealthy or hazardous air quality days, there is a strain on regional emergency services and hospitals.

Previous Occurrences

According to the Center for Technology in Government, Colorado's Front Range communities had the most air quality issues in the winter months when both urban and rural airs were in nonattainment for different air quality metrics. In fact, authors of the Air Quality Data Use, Issues and Value in Colorado state that "until the mid-1980's, carbon monoxide pollution was so severe in Colorado that levels sometimes surpass those in the Los Angeles basin".

The previous two decades have seen small improvements however, the Front Range has failed to meet federal air quality standards set in 2008 and continues to be out of compliance for the old federal standards even though stricter ones were set in 2015. In 2020, the American Lung Association gave Boulder County an "F" due to high levels of ozone.

Probability of Future Occurrences

Probability of future poor air quality occurrence is considered **highly likely**, with multiple events of varying magnitude occurring on an annual basis. Poor air quality is likely to result in fatalities that will occur on a more frequent scale over time. The region is likely to continue to experience poor air quality days that increase from higher heat days, longer consecutive high heat days, and increased wildfires due to climate change.

Magnitude/Severity

Based on the definitions established for this plan, magnitude and severity of air quality is considered **critical**, with relatively threats to agricultural and ecological assets and serious risk to the public safety.

Climate Considerations

According to the National Climate Assessment (NCA4), due to an increase in average global surface temperatures, there will be an increase in existing air pollution levels. Ozone pollution and climate change have a cyclical relationship; increases in ground-level ozone lead to faster warming of the planet and thus, accelerates the pace of climate change, which in turn, exacerbates ozone pollution.

Air quality impacts and is impacted by other natural hazards. For example, more air pollution leads to more extreme heat events including heat waves which impact infrastructure and increase mortality. Air quality will continue to deteriorate as impacts from climate change become more frequent and intense. This will result in increased damage and disruption to human health, ecosystems, agriculture, and infrastructure. According to the NAACP's 2012 "Coal-Blooded" study, communities of color are more likely to breathe in polluted air, in fact the air they breathe is 40 percent more polluted than White communities across the United States.

Ecological Considerations

Air pollution can have considerable impacts on agriculture, vegetation, and forest ecosystems. When air quality is mildly poor, impacts may include changes to soil chemistry, loss of more vulnerable plant species, and plant tissue damage. However, when air quality is significantly bad for longer periods of time, soil chemistry may be permanently altered and there is greater risk of animal and vegetation loss. Ozone pollution is likely to damage both crops and plant and forest ecosystems by reducing photosynthesis

Overall Hazard Significance

The overall hazard significance for air quality is **medium**, with a growing impact relative to other disasters. This assessment considers a high overall probability and high probability of life-threatening occurrences but limited magnitude of property damage and/or limited shutdown of facilities.

4.3.2 Avalanche

Hazard	Geographic Extent	Probability/ Frequency	Magnitude/ Severity	Increased Threat (Climate Change)	Overall Significance
Avalanche	Limited	Highly Likely	Limited	Low	Low

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 all create an avalanching 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.

Social Considerations

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 a given area however, most avalanches occur in remote locations and thus, have lower risk of personal injury.

Geographic Extent

Based on the definitions set forth previously, the geographic extent of avalanche hazard is considered **limited**, with less than 10 percent of the planning area affected. In general, avalanche hazard is highest in areas of steep slopes at high elevation where contributing conditions described above are present. This includes the alpine region of western Boulder County. More specifically, the access road to the Eldora Ski Area is an identified avalanche risk area as well as unincorporated sections of western Boulder County.

Previous Occurrences

Avalanches occur annually in western Boulder County, typically following significant snowstorms. Some of these have resulted in fatalities in Boulder County, mostly to persons recreating in the backcountry. According to the CAIC, between the winters of 1950/51 and 2021/2022, four avalanche fatalities occurred in Boulder County. Specific cases include an occurrence on December 18, 1999, on South Arapaho Peak, when two hikers were caught in an avalanche resulting in one fatality. Other notable occurrences include the closure of the Eldora Ski Area access road due to the avalanche hazard and the stranding of skiers during the March 2003 blizzard.

- **March 2003:** Colorado's Great Blizzard of 2003 caused an avalanche that closed Eldora Ski Area. The three-day storm that dumped from two to seven feet of snow across central Colorado and the "Front Range" of the Rocky Mountains -- the urban corridor stretching from Cheyenne, Wyo., to Denver and Colorado Springs -- spawned hundreds of avalanches in the mountains and foothills. One of them swept past the slopes of the Eldora Mountain Resort near Boulder, closing all the ski runs and trapping some 300 skiers in the base lodge for two days and nights.
- **March 2019 Colorado Avalanche Season:** 1,000 avalanches during the month of March 2019 throughout Colorado being the worst experience in the past 20 years.

Probability of Future Occurrences

Probability of future avalanche occurrence is considered highly likely, with multiple events of varying magnitude occurring on an annual basis. Avalanches that result in property damage or fatalities occur on a less frequent scale, and the recurrence interval for avalanche fatalities for the period 1950-2014 is approximately one every 11 years.

Magnitude/Severity

Based on the definitions established for this plan, magnitude and severity of avalanche is considered **limited**, with relatively minor threat to property inventories but serious risk to the public safety.

Climate Change Considerations

Climate change will make avalanches more unpredictable, bigger, and able to travel longer distances making them altogether more dangerous. Colorado is already experiencing an increase in observed avalanches, most of which are wet snow and wet slab avalanches connected to warmer temperatures. Warmer temperatures from climate change make snow layers less stable and more likely to collapse and then slide. This is from more rain-on-snow events and greater fluctuations in temperatures. Additionally, more moisture in the atmosphere can lead to more extreme winter snow events which are likely to increase the scale of avalanches.

Boulder County is not alone in seeing these changes. In other mountainous areas such as the Canadian Rockies or the Himalayas, the same trends are occurring and avalanches are bigger, cover a greater area and are happening more often.

Ecological Considerations

Similar to wildfires and windstorms, avalanches are natural ecological disturbances. They do have the potential to kill wildlife and destroy trees and vegetation, however they also lead to new life and enrichment of the soil through decomposition. Although destructive, the natural environment is equipped to handle avalanches and provide opportunities for new habitats to appear.

Overall Hazard Significance

The overall hazard significance for avalanche is **low**, with relatively limited impact relative to other disasters. This assessment considers a high overall probability but a low probability of life-threatening occurrences and limited magnitude of property damage and/or limited shutdown of facilities.

4.3.3 Communicable / Zoonotic Disease Outbreak

Hazard	Geographic Extent	Probability/ Frequency	Magnitude/ Severity	Increased Threat (Climate Change)	Overall Significance
Communicable/ Zoonotic Disease	Extensive	Occasional	Critical	Substantial	Medium

Description

The impact to human health that communicable disease outbreaks can have on an area can be substantial.

Communicable Diseases: Diseases such as Human Immunodeficiency Virus (HIV)/Acquired Immunodeficiency Syndrome (AIDS) and the simple head cold are communicable, or easily passed person to person through direct contact or contamination of inanimate objects or food. Hand washing and adequate personal hygiene practices can help prevent the spread of many communicable diseases.

- COVID-19 is a respiratory disease that has a zoonotic source and was most likely was transmitted by a horseshoe bat to humans although the intermediate host that was the source of the outbreak remains to be determined. Since the transfer of the virus to humans, human-to-human transmission from respiratory tract via droplets and on high-touch surfaces has helped spread COVID-19 globally.
- HIV is another disease with a zoonotic source, chimpanzees. HIV is a virus that attacks the body's immune system and if not treated, can lead to AIDS. Although a few cases were documented in the 1970's, the 1980's is when HIV/AIDS infections accelerated. By the end of the 1990's, the WHO released that AIDS was the fourth biggest cause of death worldwide and over 14 million people had died from the virus since the start of the epidemic. Today, many diagnosed with HIV receive antiretroviral treatment and are able to successfully live with infection.

Zoonotic Diseases: Zoonotic diseases are transmitted from animal to human. Examples include the Swine Flu and West Nile Virus. Zoonotic diseases can be caused by fungi, bacteria, parasites, or viruses that are transmitted through insects or animals. Zoonotic diseases are a significant hazard to both Boulder County's human population and livestock. Table 4-3 provides a list of reportable diseases in Boulder County in the last decade. The most common zoonotic diseases include hantavirus, plague, rabies, tularemia, West Nile Virus (WNV) and other mosquito-borne diseases, and tick-borne diseases.

- Hantavirus Pulmonary Syndrome (HPS) is a respiratory disease spread through contact with urine, feces and saliva of the deer mouse. Hantavirus cases occur year-round, but prevalence is higher from May to July.
- Plague (bubonic, septicemic, and pneumonic) is a disease caused by bacteria that spreads through flea bites or direct contact from animals to humans. Since the early 1970's, human plague cases in Colorado have been on the rise. Although Boulder County has had no positive cases, it is a disease that is likely to increase in prevalence Statewide as humans have more direct contact with animals.
- Swine Flu is a respiratory illness that causes influenza in pigs. Human infections can happen from interactions with pigs and in 2012 there was an increase in the number of swine flu cases in humans.
- Tularemia is another bacteria-caused disease that transfers from rabbits or other wild rodents to humans through animal tissues or ticks.
- WNV is the most common arboviral disease in Colorado and is spread most often by an infected mosquito bite. Birds are the primary host of WNV although other animals such as horses are easily infected. WNV is most common in summer months (June-August).

Safe food and animal handling practices as well as protection of natural spaces and reforestation are some of the best ways to prevent the onset of these zoonotic types of disease.

Boulder County Public Health is the primary agency which handles these types of outbreaks. Further information and resources can be found at: https://www.bouldercounty.org/families/disease/ or https://www.bouldercounty.org/departments/public-health/communicable-disease-and-emergency-management-division/

Other resources can be found at:

Communicable Disease Control: 303-413-7500 or 303-413-7517 (after hours)

Boulder County Public Health: 3482 Broadway Boulder, CO 80304

Social Considerations

Race, income, education and employment status can impact exposure to infectious diseases. Often people who are living paycheck-to-paycheck must continue to work through illness increasing risk of exposure to others and thus, increasing their risk of contracting a virus. Additionally, BIPOC and lower-income individuals often have pre-existing medical conditions that lead to increased risk of contracting a virus and more harmful impacts due to underlying health issues. Additionally, inequities exist in the ability of individuals, communities, regions and even countries in the capacity, accessibility and finances to identify, monitor and contain infectious diseases.

Geographic Extent

The geographic extent of communicable and zoonotic diseases is classified as **extensive**, with 50-100 percent of the planning area affected. As the world becomes more connected through globalization, the likelihood and extent of infectious disease spread increases dramatically. Although Boulder County Public Health Department is structured to provide education and testing for disease outbreaks, coordinated regional, state and national efforts will be most effective.

Previous Occurrences

Communicable and zoonotic diseases have the potential to impact a large number of people as well as have severe economic and ecological impacts. Although disease outbreaks can happen on their own, they may also come as a secondary impact from other hazard events such as a flood or extreme heat. The Colorado Division of Disease Control and Environmental Epidemiology collect reportable disease data for the entire state of Colorado and disseminates this data by year and by County. Below is the list of reportable diseases for Boulder County from 2010- 2018.

Table 4-3 Colorado Reportable Disease Statistics for Boulder County, 2013-2018

Disease	2013	2014	2015	2016	2017	2018	Total
Campylobacter	62	47	61	105	115	113	503
Carbapenem-Resistant Enterobacteriaceae (CRE)	n/a	n/a	n/a	n/a	17	21	38
Carbapenem-Resistant Pseudomonas Aeruginosa (CRPA)	n/a	n/a	n/a	n/a	70	45	115
Cryptosporidiosis	11	3	26	29	16	29	114
Giardiasis	33	52	38	62	49	46	280
Haemophilus Influenzae	3	1	1	6	3	4	18
Hepatitis B, Chronic	22	15	19	33	19	27	135
Hepatitis C, Chronic	79	118	107	166	191	220	881
Influenza-Hospitalized	57	106	64	81	230	207	745
Meningitis Aseptic/Viral	15	8	0	0	0	1	24
Pertussis	215	92	46	61	42	63	519

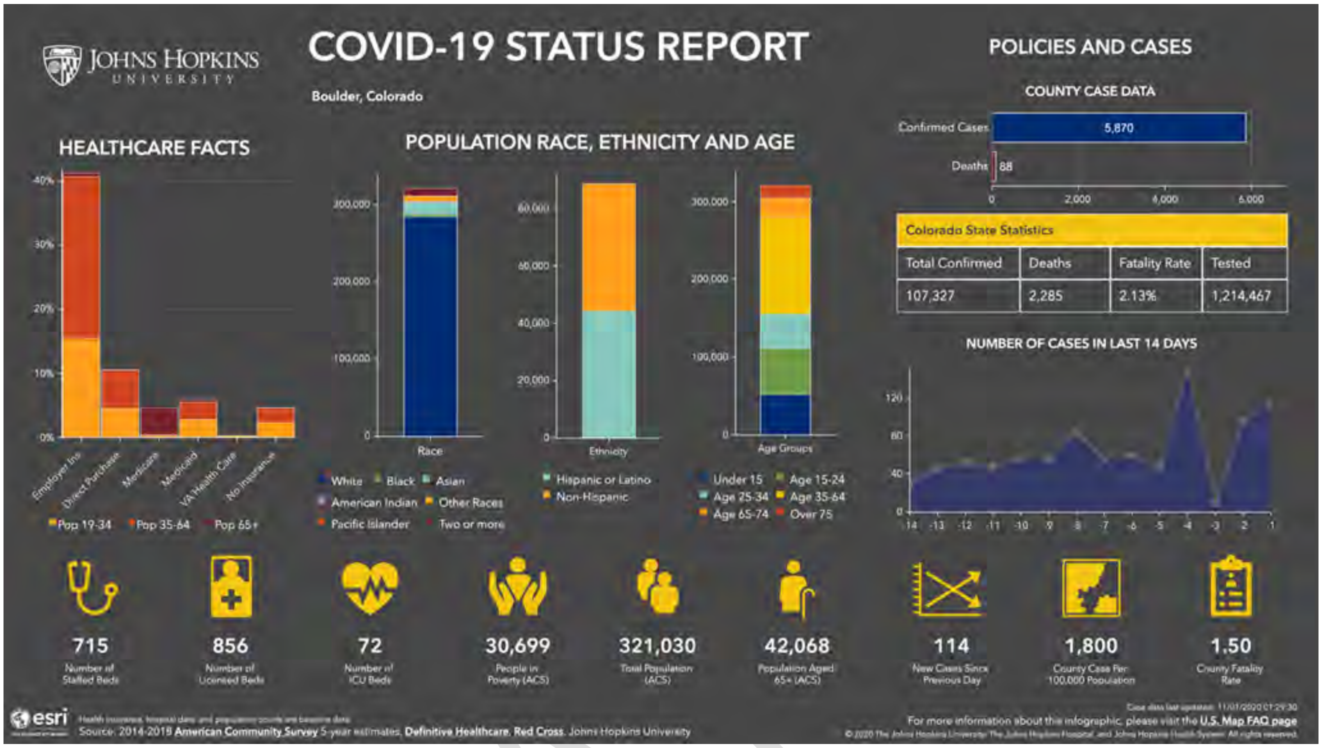
Disease	2013	2014	2015	2016	2017	2018	Total
Salmonellosis	32	35	45	46	51	39	248
Shigellosis	14	4	3	14	13	18	66
STEC (Shiga Toxin Producing E.Coli)	12	6	10	12	21	31	92
Strep Pneumo Invasive	18	17	15	20	26	19	115
Varicella (Chicken Pox)	36	27	28	31	13	23	158
West Nile Virus	n/a	n/a	n/a	0	9	11	20
Total	609	531	463	666	885	917	4071

Source: Division of Disease Control and Environmental Epidemiology (https://www.colorado.gov/pacific/cdphe/colorado-reportable-disease-data)

Pandemics

According to the Centers for Disease Control and Prevention, there have been five global pandemics since the early 1900's:

- **1918-1919 Influenza Pandemic:** Otherwise known as the Spanish Flu, this was the most severe pandemic in recent history. Over one-third of the world's population was infected and nearly 50 million people died worldwide. In the United States, 675,000 people, primarily young healthy adults, died from the virus which made it very unique. In the Denver area, nearly 13,000 influenza cases resulted in over 1,200 deaths.
- **1957-1958 Pandemic (H2N2):** Known as the Asian Flu, this pandemic originated from an avian influenza A virus. The estimated number of deaths was 1.1 million worldwide with 116,000 of those deaths in the United States.
- **1968-1969 Pandemic (H3N2):** Dubbed the Hong Kong Flu, over 1 million people are estimated to have died worldwide and nearly 100,000 in the United States. People over 65 years of age were most impacted by this pandemic. In Colorado, 50,317 cases and 955 deaths were counted by the end of 1968.
- **2009-2010 Pandemic:** The Swine Flu
- **2019- Ongoing COVID-19 Pandemic:** As of November 1, 2020, the number of confirmed global cases of COVD-19 totaled 46,196,087 cases and over 1,197,000 deaths. Since January 21, 2020, the United States has over 9 million confirmed COVID-19 cases and nearly 230,000 deaths. Boulder County has had 5,870 cases and 88 deaths.



Source: Johns Hopkins University

Probability of Future Occurrences

Based on patterns of previous occurrence, future probability is considered likely, with a 10-100 percent chance of occurrence in the next year. See Climate Considerations below for additional information about the likelihood of future occurrences.

Magnitude/Severity

The severity of outbreaks 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. Overall magnitude and severity of this hazard is classified as **limited**, with the majority of illnesses treatable and not resulting in permanent disability. The magnitude and severity of infectious disease depend on how aggressive a disease is, how easily it is transmitted and whether or not advances have been made in development of vaccines or heard immunity has been established. With epidemics and pandemics, high levels of illness and, in some cases death, can lead to economic losses, social disruptions and interruption of supply chains as demand for certain goods and services increases or decreases.

Climate Considerations

According to the WHO, "today, worldwide, there is an apparent increase in many infectious diseases, including some newly circulating ones (HIV/AIDS, hantavirus, hepatitis C, SARS, etc.). This reflects the combined impacts of rapid demographic, environmental, social, technological and other changes in our ways of living. Climate change will also affect infectious disease occurrence". Climate change will create warmer global temperatures. As average winter temperatures decrease, reproduction periods will last longer increasing likelihood of new pests and transmission of diseases. This will allow certain agricultural pests to persist year-round and increase the prevalence of parasites and diseases that affect livestock leading to increased economic and social\ impacts. Additionally, climate change is likely to have impacts on aquatic ecosystems which may lead to increased spread of non-native species and disease.

Ecological Considerations

Activities such as human driven deforestation, resource extraction, and removal of biodiversity is leading to increasing encroachment into wild spaces elevating interaction with disease carriers and providing more opportunities for viruses to jump to humans. Lee Hannah, a climate scientist for Conservation International said "deforestation is a prime driver of pandemics". As deforestation continues, pandemics are likely to emerge more often and spread more rapidly, leading to more deaths and economic hardship. Reforestation and protection of natural spaces is a critical method for reducing probability of future occurrences.

Overall Hazard Significance

Based on assessments of probability, geographic extent and magnitude/severity, the overall hazard significance of communicable and zoonotic diseases is classified as **medium**, with moderate potential impact.

4.3.4 Dam and Levee Failure

Hazard	Geographic Extent	Probability/ Frequency	Magnitude/ Severity	Increased Threat (Climate Change)	Overall Significance
Dam and Levee Failure	Significant	Unlikely	Catastrophic	Moderate	High

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. Two 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/seismic activity
- 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.

The Colorado DSB recently developed a tool that attempts to increase public awareness, preparedness, and response around high hazard dams in Colorado. The tool focuses on flood release and operational functions and provides an assessment of each dam. The Colorado DSB requires owners and managers of both high and significant hazard dams to develop and maintain Emergency Actions Plans (EAP) to help mitigate impacts.

Social Considerations

As population in Boulder County continues to grow, risk to human life from dam or levee failure grows along with it. Dam and levee breaks have the potential to cause catastrophic damage including loss of entire communities. Increasingly, social impact assessments are being utilized as part of risk assessments to consider factors such as cultural and/or indigenous sites and business investment. If failure occurs, even if not catastrophic, or controlled releases can lead to flooding downstream and have a tremendous impact on people with fewer resources, especially if water impacts their homes or personal assets. Although floods are often treated as solely infrastructure problems, they impact other social factors such as social cohesion, sense of security, sanitation, and cultural spaces. Similar to other flooding events, lower-income people and those intentionally located in 'high-risk' or 'undesirable' areas are likely to be impacted worse by small dam or levee failures or releases.

Mental health and trauma are important social care elements to integrate into engagement around dam safety and into all response and recovery materials. Having one's home, property or source of income inundated or completely wiped out by dam failure is psychologically damaging however very few resources and materials are provided to support people through that traumatic experience. Additionally, it is important to recognize the increased cascading impact of water-based illnesses that can also increase and impact people's quality of life after an event.

Geographic Extent

In general, the geographic extent of dam and levee failure hazard is **significant**, with 10-50 percent of the planning area potentially affected by inundation and directly related impacts. More specifically, HAZUS-MH contains a database of dams based on the National Inventory of Dams (NID). This database lists 73 dams in the County and classifies dams based on the potential hazard to the downstream area resulting from failure or poor operation of the dam or facilities:

- High Hazard Potential: Probable loss of life (one or more)
- Significant Hazard Potential: No probable loss of human life but can cause economic loss, environment damage, disruption of lifeline facilities, or impact other concerns; often located in predominantly rural or agricultural areas but could be located in areas with population and significant infrastructure
- Low Hazard Potential: No probable loss of human life and low economic and/or environmental losses; losses are principally limited to the owner's property

Based on these classifications, there are 23 high hazard dams and 18 significant hazard dams in Boulder County. These dams are listed in Table 4-4 and illustrated on the map of Boulder County dams in Figure 4-5. The dams are listed by hazard potential, alphabetically.

Table 4-4 High and Significant Hazard Dams in Boulder County

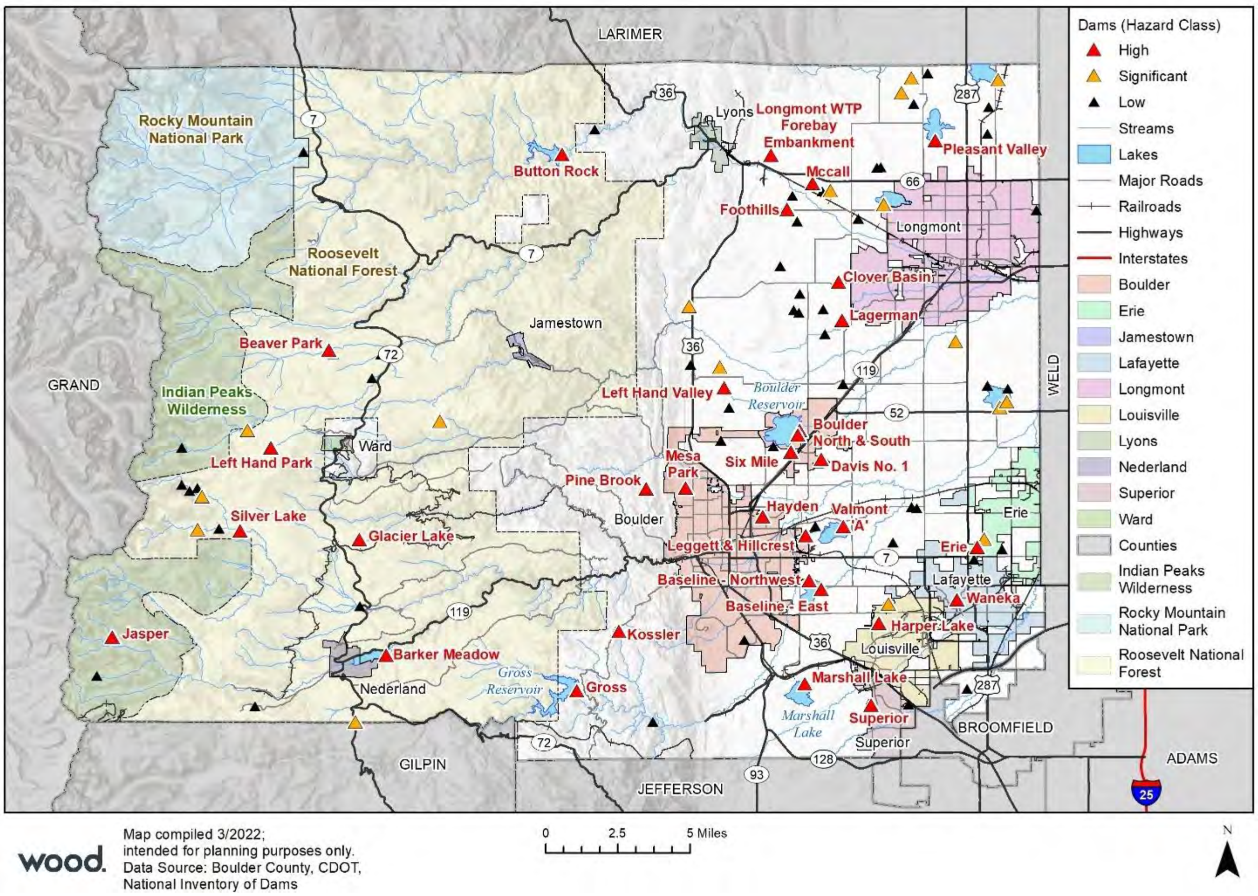
Name	River	Near City	Max Storage (acre ft.)	Hazard	Downstream Communities	Relative Downstream Impacts
Glacier Lake	Pennsylvania Gulch	Boulder	329	H	Unincorporated	Medium
Longmont Wtp Forebay Embankment	St Vrain Creek-Os	Hygiene	129	H	Unincorporated and Longmont	Medium
Pine Brook	Two Mile Creek	Boulder	140	H	Boulder	High
Barker	Middle Boulder Creek	Boulder	12,400	H	Boulder, Unincorporated	High
Baseline	Dry Creek	Boulder	6,592	H	Unincorporated	Medium
Beaver Park	Beaver Creek	Longmont	2,731	H	Lyons, Longmont	Medium
Boulder	Dry Creek	Boulder	17,700	H	Unincorporated	Medium
Button Rock	N. Fork St. Vrain Creek	Longmont	20,400	H	Lyons, Longmont, Unincorporated	High
Clover Basin	Dry Creek-Tr	Longmont	984	H	Longmont	Low
Foothills	St. Vrain Creek	Longmont	4,767	H	Longmont, Unincorporated	Medium
Gross	South Boulder Creek	Eldorado Springs	47,500	H	Boulder, Eldorado Springs, Unincorporated	High
Harper Lake	Coal Creek- Tr	Louisville	843	H	Louisville	Low
Hayden	Boulder Creek-Os	Boulder	765	H	Boulder	Low

Name	River	Near City	Max Storage (acre ft.)	Hazard	Downstream Communities	Relative Downstream Impacts
Jasper	Jasper Creek	Eldora	426	H	Unincorporated, El Dora	Low
Lagerman	Dry Creek-Tr	Longmont	1,832	H	Longmont	Medium
Lefthand Park	Left Hand Creek	Longmont	2,075	H	Ward, Unincorporated	Medium
Lefthand Valley	Dry Creek-Tr	Boulder	5,274	H	Boulder, Unincorporated	Medium
Leggett & Hillcrest	South Boulder Creek-Tr	Boulder	15,950	H	Boulder, Unincorporated	Medium
Marshall Lake	South Boulder Creek-Tr	Marshall	12,878	H	Louisville	Medium
Mc Call	St. Vrain Creek	Longmont	722	H	Longmont, Unincorporated	Low
Pleasant Valley	St. Vrain Creek	Longmont	4,562	H	Longmont	Medium
Silver Lake	North Boulder Creek	Boulder	4,819	H	Boulder, Unincorporated	Medium/High
Six Mile	Little Dry Creek-Tr	Boulder	2,186	H	Boulder, Unincorporated	Medium
Superior	Coal Creek- Os	Superior	500	H	Superior	Low
Valmont "A"	Boulder Creek-Tr	Boulder	15,950	H	Unincorporated	Medium
Waneka	Coal Creek- Os	Lafayette	838	H	Lafayette	Low
Albion Lake	North Boulder Creek	Boulder	700	S	Unincorporated, Boulder	Low
Allen Lake	Left Hand Creek	Longmont	784	S	Unincorporated, Boulder	Low
Brainard Lake	South St Vrain Creek		160	S	Unincorporated	Low
Davis No. 1	Dry Creek- Os	Boulder	185	S	Boulder, Unincorporated	Low
Erie	Boulder Creek-Os	Erie	360	S	Erie	Low
Gaynor	Boulder Creek	Longmont	754	S	Longmont, Unincorporated	Medium
Gold Lake	Bell Gulch	Longmont	648	S	Unincorporated	Low
Goose Lake	North Boulder Creek-Tr	Boulder	1,170	S	Unincorporated, Boulder	Medium
Highland #2	Little Thompson River-Tr	Longmont	4,613	S	Unincorporated	Medium
Ish #3 (East Dam)	Little Thompson River-Os	Milliken	9,065	S	rural Berthoud	Low
Los Lagos No. 3	Beaver Creek-Tr	Pinecliffe	60	S	Pinecliffe, Unincorporated	Low
Louisville No. 1	Bullhead Gulch-Tr	Louisville	212	S	Louisville	Low
Margaret Spurgeon #1	Dry Creek-Tr	Boulder	450	S	Boulder, Unincorporated	Low
McIntosh	St. Vrain Creek	Longmont	2,986	S	Longmont	Medium

Name	River	Near City	Max Storage (acre ft.)	Hazard	Downstream Communities	Relative Downstream Impacts
Mesa Park	Fourmile Canyon Creek-Tr	Boulder	260	S	Boulder	Low
Oligarchy #1	St. Vrain Creek	Longmont	2,161	S	Longmont, Unincorporated	Medium
Panama No. 1	Boulder Creek-Os	Evans	7,539	S	Erie, Unincorporated	Medium

Source: NID; http://cruncJ.tec.army.mil/nidpublic/webpages/nid.cfm and Division of Water Resources

Figure 4-5 Dam Locations, Boulder County



Areas that would be significantly impacted by a dam failure include the City of Boulder, unincorporated Boulder County along Boulder Creek and South Boulder Creek, and Lyons, Longmont, and unincorporated areas along St. Vrain Creek.

Levees in Boulder County are not as widespread as dams. Most of these are located in or around the City of Boulder. Some of the known flood levees are located at: The Canyon Centre between 6th and 9th Street; the Roche Chemical Plant (2075 55th St), and the City of Boulder Wastewater Treatment Plant. Another levee is located at Harrison Ave. along the Bear Canyon Creek and behind the Syntex property along Boulder Creek between Goose Creek and Foothills Pkwy. There are several levee/floodwall structures along Boulder Creek protecting properties that have been documented in a 2008 Boulder Creek floodplain restudy project.

According to a memo by the Colorado Water Conservation Board dated January 22-23, 2008, "FY 04/03

COUNTIES: All of the Boulder County levees have been identified; FEMA and the State have met with the City of Boulder and County to determine the interest in a PAL (Provisionally Accredited Levee) agreement and/or certification."

Previous Occurrences

Colorado has a history of dam failure, with at least 130 recorded occurrences since 1890 (Source: Flood Hazard Mitigation Plan for Colorado, 2004). The Lawn Lake Disaster of 1982 caused four deaths and over $31 million in property damage when a privately-owned dam failed on Forest Service Property above the Town of Estes Park in neighboring Larimer County.

According to historical data, to date, there have been no dam failures in Boulder County. Two dams were listed as unsafe at one time but have since been repaired and the unsafe rating removed.

Probability of Future Occurrences

Due to a lack of previous occurrences within the planning area, the recurrence interval for dam failure specific to the County cannot be calculated. The possibility for future dam failure remains, but the likelihood as a result of natural hazards is estimated to be extremely low, or **unlikely**, with less than a 1 percent chance of occurrence in next 100 years.

Magnitude/Severity

According to the information in this hazard profile, a dam failure's potential impact on the County is **catastrophic**, with shutdown of facilities for more than 30 days and/or multiple deaths.

Climate Considerations

Most dams and levees were constructed based on historic conditions and the climate of their time rather than including consideration of climate change. The mechanisms to deal with precipitation variability and extremes have often not been put in place making dams and levees infrastructure at high risk to the impacts of climate change. Climate change increases air temperatures resulting in increased moisture in the atmosphere and thus, increased precipitation during extreme storms. Extreme precipitation events put more stress on dam and levee infrastructure and increase the likelihood of the need for slow release or strategic flooding to prevent dam failure. Additionally, dams are likely to suffer from increase drought conditions impacting storage and dam effectiveness.

Furthermore, dams with bigger surface area will be impacted by increasing temperatures which increases the rate of evaporation. Increased evaporation in the region can results in a change in moisture content in the air leading to increased heavy precipitation events. This makes dams a factor in climate change and creates a regional concern since dams with larger surface areas outside of Boulder County can impact and increase heavy precipitation events within the County.

Ecological Considerations

There are a range of ecological impacts of dams. Many of the documented ecological impacts are from dams being newly constructed and damaging ecosystems. Typically issues around new dams include downstream impacts to ecosystem services, loss of vegetation and wildlife and impacts to existing species. However, existing dams are also an ecological threat. Dam failures have the potential to wipe out entire areas harming wildlife that depend on those spaces for survival and vegetation. Although nature tends to recover over time, climate change will make that recovery harder and impacts to soil nutrients and water quality are likely to be long-term impacting flora and fauna. Additionally, lack of vegetation and vegetative growth can lead to erosion and soil destabilization while trapped nutrients upstream can lead to harmful algae blooms.

Overall Hazard Significance

The overall hazard significance for dam failure is **high**. This assessment considers a relatively low probability but potentially catastrophic magnitude and widespread impacts to infrastructure, property, and public safety in the dam inundation zone.

4.3.5 Drought

Hazard	Geographic Extent	Probability/ Frequency	Magnitude/ Severity	Increased Threat (Climate Change)	Overall Significance
Drought	Extensive	Likely	Catastrophic	Substantial	High

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.

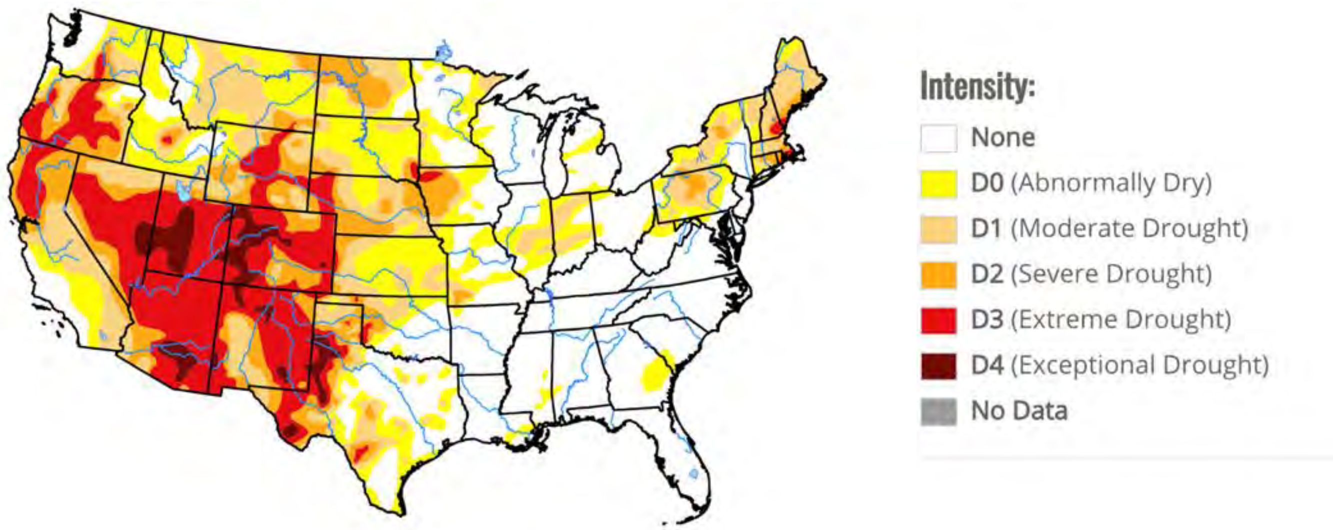
Drought is a complex issue involving many factors—it occurs when a normal amount of moisture is not available to satisfy an area's usual water-consuming activities. Drought can often be defined regionally based on its effects:

- **Meteorological drought** is usually defined by a period of below average water supply.
- **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 stream flow, 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.

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 portions 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 carryover supplies in reservoirs are depleted and water levels in groundwater basins decline.

Figure 4-6 U.S. Drought October 2020



Social Considerations

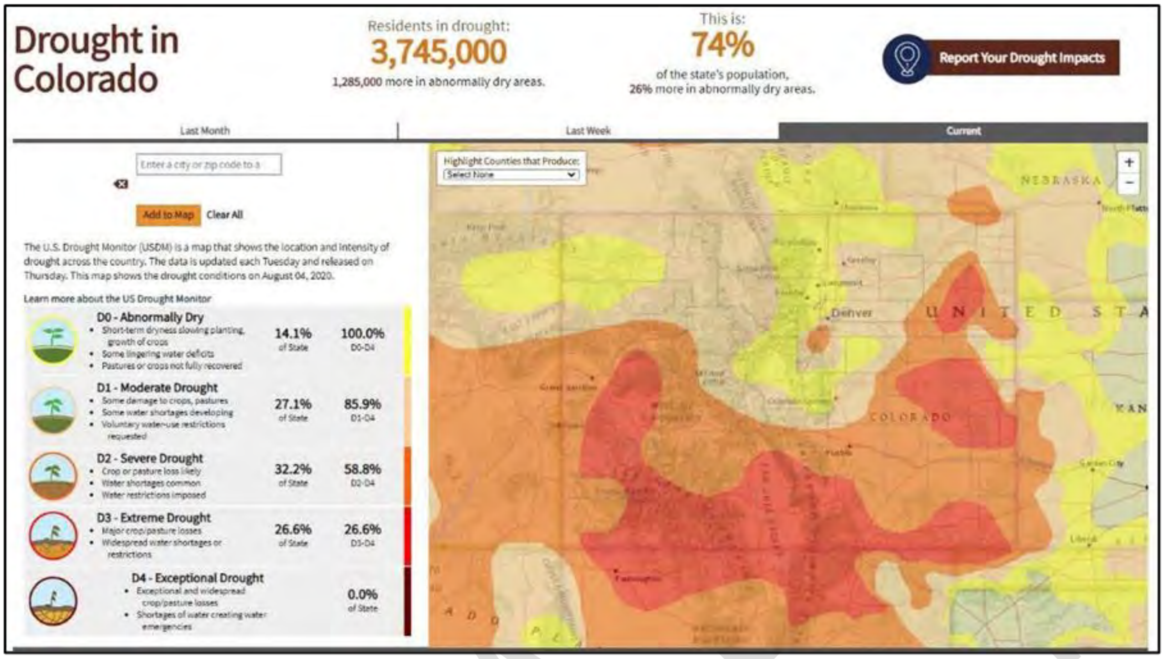
Food injustice and food insecurity disproportionately impacts BIPOC and low-income communities. For communities already experiencing difficulty accessing fresh and healthy food, drought will increase those challenges as the likelihood of crop loss increases. Additionally, BIPOC and low-income communities also tend to suffer from more respiratory illnesses and health conditions. Drought increases dust levels and dryness which can exacerbate respiratory problems and lead to other health conditions.

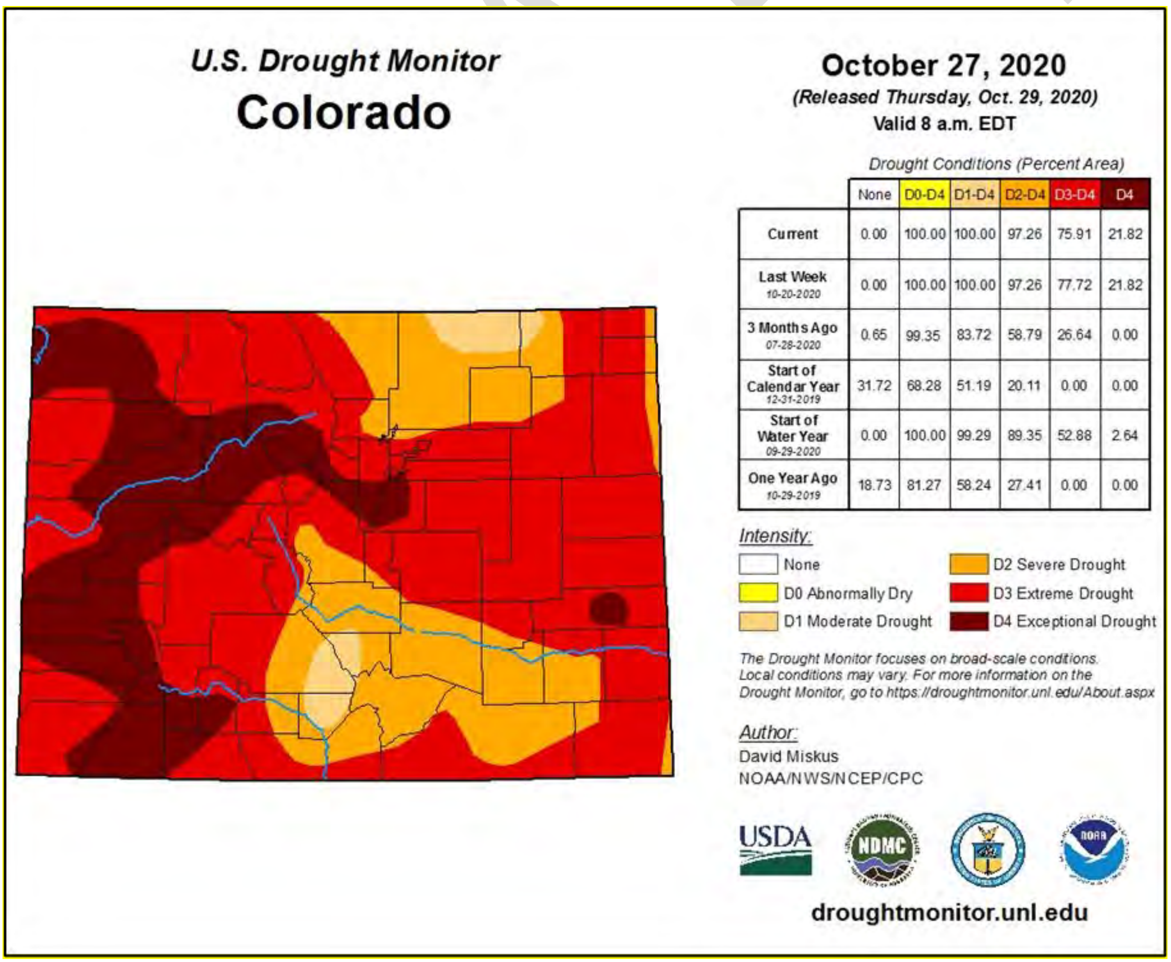
Water also plays a major role in the economy and supporting livelihoods. Access to water and use of water is inequitable. Often wealthier communities use more water and have a difficult time reducing water use in the event of a drought. Additionally, the agriculture sector relies heavily on water availability and both farmers and farm workers experience financial hardship and social strain related to ongoing drought conditions.

Geographic Extent

As a regional phenomenon, drought affects all areas of the planning area with roughly the same frequency and severity. Across a broader scale that includes all of Colorado and the nation as a whole, Figure 4-7 from the National Integrated Drought Information System (NIDIS) shows that Boulder County is situated in an area of north central Colorado and has experienced the return of normal amounts of rainfall. Boulder County is at this time, no longer considered to be in a drought. However, as data from NOAA NCEI and Co Division 2 Data show, long-term droughts (consisting of three or more years of below average rainfall) tend to occur every 10-30 years without a defined pattern.

Figure 4-7 Drought in Colorado





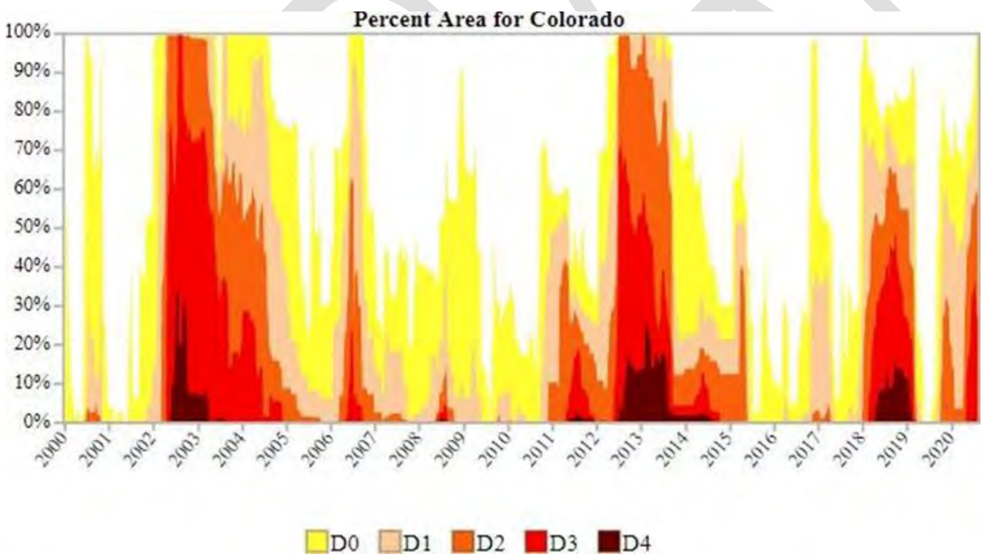
Previous Occurrences

According to the 2007 Drought and Water Supply Assessment Update, Colorado has experienced multiple severe droughts. 2002 is still considered the driest year on record for the region. In 2006 and 2007, six basins in Colorado had below 80% of average snowpack, and recovered water supplies slowly as a result. Since 2006, the County has been slowly returning to non-drought conditions due to increased precipitation levels. Table 4-5 details the most significant drought periods in Colorado.

Table 4-5 Significant Colorado Drought Periods of the Modern Instrumented Era

Years	Worst Years	Major State Impact Areas
1890-1894	1890 and 1894	Severe drought east of mountains
1898-1904	1902-1904	Very severe drought over southwestern Colorado
1930-1940	1931-1934, 1939	Widespread, severe, and long-lasting drought in Colorado
1950-1956	1950, 1954-1956	Statewide, worse than the 1930s in the Front Range
1974-1978	1976-1977	Statewide, driest winter in recorded history for Colorado's high country and Western Slope
1980-1981	Winter 1980-1981	Mountains and West Slope; stimulated writing of the Colorado Drought Response Plan and the formation of the Water Availability Task Force
2000-2006	2001-2002	Significant multi-year statewide drought, with many areas experiencing most severe conditions in Colorado in instrumented history
2011-2012	2011-2012	Southern part of the state was impacted the worst from the drought while Northern Colorado remained relatively above average

Source: Drought and Water Supply Assessment, 2004, http://cwcb.state.co.us/Conservation/Drought/Drought_Water/index_DWSA.html



The HMPC identified the following as drought events of significance in Boulder County:

- **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:** Similar to 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. According to the Colorado Drought Mitigation and Response Plan, this was considered to be the last severe and widespread drought to affect Colorado.
- **1994:** This growing season drought that impacted northeast Colorado was considered to be 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.
- **1996:** On July 29, 1996, the Colorado governor issued a drought disaster emergency declaration. Fifteen southwestern counties were included in a request for U.S. Department of Agriculture (USDA) assistance. Boulder County was not one of the 15. Fall and winter precipitation alleviated further drought concerns.
- **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 as a result 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. According to the Orodell gauge on Boulder Creek, 2002 was the worst single year on record for flow deficit.
- **2002-2006:** Damage to trees as a result of early twenty-first century drought conditions resulted in pruning and removal costs for both parks and streets estimated at approximately $122,660.
- **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.

The longest duration of drought (D1-D4) in Colorado lasted 395 weeks beginning on October 30, 2001 and ending on May 19, 2009. The most intense period of drought occurred the week of July 16, 2002 where D4 affected 34.37% of Colorado land. The Drought Impact Reporter contains information on 80 drought impacts from droughts that affected Boulder County between 1990 and 2007. The list is not comprehensive. Most of the impacts, 30, were classified as "agriculture." Other impacts include "fire" (16), "social" (14), "water/energy" (11), "environment" (7), and "other" (2). These categories are described as follows:

- **Agriculture:** Impacts associated with agriculture, farming, and ranching. Examples include damage to crop quality, income loss for farmers due to reduced crop yields, reduced productivity of cropland, insect infestation, plant disease, increased irrigation costs, cost of new or supplemental water resource development, reduced productivity of rangeland, forced reduction of foundation stock, closure/limitation of public lands to grazing, high cost/unavailability of water for livestock, and range fires.

- **Water/Energy:** Impacts associated with surface or subsurface water supplies (i.e., reservoirs or aquifers), stream levels or stream flow, hydropower generation, or navigation. Examples include lower water levels in reservoirs, lakes, and ponds; reduced flow from springs; reduced streamflow; loss of wetlands; estuarine impacts; increased groundwater depletion, land subsidence, reduced recharge; water quality effects; revenue shortfalls and/or windfall profits; cost of water transport or transfer; cost of new or supplemental water resource development; and loss from impaired navigability of streams, rivers, and canals.
- **Environment:** Impacts associated with wildlife, fisheries, forests, and other fauna. Examples include loss of biodiversity of plants or wildlife; loss of trees from urban landscapes, shelterbelts, wooded conservation areas; reduction and degradation of fish and wildlife habitat; lack of feed and drinking water; greater mortality due to increased contact with agricultural producers, as animals seek food from farms and producers are less tolerant of the intrusion; disease; increased vulnerability to predation; migration and concentration; and increased stress to endangered species.
- **Fire:** Impacts associated with forest and range fires that occur during drought events. The relationship between fires and droughts is very complex. Not all fires are caused by droughts and serious fires can result when droughts are not taking place.
- **Social:** Impacts associated with the public, or the recreation/tourism sector. Examples include health-related low-flow problems (e.g., cross-connection contamination, diminished sewage flows, increased pollutant concentrations, reduced firefighting capability, etc.), loss of human life (e.g., from heat stress, suicides), public safety from forest and range fires, increased respiratory ailments; increased disease caused by wildlife concentrations, population migrations, loss of aesthetic values; reduction or modification of recreational activities, losses to manufacturers and sellers of recreational equipment, and losses related to curtailed activities.
- **Other:** Drought impacts that do not easily fit into any of the above categories.

Probability of Future Occurrences

Based on patterns of previous occurrence, future probability is considered **likely**, with 10-100 percent chance of occurrence in the next year.

Magnitude/Severity

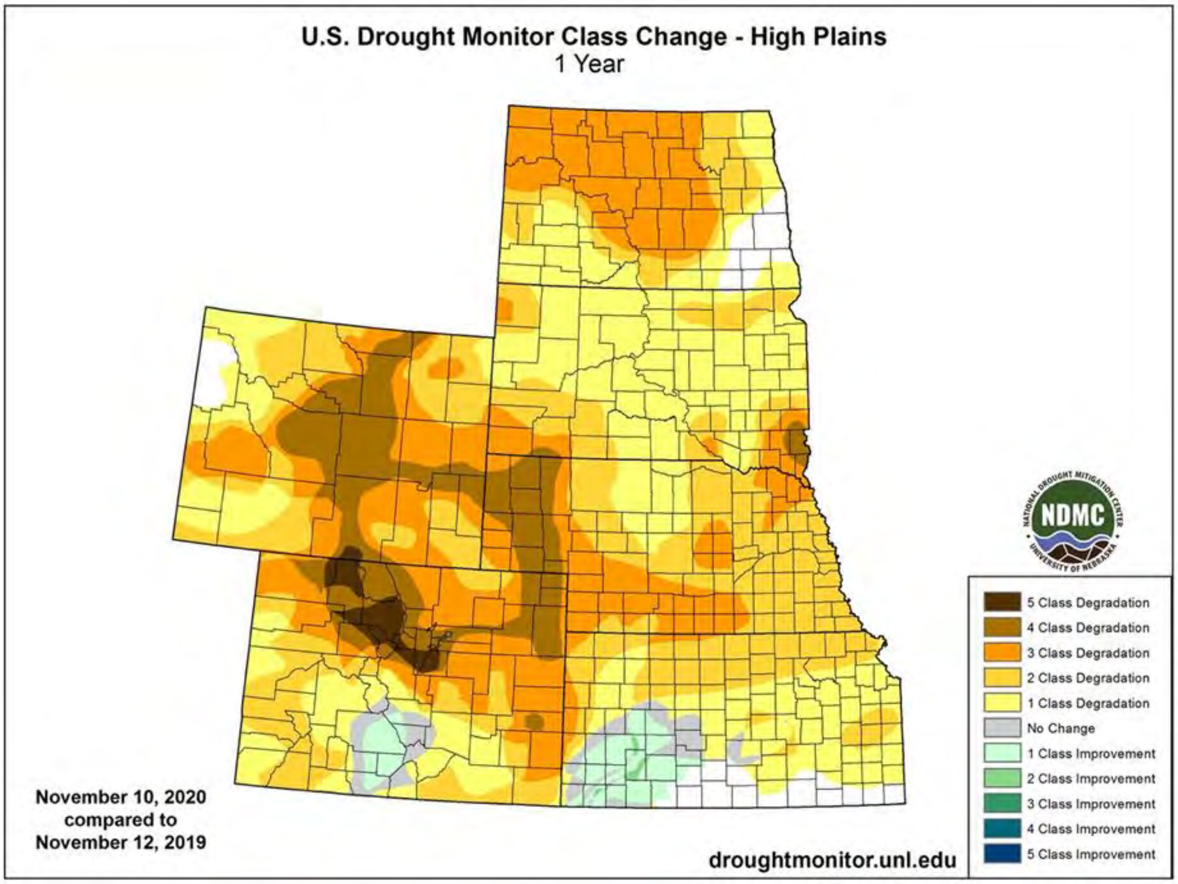
Based on assessments of potential damage to property and disruptions to commerce and day-to-day life, the magnitude and severity of drought in Boulder County is considered **catastrophic**, with the potential shutdown of facilities for 30 or more days and widespread agricultural and resource damage.

Climate Considerations

Increasing global surface temperatures and precipitation variability create conditions that make droughts more likely and persistent in the near future. Droughts have cascading impacts that increase the likelihood of other hazard events. For example, prolonged drought-like conditions dry out vegetation and reduce water supply. This creates the optimal conditions for wildfires while also making it harder to fight those wildfires. Drought conditions also impact trees and forests, increasing tree mortality and leading to more dead vegetation that is perfect for starting and spreading wildfires quickly.

Another secondary impact of drought is land subsidence which is caused from groundwater pumping. Groundwater pumping occurs in both drought and non-drought times; however, demands for water during droughts often increases to keep crops alive and support urban and rural spaces. Water demand leads to increased pumping at the subsurface which can lead to the Earth's surface slightly sinking and can have much larger long-term impacts such as permanent damage to underground aquifers.

Figure 4-8 Drought Monitor Map



Ecological Considerations

Drought conditions, especially for a long period of time, have negative impacts on biodiversity. Wildlife including reptile, bird, mammal, and amphibian populations all depend on water availability from marshes, streams, rivers and other water bodies. Drought conditions not only impact the amount of water available to wildlife and vegetation, but also the quality of water. Drought often results in lower water quality and increased water pathogens which impact wildlife

Overall Hazard Significance

The overall hazard significance for drought is **high**. This assessment is based on relatively high probability, potentially catastrophic magnitude and widespread impacts to municipal and rural water supplies, agriculture, forests and increased fire risk.

4.3.6 Earthquake

Hazard	Geographic Extent	Probability/ Frequency	Magnitude/ Severity	Increased Threat (Climate Change)	Overall Significance
Earthquake	Extensive	Occasional	Catastrophic	Low	Medium

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 amount of energy released during an earthquake is usually expressed as a Richter magnitude and is measured directly from the earthquake as recorded on seismographs. Another measure of earthquake severity is intensity. Intensity is an expression of the amount of shaking at any given location on the ground surface as felt by humans and defined in the Modified Mercalli scale (see Table 4-6). Seismic shaking is typically the greatest cause of losses to structures during earthquakes.

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, great in poorly built structures. Heavy furniture is overturned.
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 total destruction. Waves are seen on the ground surface. Objects are thrown in the air.

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

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.

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. Active faults, which represent the highest earthquake hazard, are those that have ruptured to the ground surface during the Holocene period (about the last 15,000 years).

Social Considerations

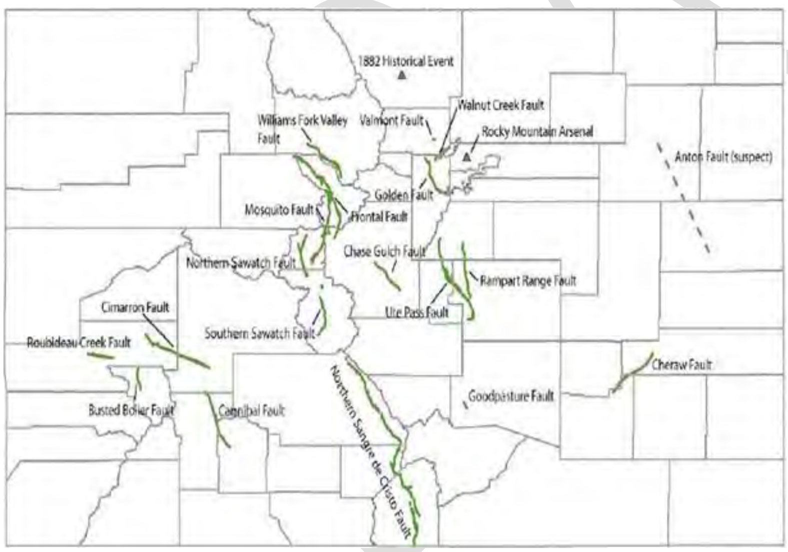
Junia Howell from Rice University conducted a study documenting the impact of natural disasters on different social groups. Howell found that when White Americans that go through a disaster, they have the highest wealth accumulation post-disaster whereas Black Americans have an overall loss of wealth. Earthquakes can cause tremendous damage. Most BIPOC people have been unable to acquire enough disposable income to purchase insurance or save money for a "rainy day". Howell's study found that there are three main factors that improve individual's ability to recovery from a disaster: advanced education, assets such as home ownership, and savings in the bank. Three factors that institutional racism have kept BIPOC people from attaining. According to the New York Times, for every $100 in White family wealth, Black families have $5.04.

Earthquakes cause building damage, infrastructure damage and reduce access to resources. Not only are low-income, elderly, youth and BIPOC individuals impacted inequitably in the disruption due to lack of adequate housing and already scare access to resources, but the aftermath has much more long-term consequences.

Geographic Extent

Geological research indicates that faults capable of producing earthquakes are prevalent in Colorado. There are about 90 potentially active faults in Colorado with documented movement within the last 1.6 million years. The map in Figure 4-9 indicates that potentially active faults exist in the vicinity of Boulder County that are capable of producing damaging earthquakes.

Figure 4-9 Colorado Major Fault Map



Source: State of Colorado NHMP, 2007

Faults have been classified based on the geologic time frame of their latest suspected movement (in order of activity occurrence, most recent is listed first):

- **H:** Holocene (within past 15,000 years)
- **LQ:** Late Quaternary (15,000-130,000 years)
- **MLQ:** Middle to Late Quaternary (130,000 - 750,000 years)
- **Q:** Quaternary (approximately past 2 million years)

Known faults in Boulder County include the Rock Creek (Q) and Valmont (MLQ) faults. Other faults that could affect Boulder County (e.g., other faults that were analyzed by the state for their potential impact on the County) are Frontal (LQ), Golden (Q), Mosquito (LQ), Ute Pass (MLQ), Valmont (MLQ), Walnut Creek (Q), Williams Fork (H) (see the Vulnerability Assessment section for the results of the state's analysis). The Golden, Ute Pass, and Walnut Creek faults, which could affect Boulder County, are three of the state's five potentially most damaging faults.

Based on the definitions set forth in the Hazard Profiles section, the geographic extent of earthquake hazard is considered **extensive**, with 50-100 percent of the planning area potentially impacted.

Previous Occurrences

According to the U.S. Geological Survey (USGS), eastern Colorado is nearly aseismic, with just a few epicenters in the Arkansas and Platte river valleys. 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 County 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 County 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:** Minor damage was caused 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 Boulder County.

Probability of Future Occurrences

Seismic hazard zone maps and earthquake fault zone maps are used to identify where such hazards are more likely to occur based on analyses of faults, soils, topography, groundwater, and the potential for earthquake shaking that can trigger landslide and liquefaction. Typically, significant earthquake damage occurs when accelerations are greater than 30 percent of gravity.

The data show peak horizontal ground acceleration, including the shaking level that has a 10 percent chance of being exceeded over a period of 50 years. Boulder County lies in the range of 3-4 percent peak acceleration. In a worst-case scenario, Boulder County lies in the range of 10-12 percent peak acceleration. Thus, probability for an earthquake producing minor shaking is considered occasional and an earthquake causing significant damage is **unlikely**, with less than a 1 percent chance of occurrence over the next 100-year period.

Magnitude/Severity

Considering a worst-case scenario, the potential magnitude of earthquakes is catastrophic, with more than 50 percent of property severely damaged, shutdown of facilities for more than 30 days and/or multiple fatalities.

Climate Considerations

According to the U.S. Geological Survey, "the only correlation that's been noted between earthquakes and weather is that large changes in atmospheric pressure caused by major storms like hurricanes have been shown to occasionally trigger what are known as slow earthquakes, which release energy over comparatively long periods of time and do not result in ground shaking like traditional earthquakes do". There is not enough information at this time to connect climate change to increase or decrease in earthquake activity.

Ecological Considerations

Earthquakes have secondary earthquake environmental effects (EEE). These are typically landslides and liquefaction in areas like Boulder County. Large earthquake events can lead to destruction of infrastructure that carry hazardous waste, sewage, chemicals and other toxins. In the event of a major earthquake, damages to human infrastructure and leaking of toxic substances into the surrounding environment is likely to have harmful long-term impacts to biodiversity, soil, water and other species.

Overall Hazard Significance

The overall hazard significance for earthquake is **medium**. This assessment is based on low probability but potentially catastrophic magnitude and widespread impacts to public safety, property and infrastructure.

4.3.7 Expansive Soils

Hazard	Geographic Extent	Probability/ Frequency	Magnitude/ Severity	Increased Threat (Climate Change)	Overall Significance
Expansive Soils	Significant	Highly Likely	Limited	Substantial	Low

Description

Expansive (swelling) soils or soft bedrock are those that increase in volume as they get wet and shrink as they dry. Expansive soils are also known as expansive clays and shrink-swell soils. 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.

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, as long as appropriate construction design and mitigation measures are followed.

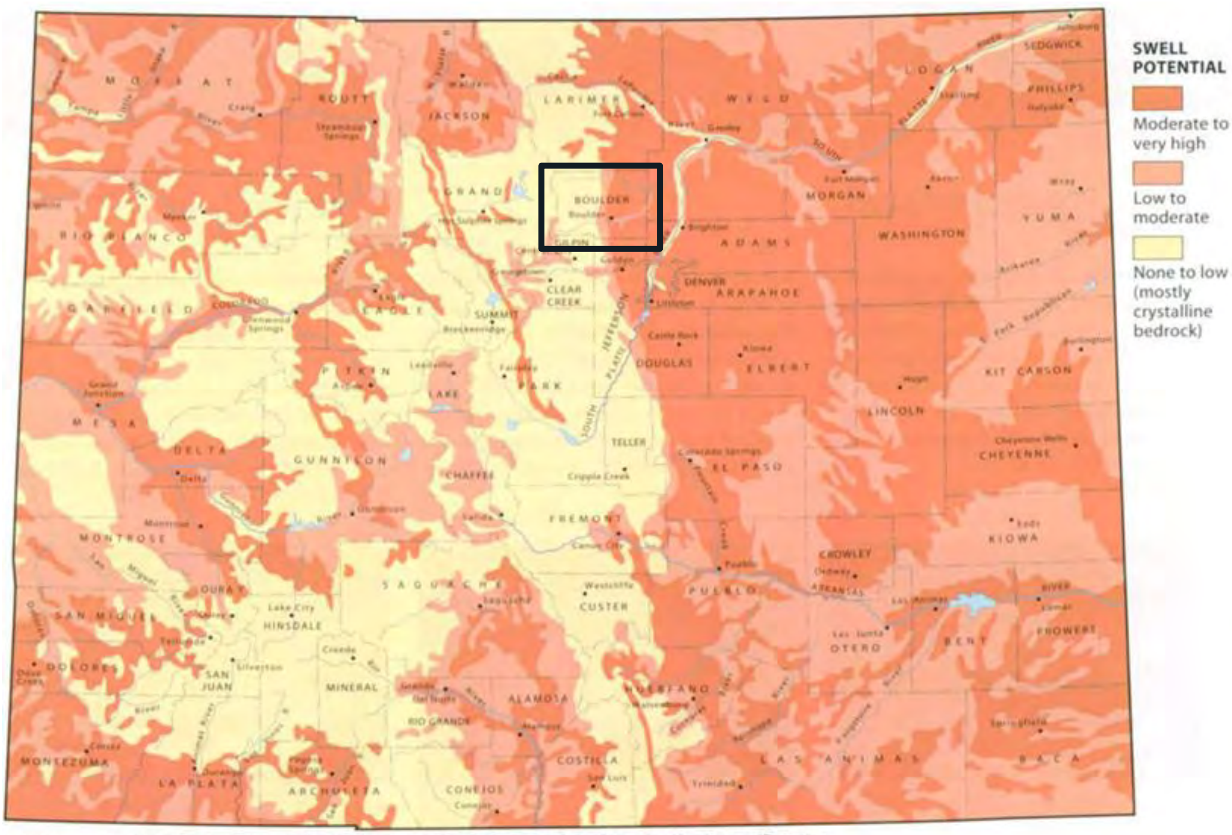
Social Considerations

Expansive soils cause damage to buildings and infrastructure. Most homeowner's insurance does not cover damage from expansive soils thus the burden is on the homeowner when damage does occur. In low-income areas people are less likely to have homeowners or renter's insurance to cover damage associated with impacts from expansive soils and are also less likely to have the funds to take proactive action. Damage from expansive soils usually takes place slowly and impacts driveways, sidewalks and floors. When this damage goes unrepaired it can turn into additional issues such as flooding, mold and mildew growth, and structural damage. Although the American Society of Civil Engineers estimates that one in four homes in the United States will experience damage from expansive soils, low-income individuals are more likely to experience impacts due to inability to afford contractors, testing, and the continuous investment it takes to prevent damage.

Geographic Extent

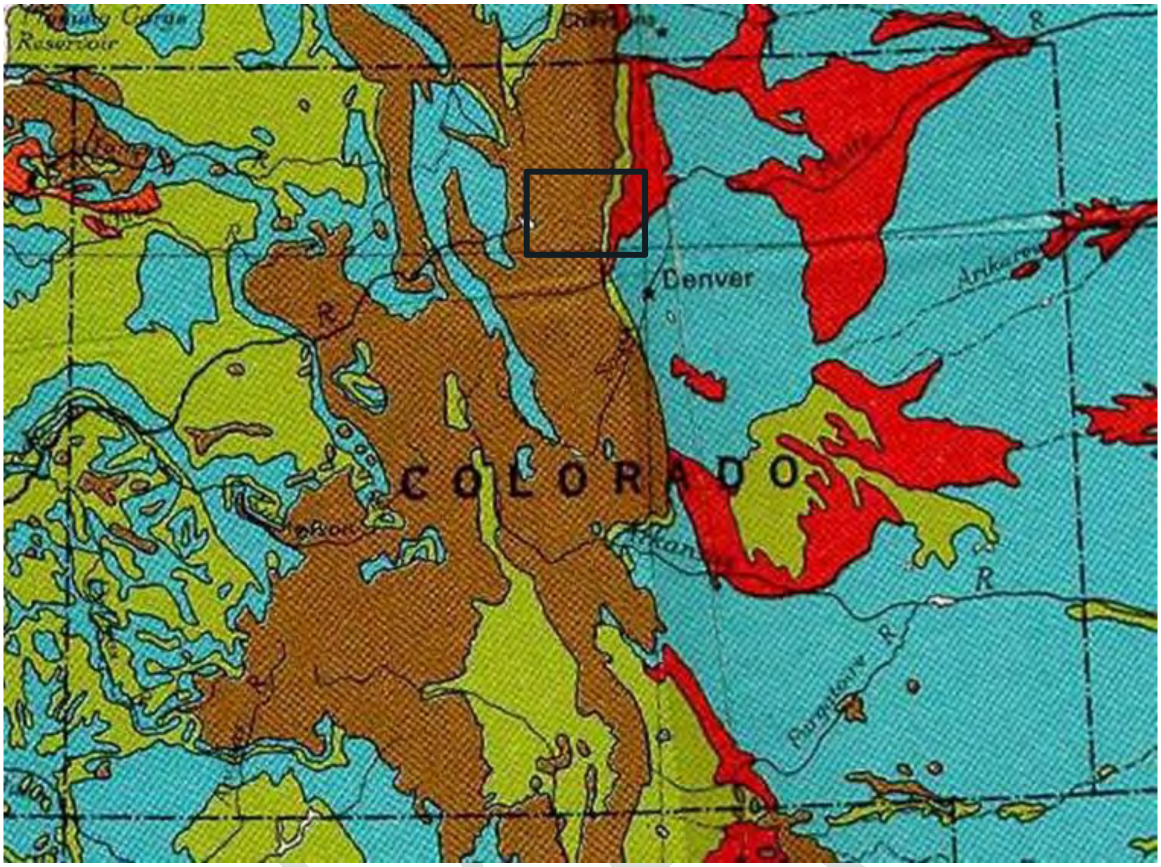
Figure 4-10 on the following page shows a large area of Boulder County consisting of soils with high swelling potential. The approximate location of Boulder County is indicated by the black box. Expensive soils tend to be most concentrated in the eastern sections of the planning area whereas the western sections of the County have significantly less occurrence of soils susceptible to swelling. Overall geographic extent is **significant**, with 10-50 percent of the planning area affected by concentrations of expansive soils.

Figure 4-10 Soil Map of Colorado- Swell Potential



This is a generalized map. The swell potential of soils at any specific location can only be determined by site-specific testing.
Map modified from "Shrink-Swell Potential" map, Colorado Land Use Commision, 1973.

Figure 4-11 Swelling Clays Map of Colorado



Source: U.S. Geological Survey publication "Swelling Clays Map of The Conterminous United States";1989; http://arcvoid.com/surevoid_web/soil_maps/ks.html

Map Legend	
Red	*Unit contains abundant clay having high swelling potential*
Blue	*Part of unit (generally less than 50%) consists of clay having high swelling potential*
Orange	*Unit contains abundant clay having slight to moderate swelling potential*
Green	*Part of unit (generally less than 50%) consists of clay having slight to moderate swelling potential*
Brown	*Unit contains little or no swelling clay*
Yellow	*Data insufficient to indicate clay content of unit and/or swelling potential of clay (Shown in westernmost states only)*

Note: White rectangle represents approximate location of Boulder County

Previous Occurrences

Damage of varying degrees of severity occurs on an ongoing and seasonal basis. The frequency of damage from expansive soils can be associated with the cycles of drought and heavy rainfall and also reflect changes in moisture content based on typical seasonal patterns. Published data summarizing damages specific to Boulder County is not available, but it is acknowledged that a certain degree of damage to property and infrastructure occurs annually.

Probability of Future Occurrences

Based on patterns of previous occurrences, probability of future occurrence is **highly likely**, with multiple occurrences on an annual basis.

Magnitude/Severity

The magnitude of expansive soils is considered **limited**, based on the definitions established previously, with 10-25 percent of property severely damaged. This assessment considers that damage of severe magnitude does not occur in a single shrink-swell cycle, but rather over much longer time periods to the effect that building foundations, underground pipes and streets and highways must be replaced over shorter timeframes.

Climate Considerations

Climate change is likely to have significant impacts on expansive soils due to changes in the freeze-thaw cycles and the amount that soils shrink and swell. These changes will impact infrastructure such as roads, bridges, culverts, and sidewalks which will require more frequent replacement and maintenance. These same factors are likely to have significant impacts on residential and commercial buildings that are constructed on expansive soils leading to increases in damage to basements and building settlement, cracks in foundations and walls, damage to utilities and pipelines and movement in retaining walls.

State of Colorado law mandates that builders make homeowners aware if expansive soils are present and provide information about how expansive soils may impact their home. The same is true when a house is resold; the homeowner must disclose expansive soil conditions to the potential home buyer. However, most homeowners and purchasers are unaware of what that information means and how much worse soil swell will likely get with climate change.

Ecological Considerations

Expansive soils are different from other soils because of their tendency to shrink and swell due to interaction with water. In dry seasons, expansive soils shrink and cause cracks. In wet seasons, these soils swell leading to upheaval. Expansive soils are a natural environmental process and most of the ecological impacts are from actions taken to stabilize soils such as insertion of moisture barriers, engineering fills and chemical treatments. Treatments impact soil quality and soil pH levels. Expansive soils also have the potential to cause damages to natural landscapes and cultural resources.

Overall Hazard Significance

The overall hazard significance for expansive soils is **medium**. This assessment is based on high probability but relatively low potential public safety impacts and moderate impacts to property and infrastructure.

4.3.8 Extreme Temperatures

Hazard	Geographic Extent	Probability/ Frequency	Magnitude/ Severity	Increased Threat (Climate Change)	Overall Significance
Extreme Temperatures	Extensive	Likely	Critical	Severe	Medium

Description

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. According to the EPA "more than 1,300 deaths per year in the United States are due to extreme heat….extreme heat contributes to far more deaths than the official death certificates might suggest". According to the 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 have to 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.

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 night-time 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. It is most likely to occur in the winter months of December, January, and February. 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. Extreme cold can disrupt or impair communications facilities.

In 2001, the NWS implemented an updated Wind Chill Temperature index. 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.

Social Considerations

Extreme temperatures are silent killers. High temperatures combined with humidity can take a significant toll on the human body leading to directly to heat-related illnesses and indirectly exacerbating pre-existing conditions. People with medical conditions often use medications that prevent the body from regulating temperature or can be in situations that make it difficult to movement into cooler or warmer spaces. Although heat-related deaths are often preventable, pre-existing medical conditions, social isolation, poverty, educational attainment, age and job type all play a role in increased vulnerability.

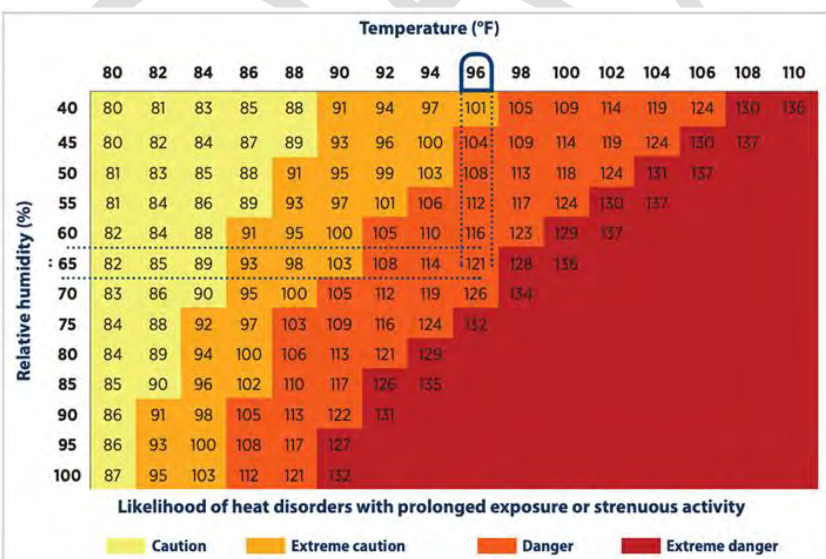
Due to centuries of discriminatory policies and practices, BIPOC communities have had less access to resources, wealth, insurance, and healthcare leading to increase vulnerability to extreme temperatures. Individuals who lack financial means to install temperature-regulating equipment or live in poor housing conditions with lack of insulation are more likely to succumb to extreme temperatures; especially if they lack housing entirely. There is a particular intersection with the COVID-19 Pandemic and extreme temperatures. As more people are unable to gather inside to access heating or cooling from common spaces such as movie theatres, malls or faith-based spaces, their bodies are exposed to extreme temperatures consistently and unable to regulate.

Additionally, children, those of advanced age, homeless, disabled, pregnant women, immigrants and low-income individuals are all populations more vulnerable to extreme temperatures. With heat, infants and small children lose water in their bodies at a faster rate than adults and without the ability to read their bodies well, children can end up with heatstroke, kidney issues and may even die. Additionally, elderly people's bodies often struggle to regulate temperature and are more likely to have pre-existing conditions that are exacerbated by extreme temperatures.

Centers for Disease Control and Prevention (CDC) data consistently shows that extreme cold poses a greater threat to human life than extreme heat. Although extreme heat data is often documented improperly and heat-related deaths are attributed to other factors, the important element to note is that "Weather-related death rates were 2 to 7 times as high in low-income communities as in high-income communities".

Outdoor workers are also at elevated risk from extreme temperatures. Landscapers, postal workers, farmworkers and construction workers are a few examples of professions where risk is already high and is likely to increase. Agricultural workers often are immigrants. In the U.S., immigrant workers are three times more likely to die from heat than American citizens, especially from extreme heat events where the combination of exposure to the sun, fewer breaks, lack of adequate medical services and health insurance all play a factor.

Figure 4-12 NOAA's National Weather Service Heat Index Chart



Temperature (°F)

Relative humidity (%)	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	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	128	136					
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 strenuous activity

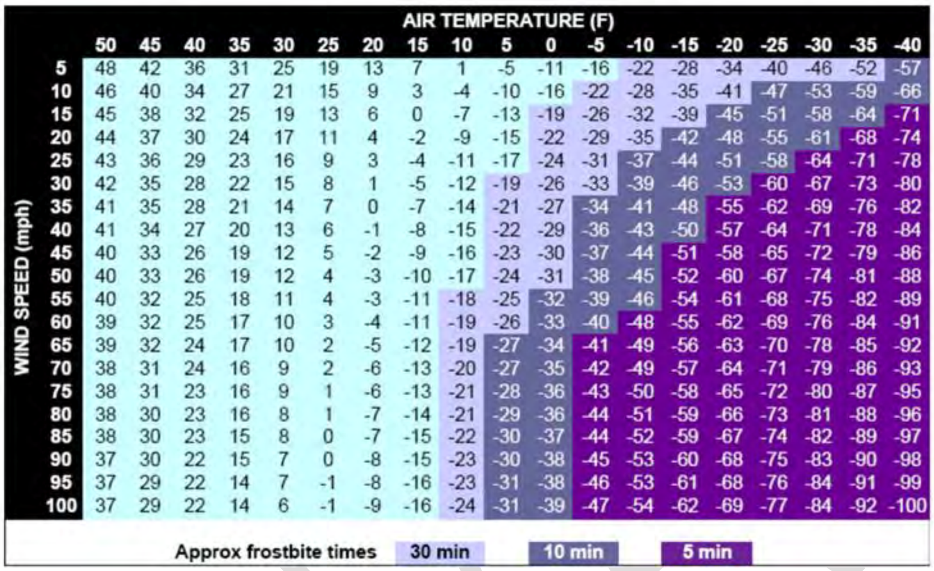
Caution / Extreme caution / Danger / Extreme danger

Source: Source: NOAA NWS

The NWS combines relative humidity and temperature to produce a heat index. The heat index is what temperatures feel like to the human body and is utilized to provide warnings on excessive heat days. The heat index chart provides general guidance for when conditions can be dangerous however, dangerous conditions for some may be deadly conditions for others, especially if they lack resources and proper housing or are working in high exposure conditions.

The NWS utilizes wind chill charts and freeze warnings to alert people about extreme cold temperatures. The chart below provides air temperature and wind speed information and estimates the amount of time it will take for frostbite to set in if one was exposed to those conditions.

Figure 4-13 Wind Chill Chart



WIND SPEED (mph)	AIR TEMPERATURE (F)																		
	50	45	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40
5	48	42	36	31	25	19	13	7	1	-5	-11	-16	-22	-28	-34	-40	-46	-52	-57
10	46	40	34	27	21	15	9	3	-4	-10	-16	-22	-28	-35	-41	-47	-53	-59	-66
15	45	38	32	25	19	13	6	0	-7	-13	-19	-26	-32	-39	-45	-51	-58	-64	-71
20	44	37	30	24	17	11	4	-2	-9	-15	-22	-29	-35	-42	-48	-55	-61	-68	-74
25	43	36	29	23	16	9	3	-4	-11	-17	-24	-31	-37	-44	-51	-58	-64	-71	-78
30	42	35	28	22	15	8	1	-5	-12	-19	-26	-33	-39	-46	-53	-60	-67	-73	-80
35	41	35	28	21	14	7	0	-7	-14	-21	-27	-34	-41	-48	-55	-62	-69	-76	-82
40	41	34	27	20	13	6	-1	-8	-15	-22	-29	-36	-43	-50	-57	-64	-71	-78	-84
45	40	33	26	19	12	5	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79	-86
50	40	33	26	19	12	4	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81	-88
55	40	32	25	18	11	4	-3	-11	-18	-25	-32	-39	-46	-54	-61	-68	-75	-82	-89
60	39	32	25	17	10	3	-4	-11	-19	-26	-33	-40	-48	-55	-62	-69	-76	-84	-91
65	39	32	24	17	10	2	-5	-12	-19	-27	-34	-41	-49	-56	-63	-70	-78	-85	-92
70	38	31	24	16	9	2	-6	-13	-20	-27	-35	-42	-49	-57	-64	-71	-79	-86	-93
75	38	31	23	16	9	1	-6	-13	-21	-28	-36	-43	-50	-58	-65	-72	-80	-87	-95
80	38	30	23	16	8	1	-7	-14	-21	-29	-36	-44	-51	-59	-66	-73	-81	-88	-96
85	38	30	23	15	8	0	-7	-15	-22	-30	-37	-44	-52	-59	-67	-74	-82	-89	-97
90	37	30	22	15	7	0	-8	-15	-23	-30	-38	-45	-53	-60	-68	-75	-83	-90	-98
95	37	29	22	14	7	-1	-8	-16	-23	-31	-38	-46	-53	-61	-68	-76	-84	-91	-99
100	37	29	22	14	6	-1	-9	-16	-24	-31	-39	-47	-54	-62	-69	-77	-84	-92	-100

Approx frostbite times: 30 min | 10 min | 5 min

Source: Source: Colorado State University

Geographic Extent

In general, extreme temperatures affect broad regions that include all parts of Boulder County, and therefore the geographic extent is **extensive**, with 50-100 percent of the planning area affected. However, extreme heat tends to affect areas of lowest elevation in the eastern portion of the County with the greatest severity and areas of higher elevation experience extreme low temperatures with greater frequency and severity.

Previous Occurrences

For the eastern sections of Boulder County over the period 1948-2022, monthly average maximum temperatures in the summer months (June, July, and August) were in the low to mid-80s. The highest recorded temperature in eastern Boulder County was recorded in Longmont at 106°F on June 27, 1994, and July 7, 1973. On average, 33 days exceed 90°F each year.

Temperature patterns for the western sections of Boulder County were retrieved from two different monitoring stations in order to provide a more comprehensive time range for the climate data. The Nederland 2 NNE station had climate data available over the time period 1970-1988 and the Niwot station located just north of the CU Mountain Research Station had climate data available from 1989-2022. Between 1970 and 1988 the monthly average maximum temperatures in the summer months (June, July, and August) ranged from 69 to 75 degrees. The highest temperature recorded during this time period was 89 degrees on September 1, 1975. From 1989-2022 the average summer temperature was between 64 and 69 degrees, and the record high was 94 degrees on June 15, 2006.

Probability of Future Occurrences

The probability of future extreme cold conditions and/or extreme heat is considered **likely**, with a 10-100 percent chance of occurrence in any given year. With Boulder County average daily temperatures project to increase and number of days over 95 degrees also likely to increase, extreme heat is **extremely likely** to occur.

Figure 4-14 Boulder County Average Daily Temp (Observed and Projected)

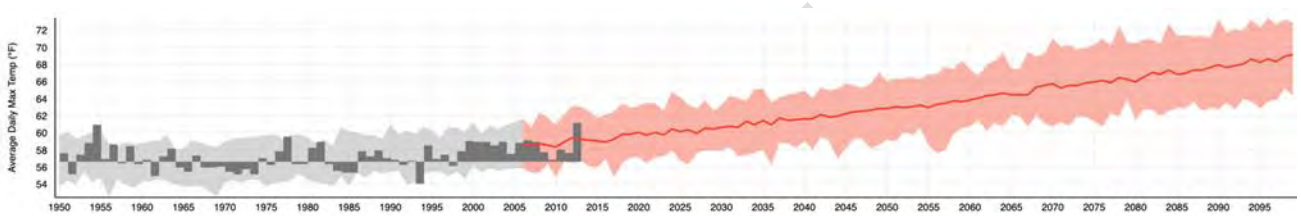


Figure 4-15 Boulder County Days Over 95 F (Observed and Projected)

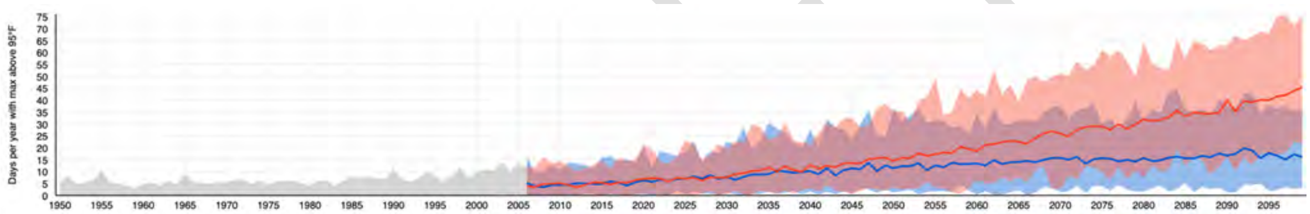


Chart Source: U.S. Climate Toolkit, The Climate Explorer

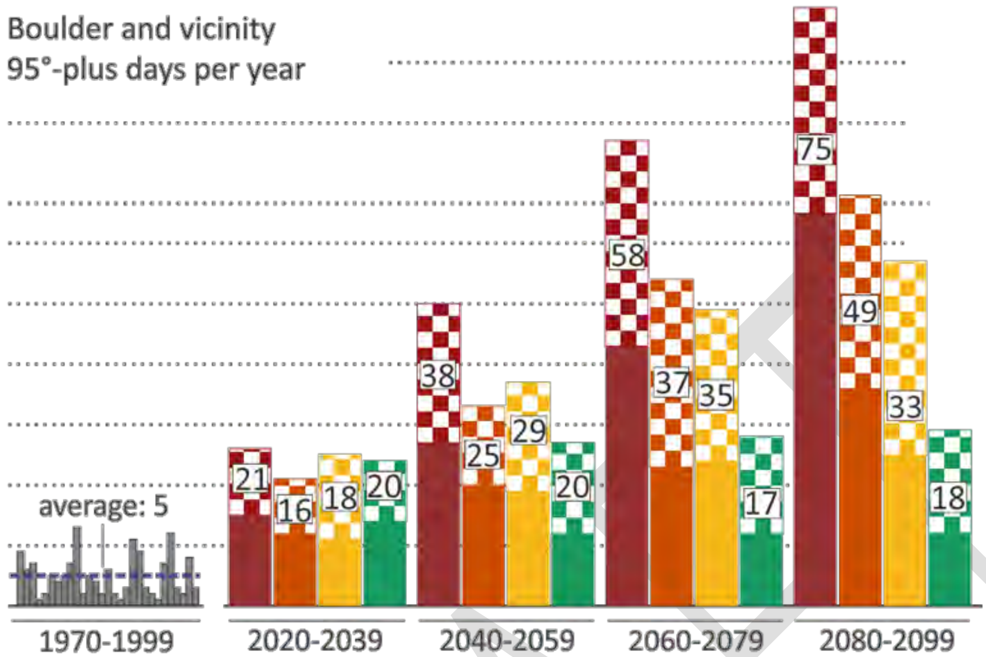
Magnitude/Severity

The magnitude and severity of extreme temperatures is classified as **critical**, with 25-50 percent of property or infrastructure severely damaged, and/or shutdown of facilities for two weeks or more, and/or injuries that result in fatality or permanent disability

Climate Considerations

Due to human actions, the planet is warming at an unprecedented rate. Warming conditions are already creating more severe extreme heat events. Within in the next 30 years, heat wave days are projected to increase from 10 events per year to nearly 50 events per year. In addition to average temperatures increasing, dewpoint temperatures are also expected to rise leading to muggier summers. In Boulder County, there is likely to be an increase in the frequency and the extent of extreme heat events leading to more record-setting high heat days for prolonged periods of time.

Figure 4-16 Future 95 Degree+ Days in Boulder County



Source: Rocky Mountain Climate Organization (RMCO)

The figure above shows how the number of days 95° or hotter in Boulder could go from an average of 5 per year late in the last century to 75 per year late in this century. For future periods, the figure shows the range of the middle 80 percent of projections from multiple climate models (the checkered portions of the columns) and the medians (the numerals), for four possible levels of future heat-trapping emissions.

Ecological Considerations

Urbanization and increased amount of man-man landscape can lead to urban spaces being significantly warmer than surrounding natural areas. Concrete and asphalt absorb more of the sun's energy making landscape a factor in impacts from extreme temperatures. Natural spaces and ecosystems are impacted by the amount of impervious surface.

Water is one of the most impacted ecological elements from extreme temperatures. In high heat events, the demand for water increases to cool both people and infrastructure. This can reduce water supply, impact water quality and organisms in the water ecosystem. Additionally, high temperatures tend to increase the likelihood of algae growth which can impact fish and mammals.

Extreme temperatures can heavily impact ecological systems since temperature impacts both growth and distribution of a species. This includes plants and animals. High temperatures often lead to prolonged dry seasons, droughts and wildfires impacting accessibility to water and ability to migrate; even breeding patterns can be impacted.

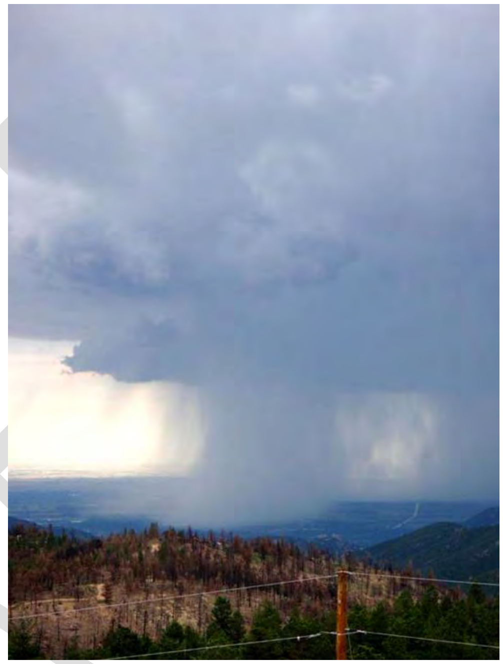
Overall Hazard Significance

The overall hazard significance for extreme temperatures is **medium**. This assessment is based on high probability, moderate potential public safety impacts and moderate impacts to property and infrastructure.

4.3.9 Flood

Hazard	Geographic Extent	Probability/ Frequency	Magnitude/ Severity	Increased Threat (Climate Change)	Overall Significance
Flood	Significant	Highly Likely	Critical	Severe	High

Description



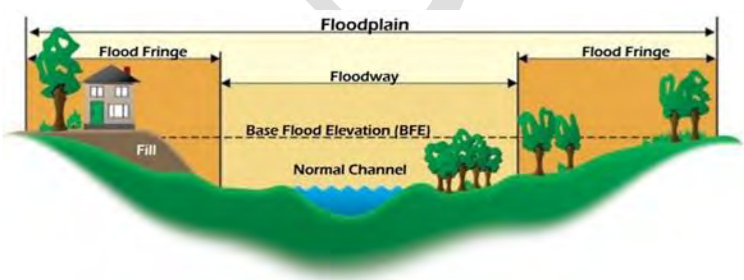
Floods can be among the most frequent and costly natural disaster in terms of human hardship and economic loss and can be caused by a number of different weather events. Floods can cause injuries and deaths and substantial damage to structures, landscapes, and utilities. Certain health hazards are also 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.

Risk of flooding in Boulder County is increased as a result of the burn scars such as that left by the Fourmile Canyon Fire in September of 2010. Heavy rainfall, especially in the form of cloudbursts, is alone capable of causing flooding, even more so if it occurs over the burn areas where vegetation has largely been lost. Floods caused by rainstorms can peak within a few minutes or hours of the rainfall, leaving little time for evacuation.

Floodplain Basics

The area adjacent to a channel is the floodplain. Floodplains are illustrated on inundation maps, 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% 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 NFIP.

Figure 4-17 Floodplain Basics



Source: FEMA NFIP Guidebook, 2009

The potential for flooding can change and increase as a result of land use changes and changes to land surface that change the floodplain. A change in environment can create localized flooding problems in and out of natural floodplains by altering or confining natural drainage channels. These changes are most often created by human activity.

Types of Flooding in Boulder County

Communities in Boulder County are susceptible to various types of flood events as described below.

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 as a result 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. The largest watersheds extend as far west as the Continental Divide and snowmelt in these watersheds dominates streamflow in late spring and early summer. Heavy rainfall on top of the snowpack can increase the rate of snowmelt and the extra runoff can produce significant flooding downstream. Other factors, such as debris blocking a waterway or channel, can further aggravate a flood event. In portions of Boulder County, development has altered the natural environment, changing and interrupting some of the natural drainage ways. 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 by definition occur very quickly and may occur with little or no warning. Flash flood risk can be greatly increased when drainages are cleared of foliage that normally absorbs and slows the rate of runoff.

Irrigation Ditch/Canal 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. Similar to flash floods, there is often little warning for these types of events.

Urban or Street Flood Events

These events occur due to the conversion of land from fields to 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.

Until recently, the Lefthand Creek floodplain was devoted entirely to agriculture. Now, because of expanding population and industrialization, urban development has begun at both ends and in the middle of the study reach.

Development in the Floodplain

Development in narrow mountain canyons presents a unique flooding problem as the floodplain and floodway occupy essentially the entire canyon floor. Historically the mountain canyons were developed extensively with infrastructure, private residences, and small amounts of commercial and industrial property. Much of this development occurred along stream banks within the canyon floodways presenting a flooding hazard to those properties as well as debris hazards for downstream stream reaches. Since floodplain management regulations were incorporated into the Boulder County Land Use Code, new development is no longer allowed within the mountain canyon floodways which causes rise in Base Flood Elevation (BFE) and cannot get a CLOMR.

The county's flood mitigation efforts have been in place for many years. Codes and ordinances have been adopted prohibiting or controlling building in floodplains. Mitigation efforts, such as channelization and detention ponds, have been built and some high-risk buildings located in floodplains have been removed. A flood warning system, made up of stream and rain gauges, is in drainages. These gauges are monitored by the Boulder OEM during high-risk rain events and automatically transmit data to a computer in the Boulder Communications Center that sounds an alarm when significant amounts of rainfall occur and when rising stream levels are detected. A flood warning plan has been developed for Boulder County, which is exercised and updated annually. The southeast portion of the County is served by the Mile High Flood Control District. The following communities participate in the NFIP: unincorporated Boulder County, City of Boulder, Erie, Lafayette, Longmont, Louisville, Jamestown, Lyons, Nederland, and Superior. Boulder County and the cities of Boulder, Longmont, and Louisville participate in the NFIP's CRS, which provides flood insurance discounts to communities that implement floodplain management activities above and beyond the minimum standards.

Levees

For flood protection from Boulder Creek, a levee was constructed around the 75th Street Wastewater Treatment Plant. The levee was found to provide protection from the 1-percent annual chance flood, and it meets all of the requirements set forth in Section 65.10 of the NFIP regulations. If this levee were breached, damage to the wastewater treatment plant could result in release of untreated wastewater to the creek.

The University of Colorado South Campus Levee provides protection from the 1-percent annual chance flood event. If this levee were breached, no development beyond CU Boulder's tennis complex would suffer damage.

Flood protection measures along Coal Creek in the Town of Erie include channelization and the construction of levees from approximately 5,700 feet downstream to approximately600 feet upstream of the Union Pacific Railroad. As a result of this project, the base flood and floodway are contained within the channel from approximately 2,750 feet down stream to the UPRR. The flooding associated with the Coal Creek West Line Overflow through the town has been eliminated. If this levee were to breach to the west, the flooding threat would be to the historic Briggs Street neighborhood in Erie. This area is outside of Boulder County but included here because it is within the municipal boundaries of Erie, one of the participating communities on the HMPC.

Other Flood Issues

All communities in Boulder County, both incorporated and unincorporated are experiencing population growth and resulting development. While a small portion of new development is occurring in the sparsely developed mountainous area of western Boulder County, the expected development in this area is unlikely to significantly affect the County's watersheds' hydrology and hydraulics related to runoff in Boulder County streams. The bulk of new development in the County is expected to occur in the high plains areas to the east of the Front Range Foothills. Increased development will likely include all typical types of land uses including residential, commercial, and industrial. Where development occurs outside of established floodplains, it will contribute to increased stormwater runoff flowing to streams due to inevitable increases in impervious surfaces from new roads and buildings. The result will be an increase in potential for urban flooding as a result of a reduced capacity of the land to absorb precipitation.

Projections and land use plans suggest that an increase in population within previously developed portions of regulatory floodplains is expected in Boulder County. It is unlikely that floodwater conveyance would be significantly affected through these previously developed areas as building footprints and other urban infrastructure will remain relatively unchanged. The Boulder County Land Use Code also allows structures to be developed in the flood fringe portion of the base floodplain. However, the Boulder County Comprehensive plan requires that development be concentrated within the municipalities. While new structures in previously undeveloped portions of the floodplain will likely represent a small fraction of development within the floodplain, any new structures will present small, localized impediments to floodwaters. This type of flood fringe development is likely to occur in rural residential and agricultural areas in unincorporated portions of the high plains east of the Front Range Foothills.

Social Considerations

BIPOC and lower-income members of the community are often at most risk of flooding and flash flooding. Discriminatory lending and housing policies created structural inequity placing BIPOC families and those with lower incomes in high-risk areas that receive less investment in infrastructure and from private groups. Their homes are often in floodplains or are more susceptible to damage. This has led to the effects from floods not impacting all people equally.

Post-flood, these same individuals are being disproportionately affected due to insufficient aid and support programs. Federal disaster and recovery programs are slow and often make inequities worse by prioritizing those with insurance, those with the ability to translate lengthy flood documentation forms, and those with the ability to hire legal teams. NFIP, HUD and FEMA programs utilize traditional cost-benefit assessments when assessing and prioritizing flood recovery efforts. For renters and low-income individuals, the value of their property is assessed and compared to wealthy areas with higher property values, thus leading to recovery money being allocated in higher income areas first. Additionally, flood insurance is typically expensive and for people living paycheck-to-paycheck, it is often unobtainable.

Geographic Extent

Boulder County has multiple creeks, tributaries, and associated floodplains that comprise the geographic extent of flooding throughout the planning area. Based on the definitions set forth previously, this extent is considered **significant**, constituting roughly 10-50 percent of the planning area.

Much of the floodplain is used for agriculture, thus the most common flooding impact is crop losses and damage to irrigation equipment and rural roads and bridges. There are also undefined, localized zones of flow-velocity hazard throughout the monitored section of Lefthand Creek. Generally, these zones are in the channel and near bridges.

All stream reaches east of the foothills, except for those on Fourmile Canyon Creek, are located within urbanized areas with occasional open space and park areas. The terrain of these sub-basins consists of mild slopes with topsoil in the B and C hydrologic soils group with some D soils. Vegetation for most of the stream reaches is characteristic of urban areas. Fourmile Canyon Creek is located in sparsely developed agricultural areas. Vegetation along Fourmile Canyon Creek and the downstream reaches of Bear, Skunk, Goose, and Wonderland Creeks consists of natural grasses and weeds.

Previous Occurrences

The flood season in Boulder County is typically April 1 through September 30, but floods can happen at any time. The most dangerous flooding in Boulder County tends to occur from mid-July through early September due to heavy precipitation from thunderstorms and monsoonal rains. Creeks with mountainous, upstream watersheds are subject to flash floods as are urban streams and drainage ways. A flood event would most likely result from a heavy rainstorm that stalls over any of the creek basins with increased risk if it stalled over the Fourmile burn area. It could rain for as little as 20-30 minutes in the foothills before the water starts overflowing stream banks.

The state of 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. Another catastrophic event occurred at Ft. Collins in 1997, when 14.5 inches of rain led to flooding that claimed five lives and caused $200 million in damages.

The state of Colorado's second worst flooding event occurred on September 11, 2013. Three days of rain occurred prior to September 11, 2013, saturating the ground. Rainfall was continuous on the 11th and by 10 p.m. widespread flooding occurred, and the rain would not stop until late on September 14th, 2013. The rainfall during this period totaled 17 inches to the northern and southern areas of the County and 8 inches of rain over the plains and foothills. Over 750 landslides occurred during this event. Extreme precipitation also caused dams numerous dams in the Front Range to fail, which added to the devastating nature of the flooding. Over 1700 homes were completely destroyed, 10 deaths and damages exceeded $2.5 billion. Boulder County had over 10,000 residences affected by flooding, over 800 homes destroyed, 150 miles of road wash out and four deaths. Major flooding events recorded within Boulder County include the following detailed by area/drainage:

Boulder Creek

- **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 the City of Boulder's downtown district. Mountain rainfall, combined with snowmelt runoff, produced the greatest flood known in Boulder County 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.

- **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 were able to 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 City of Boulder water system was destroyed.
- **June 2-7, 1921:** Rainfall totaled 3.36 inches in Boulder County. A peak discharge of 2,500 cfs was recorded on June 6, 1921.
- **September 4, 1938:** 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 County and 9.3 inches at the hydroelectric plant in Boulder Canyon. Bear Canyon Creek, Skunk Creek, and Two Mile Canyon Creek overflowed their banks. Damage from this storm was estimated at $325,000. Schools were closed. The gauging records show that floods the size of the May 1969 flood occur on an average of about once every five years on Boulder Creek.
- **July 13, 2011:** The Fourmile Canyon Fire on Sept. 6, 2010, heavily damaged the canyon area. The wildfire destroyed 169 homes and severely burned over 6000 acres of land. On July 13, 2011, a thunderstorm released over ¾ inch of rain in an hour resulting in a flow of over 1800 cfs. This caused debris and mudslides in the Fourmile Canyon area and low impact flooding along Boulder Creek.
- **September 11, 2013:** Three days of rain saturated the ground prior to September 11, 2013 causing high surface runoff and landslides/ debris flows throughout Boulder County. The rainfall totals during this event delivered 17 inches causing widespread 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. The City of Boulder Water Treatment Center was impacted causing sewer backups and flood waters overtopped many roads to the east.

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 in Figure 4-18 shows the destroyed dancehall at the Eldorado Springs Resort.

Figure 4-18 Damage to Eldorado Springs Resort, 1938 Flood

- **September 11, 2013:** Three days of rain saturated the ground prior to September 11, 2013 causing high surface runoff and landslides/ debris flows throughout Boulder County. The rainfall totals during this event delivered 17 inches causing widespread flooding. South Boulder Creek drainage had 17 inches of rain over this period. Boulder Creek had peak stream flows estimated at 5,200 cfs. While this was less than half the stream flow rate observed during the 1894 Boulder flood, it is worth noting that the average mid-September stream flow for Boulder Creek is approximately 100 cfs.

Boulder County also identifies the following flood events at South Boulder Creek with peak discharges in excess of 1,000 cfs:

- June 3, 1895—1,130 cfs
- May 9, 1900—1,100 cfs
- June 20, 1909—1,340 cfs
- May 24, 1914—1,240 cfs
- June 6, 1921—1,440 cfs
- September 2, 1938—7,390 cfs
- June 21, 1947—1,290 cfs
- June 6, 1949—1,430 cfs
- June 18, 1951—2,370 cfs
- June 4, 1952—1,080 cfs
- May 7, 1969—1,690 cfs
- September 11, 2013 – 2,100cfs

Four Mile 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 somewhat undeveloped. However, this threat has increased significantly since the Fourmile Canyon Fire in September 2010.

- **July 23, 1909:** Heavy rains caused two injuries and two deaths as flash flooding occurred in Twomile Canyon and Fourmile Canyon creeks. 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.
- **July 13, 2011:** 1.18 inches of rain in a short period of time fell over the area, resulting in over 1200 cfs in Fourmile Canyon Creek. Water and debris flow damaged homes, but no injuries or deaths were reported.

Fourmile Creek

- **July 13, 2011:** 3/4" of rain in a short period of time fell over the area, resulting in over 700 cfs in Fourmile Creek. Water and debris flow damaged homes, but no injuries or deaths were reported.
- **September 11, 2013**: Three days of rain saturated the ground prior to September 11, 2013, causing high surface runoff and landslides/ debris flows throughout Boulder County. The rainfall totals during this event delivered 17 inches causing widespread flooding. In Four Mile Creek 8 inches of rain over this period and sustained approximately 1000 cfs causing localized flooding along the creek washing out roads and flooding homes.

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.

- **September 11, 2013:** Three days of rain saturated the ground prior to September 11, 2013, causing high surface runoff and landslides/ debris flows throughout Boulder County. The rainfall totals during this event delivered 17 inches causing widespread flooding. Goose Creek flooded homes and overtopped roads in the area.

Lefthand Creek

Significant flooding on Lefthand Creek occurred in 1864, 1876, 1894, 1896, 1918, 1921, 1938, 1949, 1951, 1963, 1969, 1973 and 2013. Details of some of these events follow:

- **June 1894:** Heavy rains combined with high spring runoff caused extensive flooding throughout Boulder County. Damage was extensive along Lefthand Creek, and bridges and roads were washed out. Buildings in Ward, Rowena, Glendale, and all the towns along James Creek (a tributary of Lefthand Creek) sustained heavy damage or were swept away. Damage to nearby mines was also extensive. Trees were uprooted, roads and railroads were destroyed, and 10 families lost homes. James Creek grew to a width of 250 feet at some locations. 8.5 inches of rain from May 30 through June 1 was reported in Ward.
- **August 1913:** Jamestown suffered extensive flood damage in August 1913. Flooding damaged or destroyed most of the houses along the creek. All wagon and footbridges were destroyed, and Jamestown was isolated for two weeks when the access road washed out.
- **June 2-6, 1921:** The maximum recorded rainfall was 5.3 inches and the greatest recorded rainfall intensity was 4.3 inches in six hours at Longmont. The storm lasted for five days. This flood was produced by a combination of rainfall and snowmelt. Although this storm caused overbank flooding, neither discharges nor damage were recorded.
- **September 3, 1938:** During this storm, showers were generally over the Lefthand Creek basin accompanied by isolated cloud bursts along the foothills and the lower elevations. A maximum peak discharge of 812 cfs was recorded at U.S. Highway 287 near Longmont.
- **June 4, 1949:** Heavy and prolonged rainfall, accompanied by runoff from snowmelt, caused overbank flooding on Lefthand Creek during May and early June. The high flow caused minor damage to

irrigation headworks, bridges, and farmlands. The peak discharge was 1,140 cfs.

- **August 3, 1951:** A heavy rainstorm occurred over the Front Range and foothills east of the Continental Divide from Boulder County to near Fort Collins, a distance of approximately 50 miles. One of the storm centers was on Lefthand Creek near the town of Niwot. At this storm center, total precipitation was unofficially reported to have been over six inches. Overbank flows occurred along most of the length of Lefthand Creek. Bridges, roads, crops, and irrigation structures were damaged.
- **May 7-8, 1969:** Three days of heavy snow and rain along with spring runoff caused a flood that damaged houses and businesses in Jamestown and caused major erosion damage to roads and bridges along James Creek. Peak discharge measurement on James Creek was 1,970 cfs. Precipitation totals of approximately eight inches were recorded in the James Creek Basin. The primary damage was done to the South Pratt Parkway Bridge, which was ultimately destroyed by the floodwater.
- **September 11, 2013:** Three days of rain saturated the ground prior to September 11, 2013 causing high surface runoff and landslides/ debris flows throughout Boulder County. The rainfall totals during this event delivered 17 inches causing widespread flooding. In Lefthand Creek over 10 inches of rain fell over this period and sustained approximately 8500 cfs causing flooding to homes, damage to the Lefthand Water District infrastructure and washing out roads. 1 person died in their home when a debris flow caused by the ground saturation and rainfall.

St. Vrain Creek

St. Vrain Creek flood history dates back to 1844. Flooding also occurred in 1864, 1876, 1894, 1914, 1919, 1921, 1938, 1941, 1949, 1951, 1957, 1969, 1973, 1976 and 2013. Over the course of 100 years, floods along the St. Vrain Creek have destroyed farmland, roads, and bridges.

- **May 1876:** The flood was severe, and much valley farmland was flooded.
- **May 31, 1894:** All of the lower parts of Lyons were washed away, and 20 houses were destroyed or ruined. The St. Vrain Valley looked like a lake three miles wide. Peak discharge was estimated at 9,800 cfs, which made it greater than a 50- year event.
- **August 2, 1919:** Bridges on the North St. Vrain for about a ten-mile stretch were destroyed. Longmont and Lyons water mains up the canyon were torn out in many places. People living on the lowlands along the banks of the St. Vrain were flooded out. Peak discharge was estimated at 9,400 cfs.
- **June 2, 1921:** North and South St. Vrain creeks carried large volumes of water. Damage was done to bridges, sheds, and barns. The peak discharge at Lyons of 2,020 cfs was not indicative of conditions at Longmont because of heavy rain downstream from Lyons. Longmont recorded 5.9 inches. No estimate of the discharge at Longmont is available.
- **September 1-4, 1938:** Precipitation for the three-day period totaled 4.5 inches at Longmont. The peak discharge at Lyons was only 1,650 cfs, while it was estimated to be 8,360 cfs near the mouth of the St. Vrain Creek. Highways were underwater, some bridges were washed out, and many residents near the creek were forced from their homes.
- **June 2, 1941:** Overbank flooding as a result of four inches of rain in the Longmont area caused damage or destruction of homes, businesses, bridges, roads, water lines, crops, livestock, and irrigation structures. The peak discharge was 10,500 cfs.
- **June 4, 1949:** All bridges between Longmont and Lyons were impassable when the St. Vrain peaked at 6,700 cfs. A total of 16 bridges were damaged. Two were completely destroyed. Irrigation headworks were extensively damaged. In Longmont, 10 homes and five businesses were flooded.
- **August 3, 1951:** Lyons received 6.3 inches of rain from a cloudburst, causing flooding from Lyons to the mouth of St. Vrain Creek. The peak discharge was 3,700 cfs at Lyons and 6,200 cfs at a point seven miles east of Longmont. Railroad and highway bridges near Longmont were severely damaged. The flood lasted for less than 12 hours. Severe damage resulted to Colorado Highway 7 along South St. Vrain Creek. In the rural areas downstream from Lyons, many grain stocks were washed from the fields.

- **May 8-9, 1957:** Three to five inches of rain fell over the entire St. Vrain basin, peaking at 3,060 cfs in **Lyons. Irrigation works and bridges between Lyons and Longmont were damaged or destroyed.**
- **May 4-8, 1969:** Three days of heavy snow and rain along with spring snow melt / runoff caused flooding which damaged two bridges in Lyons, 14 bridges outside of town, numerous town streets and other property. Highways 7 and 36 were closed. Roads and bridges along streams were damaged, stream banks were eroded, and farmlands were flooded. The peak discharge at Lyons was 2,900 cfs on May 7 and 10,300 cfs on May 8.
- **June 15-21, 1969:** Roads and bridges along the stream were extensively damaged, stream banks were eroded, and farmlands were flooded.
- **August 10, 1994:** approximately three inches of rain fell in a period of 30 minutes in Lyons. An urban flash flood resulted when the drainage system was unable to manage the large amounts of water. Damage to streets alone was $65,000. There were no reported deaths or injuries. The property damage was estimated at $213,000 and other damage to streets was $65,000. Highways 7 and 36 were closed as a result.
- **September 11, 2013:** Three days of rain saturated the ground prior to September 11, 2013 causing high surface runoff and landslides/ debris flows throughout Boulder County. The rainfall totals during this event delivered 17 inches causing widespread flooding. In the Saint Vrain Basin 17 inches of rain fell over this period and sustained approximately 25,000 cfs causing flooding to the Town of Lyons, Hygiene, and Longmont. 1 person died while evacuating their home.

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, 2013:** Three days of rain saturated the ground prior to September 11, 2013 causing high surface runoff and landslides/ debris flows throughout Boulder County. The rainfall totals during this event delivered 17 inches causing widespread flooding. In Twomile Canyon Creek, approximately 6-8 inches of rain fell over this period. Homes were damaged by flooding and landslides in the area, roads washed out and two people died when their car was washed away in the flood waters.

Miscellaneous

- **May 30, 1896:** Flooding occurred in Marshall and Boulder County caused by locally heavy thunderstorms. Estimated rainfall was 4.6 inches. Large hail was also present during the storm.
- **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 rainstorm 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 County streets and across University Hill lawns and sidewalks. Damage was estimated at $4,000 to roads, bridges, and culverts. 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 and more to the north and west of the County. 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 and primarily affected Fourmile and St. Vrain canyons. Numerous roads were partially or completely destroyed.
- **August 20, 1982:** An estimated 2.1 inches fell in Rollinsville, a considerable amount for such high elevation at 9,370 feet above mean sea level.
- **May of 1995:** Boulder County received record rainfall (9.4 inches) that combined with above average snowfall in the mountains and caused flooding throughout Boulder County. St. Vrain Creek in Lyons and Longmont as well as lesser streams throughout the County overflowed. 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 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 flooding was reported in Boulder County as was damage to the University Memorial Center at CU.

Probability of Future Occurrences

Since the County has a significant history of flooding, it is clear the potential exists for more flooding in the future. According to the NCEI database maintained by NOAA, there have been 37 reported incidents of flooding or flash flooding in the County since 1997. Some of these include the same event but reported for multiple cities, such as in the 2013 floods. However, this results in an average of approximately 1.5 flood events occurring somewhere in the County every year. Given this rate, the probability of future flooding occurrence is **likely**, considering the entirety of the planning area.

Magnitude/Severity

The magnitude and severity of floods is classified as **critical**, with significant threat to public safety, 25-50 percent of property severely damaged and the potential shutdown of facilities for at least two weeks. Severity of a flood event is determined by topography, precipitation, recent soil moisture conditions, degree of vegetation and impacts to people and property. These factors are then impacted by flood duration, depth, and flow-velocity rate. The greater the depth, the longer the duration and the higher flow-velocity rate, the increased likelihood of significant damages and loss of life.

Climate Considerations

In Colorado, half of the annual rainfall occurs in a short period of time; around 12 days of the year. With climate change, rainfall is expected to increasingly fall in a few concentrated days leading to more severe flooding. Drought and wildfires play a role in the impact of flood events. As the planet continues to warm, drought events will harden the soil and more frequent wildfires will remove water absorbers such as trees and vegetation. In turn, this will lead to more extreme flood events- especially as rainfall patterns become more variable. Cloudbursts are becoming more common as the climate changes. Warmer air means that more moisture can be held in the clouds which, in turn, leads to more rain. These extreme precipitation events quickly dump large amounts of water on smaller areas of land and are likely to lead to flash flood events.

Stratus Consulting produced the *Boulder County Climate Change Report* in 2012 and provided a general outlook on the expected effects of climate change on local natural systems and processes including those related to runoff and flooding. The report documented a seasonal shift in precipitation patterns with an increase in precipitation expected to fall between December through March and a decrease in precipitation in spring months of April and May. The report cites studies that suggest an increase in late winter and spring heavy precipitation events with two-year recurrence intervals and a decrease in events of similar recurrence intervals in the summer months. However, another study cited in the report suggests that precipitation events in the Front Range area with recurrence intervals of three years and greater will likely increase in intensity. The report summarizes the expected change in precipitation patterns by stating that research indicates a general decrease in event frequency but an increase in event intensity. It may be expected then, that more intense events will have the potential to affect areas beyond the acknowledged and regulated floodplains.

Ecological Considerations

Flooding can have both positive and negative impacts on the environment and ecosystems. On the positive side, floods are natural and aid in biological productivity and replenishing of rivers, streams and lakes. Ecological systems can also benefit communities and help to reduce flooding. For example, wetlands are valuable natural areas that protect wildlife and provide natural floodplain protection. They help to reduce flow rates and capture water and then slowly release it while also removing sediment brought in by floodwaters.

On the negative side, floods can lead to environmental degradation, erosion and sedimentation. Flash floods produce fast moving water that erodes away riverbanks and can bring pollutants and other debris into riverbeds, creating sediment deposits, polluting the water and potentially leading to huge debris removal efforts. Flash floods can also have negative impacts on small animals and those that burrow who are unable to escape quickly. They may bring human waste and litter into waterways, negatively impacting fish and other parts of the riverine ecosystem.

Overall Hazard Significance

Based on assessments of probability, risk to public safety and property, the overall hazard significance for flooding is **high**.

4.3.10 Hailstorm

Hazard	Geographic Extent	Probability/ Frequency	Magnitude/ Severity	Increased Threat (Climate Change)	Overall Significance
Hailstorm	Extensive	Likely	Limited	Moderate	Low

Description

Hail is associated with thunderstorms that can also bring high winds and tornadoes. It forms when updrafts carry raindrops into extremely cold areas of the atmosphere where they freeze into ice. Hail falls when it becomes heavy enough to overcome the strength of the updraft and is pulled by gravity towards the Earth

Hailstorms occur throughout the spring, summer, and fall in the County, but are more frequent in late spring and early summer. Hailstones are usually less than two inches in diameter and can fall at speeds of 120 mph.

Severe hailstorms can be quite destructive. In the United States, hail causes more than $1 billion in damage to property and crops each year. In 2005, hail and wind damage made up 45 percent of homeowners' insurance losses. Much of the damage inflicted by hail is to crops. Even relatively small hail can shred plants to ribbons in a matter of minutes.

Vehicles, roofs of buildings and homes, and landscaping are the other things most commonly damaged by hail. Hail has been known to cause injury to humans, and occasionally has been fatal.

Hail is a major cause of property damage in the plains just east of the Rockies. The past 30 years have brought one catastrophic hailstorm after another to the Front Range. One of these large storms occurred on July 11, 1990, when Denver took a direct hit by hail during a severe thunderstorm. Damage totals close to $600 million were reported—the greatest property losses from hail ever reported from one storm up to that time and one of the most expensive natural disasters to affect Colorado.

Colorado's Front Range is located in a region known as "hail alley" encompassing land from Texas up to North Dakota. This region is known for the highest amount of large hail in North America and as population continues to grow in Boulder County, so does the potential for more costly impacts from hailstorms. From 2017-2019, Colorado was ranked as the state with the second highest number of hail loss claims, just behind Texas.

Social Considerations

Hail causes significant damage to homes and vehicles. For low-income individuals, the quality of housing is often insufficient to handle a hailstorm. Cheaper construction materials such as vinyl siding are often used on mobile homes or in low-income housing. Although they help improve affordability, siding is easily damaged by hail and severe hailstorms can leave homes with siding and weak roofs looking like swiss cheese. Currently, Coloradans have the third fastest-rising homeowners insurance rates in the country.

Additionally, low-income vehicle-owners, homeowners and renters are often unable to afford insurance which can assist with repair from hail damage. As hailstorms are often difficult to predict, they are also difficult to avoid and very few alternative options are available to low-income members of the community.

Hailstorms also impact the agricultural sector. Local farms can go from having a field nearly ready to harvest to a field of completely destroyed crops in a matter of minutes. Hailstorms impact crops and hurt livestock leading to loss in revenue for local farms and impacting livelihoods of famers and agricultural workers.

Geographic Extent

Hailstorms can occur across broad regions that includes all sections of Boulder County. The geographic extent is **extensive**, with 50-100 percent of the planning area exposed to hailstorm impacts.

Previous 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

Table 4-7 Colorado's Most Costly Hailstorms

Date	Location	Cost When Occurred (Millions)	2020 Dollars (Millions)*
May 8, 2017	Denver Metro	$2.3 Billion	$2.4 Billion
July 20, 2009	Denver Metro	$767.6	$923.5
July 11, 1990	Denver Metro	$625.0	$1.23 Billion
June 6-15, 2009	Denver Metro	$353.3	$425
July 28, 2016	Colorado Springs	$352.8	$379.4
June 6-7, 2012	CO Front Range	$321.1	$360.9
June 13-14, 1984	Denver Metro	$276.7	$687.3
June 18-19, 2018	North Denver and Denver Metro	$276.4	$284
July 29, 2009	Pueblo	$323.8	$280
October 1, 1994	Denver Metro	$225.0	$391.8
September 29, 2014	Denver Metro	$213.3	$232.5
May 22, 2008	Windsor	$193.5	$231.9

Source: Rocky Mountain Insurance Information Association

Data from the NCEI and SHELDUS identified 109 hail events in Boulder County between January 1, 1955, and November 30, 2014, with hailstones at least one inch in diameter 65 times. Of these, the following hail events resulted in reported damage to people or property:

- **August 2, 1986:** Hailstones of 1.75 inches caused six injuries.

- **July 1989:** A storm caused hail damage in the City of Boulder and Lafayette.
- **July 1990:** A severe hailstorm caused massive hail damage, localized flooding, and rockslides on Highway 119 at the mouth of Boulder Canyon.
- **September 17, 1993:** Hailstones of 0.75 inches (in Lafayette) caused $5,000 in property damage.
- **July 12, 1996:** 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 County and northern Jefferson County. Damage estimates in the Broomfield area alone were approximately $1 million.
- **June 28, 2013:** Severe thunderstorms developed over the Front Range Foothill of Boulder, Larimer and Gilpin Counties; then spread east into the urban corridor and adjacent plains. Large hail, ranging from quarter to golf ball size, was reported. In addition, damaging thunderstorm winds snapped large branches and knocked down power lines.
- **May 2017:** Colorado was hit with its costliest hailstorm in history, a battery that triggered 267,000 claims in the Denver region and caused $2.3 billion in damages, according to the Rocky Mountain Insurance Information Association (RMIIA).
- **2018:** Colorado surpassed Texas as the costliest state for hail damage to homes and vehicles as reported by State Farm.
- **June 18, 2018:** Severe thunderstorm hit Boulder County with 1.25-inch hail causing 1.3 million dollars in agricultural losses and personal property beyond reported losses.
- **July 07, 2019:** A severe thunderstorm was located 5 miles northeast of sunshine, or 30 miles northwest of Denver, moving east at 10 mph (radar indicated). Hazards include quarter size hail. Damage to vehicles is expected. Locations impacted include northern Boulder and Niwot.

Probability of Future Occurrences

Probability of future occurrence is classified as likely, with 10-100 percent chance of occurrence within a range of severity in the next year.

Magnitude/Severity

Based on the definitions established for this plan, magnitude and severity is classified as **limited**, with 10-25 percent of property, agricultural crops and natural resources potentially damaged and a limited history of public safety impacts.

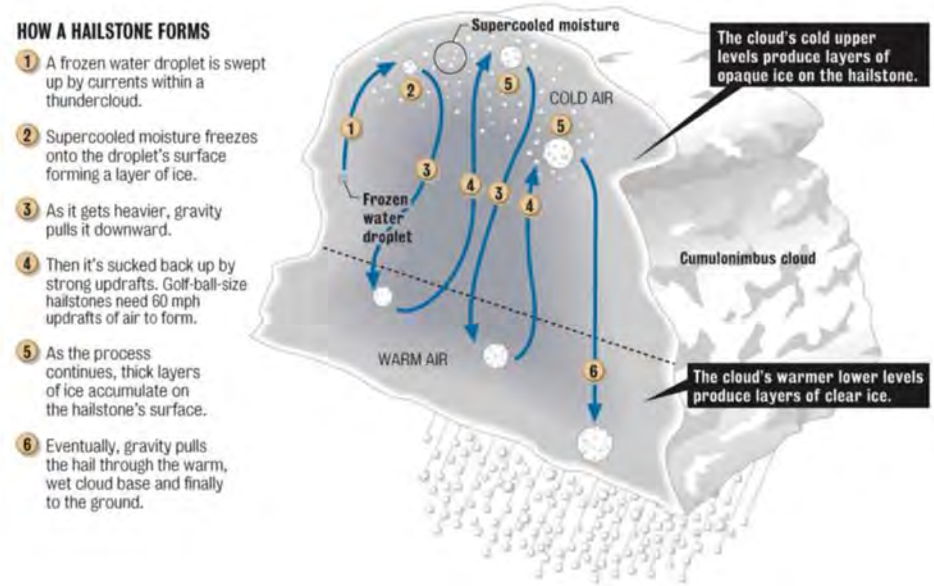
Climate Considerations

Hailstorms are increasing in frequency in the United States. Currently, hailstorms account for 70 percent of insured loss from severe storms, mostly for roof and siding replacements. One reason insurance claims are increasing is that population is increasing thus, providing more buildings and infrastructure as targets. Climate change is likely to impact thunderstorm clouds which, in turn, will likely impact hailstone formation. Warmer temperatures are likely to impact the strength of updrafts leading to the development of storms that can create larger hailstones. In lower laying areas, warmer temperatures may help to melt hailstones before they can cause damage however, in Boulder County and the rest of the Front Range, the combination of high altitude and dry air makes it more likely that hailstorms will increase in size and impact as average global surface temperatures continue to climb.

In addition to likelihood of more hailstorms, hailstone sizes have also been increasing. In 2018, there were hundreds of reports of hail larger than 2 inches in diameter, primarily from states in “hail alley”. As the Boulder County region becomes warmer and moister with climate change, storms will have more moisture availability which is likely to lead to increase in average hail diameter along with increase occurrences.

Figure 4-19 Increase in Size of Hailstones

Source: Storm Prediction Center. Chart Colorado State CC-BY-ND



Source: National Severe Storms Laboratory (NSSL)

Ecological Considerations

Hailstorms can harm animals, birds, plants, trees, and crops. Storms that produce hail tend to damage trees and vegetation that are unprotected from the intense impact. However, once hail melts, it has similar impacts as rainwater and is good for the soil, streams, and water bodies.

Overall Hazard Significance

Based on assessments of probability, risk to public safety and property, the overall hazard significance for hailstorms is **high/medium**.

4.3.11 Landslide/Mud and Debris Flow/Rockfall

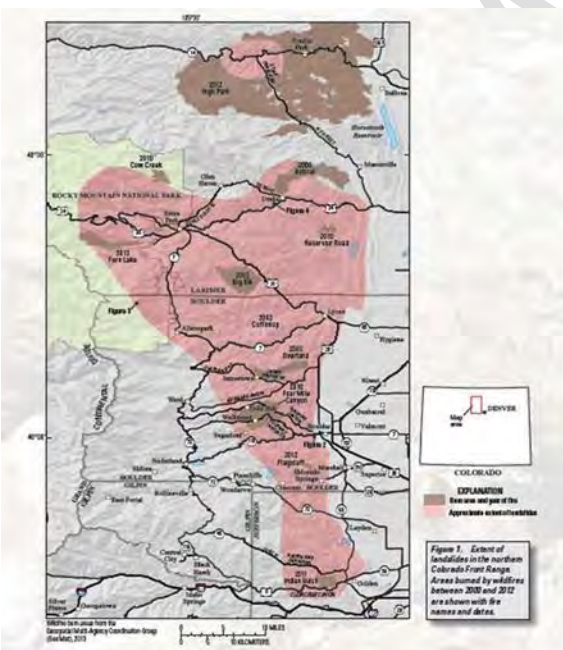
Hazard	Geographic Extent	Probability/ Frequency	Magnitude/ Severity	Increased Threat (Climate Change)	Overall Significance
Landslide	Limited	Occasional	Limited	Substantial	High

Description

Landslide

A landslide is a general term for a variety of mass-movement processes that generate a downslope movement of soil, rock, and vegetation under gravitational influence. Some of the natural causes of ground instability are stream and lakeshore erosion, heavy rainfall, and poor-quality natural materials. In addition, many human activities tend to make the Earth materials less stable and, thus, increase the chance of ground failure. Human activities contribute to soil instability through grading of steep slopes or overloading them with artificial fill, by extensive irrigation, construction of impermeable surfaces, excessive groundwater withdrawal, and removal of stabilizing vegetation. Landslides typically have a slower onset and can be predicted to some extent by monitoring soil moisture levels and ground cracking or slumping in areas of previous landslide activity.

Figure 4-20 Extent of Landslides in CO Front Range



Mud and Debris Flow

According to the CGS, a mudslide is a mass of water and fine-grained earth materials that flows down a stream, ravine, canyon, arroyo, or gulch. If more than half of the solids in the mass are larger than sand grains-rocks, stones, boulders—the event is called a debris flow. A debris fan is a conical landform produced by successive mud and debris flow deposits, and the likely spot for a future event.

The mud and debris flow problem can be exacerbated by wildfires that remove vegetation that serves to stabilize soil from erosion. Heavy rains on the denuded landscape can lead to rapid development of destructive mudflows.

Rockfall

A rockfall is the falling of a detached mass of rock from a cliff or down a very steep slope. Weathering and decomposition of geological materials produce conditions favorable to rockfalls. Rockfalls are caused by the loss of support from underneath through erosion or triggered by ice wedging, root growth, or ground shaking. Changes to an area or slope such as cutting and filling activities can also increase the risk of a rockfall. Rocks in a rockfall can be of any dimension, from the size of baseballs to houses. Rockfall occurs most frequently in mountains or other steep areas during the early spring when there is abundant moisture and repeated freezing and thawing. Rockfalls are a serious geological hazard that can threaten human life, impact transportation corridors and communication systems and result in other property damage. Due to the Fourmile Canyon Fire in 2010, there is an increased risk of debris flows in Fourmile Canyon.

Spring is typically the landslide/rockfall season in Colorado as snow melts and saturates soils and temperatures enter into freeze/thaw cycles. Rockfall and landslides are influenced by seasonal patterns, precipitation and temperature patterns. Earthquakes could trigger rockfalls and landslides too.

Social Considerations

Similar to flooding, landslides and mudslides are natural disasters that are covered by flood insurance policies from the NFIP. Minimizing impacts from landslides and mudslides requires investments in land stabilization and infrastructure. Although most heavily populated areas in Boulder County are not at high risk of landslides and rockfall, insurance and proactive mitigation on personal property are expenses that low-income people are unable to afford.

Geographic Extent

This hazard is most prevalent in the foothills of western Boulder County, particularly in the canyons that dissect the region, most of which have County roads or State highways running through them, and some residential development. Developed areas with rockfall potential include Eldorado Springs and sections of Boulder Canyon. Areas of recent wildfire burns are susceptible to debris flow. These areas include the Black Tiger Fire burn area in Boulder Canyon and the Overland Fire area near Jamestown. Rock fall and debris flows can impact foothills transportation corridors from Lyons to Allenspark, Boulder to Nederland, and Ward to Jamestown, and along the Peak to Peak highway (Highways 7, 72, 36, 119, and 72).

The Colorado Landslide Hazard Mitigation Plan, developed in 1988 and updated in 2002, identified 49 areas in Colorado where landslides could have the "most serious or immediate potential impact on communities, transportation corridors, lifelines, or the economy." One area in Boulder County was identified from the Black Tiger wildfire in 1989. The Fourmile Canyon Fire burn area from September 2010 is also a high-risk area for debris flows, rockfalls and erosion. The wildfire leaves the potential for debris flows, rockfalls and extreme erosion in the area around the fire. Minor landslides will likely continue in susceptible areas as a result of post-fire conditions or when heavy precipitation occurs.

The underlying geology in the steeper slopes of western Boulder County is generally granitic bedrock, and thus resistant to landslide issues, but can be prone to rockfall. Based on assessments of the potential area affected by landslide, debris flow and rockfall, geographic extent is considered **limited**, with less than 10 percent of the planning area prone to occurrence. It should be noted however that when this hazard causes road closures, the overall area affected indirectly can be much larger than the slide area itself.

Previous Occurrences

On September 11, 2013, 1 person died due to debris flow /landslide caused by ground saturation and rainfall over the burn scar above Jamestown. During the 2013 flood over 800 landslides occurred in Boulder County alone. Damage to structures, infrastructure and highways occurred as a result of landslides. In

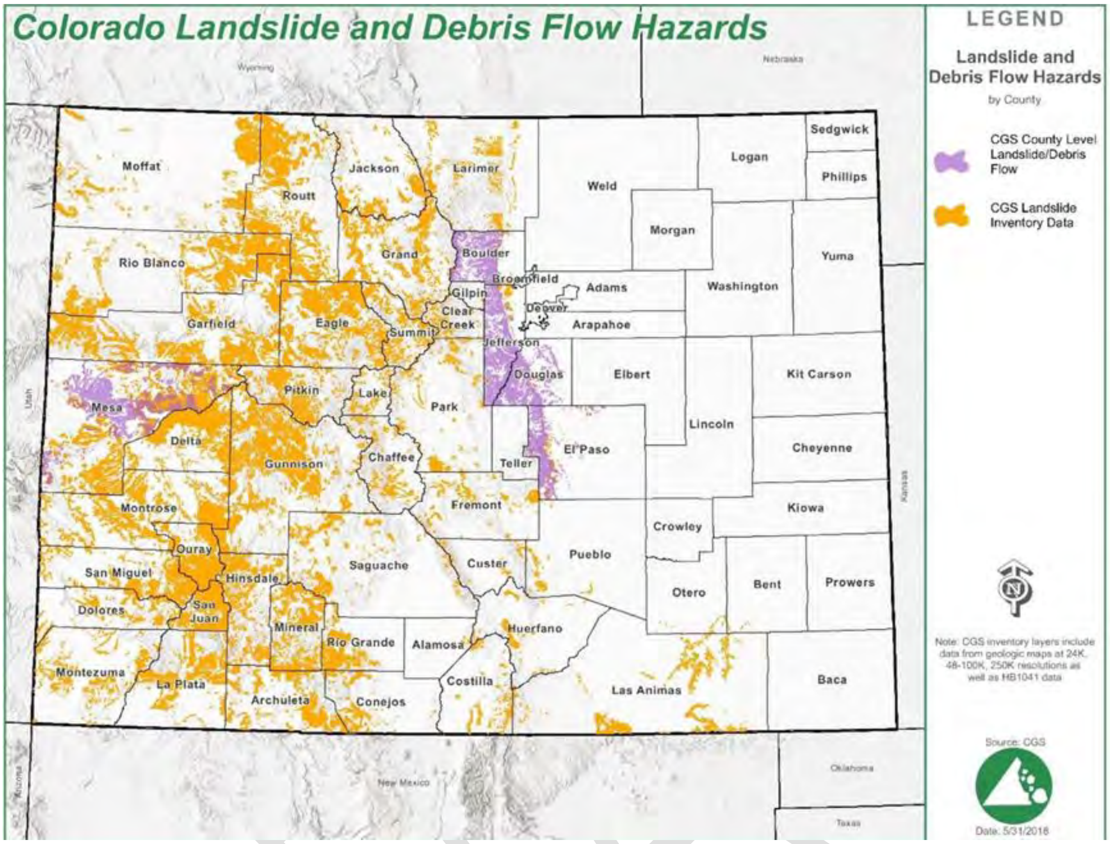
addition, landslides during inundation events also exacerbates flash flooding due to damming of canyons holding back large creeks creating devastating hydraulic forces. Development in areas vulnerable to landslides increases the potential for destructive landslides and rockfalls. Most historical landslides that have occurred in Boulder County 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.

According to an HMPC team member from the Town of Jamestown, multiple landslides occurred as a result of unstable soil in a burn area from the Overland fire. The landslides occurred between the burn area and James Creek on June 23, 2004, July 23, 2004, July 29, 2004, July 25, 2005, and July 20, 2006. County Road 94 was closed due to the mudslides. The damage to culverts and channels could exceed $150,000 before the soil stabilizes. Mudslides are expected to continue over the next 5 to 10 years. Property damage mitigation costs have been $80,000 to $100,000 to date.

According to a newspaper article from the Daily Camera in the mid-1990's (exact date unknown) a boulder the size of a Volkswagen impacted a home in the unincorporated community of Eldorado Springs. No one was injured in the incident.

In July 1990 a severe hailstorm caused massive hail damage, localized flooding and rockslides on Highway 119 at the mouth of Boulder Canyon. Most recently, on July 20, 2006 heavy rain in the Overland burn area caused minor flash flooding in Jamestown. The roads behind the Jamestown Fire Hall were washed out when a culvert became blocked with debris. A rockslide was also reported in the town.

Figure 4-21 Colorado Landslide and Debris Flow Hazards



Source: State of Colorado Hazard Mitigation Plan

Probability of Future Occurrences

Based on patterns of previous occurrences, future probability of landslide/debris flow/rockfall occurrence is classified as **occasional**, with a 1-10 percent chance of occurrence in the next year. However, with population increases, the State of Colorado Hazard Mitigation Plan recently classified Boulder County growth risk rating for landslides as **severe**.

Magnitude/Severity

Based on the definitions established for this plan, magnitude and severity is considered **limited**, with 10-25 percent of property severely damaged and/or shutdown of facilities for more than one week. Landslide severity is often determined by the amount of soil, debris and rocks that are transferred and where that transfer stops (e.g. on a transportation route versus a natural space). Landslides and mudslides are hard to predict and often occur without warning. They tend to have long-term impacts that impact access, utilities and mobility due to difficulty in debris removal along impacted areas.

Climate Considerations

Landslides often result from intense rainfall events that cause runoff. Climate change is expected to increase the intensity of heavy precipitation events leading to a potential increase in landslide frequency. The combination of drier and warmer days which increase the likelihood of wildfires and drought along with more extreme rainfall events is an unfortunate recipe for more landslides and mudslides.

The impact of climate change on the wildfire season means Boulder County is likely to experience more frequent and larger wildfires. Wildfires remove soil stabilizing vegetation and burn soil surfaces which leads to more rainfall runoff. Wildfires are also likely to create more debris which will be carried into Boulder County communities and transportation routes from landslides and mudslides.

Ecological Considerations

Landslides and rockfall are natural environmental occurrences. Many of Colorado's landslides occur in remote areas impacting the natural ecosystems. These impacts are often difficult to measure and document however, in most cases landslides contribute to biodiversity and play a role in sediment transfer; although they wipe out entire areas, this is an essential for ecosystem services.

However, even landslides in remote areas can have negative impacts to Boulder County and the natural resources the County depends on. Landslides can pollute waterbodies with sediment while also having the potential to dam up streams and rivers. Landslides and mudslides can also wipe out entire tracts of land impacting forests, soils and killing wildlife habitat. As humans continue to alter the landscape and the state continues to warm, landslides are likely to occur more often which can lead to the inability of natural systems to regenerate.

Overall Hazard Significance

Based on assessments of probability, public safety risk and the potential for property and/or infrastructure damage, the overall hazard significance for landslide/debris flow/rockfall is **high/medium**.

4.3.12 Lightning

Hazard	Geographic Extent	Probability/ Frequency	Magnitude/ Severity	Increased Threat (Climate Change)	Overall Significance
Lightning	Extensive	Likely	Limited	Moderate	Medium

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, similar to a cloud-to-ground flash, can be visible for many miles.

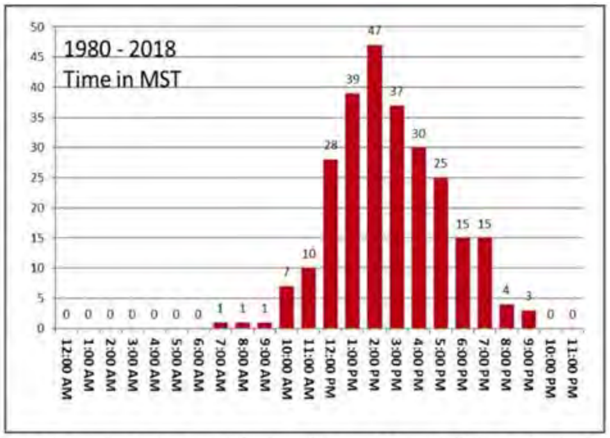
Although not as common, cloud-to-ground lightning is the most damaging and dangerous form of lightning. Most flashes originate near the lower-negative charge center and deliver negative charge to Earth. However, a large minority of flashes carry positive charge to Earth. These positive flashes often 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.

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.

Boulder County implemented the use of lightning software to monitor lightning occurrences in the County.

All Fire Departments and Districts were trained in July 2012 on the use of the software and provided a username and password to access it. This enables Fire Departments and Districts to monitor cloud-to-ground strike within their jurisdictions and respond as they see appropriate, given the fire conditions.

Social Considerations



The chart above shows the time when lightning casualties occurred in the state of Colorado. Data since 1980.

Lightning does not necessarily impact one group of people more than others however, there are a few elements to consider regarding social equity and lightning. First, certain members of the population rely on constant power for their health and well-being. This is especially true of the elderly population and people with disabilities who may rely on respirators or special equipment and would be disproportionately impacted from prolonged power outages.

Second, BIPOC and low-income families are more likely to live in lower quality housing conditions. Although there are retrofits and measures that people can take to reduce impact from lightning strikes on their homes, these alterations require licensed contractors and funds. Home protection systems range from installing small things like surge protectors to large items like highly conductive copper and lightning rods. Impacts on property from lightning are often covered by homeowners and renter’s insurance however insurance is often too costly for low-income residents. Additionally, mobile homes, where many low-income residents reside, can be more dangerous places to be in lightning storms.

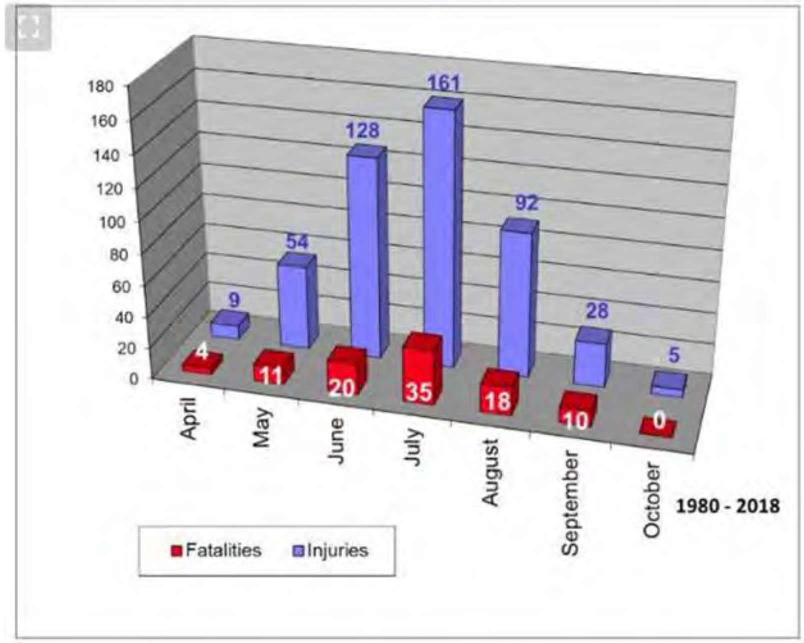
Lastly, lightning strikes to humans are rare however, if struck, those who survive often suffer from lasting impacts such as dizziness, memory loss, numb limbs and weakness. Cardiac arrest and severe burns are other outcomes from humans being struck by lightning.

Geographic Extent

Lightning can potentially impact any portion of Boulder County, though isolated peaks and other points of high elevation relative to their surroundings are at increased probability of direct impact. It should also be noted that power outages caused by lightning strikes can affect a much broader region beyond the location of the lightning strike or storm.

Therefore, geographic extent is classified as extensive, with 50-100 percent of the planning area at risk from lightning and its affects.

Previous Occurrences



Lightning strikes by month. Media and Data Credit: National Weather Service.

Data from the National Lightning Detection Network ranks Colorado 31st in the nation (excluding Alaska and Hawaii) with respect to the number of cloud-to-ground lightning flashes with an average number of 517,217 flashes per year (based on data collected between 1996 and 2005). Boulder County has an average of 3,500 flashes per year. According to the NWS, an average of 62 people are killed each year by lightning in the United States. In 2012, only one person was injured by lightning in Colorado. In an average year, 3 people in the Centennial State are killed by lightning and 13 are injured (1980-2012 data). 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.

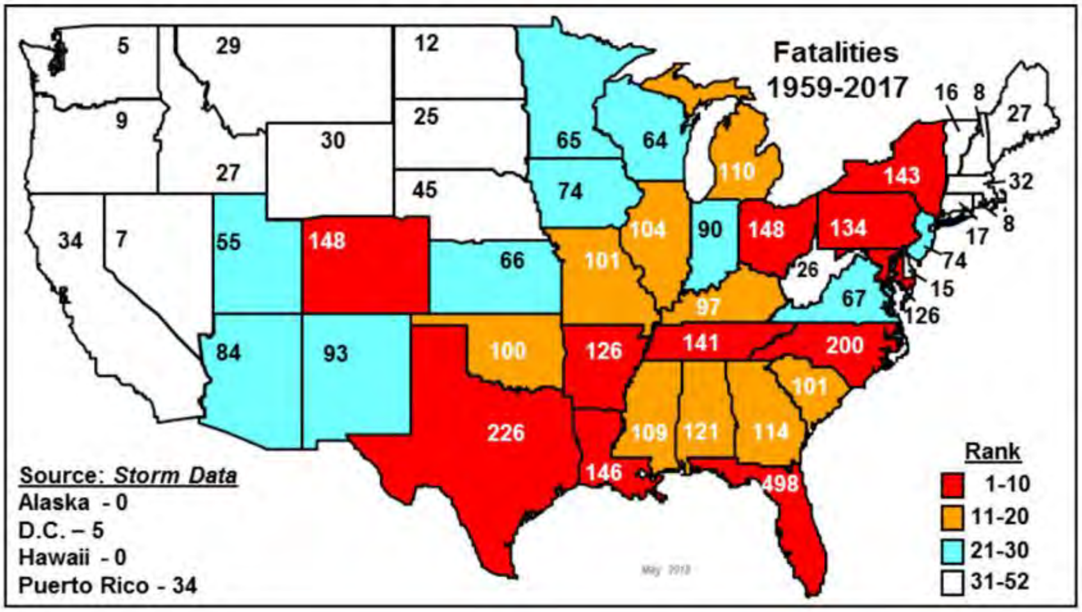
U.S. lightning statistics compiled by the National Oceanic and Atmospheric Administration between 1959 and 1994 indicate that most lightning incidents occur during the summer months of June, July, and August and during the afternoon hours from between 2 and 6 p.m. Figure 4-23 shows state-by-state lightning deaths between 1959 and 2017. Colorado ranks in the top ten percentile with 148 deaths.

Table 4-8 National Weather Service 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.

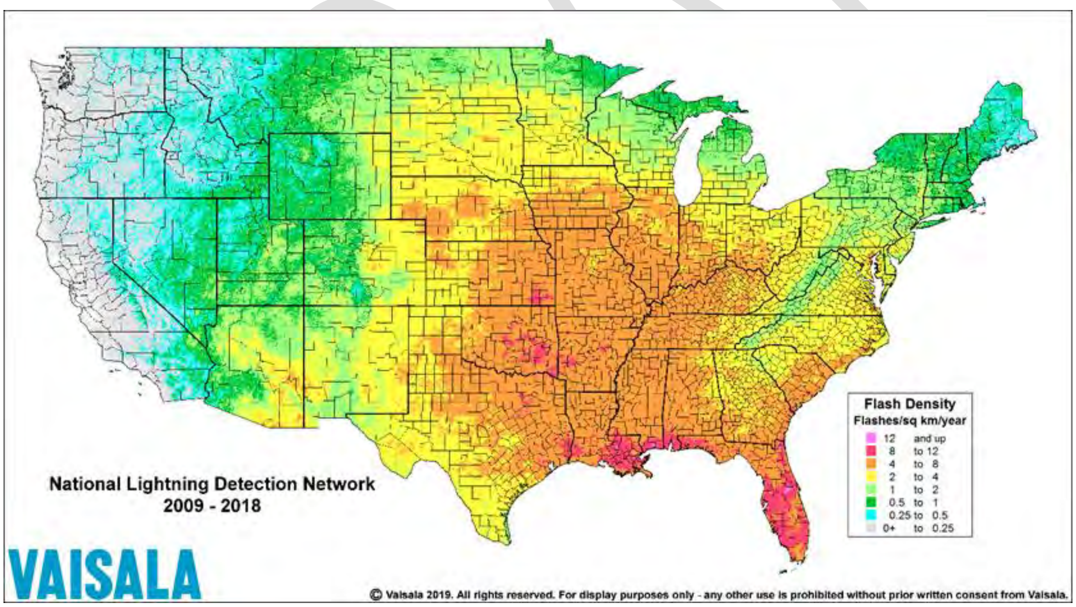
Source: NWS

Figure 4-22 Lightning Fatalities by State, 1959 - 2017



Source: NWS, http://www.lightningsafety.noaa.gov/stats/03-12_deaths_by_state.pdf

Figure 4-23 Average Lightning Flash Density in the United States



Source: https://www.weather.gov/pub/lightningFlashDensityMaps

Table 4-9 contains information from the NWS on lightning casualties in Boulder County:

Table 4-9 Lightning Casualties in Boulder County, 1980-2019

Date	Time	Killed	Injured
June 27, 1980	2:12 p.m.	0	4

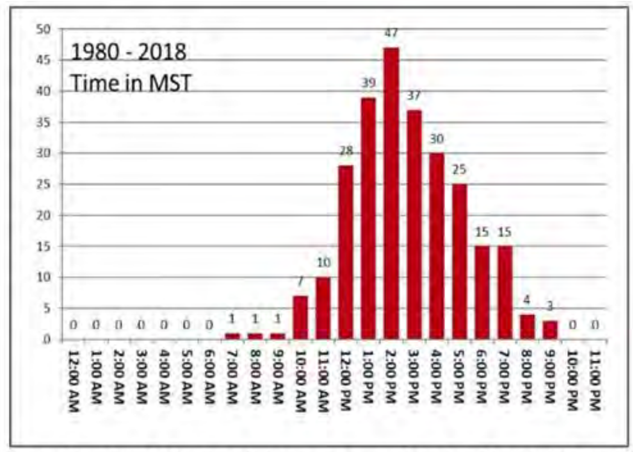
Date	Time	Killed	Injured
June 3, 1981	12:00 p.m.	1	2
August 22, 1981	Morning	0	2
August 5, 1983	Evening	0	1
July 2, 1987	5:34 p.m.	0	4
August 7, 1987	7:30 p.m.	0	1
June 25, 1988	3:30 p.m.	1	1
August 19, 1989	12:35 p.m.	1	1
June 13, 1991	2:00 p.m.	0	1
August 30, 1992	11:30 a.m.	0	1
June 27, 1995	3:30 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 p.m.	0	1
July 7, 2018	1:30 p.m.	1	
July 14, 2019	1200		1
Totals		5	31

Source: NWS, http://www.crJ.noaa.gov/pub/?n=/ltg/county_stats_1.php

According to the State of Colorado Natural Hazards Mitigation Plan, a study determined that one out of 52 lightning flashes results in an insurance claim. Data from the NCEI and SHELDUS identified 40+ lightning events in Boulder County between January 1, 1993, and November 30, 2014 (note: since this data is from a different source, it does not track exactly with the incidents reported in Table 4-9). The 17 lightning events that resulted in death/injury and/or property damage are detailed below:

- **May 15, 1993, 4:00 p.m.:** Lightning resulted in property damage of $5,000.
- **May 27, 1993, 2:55 p.m.:** Lightning resulted in property damage of $5,000 (Lyons).
- **May 31, 1994, 6:00 p.m.:** Lightning resulted in property damage of $1,000 (Louisville).
- **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 damage to building and contents).
- **June 2, 1995, 11:10 a.m.:** Lightning resulted in property damage of $5,000 (Nederland).
- **June 2, 1995, 5:30 p.m.:** Lightning resulted in property damage of $20,000.
- **June 27, 1995, 3:30 p.m.:** Lightning resulted in one injury (Longmont).
- **September 14, 1996, 5:00 p.m.:** Lightning resulted in property damage of $7,000 (West Longmont).
- **June 5, 1997, 2:00 p.m.:** Lightning resulted in one injury (Nederland).
- **June 7, 1997, 12:00 p.m.:** Lightning resulted in one injury (Ward).
- **June 19, 1997, 2:04 p.m.:** Lightning resulted in one injury (Broomfield).
- **July 10, 2000, 3:40 p.m.:** Lightning resulted in three injuries.
- **July 12, 2000, 2:00 p.m.:** Lightning resulted in one death (Allenspark). (A climber was struck and killed by lightning as he and a companion were ascending a sheer rock face near the summit of Longs Peak).

- **July 24, 2000, 3:00 p.m.:** Lightning resulted in two injuries (Longmont).
- **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.
- **June 22, 2006:** Lightning kills a motorcyclist on Highway 36
- **May 21, 2007, 2:00 p.m.:** Lightning resulted property damage of $5,000. The 15,000-gallon fuel tank, which stored diesel gas for farm equipment, was also struck. The explosion shot the tank an estimated 150 feet in the air and it landed approximately 400 feet from its original location.
- **June 26, 2012:** Flagstaff Fire – Lightning caused a fire that threatened residences and the City of Boulder. Total cost to fight the blaze was 1.9 million.
- **July 7, 2018:** 1 person injured from a lightning strike while camping off the Peak to Peak Hwy.
- **July 17, 2019:** person was killed and one injured from a lightning strike while hiking on Bear Peak West Ridge Trail.



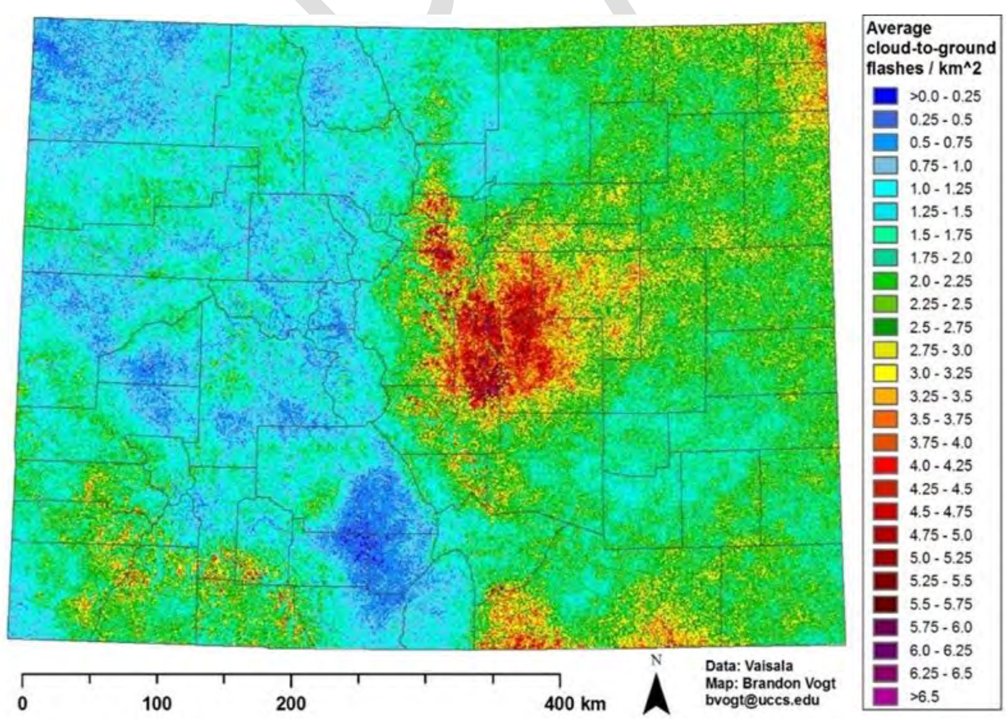
The chart above shows the time when lightning casualties occurred in the state of Colorado. Data since 1980.

Also, according to an HMPC team member from Lyons, lightning caused a three-hour electric power outage on August 10, 1994 in Lyons. This was in conjunction with heavy rain and high winds.

Probability of Future Occurrences

Based on patterns of previous occurrences, the future probability for damaging lightning strikes is classified as **likely**, with a 10-100 percent chance of occurrence in the next year.

Figure 4-24 Colorado Lightning Flash Density Map



Source: NWS Denver

Magnitude/Severity

Based on the definitions set forth in previously, the magnitude and severity of lightning is classified as **limited**, with 10- 25 percent of property severely damaged and/or shutdown of facilities for more than one week.

Climate Considerations

According to Colin Price, author of *Thunderstorms, Lightning and Climate Change*, "The distribution of lightning around the planet is directly linked to the Earth's climate". In his book, Price identifies that climate change is likely to increase the number of intense thunderstorms which will lead to an "increase in the amount of lightning by 10% for every one-degree global warming". Scientists have started to document changes in lightning frequency as the climate changes. As average global surface temperatures increase, it is likely that there will be more intense thunderstorms, more frequent lightning strikes, and more wildfires ignited by lightning strikes.

Another key component to keep in mind is that lightning plays more than one role in climate change. Lightning produces nitrogen oxides which are strong greenhouse gases. As lightning strikes increase so will the production of greenhouse gases, further impacting the rate of warming on the planet and impacting air quality.

Ecological Considerations

Lightning is a natural environmental process. It leads to wildfires and other environmental impacts such as vaporizing water inside a tree that can blow it apart. It has not been proven to have severe negative impacts on ecological systems and in some cases has been shown to help to dissolve unusable nitrogen in water which does create natural fertilizer for plants.

Overall Hazard Significance

Overall hazard significance is considered **medium**, due to risk to public safety, threat to facilities, power outages and property and natural resource damage caused by fire ignitions or direct strike.

4.3.13 Subsidence

Hazard	Geographic Extent	Probability/ Frequency	Magnitude/ Severity	Increased Threat (Climate Change)	Overall Significance
Subsidence	Significant	Likely	Limited	Moderate	Medium

Description

The CGS 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.

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 high 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.

Room and pillar mining was the mining technique used almost exclusively in early Colorado mining. In the room and pillar technique, a shaft or adit was driven or dug to the layer of coal. Passageways were excavated in the coal seam and openings, or rooms of coal were dug out on either wide of the tunnel. Between the rooms, pillars of coal were left in place to support the roof of the mine. When the coal be "ran out", the miner's started to "pull pillars" at the back of the mine. Ideally, pillars were removed until the roof started to cave in and settle. In reality, pillars were not always removed in a systematic manner and many pillars were left to support the roof.

In some cases, coal was "poached" or more coal was removed from an area than would be noted on the mine map. Also, many mines were dislocated relative to surface features due to surveying errors. Consequently, the precise location and extent of underground mines can be difficult to determine. The possible inaccuracies in mining records and the ability to determine present mine conditions combine to make subsidence resulting from room and pillar mining unplanned and unpredictable.

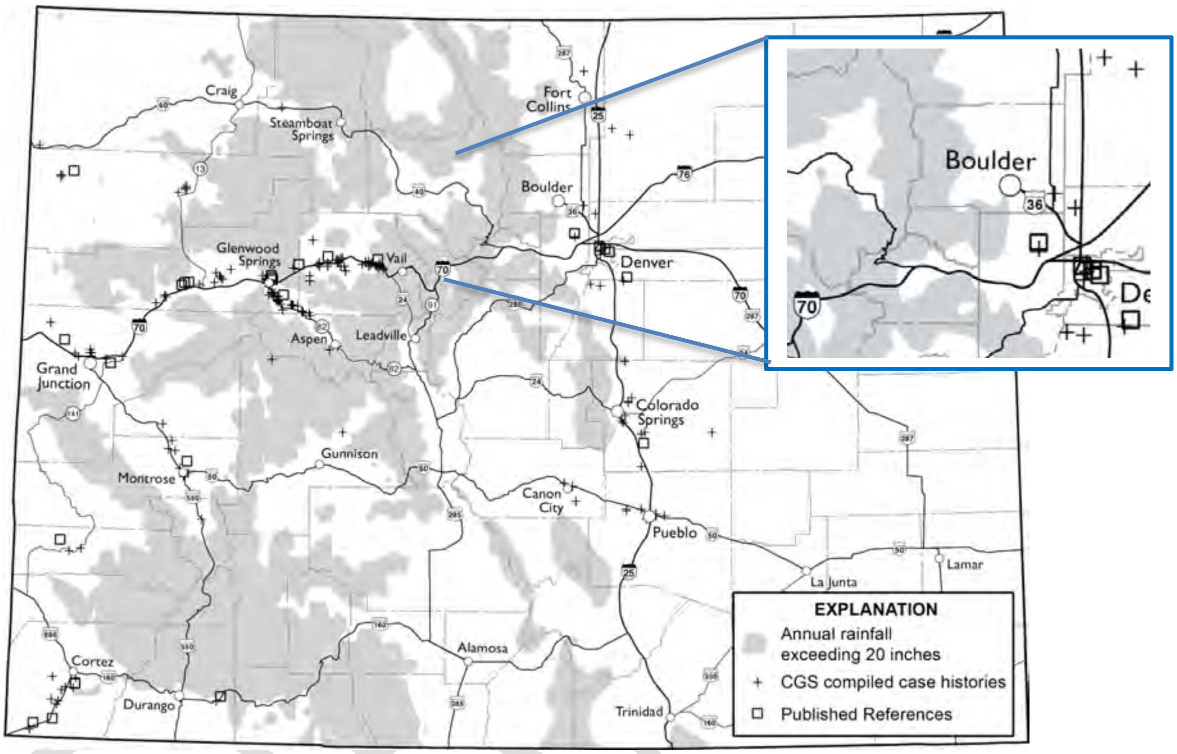
Social Considerations

Land subsidence is typically caused by human activities such as removal of subsurface water and underground mining. Subsidence has serious consequences from small sinkholes to entire sections of land disappearing. Subsidence has the ability to weaken, damage or even destroy structures and infrastructure. In BIPOC and low-income neighborhoods, infrastructure and buildings tend to be in worse shape and suffer from years of neglect and lack of maintenance. Impacts from land subsidence are threats to human safety and well-being but the most likely impact is the damage to already weak infrastructure and buildings in underinvested areas. The impact of not having sewer, power, and water services for a period of time or not having the money to repair a home or elements on personal property is how land subsidence inequitable impacts low-income and BIPOC communities.

Geographic Extent

Based on information included in the state hazard mitigation plan, a substantial area within Boulder County is a major mining district and a portion of the southeastern county is a coal region. As previously noted, there is a direct correlation with areas of current or previous coal production and land subsidence. Specifically, Figure 4-25 and Figure 4-26 below indicate an area in the southeast section of the County where coal deposits and/or abandoned coal mines are located. Based on the size of these areas relative to the County overall, the geographic extent of land subsidence is considered **significant**, with 10-50 percent of the planning area affected.

Figure 4-25 Collapsible Soil Event in Colorado



Source: CGS

Figure 4-26 Coal Deposits by Region, State of Colorado

Source: Subsidence above Inactive Coal Mines

Figure 4-27 Locations of Inactive Coal Mines, State of Colorado

Source: Subsidence above Inactive Coal Mines

These maps display the Boulder-Weld Coal Field in the southeastern area of Boulder County and identify the land most at risk of mine subsidence.

Previous Occurrences

Records of previous subsidence occurrences are difficult to track, as there is no coordinating or monitoring agencies for this hazard. The CGS manages the Colorado Mine Subsidence Information Center (MSIC) which houses maps and data about abandoned coal mines throughout the state however, there is not monitoring conducted at this time. A recent event in fall of 2007 involved the closure of a sunken road due to a coal mine collapse near the town of Erie. A 1986 study on land subsidence in southeastern Boulder County conducted by the State of Colorado Department of Natural Resources Mined Land Reclamation Division found evidence of 595 subsidence occurrences across a 50 square mile study area. The report also found extensive evidence of wall and foundation damage in a survey of homes in the Lafayette and Louisville area, directly attributed to undermining from abandoned coal shafts.

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.

Probability of Future Occurrences

Based on patterns of previous occurrence and the numerous locations of abandoned coal mines in the planning area, probability of future occurrence is considered **likely**, with a recurrence interval of significant impacts estimated at 10 years or less.

Magnitude/Severity

Magnitude and severity of land subsidence is classified as **limited**, with 10-25 percent of property at risk of severe damage.

Climate Considerations

More intense rainfall and drought events from climate change are likely to have an impact on land subsidence. Subsidence related to groundwater withdrawal is more common in areas with a mix of dense urban space, oil and gas extraction, mining, and agricultural uses. In Boulder County, most subsidence is likely to be related to more intense rainfall and population growth in high-risk areas.

Ecological Considerations

Sinkhole subsidence is more likely to have negative environmental impacts. As subsidence is due to the extraction of minerals from underground mines, much of the environmental degradation is related to the initial extraction. However, subsidence can impact hydrogeology, vegetation and animals, water and streams and agriculture. Dangerous gases may leak from mines impacting the roots of trees and plants as well as soils quality. Leaking of the underlying strata also can impact surface water bodies and water systems leading to contamination of streams, rivers and lakes.

Overall Hazard Significance

Based on assessments of probability, geographic extent and magnitude/severity, the overall hazard significance of land subsidence is considered **medium**, with moderate potential impact.

4.3.14 Tornado

Hazard	Geographic Extent	Probability/ Frequency	Magnitude/ Severity	Increased Threat (Climate Change)	Overall Significance
Tornado	Significant	Likely	Limited	Low	Medium

DESCRIPTION

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 less than 300 yards wide. Closely associated with tornadoes are funnel clouds, which are rotating columns of air and condensed water droplets that unlike tornadoes, do not make contact with the ground.

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 takes into account the materials affected and the construction of structures damaged by a tornado. Table 4-10 shows the wind speeds associated with the original Fujita scale ratings and the damage that could result at different levels of intensity. Table 4-11 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 4-10 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 4-11 Enhanced Fujita Scale

Enhanced Fujita (EF) Scale		
Category	**Wind Speed (mph)**	**Potential Damage**
EF0	65-85	Light damage: Peels surface off some roofs; some damage to gutters or siding; branches broken off trees; shallow-rooted trees pushed over.
EF1	86-110	Moderate damage: Roofs severely stripped; mobile homes overturned or badly damaged; loss of exterior doors; windows and other glass broken.
EF2	111-135	Considerable damage: Roofs torn off well-constructed houses; foundations of frame homes shifted; mobile homes completely destroyed; large trees snapped or uprooted; light-object missiles generated; cars lifted off ground.
EF3	136-165	Severe damage: Entire stories of well-constructed houses destroyed; severe damage to large buildings such as shopping malls; trains overturned; trees debarked; heavy cars lifted off the ground and thrown; structures with weak foundations blown away some distance.
EF4	166-200	Devastating damage: Well-constructed houses and whole frame houses completely leveled; cars thrown, and small missiles generated.
EF5	>200	Incredible damage: Strong frame houses leveled off foundations and swept away; automobile-sized missiles fly through the air in excess of 100 m (109 yds.); high-rise buildings have significant structural deformation; incredible phenomena will occur.

Source: National Oceanic and Atmospheric Administration Storm Prediction Center

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.

Social Considerations

In a 2017 study published in Regional Science and Urban Economics, researchers found that social inequity and poverty increase the likelihood of people being killed by a tornado. Lower-income people are more likely to be impacted by tornadoes due to the fact that many live in manufactured homes and lack tornado shelters or basements. The death rate of people living in manufactured homes is nearly 20 times higher than site-built homes. Additionally, tornado warnings typically provide very little time for people to prepare and evacuate. For families without access to their own modes of transportation or for less able-bodied individuals, the likelihood of enduring a tornado event at home is much more likely.

Geographic Extent

While the potential for tornado occurrence is present throughout the planning area, probability is significantly higher for the eastern sections of the County. Based on this the geographic extent of tornadoes is classified as **significant**, with 10- 50 percent of the planning area potentially affected.

Previous Occurrences

According to the Denver Museum of Nature and Science, Colorado's tornado activity rivals that of Tornado Alley. Nevertheless, Colorado tornadoes tend to be small, short-lived, and relatively weak as compared with tornadoes in the plains states. Statistics indicate that Colorado tornadoes last only a few minutes, are generally only about 100 yards in diameter at the surface and have an average path length of 1½ miles. Wind speeds appear to average 100 mph or less.

According to the NCEI, Colorado ranks 7th among all U.S. states for the frequency of tornadoes, with an average of 53 per year. Tornadoes in Boulder County are rare and usually only affect the lower elevations in the eastern portion of Boulder County. The NCEI documents 11 incidents of tornadoes in Boulder County between January 1, 1950, and December 30, 2021. Information on these events is detailed below:

- **September 17, 1953, 3:00 p.m.:** Magnitude F1, property damage of $3,000
- **May 12, 1955, 4:30 p.m.:** Magnitude F1, property damage of $3,000
- **May 17, 1978, 3:45 p.m.:** Magnitude F1, property damage of $3,000
- **April 30, 1980, 11:00 a.m.:** Magnitude F1, no property damage
- **October 15, 1980, 6:22 p.m.:** Magnitude F2, property damage of $25,000 (roof at Vo-Tech on East Arapahoe)
- **June 5, 1988, 3:25 p.m.:** Magnitude F2, property damage of $250,000
- **June 1, 1990, 5:03 p.m.:** Magnitude F0, no property damage
- **June 16, 1996, 4:35 p.m.:** Magnitude F1, no property damage recorded
- **July 12, 1996, 7:40 p.m.:** Magnitude F0, no property damage recorded
- **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.)
- **June 5, 2015, 6:59 p.m.:** Tornado EF1 – EF3 (Longmont Berthoud), 25 homes damaged

Probability of Future Occurrences

Based on patterns of previous occurrences, future probability is considered **likely**, with a 10-100 percent chance of occurrence in the next year.

Magnitude/Severity

Based on assessment of impacts from previous occurrences, magnitude and severity is classified as *limited*, with 10-25 percent of property severely damaged and/or shutdown of facilities for more than one week.

Climate Considerations

To date, there is not enough evidence to show a direct correlation between tornadoes and climate change. Scientists have been unable to document an observable increase in the number of tornadoes or the severity of tornadoes as average global temperatures warm. Although there has been evidence of tornadoes becoming more clustered together and outbreaks including multiple tornadoes, the total number per year has not shifted significantly enough to tie tornado action to climate change. According to the 2018 Fourth National Climate Assessment, tornadoes are exhibiting changes that may be related to climate change, but scientific understanding is not confident enough to project the likelihood of future conditions.

Ecological Considerations

Tornadoes destroy almost everything in their path. They can have impacts on natural systems by uprooting trees and vegetation, damaging wildlife and negatively impacting soils. Tornadoes can also lead to environmental contamination by bringing raw sewage, asbestos, dioxides and other debris into water supplies and soil. Although nature is often able to recover from a tornado, it can often take years for soil and water systems to recover fully.

Overall Hazard Significance

Based on assessments of probability, geographic extent and magnitude/severity, overall hazard significance of tornadoes is considered *medium*.

4.3.15 Wildfire

Hazard	Geographic Extent	Probability/ Frequency	Magnitude/ Severity	Increased Threat (Climate Change)	Overall Significance
Wildfire	Significant	Highly Likely	Critical	Severe	High

Description

Wildfire and urban wildfire are an ongoing concern for Boulder County residents, businesses, and government as well as the state of Colorado. Historically, the fire season extends from spring to late fall. With the increase in average global surface temperatures, "earlier springs and hotter summers are projected throughout the state, with more frequent and severe heat waves" which will lead to longer fire seasons in the near future. 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. 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 as well as negatively impact human health and well-being. Significant wildfires can also occur in heavily populated areas leading to more extensive social and economic impacts and exacerbating existing inequities. Rangeland and grassland fires are a concern in the eastern portion of Boulder County, including urbanized areas, due to increased residential development in the urban-wildland interface.

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 in 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, 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 however, drought conditions and vegetation mortality will continue to increase due

to our rapidly warming climate requiring increased capacity and funding to proactively control fuel sources.

Topography: Boulder County'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 contributes to increased fire activity on slopes.

Weather: Weather components such as temperature, relative humidity, wind, and lightning also affect the potential for wildfire. Weather and climate are addressed together later in this section since weather is short-term changes in the atmosphere and climate is trends in weather over a longer period of time. Since climate is changing so rapidly, these two elements are highlighted below.

Social Considerations

Smoke and air pollution from wildfires can be a severe health hazard and are likely to impact frontline communities first and worst. Due to decades of discriminatory policies and practices, BIPOC members of the community are more likely to experience negative impacts due to pre-existing conditions, lack of access to healthcare, and inability to access resources to protect themselves proactively. Additional social damages from wildfires include evacuations, physical injuries, impacts to air quality and water quality, and loss of human life all of which are likely to become more frequent as the magnitude and severity of wildfires grows in the region. Similar to other hazards, wildfires can lead to loss of electricity, mobility and hinder communication all of which are more difficult for lower-income people to recover from.

Geographic Extent

Most of the County is susceptible to wildland fires, with highest risk areas located in the Front Range Foothills in the central portions of Boulder County. The Colorado Forest Atlas, formerly known as the Colorado Wildfire Risk Assessment Project (CO-WRAP) is an initiative led by the Colorado State Forest Service to provide information to the public and wildfire professionals to identify areas in need of wildfire planning, disseminate information, encourage collaboration, plan response actions, and prioritize fuels treatments in the state.

The Colorado Forest Atlas calculates a composite risk rating, defined as the possibility of loss or harm occurring from a wildfire. It identifies areas with the greatest potential impacts from a wildfire – i.e. those areas most at risk - considering all values and assets combined together – wildland urban interface (WUI) Risk, Drinking Water Risk, Forest Assets Risk and Riparian Areas Risk. This risk index has been calculated consistently for all areas in Colorado, allowing for comparison and ordination of areas across the entire state. The Wildfire Risk Classes for Boulder County are shown in Figure 4-28.

The areas of greatest concern for wildfire risk are in the WUI, where development is interspersed or adjacent to landscapes that support wildland fire. While traditionally associated with forested mountain areas, WUI areas are also present in grasslands, prairies, valleys, or in any area where a sustained wildfire may occur and impact developed areas. Fires in the WUI may result in major losses of property and structures, threaten greater numbers of human lives, and incur larger financial costs. In addition, WUI fires may be more dangerous than wildfires that do not threaten developed areas, as firefighters may continue to work on more dangerous conditions in order to protect structures such as businesses and homes. Increased development in WUI areas puts more people and structures potentially at risk. Figure 4-29 shows WUI areas within Boulder County as determined by the Colorado Forest Atlas. CO-WRAP defines the WUI using housing density data to delineate where people and structures meet and intermix with wildland fuels.

Within Colorado, Boulder County has the highest number of residential structures within 500m of public wildland and ranks tenth overall in the west in terms of existing wildfire risk. Based on this assessment the geographic extent is classified as **significant**, with 10-50 percent of the planning area potentially affected

Figure 4-28 Wildfire Hazard, Boulder County

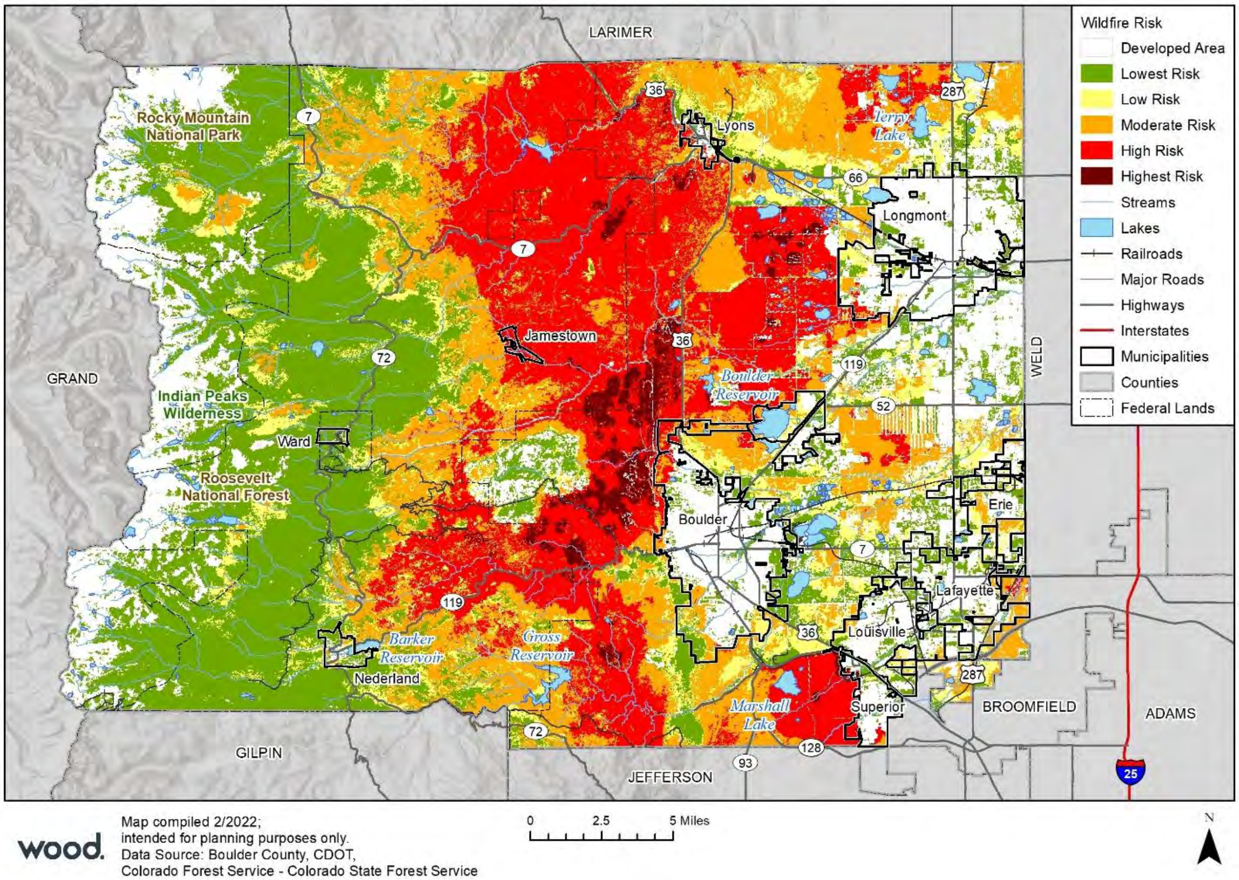
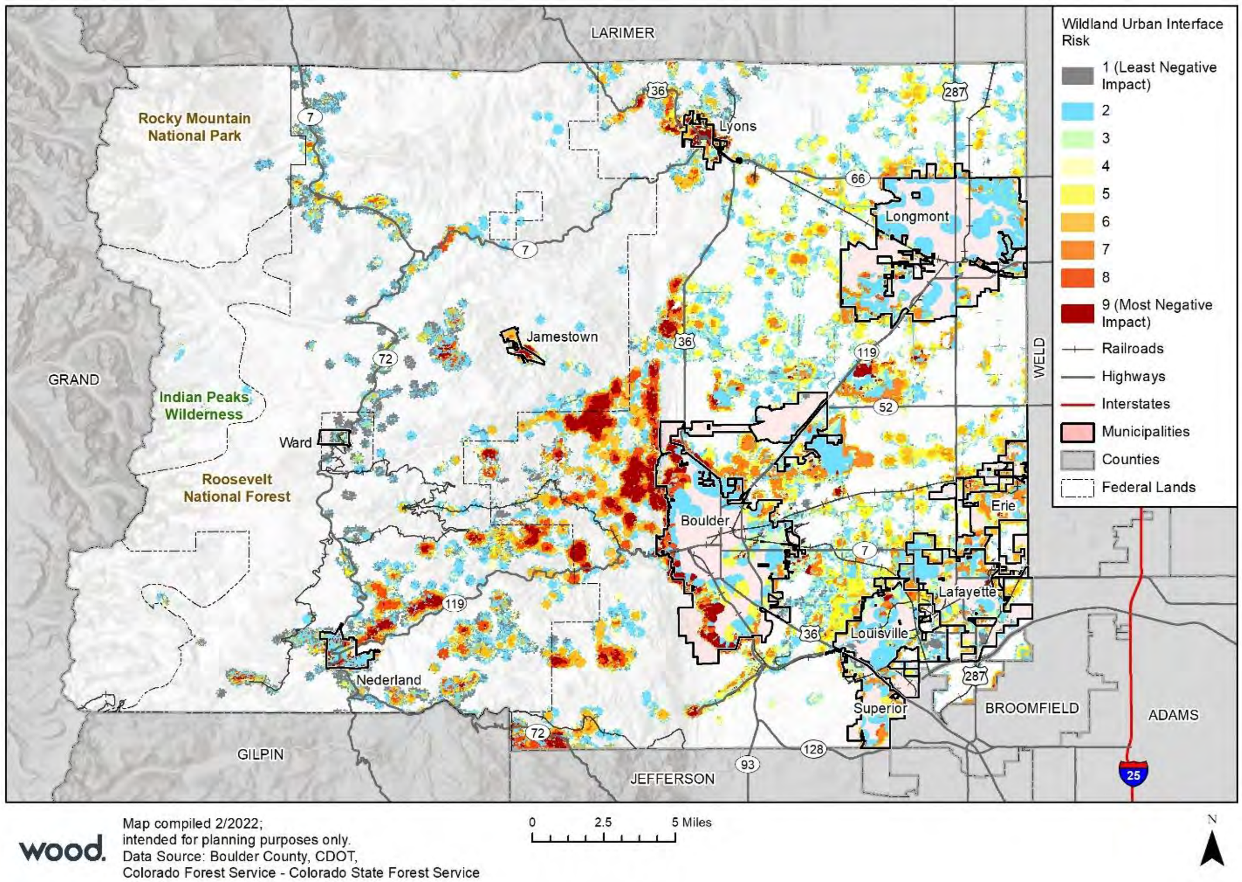


Figure 4-29 Boulder County Wildland Urban Interface (WUI) Areas



Previous Occurrences

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. Climate change is likely to increase the frequency and size of wildfires in the region leading to more severe damage and impacts to quality of life. Climate change is just one human-caused element making wildfires more likely and deadly. Additionally, human decision-making error attributed to activities such as smoking, uncontrolled campfires, equipment use, and arson are also contributors.

The 2002 wildfire season was the worst in Colorado history however as global temperatures continue to rise, so does the likelihood that record will soon be broken. Recent wildfire history in Colorado is summarized in Table 4-12 and Figure 4-30 below.

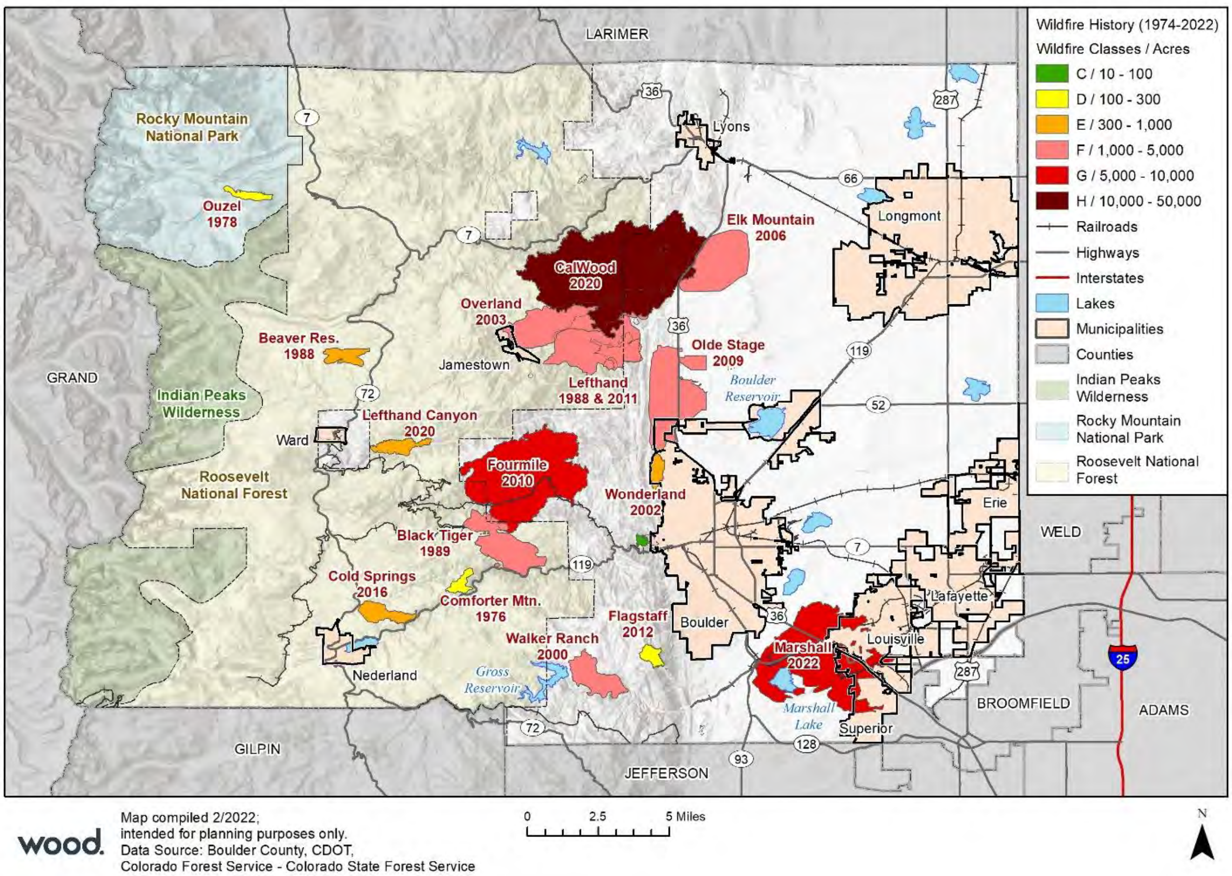
Table 4-12 Recent Colorado Wildfire History

Year	Number of Wildfires	Number of Acres Burned
2021	1,017	48,195
2020	1,080	625,357
2013	1,176	195,145
2012	1,498	246,445
2011	1,286	161,167
2010	1,076	40,788

Year	Number of Wildfires	Number of Acres Burned
2009	1,190	50,456
2008	1,133	141,966
2007	1,351	20,739
2006	2,025	94,484
2005	1,364	27,390
2004	1,290	24,996
2003	2,027	27,655
2002	3,067	926,502

Source: National Interagency Fire Center

Figure 4-30 Wildfire History, Boulder County



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, 14 miles southwest of Lyons, 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 outbuildings, and approximately 3,000 acres were burned in the fire.
- **September 15, 2000:** Walker Ranch/Eldorado fire, likely a human-caused fire, burned approximately 1,061 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. The fire is suspected to be human-caused.
- **June 19, 2002:** All but five Colorado Counties are part of a federal disaster declaration (DR-1421) as a result of an extended period of wildfire activity.
- **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 northwest 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. Property damage was estimated in excess of $8 million but no infrastructure damage was reported. The town was evacuated, and roads and schools were closed for 24 hours.
- **February 14, 2006:** The Elk Mountain fire consumed an estimated 600 acres of brush and grassland. 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.
- **September 6-16, 2010:** The Fourmile Canyon Fire burned 6200 acres and destroyed 169 structures. The fire started when a resident did not fully extinguish a fire in a fire pit. High winds fanned the embers and the subsequent fire grew rapidly. The fire started in Emerson Gulch and impacted the communities of Four Mile, Sunshine, and Gold Hill.
- **July 9, 2016:** The Cold Springs Fire was first reported on July 9, 2016, two miles northeast of Nederland, Colorado. Started by a campfire on private property that had not been properly extinguished, the fire quickly spread to more than 500 acres. More than 1,900 residents were evacuated with one thousand homes directly threatened. Due to the valiant efforts of firefighters, only eight homes were lost. There were no casualties. All home within the fire's perimeter that were part of the Wildfire Partners Program survived.
- **March 19, 2017:** Sunshine Fire 62 acres, 426 homes evacuated, no structures damaged or lives lost.
- **October 17, 2020:** The Cal-Wood Fire began near Jamestown on the afternoon of October 17, 2020. Due to dry conditions and high westerly winds the fire rapidly grew in size and did not reach 100% containment until November 14th, 2020. The Cal-Wood Fire ultimately burned 10,113 acres and 26 structures were lost or damaged.
- **December 20, 2021:** The Marshall Fire ignited on the morning of December 30, 2021 and rapidly grew into a fast-moving grassland fire near Marshall Lake in unincorporated Boulder County. Dry conditions and very high winds gusting up to 115 mph drove the fire east towards suburban communities in Superior and Louisville. Evacuation orders were issued for tens of thousands of residents in the town of Superior and the cities of Louisville, Broomfield, and unincorporated Boulder County. The fire was ultimately extinguished by heavy snowfall the following evening. From December 30-31, approximately

6,026 acres were burned, 1,084 buildings destroyed, and approximately $513 million in damages. One person was confirmed dead as a result of the fire, and another is missing and presumed dead. Within 12 hours of igniting the Marshall Fire had already become the most destructive fire in Colorado state history in terms of structures lost.

Other notable fires (greater than 50 acres in size) in Boulder County 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, (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)
- **October 2010:** The Dome Fire to the west of the City of Boulder and was 800 acres and threatened homes
- **June 26, 2013:** Flagstaff Fire was started by lightning causing home evacuations, but no structures were lost. The fire was 300 acres in size
- **July 9, 2016:** Cold Springs Wildfire occurred 2 miles Northwest of Nederland and burned 500 acres. There were no casualties and more than 1,900 residents were evacuated. The fire was started by a campfire on private property
- **March 19, 2017:** The Sunshine Fire burned 62 acres west of Boulder and caused 426 homes to evacuate and put 20,000 residents on stand-by evacuation status. The fire did cause any damage to homes but did cost $800,000 to control. The fire was human-caused and due to an unattended fire at a campsite

Probability of Future Occurrences

Based on historical data, Boulder County experienced at least 23 significant (>50 acres) fires since 1916. This relates to a four-year recurrence interval or a 25 percent chance of wildfire in any given year. Smaller wildfires occur on an annual basis, either in forests or in grasslands within the planning area. Based on these assessments, future probability is classified as **highly likely**, with a near 100 percent chance of occurrence in a given year.

Magnitude/Severity

Based on the definitions established for this plan, magnitude and severity of wildfire is considered **critical**, with 25-50 percent of property severely damaged and/or the potential shutdown of facilities for at least two weeks.

Climate Considerations

Weather and Climate: Weather components such as temperature, relative humidity, wind, and lightning affect the potential for wildfire. There is also a strong connection between climate change and wildfires.

- 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. Colorado has already observed increases in average temperatures and drier soils from increased evaporation which contribute to surges in wildfire activity. Increased temperatures also lead to longer breeding seasons for bark beetles which destroy forests leading to increased fuel.

- Wind is the most treacherous weather factor. The greater the wind, the faster a fire will spread, and the more intense it will be. 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. As climate change increases the number of extreme weather events, it is likely that extreme winds will increase and play a role in spreading fires faster.
- Lightning also ignites wildfires, which are often in terrain that is difficult for firefighters to reach. An article in the journal Science, estimates that we can expect to see a 12% increase in lightning activity for every 1.8oF of global warming, translating to a potential increases of 50% in strikes by the turn of the century.
- Drought conditions contribute to concerns about wildfire vulnerability. During periods of drought, the threat of wildfire increases. Colorado is experiencing more multi-year droughts and variability in precipitation due to climate change. This trend is likely to continue leading to increased vulnerability.

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. In addition, catastrophic wildfire can lead to secondary impacts or losses, such as future flooding and landslides during heavy rains.

Ecological Considerations

Wildfires have both positive and negative impacts on the natural environment. They impact air quality, water quality, and vegetation. Small fires can help an ecosystem regenerate and increase biodiversity however large wildfires can impact the ability of an ecosystem to recover and have the potential to permanently damage native vegetation and species.

- **Air Quality:** Wildfires generate smoke which is made up of gases, water vapor and microscopic particles. The small particles are referred to as PM which impacts air quality tremendously and has a range of negative impacts on the human body including difficulty breathing, heart stress and irritation to eyes. Smoke from fires can travel long distances and will impact humans and animals.
- **Water Quality:** Wildfires can have impacts on water quality for years and even decades. Wildfires increase stormwater runoff through reduction in vegetation and degradation of soil. Without vegetation to slow the flow of water down, runoff water transports sediment and debris into nearby water bodies. This impacts nutrient levels and can also result in algal blooms that impact downstream waterbodies.
- **Vegetation and Biodiversity:** Trees and vegetation are important for wildfire management and human health. Diverse vegetation and promotion of ecosystem resilience will help to improve biodiversity and reduce fire risk.

Overall Hazard Significance

Based on assessments of probability, geographic extent and magnitude/severity, the overall hazard significance of wildfire is classified as **high**, with widespread potential impact.

4.3.16 Windstorm

Hazard	Geographic Extent	Probability/ Frequency	Magnitude/ Severity	Increased Threat (Climate Change)	Overall Significance
Windstorm	Extensive	Highly Likely	Critical	Moderate	High

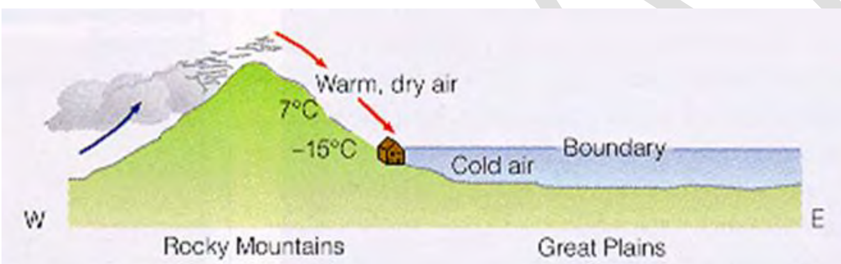
Description

High winds can result in property damage and injury and are a frequent occurrence throughout the region that includes Boulder County. Strong wind 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. Windstorm types that are prevalent in Boulder County include the following:

Chinook Winds

Downslope winds in the region of Colorado that includes Boulder County are referred to as Chinook winds, after the Native American Tribe of the Pacific Northwest. These downslope winds can occur with violent intensity in areas where mountains stand in the path of strong air currents. These warm and dry winds occur when the winds blow across the Continental Divide from the west and descend from the foothills and out onto the plains (see Figure 4-31). They are caused by high pressure conditions west of Boulder County, low pressure over and/or east of the County, and strong westerly winds in the mountains.

Figure 4-31 Chinook Wind Pattern



Source: University of Colorado at Boulder Atmospheric and Oceanic Services (ATOC) Weather Lab

Bora Winds

In general, Bora winds are downslope winds that replace relatively warm light wind conditions with cold temperatures and strong wind gusts. The specific Bora winds that affect Boulder County are relatively dry and cold and blow from the west. While their pattern onset is similar to Chinook winds, they are comprised of cold air, whereas a Chinook brings warmer and drier air. Generally, but with certain notable exceptions, Bora winds are less extreme than winds generated during Chinook events.

Damaging winds are measured using the Beaufort Wind Scale.

Table 4-13 Beaufort Wind Scale

Beaufort Rank	Description	Windspeed (MPH)	Land Conditions
0	Calm	<1	Calm. Smoke rises vertically.
1	Light air	1 – 3	Wind motion visible in smoke.
2	Light breeze	3 – 7	Wind felt on exposed skin. Leaves rustle.

Beaufort Rank	Description	Windspeed (MPH)	Land Conditions
3	Gentle breeze	8 – 12	Leaves and smaller twigs in constant motion.
4	Moderate breeze	13 – 17	Dust and loose paper raised. Small branches begin to move.
5	Fresh breeze	18 – 24	Branches of a moderate size move. Small trees begin to sway.
6	Strong breeze	25 – 30	Large branches in motion. Whistling heard in overhead wires. Umbrella use becomes difficult. Empty plastic garbage cans tip over.
7	High wind, Moderate gale, Near gale	31 – 38	Whole trees in motion. Effort needed to walk against the wind. Swaying of skyscrapers may be felt, especially by people on upper floors.
8	Gale, Fresh gale	39 – 46	Some twigs broken from trees. Cars veer on road. Progress on foot is seriously impeded.
9	Strong gale	47 – 54	Some branches break off trees, and some small trees blow over. Construction/temporary signs and barricades blow over. Damage to circus tents and canopies.
10	Storm, Whole gale	55 – 63	Trees are broken off or uprooted, saplings bent and deformed. Poorly attached asphalt shingles and shingles in poor condition peel off roofs.
11	Violent storm	64 – 72	Widespread vegetation damage. Many roofing surfaces are damaged; asphalt tiles that have curled up and/or fractured due to age may break away completely.
12	Hurricane	≥ 73	Very widespread damage to vegetation. Some windows may break; mobile homes and poorly constructed sheds and barns are damaged. Debris may be hurled about.

Source: National Oceanographic and Atmospheric Association, http://www.spc.noaa.gov/faq/tornado/beaufort.html

Social Considerations

Windstorms can severely impact human health. Direct impacts such as flying debris or falling trees can lead to severe injury or even death. Indirect impacts may include exacerbation of chronic illnesses or power outages leading to issues with mobility, access to resources, and medical care. Windstorms can also have an inequitable impact on outdoor workers who are at more risk of being impacted by debris. Additionally, windstorms can severely damage property which, as noted in social considerations for many hazards, low-income people are unable to afford to repair.

Geographic Extent

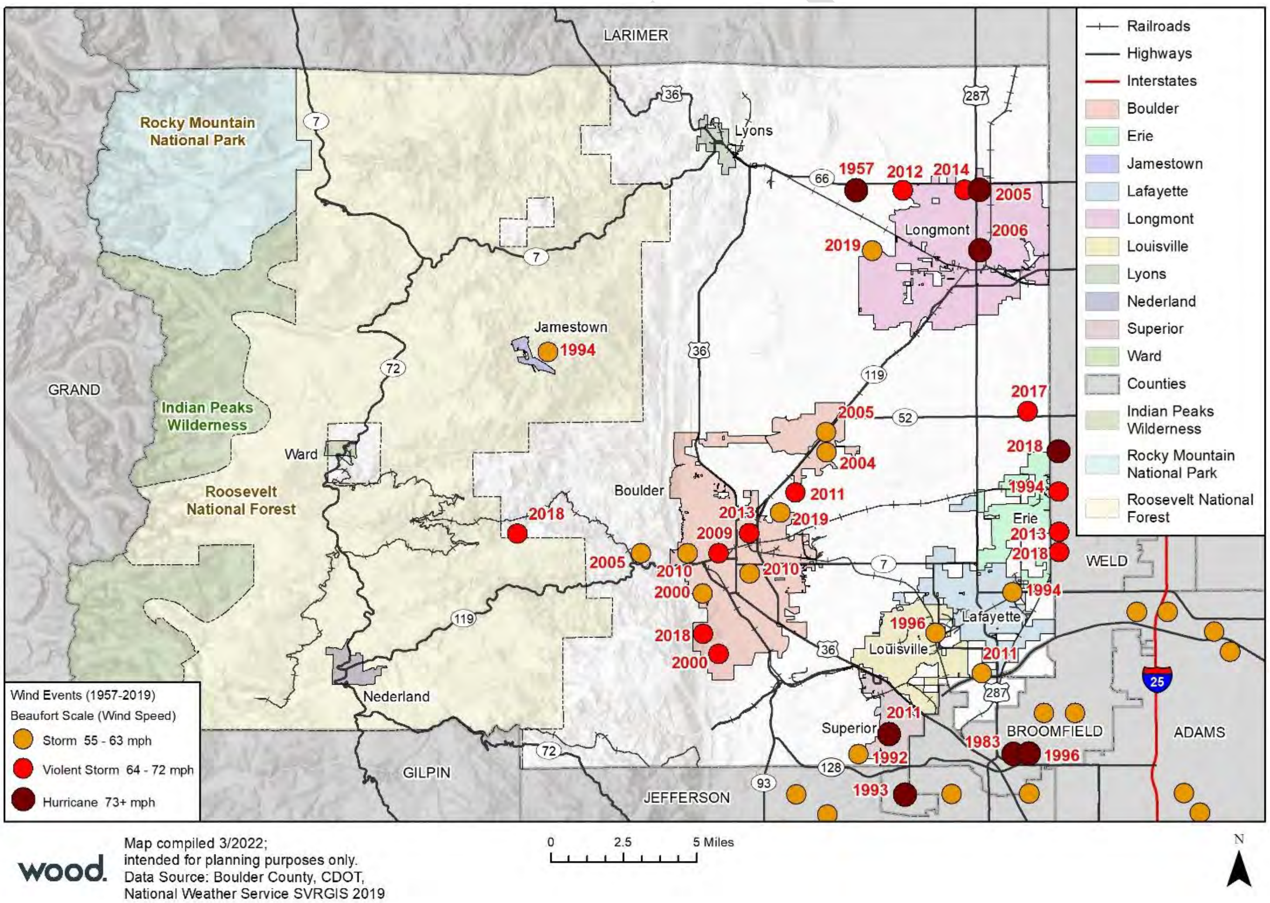
The geographic extent of windstorm is considered **extensive**, with 50-100 percent of the planning area affected. While the entire county can be affected by strong winds, the western county foothills and communities located at the base of the foothills experience the highest winds speeds. High alpine areas of the County are also subject to high winds but the impact in these locations is limited mostly to resource damage due to lower density of development. The Colorado Front Range Gust Map and Snow Load Design Data for Colorado provided by the Boulder County Land Use Department indicates general patterns of wind intensity through the prescription of more stringent wind shear design standards in western sections of the County.

Previous Occurrences

High wind events are one of the most notable natural hazards affecting Boulder County. According to NOAA's Climate Diagnostics Center, the County experiences some of the highest peak winds in the United States. Locations within the planning area experience wind gusts in excess of 100 mph with nearly annual frequency. 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 $17 million in damages and extensive structural impacts in Boulder County.

The peak of the wind season is December and January, but downslope windstorms have been recorded in every month except July. The map in Figure 4-32 shows notable wind occurrences throughout Boulder County between 1957 and 2019 based off data from the NWS Storm Prediction Center.

Figure 4-32 Boulder County Wind Events, 1957-2019



Historical windstorm events are summarized below:

Since 2007 there has been 105 days with winds above 39 knots in Boulder County. According to the NCEI, between January 1, 1955, and December 31, 2021, Boulder County experienced 414 wind events that reached wind speeds of at least 50 knots (57.6 mph). This number includes instances of the same wind event reported at multiple locations throughout the County, as the NCEI further clarifies that these events occurred across 263 individual days throughout this same time period.

Of these wind events, three deaths, 12 injuries, and approximately $22,358,000 in property or crop damage were reported. Information on selected events provided by the NCEI from this period is detailed below.

Note that costs may include damages across a multiple county region are not necessarily specific to Boulder County:

- **February 24, 1994**—High winds, 96 knots (~110 mph), property damage of $500,000
- **March 23, 1994**—High winds, 67 knots (~80 mph), property damage of $5,000
- **October 29, 1996**—High winds, 88 knots (~103 mph), one death, five injuries, property damage of $5.2 million
- **February 2, 1999**—High winds, 110 knots (~127 mph), property damage of $3 million
- **April 8, 1999**—High winds, 100 knots (~115 mph), property damage of $7.2 million
- **April 9, 1999**—High winds, 85 knots (~98 mph), property damage of $13.8 million.
- **May 20, 2001**—High winds, 72 knots (~82 mph), 6 injuries, property damage of $3.4 million
- **October 29, 2003**—High winds, 70 knots (~81 mph), property damage of $979,000
- **December 20, 2004**—High winds, 88 knots (~102 mph), 3 injuries, property damage of $3,400,000
- **December 5, 2005**—High winds, 85 knots (~98 mph), high winds reportedly broke windows and caused roof damage, winds downed trees and power lines throughout Boulder County
- **January 8, 2007**- Peak wind gusts included: 115 mph at the National Wind Technology Center near Eldorado Springs, 89 mph; 7 miles west-northwest of Berthoud, 78 mph at Lafayette, with 77 mph; 3 miles west-southwest of Boulder.
- **December 12, 2009**- Very strong Chinook winds blasted areas in and near the Front Range Foothills of Larimer, Boulder and Jefferson Counties. The wind blew down trees and power poles, downed electrical lines and fences, and damaged homes and vehicles. Scattered power outages were reported all along the Front Range. In Metropolitan Denver alone, 24,000 Xcel customers were affected by the outages. Strong crosswinds also blew over some semi-trailers along Interstate 25, near the Wyoming state line. In Larimer County, two small wildfires were sparked by downed power lines in Rist Canyon and near the Laporte/Bellevue areas. Four planes were damaged at the Vance Brand Municipal Airport in Longmont; one was wrecked. Insurance companies estimated up to $7 million in damage along the Front Range and adjacent plains, making it the 4th costliest windstorm to hit Colorado. Peak wind gusts included: 111 mph, 3 miles north of Masonville; 98 mph at Carter Lake; 87 mph at the National Wind Technology Center; 86 mph, 2 miles north of Longmont and at Pinewood Lake; 81 mph, 3 miles east of Gold Hill; 78 mph, 2 miles west-southwest of Broomfield; 77 mph at Erie; 76 mph, 21 miles north of New Raymer and 75 mph at Lafayette.
- **December 31, 2011**- A fast moving upper-level storm system, along with a deep low-pressure system over Nebraska and high pressure building over Utah, combined to create a powerful windstorm across Northeast and North Central Colorado. In the mountains and foothills, several locations recorded wind gusts in excess of 100 mph. Numerous trees were knocked down throughout Arapahoe National Forest. One man was killed when he was impaled by a falling tree limb while driving along U.S. Highway 36, north of Boulder.
- **January 18, 2012**- Damaging winds developed in and near the Front Range. A peak wind gust to 104 mph was recorded in the foothills of Boulder County. In Boulder, the high winds knocked down several trees, power poles and electrical lines. Some of the fallen trees damaged homes and automobiles. A semi-trailer was blown on its side along State Highway 93 near Marshall. In Loveland, the strong winds downed power lines and caused scattered electrical outages, which affected approximately 150 residents. In the mountains, the combination light to moderate snow driven by high winds, produced blizzard conditions above timberline. Storm totals generally ranged from 3 to 8 inches.
- **February 10, 2017** - Hurricane force winds toppled trees and knocked over several semis in and near the Front Range Mountains and Foothills. Nearly four thousand residents in Boulder County were left without power. The temperature in Denver reached 80 degrees. It was the first 80-degree temperature recorded in the month of February and established the all-time record for the month. The high wind and extremely warm temperatures helped to spread three grassfires in Boulder and Larimer Counties;

however, no homes were damaged or lost. Intense wind gusts on the 10th caused power outages and damage to trees, fences, and power lines across Boulder County.

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

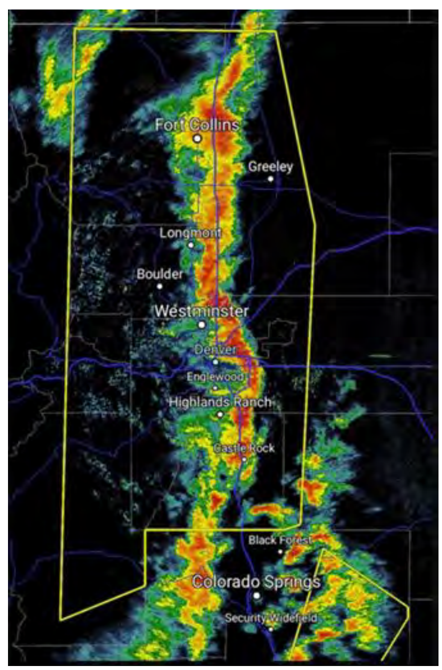
- **January 11, 1972:** Winds gusting to 97 mph damaged 40 trailers at Boulder Valley Village, including three that burned. Damage was estimated near $3 million.
- **January 17, 1982:** In one of the most devastating windstorms in Boulder County, winds were clocked at 137 mph at NCAR. Twenty gusts in excess of 120 mph were measured during a 45-minute period. The southern section of the City of 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.

Previous occurrences of wind events resulting in fatalities in Boulder County include the following:

- **March 18, 1920:** Three people were killed when a fire truck responding to a fire collided with a car.
- **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.
- **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 in excess of 100 mph. The trailer blew over on top of him. Trees were downed and cars and property damaged.
- **February 3, 1999:** Downed power poles and tree limbs cut power to over 10,000 homes. The peak gust of 127 mph was recorded at Sugarloaf. 80 mph winds were recorded at Nederland, 98 mph winds in the City of Boulder, 120 mph winds in the town of Lafayette, 100 mph winds in Longmont, and 119 mph winds were recorded in Wondervu. Nearly a dozen power poles were toppled between Baseline Road and Arapahoe on 95th street near Lafayette. The roof of the Boulder County Jail sustained approximately $150,000 in damage. Damage across the Front Range region was estimated at $3 million.
- **April 8-10, 1999:** High winds hit Boulder County on April 8, 1999, and then again on April 10 with 120 mph winds recorded at Sugarloaf, 100 mph winds recorded in southern sections of the City of Boulder, and 90 mph in Longmont. Trees were uprooted and semi-trailers overturned.
- **March 6, 2004:** Tree cleanup costs were estimated at $5,000.
- **June 2004:** Tree cleanup costs were estimated at $2,000.
- **June 6, 2007:** Intense wind conditions occurred along the North Central Mountains, Front Range Foothills and Urban Corridor. 92 mph wind gusts were recorded at the City of Boulder. Several trees were uprooted across the urban corridor. Xcel Energy reported service outages in Boulder, Denver, Lakewood, Longmont and Windsor.
- **October 19, 2007:** Strong winds developed in the Front Range Foothills and portions of the Northeast Plains. Peak wind gusts included: 78 mph at Georgetown, 70 mph at Estes Park, 62 mph; 3 miles east of Amherst, and 61 mph; 3 miles northeast of Wiggins.
- **April 17, 2018:** A woman in Louisville died after she was struck by a falling tree branch. She stopped to rest under a tree when a large branch broke off and struck her in the head.

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
- **December 4, 1978:** 148 mph, one death
- **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
- **January 1, 2007:** 100kts
- **December 29, 2008:** 96kts
- **January 7, 2009:** 93kts
- **November 12, 2011:** 100kts
- **December 31, 2011:** 101kts
- **December 31, 2011:** 109kts
- **January 18, 2012:** 90 kts
- **January 9, 2017:** High winds developed in and near the Front Range Foothills. Peak wind gusts included: 90, 3 miles north-northeast of Pleasant View; 88, 3 miles west-southwest of Louisville; 87, 2 miles south of Gold Hill; 79 at the NCAR Mesa Laboratory; 76 at Glen Haven; 60 in Littleton and 58 in Arvada. Scattered outages affected approximately 2,400 customers in Boulder and Jefferson Counties. In Berthoud, strong winds destroyed a barn
- **June 6, 2020:** First Recorded Derecho. A derecho is a straight-line wind event with sustained gusts connected to a long line of thunderstorms. Derechos are not common in Colorado with the last one being documented in 1994. The derecho on June 6th was a low dewpoint derecho that sped across the Rocky Mountains at 75 MPJ. Strong winds uprooted trees and disrupted power to more than 100,000 residents in the metro area. The severe wind from the derecho extended nearly 700 miles from eastern Utah across the state and into North Dakota
- **December 30, 2021-January 1, 2022:** High sustained winds with gusts recorded up to 115 mph were a driving factor in the rapid spread and destructive nature of the Marshall Fire, which



burned over 6,000 acres and upwards of 1,000 structures

Probability of Future Occurrences

Based on the frequency of previous occurrences and the definitions established for this plan, future probability of occurrence is classified as **highly likely**, with nearly a 100 percent chance of occurrence in the next year.

Magnitude/Severity

Based on assessments of the typical impacts of windstorms, magnitude and severity is considered **critical**, with 25-50 percent of property severely damaged and/or shutdown of facilities for at least two weeks.

Climate Considerations

A study published in the journal Nature Climate Change found that winds have been getting faster and more intense since 2010. The increase in average global wind speed over the past decade has gone from 7mph on average to 7.4 mph on average. The research team found that climate patterns are influencing wind speeds. Due to temperature differences between regions, wind speeds will either pick up or slow down. With average global surface temperatures increasing, wind speeds could continue to pick up however there is not conclusive evidence.

Ecological Considerations

Windstorms can lead to significant environmental impacts. Severe wind events are capable of uprooting trees, destroying wildlife habitat and providing opportunities for invasive species to establish themselves. Invasive species make it more difficult for forests and native vegetation to recover. Loss of native trees and vegetation can impact ability to sequester carbon and biodiversity.

Overall Hazard Significance

Based on assessments of probability, geographic extent and magnitude/severity, the overall hazard significance of windstorm is classified as **high**, with widespread potential impact.

4.3.17 Winter Storms (Severe)

Hazard	Geographic Extent	Probability/ Frequency	Magnitude/ Severity	Increased Threat (Climate Change)	Overall Significance
Winter Storm (Severe)	Extensive	Highly Likely	Catastrophic	Substantial	High

Description

Winter storms can include heavy snow, ice, and blizzard conditions. 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. In rural areas, homes and farms may be isolated for days, and unprotected livestock may be lost. 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 damage can be repaired. Even small accumulations of ice may cause extreme hazards to motorists and pedestrians.

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.

Winter storms in Boulder County, including strong winds and blizzard conditions, can result in localized power and phone outages and closures of streets, highways, schools, businesses, and nonessential government operations. People can also become isolated from essential services in their homes and vehicles. A winter storm can escalate, creating life-threatening situations when emergency response is limited by severe winter conditions. Other issues associated with severe winter weather include the threat of physical overexertion that may lead to heart attacks or strokes. Snow removal costs can also impact budgets significantly. Heavy snowfall during winter can also lead to flooding or landslides during the spring if the area snowpack melts too quickly.

The NWS defines winter watches, warnings and advisories including:

- **Ice Storm Warning** is issued when a period of freezing rain is expected to produce ice accumulations of 1/4" or greater or cause significant disruptions to travel or utilities.
- **Heavy Sleet Warning** is issued when a period of sleet is expected to produce ice accumulations of 1" or greater or cause significant disruptions to travel or utilities.
- **Heavy Snow Warning** is issued when snow is expected to accumulate 4 inches or more in 12 hours, or 6 inches or more in 24 hours.
- **Winter Storm Warning** is issued for a winter weather event in which there is more than one hazard present, and one of the warning criteria listed above is expected to be met.
- **Blizzard Warning** is issued for sustained wind or frequent gusts greater than or equal to 35 mph accompanied by falling and/or blowing snow, frequently reducing visibility to less than 1/4 mile for three hours or more. Watches are issued when conditions may be met 12 to 48 hours in the future.
- **Winter Weather Advisory** is issued when wintry weather is expected, and caution should be exercised. Light amounts of wintery precipitation of patchy blowing snow will cause slick conditions and could affect travel if precautions are not taken

Social Considerations

Winter storms have impacts to several of the systems we rely on daily. For low-income families, winter storm events can shut down schools and require parents or caretakers to take time off of work. On tight budgets, this can be a tremendous impact, especially if children receive one or more free or reduced meals at school.

Winter storm events can also reduce mobility and disrupt public transportation services which impact the ability for many to get to work. Public buses can be significantly delayed or even stuck which hinders the ability of many to get resources they need or to get to their place of employment.

Additionally, winter storms are often accompanied by cold weather which impacts heating costs. For low-income families that spend a larger percentage of their income on heating their home, this can quickly become unaffordable.

Geographic Extent

The geographic extent of severe winter storms is classified as **extensive**, with 50-100 percent of the planning area potentially affected. While certain sections of Boulder County have a significantly higher probability of impact from winter storms, all areas can potentially be affected by blizzard conditions, snow drifts, ice, wind and downed power lines. The highest point in the County is 14,255 feet and the lowest is 4,986 feet. Over 50 percent of the County is 6,000 feet or above in elevation and therefore located in areas with significant risk of winter storm impacts in any given year. The Colorado Front Range Gust Map and Snow Load Design Data for Colorado (available through the Boulder County Land Use Department) indicates a pattern of more intense of winter storms in western Boulder County correlating with increases in elevation. While this map does not represent direct observations for wind intensity and snow depth, it does indicate the need for more robust building design standards to the west and as elevation increases.

Previous 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 County of Boulder based on data from the Western Regional Climate Center.

10-year snowfall averages in Boulder, 2010 to 2019

Days		Inches	Centimetres
6.0	January	14.5	36.8
5.0	February	14.6	37.1
4.0	March	16.2	41.1
4.0	April	10.2	25.9
2.0	May	7.4	18.8
0.0	September	0.0	0.0
6.0	October	26.4	67.1
4.0	November	29.5	74.9
1.0	December	3.4	8.6
21.4	Year	96.1	244.0

- **Seasonally, December to February**: Regular winter snowstorms
- **April 13, 2020:** The record "coldest maximum" was also set on Monday when the high temperature for the day never reached above 25 degrees. It had never stayed so cold on April 13 in Denver's recorded history.
- In addition to the cold, most areas along the Front Range measured significant snow Wednesday night into Thursday this week. The biggest snow total was in Jamestown which is located in the foothills west of Boulder. Jamestown measured 30 inches while Fort Collins received 14 inches. Boulder received 16.9 inches of snow which brings their total for the season to a record 151.2 inches. Meanwhile Denver's official total was only 1.3 inches measured at DIA.
- **November 26, 2019:** A powerful snowstorm delivered significant accumulation west of the Interstate

25 corridor. Boulder received 20.7 inches of snow, making it the third-snowiest day ever recorded in the city. The first was Oct. 25, 1997; the second was Nov. 20, 1979. The 20.7-inch total also set a new daily snowfall record for Nov. 26, smashing the old record for the date of 13.0 inches set in 1959. Additionally, the 22.3-inch two-day total (Nov. 25-26) is the third biggest for a November snowstorm. Only Nov. 20-21, 1979, and Nov. 3-4, 1946 had higher totals, according to the Colorado Climate Center.

- **March 25, 2016:** A monster snowstorm dumped a record-breaking 16.4 inches of snow on Boulder on Wednesday while crippling cities all along the Front Range and stranding would-be spring break travelers. That Boulder snowfall, as reported by meteorologist Matt Kelsch, shattered the record for snowfall on March 23, which was 10.6 inches set in 2013. In fact, Wednesday's dump exactly equaled Boulder's average March snowfall for the past 30 years and comes on top of last week's 15-inch snowfall.
- **March 2003:** A winter snowstorm dumped up to 60 inches of snow. The town was without electricity and phone service for three days. Significant storms over the past few years include March 2003 (over six feet of snow), March 1992 (20 inches), March 1990 (24 inches), December 1982 (24 inches), and December 1987 (over 24 inches). Boulder County was included in both the 2003 and 2006 Presidential Emergency declarations for snowfall.

Data from the NCEI and SHELDUS identified 190 winter storm events between January 1, 1993, and November 30, 2007, which impacted Boulder County or its major forecast zones (Z035 and Z039). 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 County 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 mid- afternoon. Power outages affected nearly all of 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:** Blizzard, property damage of $62 million. 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 County 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 NWS office in Boulder measured 19 inches of snowfall. This blizzard forced the closure of interstates, businesses, schools, and airports, stranding thousands of holiday travelers. This storm resulted in a presidential snow emergency declaration. Eligible snow removal reimbursement costs in Boulder County totaled $279,044 federal share, and $93,014 local share, for $372,058 total. The St. Vrain Valley School District reported that 20 employees, 6 visitors and 59 students reported injuries. The employee injury costs were $97,736. Snow removal expenses amounted to $32,846 and the disaster relief funding from FEMA was $23,679.29. There was also a report of some vehicle damages as well as school and road closures.

- **January 7, 2007:** Strong winds associated with an intense upper-level jet, and a very strong surface pressure gradient, developed in and near the Front Range Foothills. Peak wind gusts ranged from 77 mph to 115 mph. The strong winds coupled with freshly fallen snow resulted in whiteout conditions and several highway closures due to blowing and drifting snow. Road closures included: State Highway 93, between the cities of Golden and Boulder; and State Highway 36, from the Boulder Turnpike, in Broomfield, to South Boulder Road; More than 100 people were stranded in their cars between Golden and Boulder as blowing and drifting snow made the highway impassable. Snow drifts along State Highway 93 were over 6 feet in depth. Up to twenty cars were also abandoned along the Diagonal Highway, between Boulder and Longmont. Thirty vehicles were stranded along State Highway 128. The high winds also caused intermittent power outages in Boulder County.
- **February 16, 2007:** A strong upper-level jet stream over northern Colorado, coupled with a passing weather disturbance, brought a one-two punch of heavy snow and strong winds to areas in and near the Front Range. At the National Wind Technology Center, the peak wind gust topped out at 101 mph. In and near the Front Range Foothills, the wind stirred up intense ground blizzards which resulted in several road closures. State Highway 93, between Golden and the City of Boulder was closed for much of the day.

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

- **May 1978:** The spring storm of 1978 dropped 30 inches of snow on Boulder County and was responsible for at least one death and a serious 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.
- **Christmas storm of 1982:** The storm began on Christmas Eve, lasting through Christmas Day. Winds created large drifts, closing roads and stranding travelers.
- **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 the City of 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 in the City of Boulder. Total damage and associated costs equaled $363,710.
- **April 24, 1997:** A snowstorm dumped over 16 inches of snow in Boulder County; mountain areas

received around 30 inches.

- **October 24, 1997:** During this "Blizzard of 1997," Boulder County received 30 inches of snow in 48 hours. A total of 51 inches fell in Coal Creek Canyon. 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 county 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).
- **December 12, 2012:** Damaging winds developed in and near the Front Range. A peak wind gust to 104 mph was recorded in the foothills of Boulder County. In Boulder, the high winds knocked down several trees, power poles and electrical lines. Some of the fallen trees damaged homes and automobiles. In the mountains, the combination of light to moderate snow driven by high winds, produced blizzard conditions above timberline. Storm totals generally ranged from 3 to 8 inches.

  Peak wind gusts included: 104 mph in south Boulder; 98 mph, 3 miles southwest of Pinecliffe; 95 mph, 2 miles northwest of Rocky Flats; 92 mph, along State Highway 93 near Marshall; 87 mph atop Berthoud Pass and in Boulder Canyon; 80 mph, 5 miles west-northwest of Boulder; 83 mph at NCAR Mesa Lab; 78 mph, 8 miles northeast of Four Corners; 79 mph at the National Wind Technology Center; 76 mph at Wondervu; 75 mph atop Loveland Pass and the NCAR Foothills Lab in Boulder; 74 mph at Blue Mountain, Boulder Municipal Airport, 9 miles east of Dillon and 1 mile northwest of Lyons; 73 mph, 4 miles east-northeast of Nederland; 72 mph at the Junction of State Highways 72 and 93.
- **September 8-9, 2020:** The second earliest recorded snowfall since 9/3/1961 occurred in the Denver Metro Area and it was the earliest recorded snow fall for the City of Boulder since 1948. This storm also set a record in the widest temperature swing over a 24-hour period going form the high 90s to freezing the next day. Impacts from this storm mainly were downed tree lines and power outages across the County.

Seasonal Snowfall Last 10 Years:

Season	Snowfall (inches)
2019-2020	57.6
2018-2019	48.1
2017-2018	25.7
2016-2017	21.8
2015-2016	72.8
2014-2015	57.8
2013-2014	38.4
2012-2013	78.4
2011-2012	55.6
2010-2011	22.8

Other storms with measurable snowfall 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
- **May 5-6, 1978**: 31 inches
- **November 20, 1979**: 22 inches
- **November 26-27, 1983**: 23 inches
- **January 5, 2007**: 17 inches
- **May 3-5, 2007**: 14.5 inches
- **December 12, 2007**: 11 inches
- **January 12, 2009**: 9 inches
- **April 18, 2009**: 2 feet
- **October 29, 2009**: 20 -46 inches in the mountains and 12-26 inches in the urban corridor
- **April 03, 2011**: 16 inches
- **February 12, 2012**: 4 feet mountains and 12 inches in the urban corridor
- **January 3, 2014:** 2 feet

Probability of Future Occurrences

Based on patterns of previous occurrences, future probability is considered **highly likely**, with impacts attributed to severe winter storms occurring on an annual basis at locations within the planning area.

Magnitude/Severity

Based on the definitions set forth in previously, the magnitude and severity of severe winter storms in Boulder County is considered **catastrophic**, with more than 50 percent of property severely damaged and/or shutdown of facilities for more than 30 days and/or multiple fatalities.

Climate Considerations

Climate change is likely to increase the severity and intensity of severe winter storms. Although warming temperatures have already led to decreased snowpack and earlier melting, precipitation events are predicted to become more extreme leading to heavy amounts of snow and rapid melting. As the planet warms, Boulder County will continue to experience severe winter storms however these storms will be fewer and farther between. Additionally, the winter season will decrease in number of days leading to more spring flooding and erosion. Snow is already melting on average 2-4 weeks earlier than a half century ago.

Ecological Considerations

Winter storms tend to help the natural ecosystem by ending reproduction for pine beetles and insects. As temperatures warm and conditions fluctuate between heavy snow events and warm temperatures, insects and invasive species are likely to have longer breeding and growing seasons leading to significant impacts to native tree species and biodiversity.

Overall Hazard Significance

Based on assessments of probability, geographic extent and magnitude/severity, the overall hazard significance of severe winter storms is considered **high**.

4.4 Vulnerability Assessment

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 area.

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.

This vulnerability assessment identifies the assets and systems at risk to natural hazards and then estimates potential losses for specific hazards. Following the hazard profile methodology, the vulnerability assessment considers social, environmental, and technological vulnerabilities that will impact Boulder County, and the impact that significant hazards would have on the populations and assets in Boulder County.

This vulnerability assessment followed the methodology described in the FEMA publication Understanding Your Risks— Identifying Hazards and Estimating Losses. The vulnerability assessment first describes the total vulnerability and systems at risk and then discusses vulnerability by hazard.

4.4.1 Methodology

This assessment is an attempt to identify how social, ecological, and technological systems within Boulder County are affected by hazard impacts, to quantify assets at risk, by sector and jurisdiction where possible, and to identify opportunities for the whole community to participate in mitigation now and into the future. Note that this assessment was limited to the hazards that were considered medium or high in planning significance, based on HMPC input and the hazard profiles. This assessment is also limited by the data available for the high or moderate ranked hazards. The methods of analysis vary by hazard type and data available and are discussed further in the Future Development section under each hazard analyzed. It is important to note that the various analyses are data driven, and that potential errors or omissions may exist in the data. In some cases, these specific data limitations are noted, where known. The information presented is for planning level assessments only.

The avalanche and expansive soils hazards are omitted from this vulnerability assessment. Generally, these hazards were omitted because they were either low significance, research did not discover noteworthy damage in the past, or data did not support quantifying future losses.

- Data to support the vulnerability assessment was collected and compiled from the following sources
- County and municipal GIS data (hazards, base layers, critical facilities and assessor’s data)
- FEMA’s HAZUS-MH MR 3 GIS-based inventory data (January 2005)
- Housing and Urban Development reports (2018 and 2020) and EPA datasets
- Colorado Department of Public Health and Environment data and assessment tools
- Written descriptions of inventory and risks provided by participating jurisdictions
- Census and American Community Survey data
- Boulder Community Foundation TRENDS Report
- Existing plans and studies from County departments
- Personal interviews with planning team members, hazard experts, and County and municipal staff

The scope of the vulnerability assessment is to describe the risks to the County as a whole. The vulnerability assessment breaks down the social, ecological, and technological systems within the County by sector, including transportation, critical facilities and infrastructure systems, housing, public health, community, economy, and the natural environment. Development trends, including population growth and land status, are analyzed through the lens of each sector. Next, where data was available, hazards of high and medium significance are evaluated in more detail and potential losses are estimated. Data from each jurisdiction was also evaluated and is integrated here and noted where the risk varies for a particular jurisdiction from the rest of the planning area.

4.4.2 Critical Facilities

Critical facilities provide services and functions that are essential for the whole community, especially during hazard response and recovery. The diversity of communities in Boulder County mean that critical facilities vary by geography and function; what is critical for Latinx community members in Longmont may be different than critical facilities for elderly residents in Nederland. In order to reflect the various needs of communities throughout Boulder County, examples of critical facilities and other facilities of importance to the HMPC are included for each sector below. Critical facilities are also included in the vulnerability assessments by hazard to identify specific impacts as appropriate.

Boulder County and certain municipalities have GIS databases of critical facilities and infrastructure. The data layer themes and their source are noted in Table 4-14 below. The best available data was used, but some limitations include lack of complete or comprehensive data and values such as replacement costs. Each critical facility was further categorized by the FEMA Community Lifeline category into which it falls. FEMA defines community lifelines as the most fundamental services in the community that, when stabilized, enable all other aspects of society. Essentially, these are the most important elements to the proper function of society and delivery of essential services, and as such it is vital to understand the community's vulnerabilities to these facilities.

Table 4-14 Summary of Critical Facilities by Jurisdiction and FEMA Lifeline

Jurisdiction	Communications	Energy	Food, Water, Shelter	Hazardous Material	Health and Medical	Safety and Security	Transportation	Total
Boulder	26	9	44	73	45	212	85	**494**
Erie	-	-	2	-	2	14	4	**22**
Jamestown	1	-	-	1	-	3	2	**7**
Lafayette	6	-	8	5	19	65	17	**120**
Longmont	-	-	7	17	38	150	47	**259**
Louisville	6	-	6	2	8	43	4	**69**
Lyons	3	-	1	1	-	10	6	**21**
Nederland	3	-	3	2	1	14	2	**25**
Superior	2	-	2	-	-	19	8	**31**
Ward	-	-	-	-	-	3	-	**3**
Unincorporated	16	14	149	94	2	127	143	**545**
Total	**63**	**23**	**222**	**195**	**115**	**660**	**318**	**1,596**

Source: Boulder County, Boulder OEM, City of Boulder, HIFLD, NID, National Bridge Inventory, CDPHE, EPA, Wildfire DSS

4.4.3 Community Assets

An asset is a "resource of value requiring protection." Assets may be tangible or intangible and may provide value at different phases of the emergency management cycle. Boulder County communities occupy different geographic and climatic areas and maintain different demographic profiles, and so live with diverse exposures to various natural hazards. All communities have a variety of social and physical assets which they use to mitigate, respond to, and recover from these hazard impacts. Likewise, all community members differ in the systems, resources, and capacities to which they have access.

For all Boulder County communities, both the access to and health of social, ecological, and technological systems around them influence their risk profiles. This includes physical and financial capacities, cultural literacy, housing, education, etc. Access to these systems has immense repercussions for the resilience of the whole community. Many individuals are not prepared to respond to hazard events, and even less equipped to deal with recovery. As a result, communities have developed highly individualized safety nets that depend on a variety of localized solutions and are often not codified or legible to outside government or other representatives. It is vital to consider these community safety nets and diverse asset pools when assessing the vulnerability of communities. While they may not directly impact the County's official systems of emergency response, it is important to build partnerships that will aid in identifying, mitigating, and preparing community assets in order to maintain existing safety nets. If communities are cut off from government services, as happened during the 2013 flood, local safety nets are vital for supporting vulnerable populations and assisting with the transition into recovery. If unprepared, the loss of safety net-supporting community assets will be devastating for some of the most vulnerable populations in Boulder County communities.

4.4.4 Social Systems

Social systems are not divorced from technological and ecological systems, but instead take a specific focus on human focused systems, the hazard outcomes for those systems, and community members' interactions with them. These systems are analyzed firstly in order to identify critical facilities and current and future vulnerabilities that may impact the health and safety of Boulder County community members, but will not be identified through a focus on individual hazards; and secondarily to surface opportunities for mitigation partnerships with other County departments and whole community partners. Social system vulnerabilities for Boulder County focus on the interactions and outcomes with Public Health, Community, and Economy.

Public Health

Background

Public health assets are both tangible and intangible, including hospitals and clinics, as well as access to services. Major hazard events will increase the burden on public health systems and may require longer term assistance for residents. This includes but is not limited to health impacts such as mold growth and waterborne diseases from flooding, toxic runoff from pollutants in the flood plain; poor air quality from fires and drought; and exposure to extreme heat or cold.

Critical Facilities

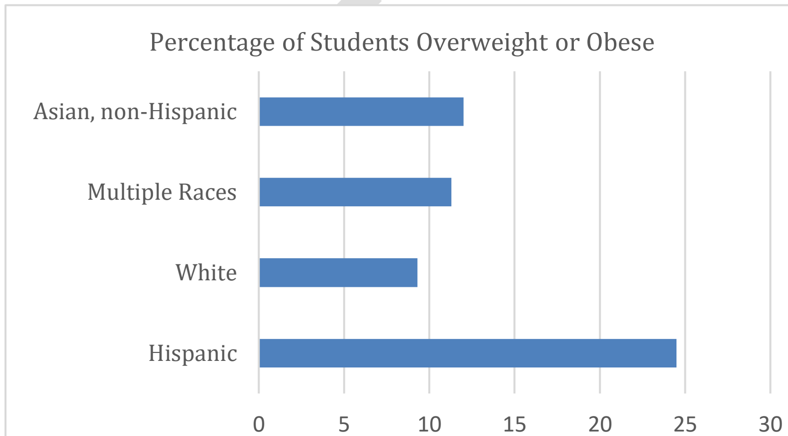
- Hospitals
- Pharmacies
- Mental Health Centers
- Nursing Homes

Other key facilities identified by the HMPC

- Avista

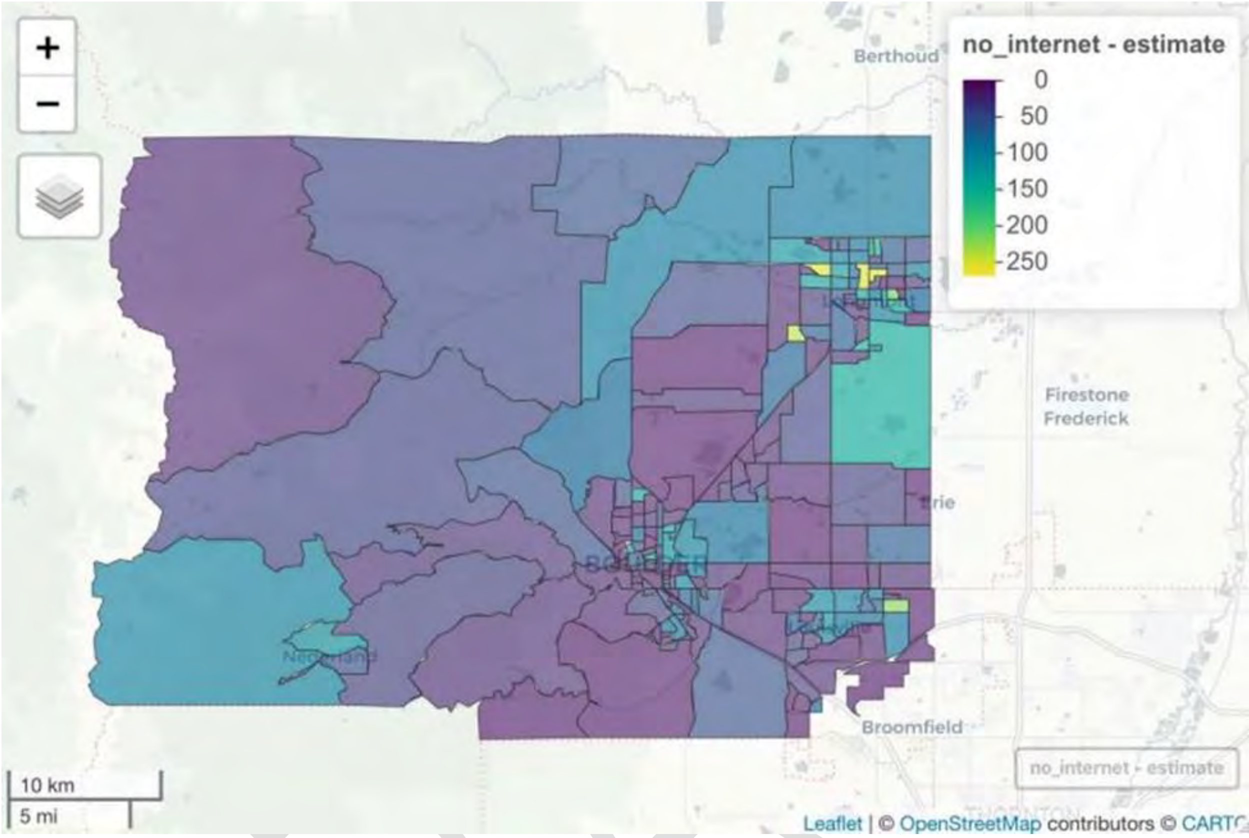
- Boulder Community Health System
- Good Samaritan Hospital
- Longmont United Hospital
- Centennial Peaks
- Wardenburg Health Center
- Clinica Medical Center
- Boulder Women's Clinic
- Foothills Medical Center

Equity



The history of systemic racism in Boulder County has left its mark in a myriad of ways, including in public health. Institutional barriers to preventive medical care, healthy food, clean air, and secure housing have contributed to higher instances of chronic disease in minority populations. In Boulder County this has contributed to large health disparities especially for the Latinx community. In October 2019, Boulder County declared a childhood obesity epidemic (Boulder County Public Health 2019); an epidemic which disproportionately impacts Hispanic children and can contribute to longer term health problems. These health issues also manifest an increased vulnerability to hazard related health impacts. This has contributed to the current health disparities during COVID-19 Pandemic, where Latinx patients represented 24% of cases in April 2020 and 31.9% of those hospitalized (Boulder County Public Health 2020) even though they are only approximately 14% of the total population of Boulder County (American Community Survey 2019). These pre-existing conditions are combined with a lower income for Latinx families than for Whites. Additional inequities for low-income families may include lack of internet service or cell phone coverage, which reduces the ability to access public health warnings and services.

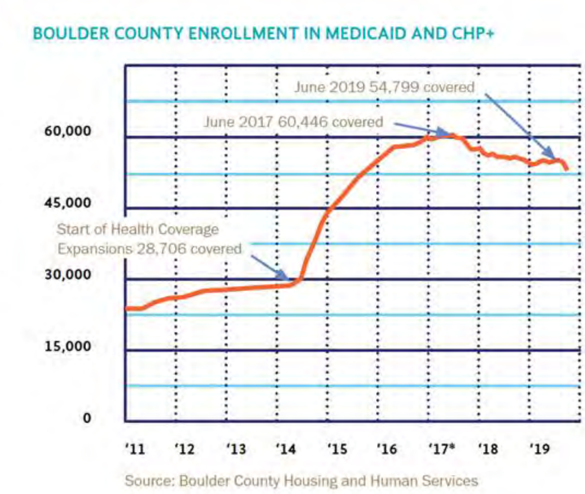
Figure 4-33 Map of Boulder County Households with No Internet Service

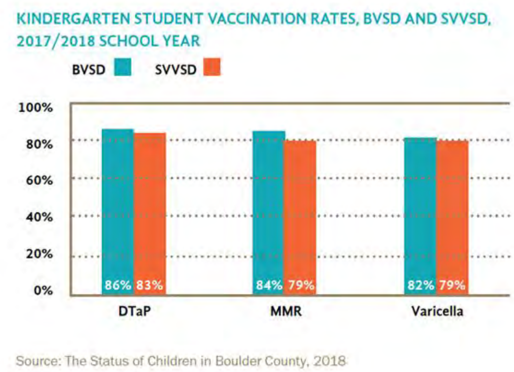


Past events have also shown major vulnerabilities created from Boulder County residents' geographic inability to access critical public health facilities during a crisis. The most obvious example being that most medical, mental health, etc. services are located in the plains/eastern half of the County. This can increase the financial burden for mountain residents to access health care services as well as the time needed to obtain care.

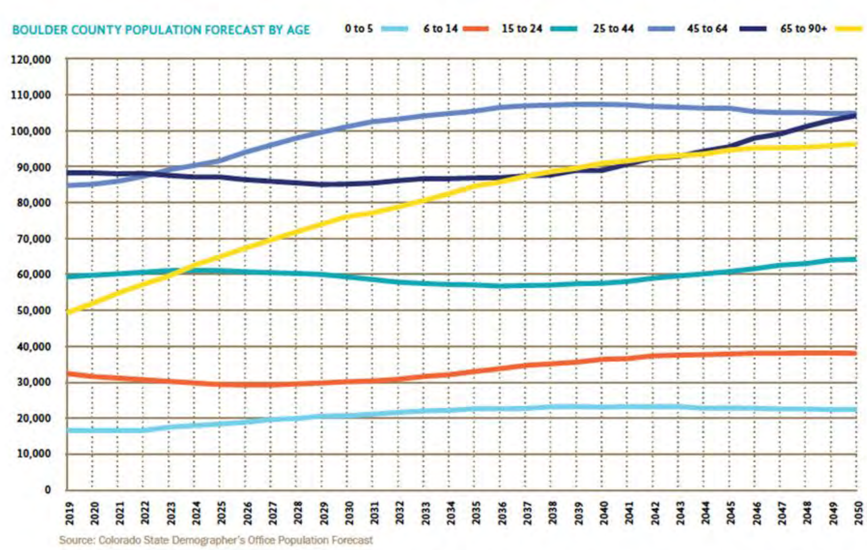
Future Development

Current public health trends show that the rate of Medicaid enrolment has decreased since 2017, meaning that fewer vulnerable community members have health insurance (TRENDS 2019). Boulder County also has low rates of child vaccination, suggesting that the area is more likely to experience an outbreak of diseases such as pertussis, the measles, etc. (TRENDS 2019). The median age of County residents also continues to increase, and 60% of residents over 65 have a disability. As the median age increases, this will create greater demand for assets such as accessible housing and assistance with transportation, and increased strain on hospitals and nursing homes.





As climate change stresses natural systems, new diseases will emerge, and air quality is likely to worsen. These trends will increase the burden of care, especially for those with pre-existing conditions and low-income families. Further public health impacts from climate change will include mental health consequences such as post-traumatic stress disorder after hazard events, which is likely to impact already vulnerable populations such as children and the elderly, as well as first responders. The rising age of the population in combination with climate change projections indicates that more residents will be susceptible to the impacts of hazards such as extreme heat, cold, and winter storms. For more detail on individual hazard impacts, see the relevant sections below.



4.4.5 Community Services

Background

Community assets include intangibles such as existing capacities for preparedness and response, as well as structures and resources such as schools and food banks, emergency services, and cultural and historical landmarks. The occurrence of a hazard may strain community assets, but preserving these services will assist residents in transitioning from response into recovery. Hazard impacts to community facilities may have major impacts on life safety during response and may destroy important cultural or historic artifacts. Recognizing their location and community importance before a disaster will aid in restoring or protecting them during a hazard event.

More information about the Boulder County historic preservation program can be found under the Property & Land Department. A list of Designated Historic Properties is available on their website and maintained in County GIS database:

https://www.bouldercounty.org/property-and-land/land-use/historic-preservation/designated-historic-sites/

The National Register of Historic Places is the Nation's official list of cultural resources worthy of preservation. The National Register is part of a national program to coordinate and support public and private efforts to identify, evaluate, and protect historic and archaeological resources. Properties listed include districts, sites, buildings, structures, and objects that are significant in American history, architecture, archaeology, engineering, and culture. The National Register is administered by the National Park Service, which is part of the U.S. Department of the Interior.

The Colorado State Register of Historic Properties is a listing of the state's significant cultural resources worthy of preservation for the future education and enjoyment of Colorado's residents and visitors. Properties listed in the Colorado State Register include individual buildings, structures, objects, districts, and historic and archaeological sites. The Colorado State Register program is administered by the Office of Archaeology and Historic Preservation within the Colorado Historical Society. Properties listed in the National Register of Historic Places are automatically placed in the Colorado State Register.

It should be noted that as defined by the National Environmental Policy Act (NEPA), any property over 50 years of age is considered a historic resource and is potentially eligible for the National Register. Thus, in the event that the property is to be altered, or has been altered, as the result of a major federal action, the property must be evaluated under the guidelines set forth by NEPA. Structural mitigation projects are considered alterations for the purpose of this regulation.

Critical Facilities:

- Food banks
- Shelters
- Schools
- Day care centers
- Main government buildings
- Domestic violence shelters
- Sexual assault hotlines
- Police Stations
- Fire Stations
- Emergency Operations Centers

Other key facilities identified by the HMPC:

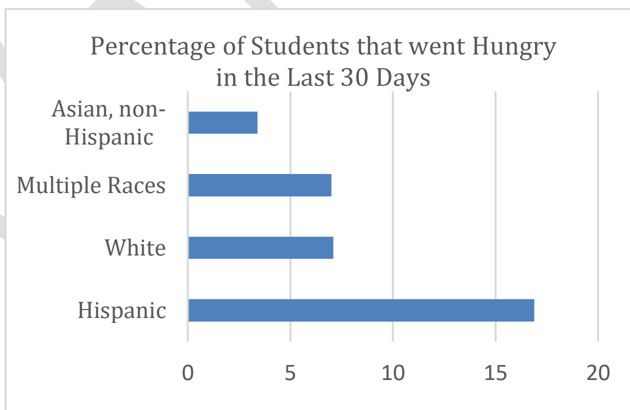
- Criminal Justice Center
- Municipal Building
- Army Reserve
- National Guard
- PSB
- Courthouse
- Jail
- PS&J (Longmont)
- Pridemark
- Boulder County Paramedics

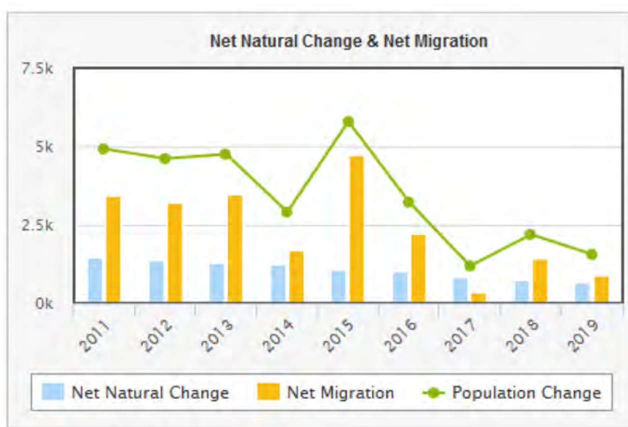
Equity community capacities are diverse throughout the County and have developed different coping mechanisms to handle hazard impacts. Despite many existing community strengths, disparities in income, racial equity, and lack of resource access create disproportionate vulnerabilities for some populations. In terms of disaster preparedness, low-income families are less likely to be able to afford to stockpile food let alone expensive insurance payments for natural hazards. Systemic racism plays a part as well, as Latinx children are more than twice as likely to go hungry as White students in Boulder County (Healthy Kids Colorado Survey 2019). This indicates Latinx families are less able to purchase and store food in the event of a disaster and underscores the importance of local food banks as critical facilities.

In addition, the list of historic and cultural places has been largely confined to places that celebrate White history, while disenfranchising the contributions, culture, and historic monuments of the Indigenous and Latinx populations that also inhabit Boulder County. This includes the Valmont mill site, which has been the location of a public battle between the City of Boulder and the Arapaho and Cheyenne Tribes that originally occupied the area now known as Boulder County.

4.4.6 Future Development

Population along Colorado's Front Range is expected to continue rising throughout the century, putting increased strain on community services, transportation systems, and natural resources. Income inequality is rising as is the median age of the population. All of these factors will reduce the resources that low-income and vulnerable populations have to put towards hazard response and recovery. Additionally, the majority of the population growth is through in-migration, indicating an increase in the segment of the population that is not aware of existing hazards or connected to resource networks. The racial composition of the County is also diversifying, with new cultural mores and languages arriving. This will require agile response in communication systems and may put more strain on cultural broker networks, which are already stressed by lack of services for Latinx populations in the County (Mosaics Report 2019).





Data Source: U.S. Census Bureau Population Estimates

4.4.7 Economy

Background

Economic assets include businesses, agriculture, tourism, jobs, and economic diversity. Impacts to economic assets will reduce the whole community's ability to recover. After a disaster, economic vitality is the engine that drives recovery. Every community has a specific set of economic drivers, which are important to understand when planning ahead to reduce long-term disaster impacts to the economy.

Table 4-15 Top Employers in Boulder County

Name	Address	City
10,000+ Employees		
University of CO - Boulder	Boulder	Boulder
5,000-9,999 Employees		
IBM	Diagonal Hwy	Boulder
1,000-4,999 Employees		
University of Boulder	Marine St	Boulder
Boulder Community Hospital	Balsam Ave	Boulder
Boulder Community Hospital	Mapleton Ave	Boulder
Covidien	Gunbarrel Ave	Boulder
Covidien	Longbow Dr	Boulder
Exempla Good Samaritan Med Ctr	Exempla Cir	Lafayette
Seagate Technology	Disc Dr	Longmont
IBM Business Continuity	Diagonal Hwy	Boulder
Longmont United Hospital	Mountain View Ave	Longmont
Office of Oceanic & Atmospheric	Broadway St	Boulder
500-999 Employees		
Digital Globe Inc	Dry Creek Dr # 260	Longmont
Emerson Process Management	Winchester Cir	Boulder
Eess Operations Manager	Broadway St	Boulder
Intrado Inc	Dry Creek Dr # 250	Longmont
Agilent Technologies Inc	Airport Blvd # 1	Boulder
Avista Adventist Hospital	Health Park Dr	Louisville
Boulder Valley School District	Arapahoe Rd	Boulder
Education Center	Arapahoe Rd	Boulder
Mental Health Boulder County	Iris Ave	Boulder
University Corp-Atmospheric	Table Mesa Dr	Boulder
250-499 Employees		
Epsilon	Crescent Dr	Lafayette
Markit On Demand	Central Ave	Boulder
Trans First	Centennial Pkwy	Louisville

Source: Colorado Department of Labor and Employment, https://www.colmigateway.com/analyzer/default.asp?fromaltentry=1

Critical Facilities

- Banks
- Major Employers

Other Facilities Identified by HMPC:

- NIST
- NOAA

- NCAR
- CU
- IBM
- Hauser
- Amgen
- Lexmark
- StorageTek
- Roche
- Ball

Equity

Increasing economic disparities and ongoing struggles with systemic racism in Boulder County have created high variability in how hazards impact different populations around the County. Boulder County has slightly higher income inequality than the rest of Colorado, with the top 1% of earners making 26.5 times more than the entire remaining 99% (TRENDS 2019). This is slightly more than the U.S., and much more than the rest of the state. At the same time, according to Bank on Boulder County, approximately 5,000 families in Boulder County are unbanked, and 15,000 are underbanked (Bank on Boulder). This, combined with the rising number of residents that pay more than 30% of their earnings on housing, indicates that many county residents are economically unprepared to deal with hazard impacts. A survey by Out Boulder indicated large disparities in economic opportunities for genderqueer or trans men, as they reported an 8% unemployment rate compared to 3-4% for other LGBTQIA+ residents of the County (TRENDS 2019). Additionally, women continue to not only earn less in Boulder County than they do in the rest of the United States as a whole, but to also experience greater pay disparities with men. When combined with the 76% increase in the cost of childcare since 2000 (TRENDS 2019), this could pose a significant barrier to recovery for certain members of the population.

WOMEN'S MEDIAN EARNINGS BY EDUCATIONAL ATTAINMENT 2017

	Boulder County	U.S.
Less than high school graduate	$24,063	$17,391
High school graduate	$26,548	$24,159
Some college or associate's degree	$29,109	$30,512
Bachelor's degree	$42,422	$45,233
Graduate or professional degree	$55,585	$60,691

Source: American Community Survey, 1-year data

Future Development

Climate change will create unpredictable stresses on and increase costs for residents, major employers and the economy as a whole in Boulder County. Under the most extreme scenarios, climate impacts are projected to cost taxpayers over $100 million in Boulder County alone (Boulder County Sustainability Plan 2018). Government is currently one of the largest job sectors in Boulder County, representing 20% of the non-farm payroll (HUD 2020). This includes 17 federal research labs that combined created a $1.1 billion economic impact in 2016 (HUD 2020). Government shutdowns, loss of sales, and property taxes have already reduced the budgets for this employment sector in Boulder County. These types of stresses and unpredictable costs from events such as the COVID-19 Pandemic are likely to continue as climate change alters natural systems and increases strain on existing supply chains and markets.

In addition to affecting major employers, the negative impacts of climate change on natural environments will decrease the amount of revenue and overall stability of tourism in Boulder County (Resilient Analytics 2018). This may have larger impacts on mountain areas, where hazard occurrence can drive down tourism. Impacts to winter snowpack will also reduce employment and tourist revenue associated with ski resorts and winter recreation. Other employment sectors in Boulder County will experience local, regional, national, and global impacts of climate change in areas such as supply chains, natural hazard impacts, and workforce availability. Locally, this will have outsize repercussions for low-income households, where economic instability will make disaster preparedness and recovery more difficult.

4.4.8 Ecological Systems

Ecological systems interact closely with technological and social systems, creating, connecting with, and shaping many pieces of the built and cultural environment. Ecological systems take a specific focus on natural systems, and the benefits from and hazard outcomes for those systems. These systems are analyzed to identify current and future vulnerabilities that may impact the health and safety of Boulder County community members, but will not be identified through a focus on individual hazards; and also, to identify opportunities for mitigation partnerships with other County departments and whole community partners. Ecological vulnerabilities for Boulder County focus on natural areas, endangered species, and wetland areas in Boulder County.

Natural Systems and Watersheds

Background

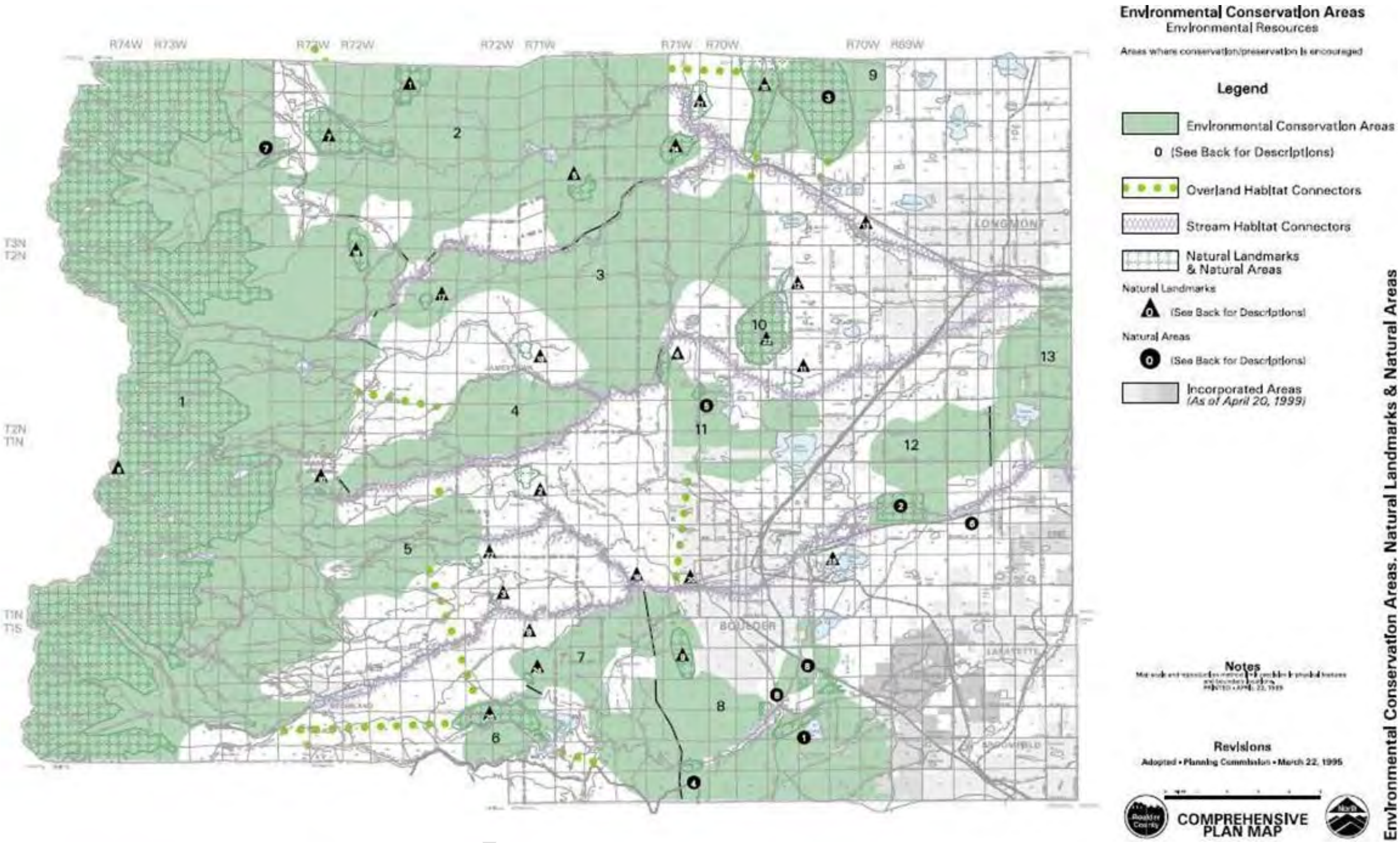
Natural environment and watershed assets include clean water and air, soil health, and ecosystem services. Hazard effects on natural assets may result in the loss of drinking water, reductions in air quality, or the occurrence of related hazards such as landslides following heavy precipitation or floods following wildfires. Awareness of natural assets can lead to opportunities for meeting multiple objectives. For instance, protecting wetlands areas protects sensitive habitat as well as attenuates and stores floodwaters.

Boulder County contains a unique combination of prairie, forest and tundra environments. The County recognizes three types of valuable natural resources worthy of protection: environmental conservation areas, natural landmarks, and natural areas. These areas are described below and mapped in Figure 4-29.

Environmental conservation areas are so designated because of the value they provide in the perpetuation of those species, biological communities, and ecological processes that function over large geographic areas and require a high degree of naturalness. Natural landmarks are defined as prominent landscape features that distinguish a specific locality in Boulder County and are important because of the views they afford, their value as scenic vistas and backdrops, and the intrinsic value they hold as wildlife or plant habitats, natural areas, park and open space preserves, and open land areas.

Natural areas are physical or biological areas that either retain or have reestablished their natural characters, although they need not be completely undisturbed, and that typify native vegetation and associated biological and geological features or provide habitat for rare or endangered animal or plant species or include geologic or other natural features of scientific or educational value.

Figure 4-34 Boulder County Environmental Conservation Areas, Natural Landmarks, and Natural Areas



Environmental Conservation Areas

1 Indian Peaks
Size - 1,000,000 Acres
Lifezones - Montane/Subalpine/Alpine

2 North St. Vrain
Size - 34,500 Acres
Lifezones - Montane/Foothills

3 South St. Vrain/Foothills
Size - 21,800 Acres
Lifezones - Montane/Foothills

4 Walker Mountain
Size - 7,500 Acres
Lifezones - Montane

5 Fourmile Creek/Bald Mountain
Size - 6,700 Acres
Lifezones - Montane

6 Winiger Ridge
Size - 3,000 Acres
Lifezones - Montane

7 Hawkin Gulch/Walker Ranch/
Upper Eldorado Canyon
Size - 9,500 Acres
Lifezones - Foothills/Plains

8 Boulder Mountain Park/South Boulder
Size - 17,500 Acres
Lifezones - Foothills/Plains

9 Rabbit Mountain
Size - 7,500 Acres
Lifezones - Foothills/Plains

10 Table Mountain
Size - 7,500 Acres
Lifezones - Plains

11 Boulder Valley Ranch/ Beech Open Space
Size - 5,500 Acres
Lifezones - Plains

12 White Rocks/Gunbarrel Hill
Size - 6,200 Acres
Lifezones - Plains

13 East County
Size - 7,300 Acres
Lifezones - Plains

Natural Landmarks

1 Big Elk Park
2 Bighorn Mountain
3 Boulder Falls
4 Buckingham Park Hogback
5 Coffintop Mountain
6 Continental Divide
7 Deer Ridge
8 Eagle Rock
9 Flatirons
10 Grassy Top Mountain
11 Haystack Mountain
12 Hygiene Hogback
13 Hygiene Plains Cottonwood
14 Indian Lookout Mountain
15 Indian Mountain
16 Ironclads
17 Miller Rock
18 Porphyry Mountain
19 Profile Rock
20 Red Rocks
21 Steamboat Mountain
22 Sugarloaf Mountain
23 Table Mountain
24 Twin Sisters Peak
25 Valmont Dike
26 Winiger Ridge

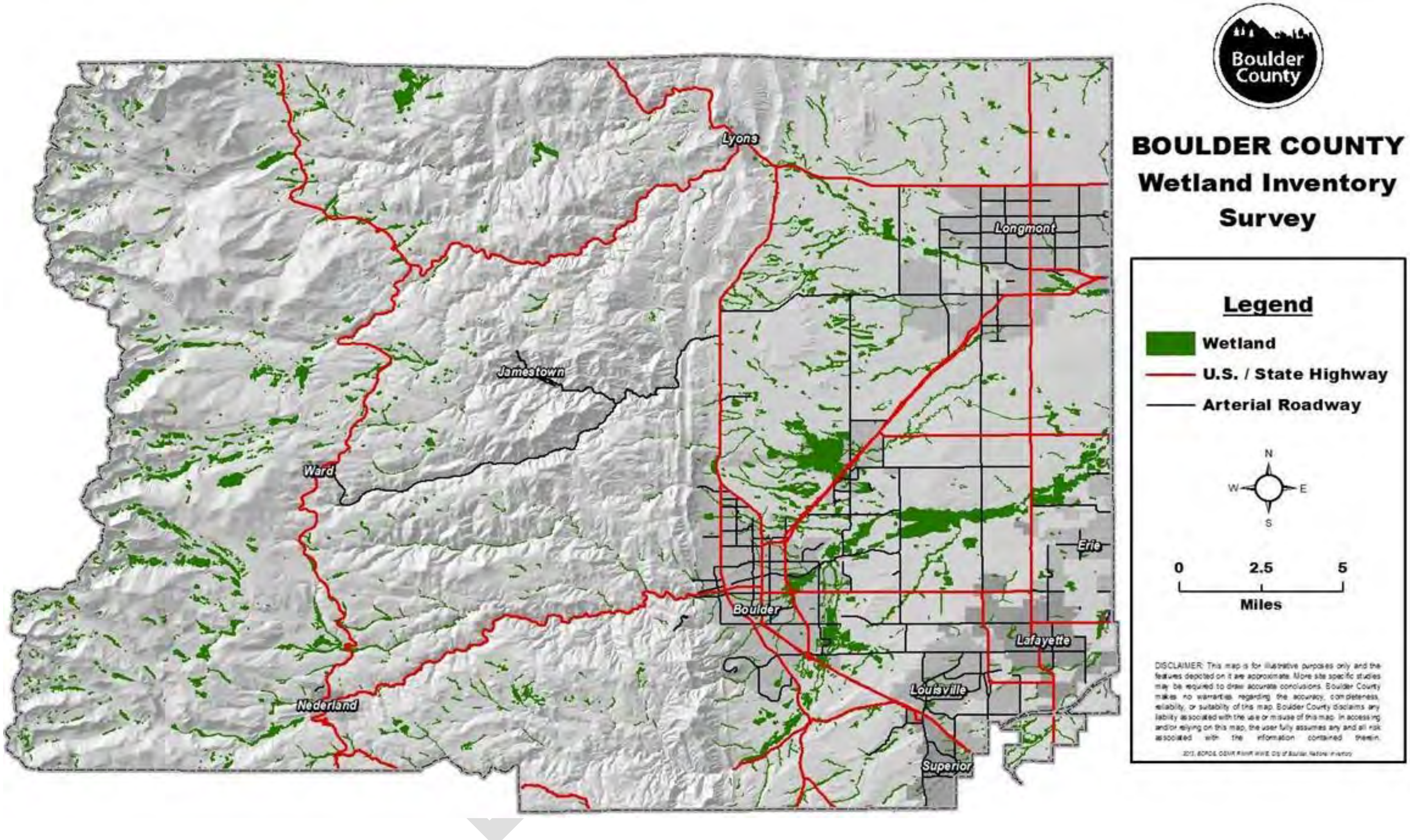
Natural Areas

1 Marshall Mesa
2 White Rocks
3 Rabbit Mountain
4 Eldorado Springs Canyon
5 Sixmile Fold
6 Heron Rookery
7 Copeland Willow Carr
8 Tallgrass Prairie

Wetlands

Wetlands are a valuable natural resource for communities, due to their benefits to water quality, wildlife protection, recreation, and education, and play an important role in hazard mitigation. Wetlands reduce flood peaks and slowly release floodwaters to downstream areas. When surface runoff is dampened, the erosive powers of the water are greatly diminished. Furthermore, the reduction in the velocity of inflowing water as it passes through a wetland helps remove sediment being transported by the water. They also provide drought relief in water-scarce areas where the relationship between water storage and streamflow regulation are vital. Figure 4-35 illustrates the location of wetland areas in Boulder County.

Figure 4-35 Boulder County Wetland Inventory Survey



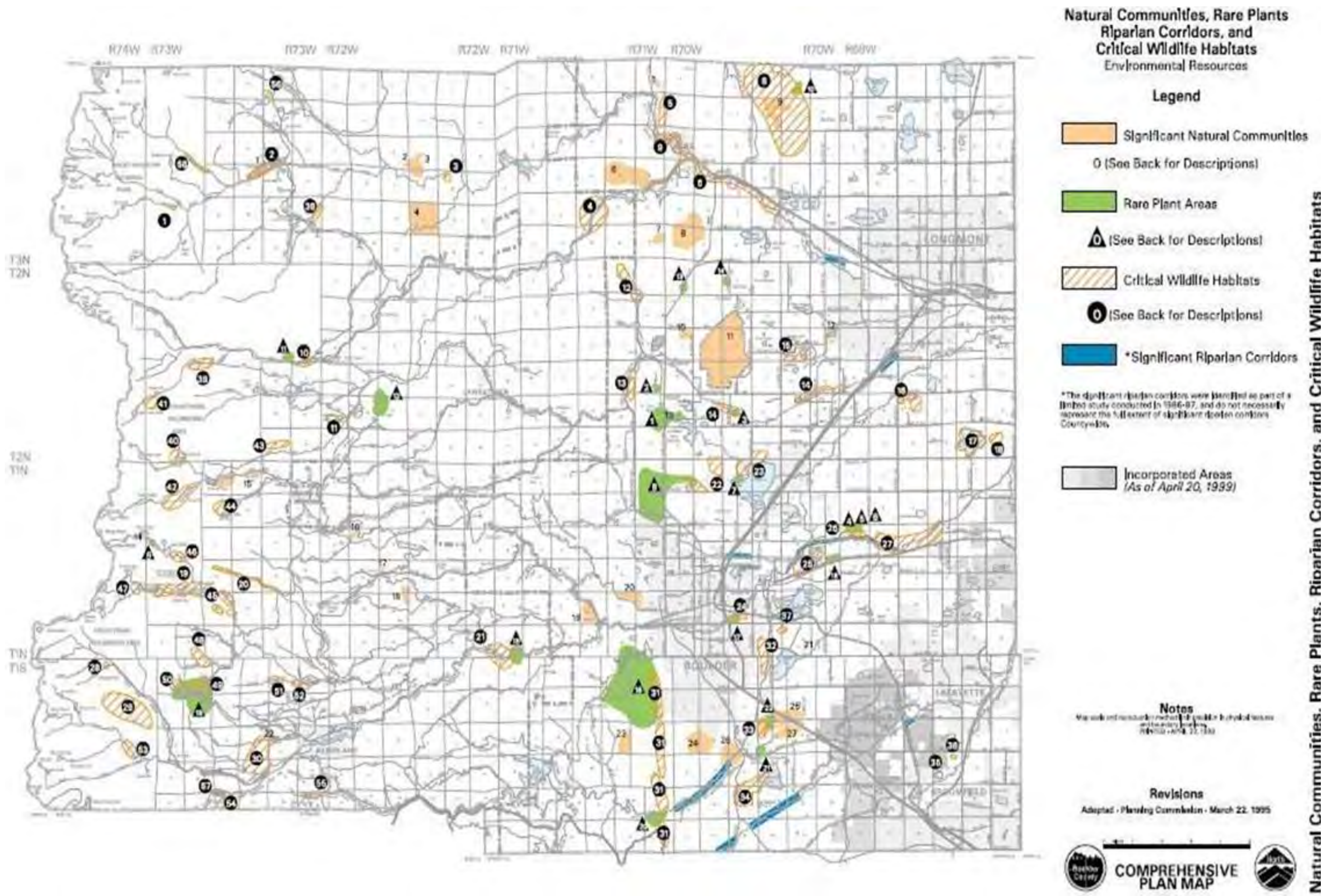
Endangered Species and Imperiled Natural Plant Communities

To further understand natural resources that may be particularly vulnerable to a hazard event, as well as those that need consideration when implementing mitigation activities, it is important to identify at risk species (i.e., endangered species) in the planning area. An endangered species is any species of fish, plant life, or wildlife that is in danger of extinction throughout all or most of its range. A threatened species is a species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range. Both endangered and threatened species are protected by law and any future hazard mitigation projects are subject to these laws. Candidate species are plants and animals that have been proposed as endangered or threatened but are not currently listed.

According to the U.S. Fish and Wildlife Service, as of March 2022, there were 16 federally endangered, threatened, candidate, or species of concern in Boulder County. For a list of those species along with state listed species (excluding those identified in the County as extirpated or casual/accidental), see Appendix XXX, or visit the following link: https://ecos.fws.gov/ecp/

According to the Colorado Natural Heritage Program, there are also a number of natural plant communities in Boulder County that have been identified as critically imperiled, imperiled, or rare/uncommon. These communities can be found in Appendix 4.2, Some of these communities, as well as critical wildlife habitat that support endangered species within the County are mapped in Figure 4-36.

Figure 4-36 Boulder County Natural Communities, Rare Plants, Riparian Corridors, and Critical Wildlife Habitats



Significant Natural Communities

1 Montane Willow Carr
2 Foothills Ponderosa Pine Scrub Woodland (Purshia)
3 Mixed Foothills Shrubland (Purshia)
4 Foothills Ponderosa Pine Savanna
5 Mixed Foothills Shrubland (Cercocarpus)
6 Xeric Tallgrass Prairie
7 Foothills Ponderosa Pine Scrub Woodland (Cercocarpus)
8 Foothills Ponderosa Pine Scrub Woodland (Cercocarpus)
9 Foothills Ponderosa Pine Scrub Woodland (Cercocarpus)
10 Great Plains Mixed Grass Prairie (Stipa comata)
11 Great Plains Mixed Grass Prairie (Stipa neomexicana)
12 Great Plains Salt Meadow
13 Great Plains mixed Grass Prairie (Stipa comata)
14 Alpine Wetlands
15 Montane Wet Willow Carr
16 Montane Grasslands
17 Foothills Ponderosa Pine Savanna
18 Montane Grasslands
19 Foothills Ponderosa Pine Savanna
20 Xeric Tallgrass Prairie
21 Great Plains Mixed Grass Prairie
22 Montane Willow Carr
23 Montane Grasslands
24 Wet Prairie
25 Wet Prairie
26 Wet Prairie
27 Xeric Tallgrass Prairie

Rare Plant Areas

1 *Physaria bellii*
2 *Physaria bellii*
3 *Physaria bellii*
4 *Aristida basiramea*
5 *Apios americana*
6 *Asplenium adiantum-nigrum*
7 *Physaria bellii*
8 *Physaria bellii*
9 *Phippsia algida*
10 *Physaria bellii*
11 *Listera convallarioides*
12 *Eustoma grandiflorum*
13 *Physaria bellii*
14 *Physaria bellii*
15 *Selaginella weatherbiana*
16 *Amorpha nana, Betula papyrifera, Carex saximontana, Listera convallarioides, Malaxis brachypoda, Pyrola picta, Selaginella weatherbiana*
17 *sensitive species*
18 *Eustoma grandiflorum*
19 *Botrychium echo, Botrychium hesperium, Botrychium lanceolatum, Botrychium pallidum, Listera convallarioides, Botrychium minganense*
20 *Selaginella weatherbiana*
21 *Amorpha nana*
22 *Amorpha nana*

Critical Wildlife Habitats

1 Ouzel Falls
2 Copeland Willow Carr (+wetlands)
3 South Sheep Mountain
4 Deadman Gulch and South St. Vrain
5 Steamboat Mountain
6 St. Vrain Creek (+wetlands)
7 St. Vrain Corridor (+wetlands)
8 Rabbit Mountain
9 Old Apple Valley
10 Middle St. Vrain Willow Carr (+wetlands)
11 Tumbleson Lake (+wetlands)
12 Marietta Canyon
13 Lefthand Palisades
14 Lefthand Creek Cottonwood Groves (+wetlands)
15 Lagerman Reservoir (+wetlands)
16 Gaynor Lakes (+wetlands)
17 Panama Reservoir (+wetlands)
18 B-J Acres Ranch
19 City of Boulder Watershed (Special Consideration)
20 Como Creek (Special Consideration)
21 Boulder Falls area
22 Boulder Valley Ranch (+wetlands)
23 Boulder Reservoir (+wetlands)
24 Cottonwood Grove on Boulder Creek (+wetlands)
25 Walden and Sawhill Ponds (+wetlands)
26 White Rocks (+wetlands)
27 Cottonwood Grove & Heron Rookery (+wetlands)
28 Diamond Lake Outlet
29 Chittenden Meadows (+wetlands)
30 Arapaho Ranch • Tucker Homestead (+wetlands)
31 Boulder Mountain Parks - Eldorado Mountain
32 South Boulder Creek (+wetlands)
33 Tallgrass Prairie
34 Marshall Mesa
35 Stearns Lake (+wetlands)
36 Carolyn Holmberg Preserve at Rock Creek Farm
37 Sombrero Marsh (+wetlands)
38 Lazy H, Ranch Willow Carr (+wetlands)
39 Coney Flats Willow Carr (+wetlands)
40 Mitchell Lake Willow Carr (+wetlands)
41 Coney Lake Willow Carr (+ wetlands)
42 Long Lake Willow Carr (+wetlands)
43 South St. Vrain Willow Carr (+wetlands)
44 Lefthand Reservoir Willow Carr (+wetlands)
45 Boulder Watershed Willow Carr (+wetlands)
46 Lake Albion Willow Carr (+wetlands)
47 Triple Lakes Willow Carr (+wetlands)
48 Horseshoe Creek Willow Carr (+wetlands)
49 Caribou Park Willow Carr (+wetlands)
50 Upper Caribou Park Willow Carr (+wetlands)
51 Delonde Creek Willow Carr (+wetlands)
52 Caribou Ranch Willow Carr (+wetlands)
53 Woodland Flats Willow Carr (+wetlands)
54 Buckeye Basin Willow Carr (+wetlands)
55 Los Lagos Willow Carr (+wetlands)
56 Roaring Fork Willow Carr (+wetlands)
57 Peterson Lake (+wetlands)
58 Hunter's Creek

Source: Colorado Natural Heritage Program, www.cnhp.colostate.edu/

Critical Facilities

- Trailheads
- Environmental Conservation Areas

Other Facilities identified by the HMPC:

- USFS Campgrounds

Future Development

Natural systems and watersheds will continue to be heavily impacted by climate change. Various emissions scenarios and projections sampled down to the County level indicate that there will be an increase in hotter days, more extreme and variable precipitation events, and reduction in water resources. In addition to these changes, many species are simply unable to cope with the extreme variability in temperatures and moisture availability. As population increases in Boulder County, more houses and people are likely to occupy the WUI. This will put further strain on firefighting and emergency response resources and create further costs for environmental restoration.

Damage to natural systems will result in impacts to the economy, especially for mountain towns and areas dependent on tourism. It will also have a more intangible impact on mental health and will reduce resources available to populations around the County.

4.4.9 Technological Systems

Technological systems can both facilitate and prevent access to social and ecological systems. Specific focus on human focused systems, the hazard outcomes for those systems, and community members interactions with them. These systems are analyzed firstly in order to identify critical facilities and current and future vulnerabilities that may impact the health and safety of Boulder County community members, but will not be identified through a focus on individual hazards; and secondarily to surface opportunities for mitigation partnerships with other County departments and whole community partners. Technological system vulnerabilities for Boulder County focus on Housing and Infrastructure.

Housing

Background

Housing assets include affordable housing, access to structures, and safe spaces. Hazard impacts to housing cause severe shock to community members, as well as ripple effects in the economy, reductions to public safety, population loss, etc.

Total Exposure of Population and Structures

Table 4-16 shows the estimated total population. There were 135,409 housing units in Boulder County with a vacancy rate of 5.9% in 2020 according to the U.S. Census Bureau.

Table 4-16 Estimated Total Population

Jurisdiction	2020 Population
City of Boulder	108,154
Town of Erie*	12,791
Town of Jamestown	255
City of Lafayette	30,377
City of Longmont*	97,833
City of Louisville	21,171
Town of Lyons	2,202

Jurisdiction	2020 Population
Town of Nederland	1,481
Town of Superior	13,099
Town of Ward	129
Unincorporated Boulder County	23,368
Total County	330,860

Source: U.S. Census Bureau, 2020 Census and 2018 estimates for Town of Ward
**Partial estimate for Boulder County only*

Assessments in this plan are based on two building inventories: one from Boulder County's Assessor's Office and the other from FEMA's HAZUS-MH. Table 4-17 shows the property inventory from the Assessor's Office for the entire county, organized by jurisdiction and property type. The parcel layer and Assessor Data Table were obtained from Boulder County in early 2022. The accounts in the assessor data undergo a full assessment in May of every odd year. Hence, actual values of the data are current as of May 2021. The only exception to this is when major improvements are made on a property. According to the assessor's data, the sum of the value of improvements in the County is $61.5 billion (building exposure only, not including land value).

Table 4-17 Boulder County Property Inventory by Jurisdiction and Property Type

Jurisdiction	Property Type	Improved Parcels	Building Count	Improved Value	Content Value	Total Value
Boulder	Agricultural	6	53	$27,267,100	$27,267,100	$54,534,200
	Commercial	1,437	1,296	$2,679,277,149	$2,679,277,149	$5,358,554,298
	Exempt	735	1,315	$2,600,750,622	$2,600,750,622	$5,201,501,244
	Industrial	309	304	$929,081,250	$1,393,621,875	$2,322,703,125
	Mixed Use	83	187	$314,016,168	$314,016,168	$628,032,336
	Residential	31,523	26,925	$16,575,234,102	$8,287,617,051	$24,862,851,153
	Vacant	1	7	$7,800	$7,800	$15,600
	Total	**34,094**	**30,087**	**$23,125,634,191**	**$15,302,557,765**	**$38,428,191,956**
Erie	Agricultural	6	9	$2,763,400	$2,763,400	$5,526,800
	Commercial	11	17	$15,255,400	$15,255,400	$30,510,800
	Exempt	20	34	$25,158,621	$25,158,621	$50,317,242
	Industrial	4	5	$5,033,400	$7,550,100	$12,583,500
	Mixed Use	4	29	$11,297,600	$11,297,600	$22,595,200
	Residential	4,478	4,513	$1,849,076,559	$924,538,280	$2,773,614,839
	Total	**4,523**	**4,607**	**$1,908,584,980**	**$986,563,401**	**$2,895,148,381**
Jamestown	Commercial	1	1	$50,000	$50,000	$100,000
	Exempt	25	29	$970,900	$970,900	$1,941,800
	Mixed Use	2	2	$492,800	$492,800	$985,600
	Residential	121	157	$44,864,776	$22,432,388	$67,297,164
	Total	**149**	**189**	**$46,378,476**	**$23,946,088**	**$70,324,564**
Lafayette	Agricultural	4	13	$2,263,500	$2,263,500	$4,527,000
	Commercial	296	317	$350,497,615	$350,497,615	$700,995,230
	Exempt	206	280	$288,637,394	$288,637,394	$577,274,788
	Industrial	84	99	$136,223,730	$204,335,595	$340,559,325

Jurisdiction	Property Type	Improved Parcels	Building Count	Improved Value	Content Value	Total Value
	Mixed Use	20	52	$29,404,800	$29,404,800	$58,809,600
	Residential	10,283	10,464	$3,926,237,876	$1,963,118,938	$5,889,356,814
	Vacant	1	1	$8,700	$8,700	$17,400
	Total	**10,894**	**11,226**	**$4,733,273,615**	**$2,838,266,542**	**$7,571,540,157**
Longmont	Agricultural	10	30	$2,916,700	$2,916,700	$5,833,400
	Commercial	1,072	958	$854,929,370	$854,929,370	$1,709,858,740
	Exempt	432	777	$633,312,850	$633,312,850	$1,266,625,700
	Industrial	195	271	$489,665,660	$734,498,490	$1,224,164,150
	Mixed Use	111	215	$118,634,626	$118,634,626	$237,269,252
	Residential	29,473	31,946	$11,279,145,691	$5,639,572,846	$16,918,718,537
	Vacant	10	18	$1,209,367	$1,209,367	$2,418,734
	Total	**31,303**	**34,215**	**$13,379,814,264**	**$7,985,074,249**	**$21,364,888,513**
Louisville	Agricultural	3	6	$728,800	$728,800	$1,457,600
	Commercial	251	245	$433,063,223	$433,063,223	$866,126,446
	Exempt	88	158	$165,149,034	$165,149,034	$330,298,068
	Industrial	148	117	$501,166,046	$751,749,069	$1,252,915,115
	Mixed Use	9	22	$16,367,500	$16,367,500	$32,735,000
	Residential	7,325	7,201	$2,872,098,425	$1,436,049,213	$4,308,147,638
	Vacant	2	2	$699,500	$699,500	$1,399,000
	Total	**7,826**	**7,751**	**$3,989,272,528**	**$2,803,806,339**	**$6,793,078,867**
Lyons	Agricultural	2	6	$863,500	$863,500	$1,727,000
	Commercial	42	55	$15,447,800	$15,447,800	$30,895,600
	Exempt	48	61	$6,924,600	$6,924,600	$13,849,200
	Industrial	7	4	$189,000	$283,500	$472,500
	Mixed Use	17	41	$7,100,300	$7,100,300	$14,200,600
	Residential	831	940	$457,921,997	$228,960,999	$686,882,996
	Total	**947**	**1,107**	**$488,447,197**	**$259,580,699**	**$748,027,896**
Nederland	Commercial	45	51	$17,156,126	$17,156,126	$34,312,252
	Exempt	39	44	$7,300,800	$7,300,800	$14,601,600
	Industrial	1	1	$160,000	$240,000	$400,000
	Mixed Use	14	15	$4,268,200	$4,268,200	$8,536,400
	Residential	706	807	$288,663,998	$144,331,999	$432,995,997
	Vacant	1	1	$10,900	$10,900	$21,800
	Total	**806**	**919**	**$317,560,024**	**$173,308,025**	**$490,868,049**
Superior	Commercial	32	49	$162,963,009	$162,963,009	$325,926,018
	Exempt	28	52	$13,671,675	$13,671,675	$27,343,350
	Mixed Use	1	13	$3,110,000	$3,110,000	$6,220,000
	Residential	3,925	3,973	$2,052,115,131	$1,026,057,566	$3,078,172,697
	Total	**3,986**	**4,087**	**$2,231,859,815**	**$1,205,802,250**	**$3,437,662,065**
Ward	Exempt	16	16	$74,500	$74,500	$149,000

Jurisdiction	Property Type	Improved Parcels	Building Count	Improved Value	Content Value	Total Value
	Mixed Use	3	3	$407,200	$407,200	$814,400
	Residential	96	109	$17,764,107	$8,882,054	$26,646,161
	Total	**115**	**128**	**$18,245,807**	**$9,363,754**	**$27,609,561**
Unincorporated	Agricultural	1,072	3,331	$684,114,839	$684,114,839	$1,368,229,678
	Commercial	154	350	$105,066,942	$105,066,942	$210,133,884
	Exempt	1,003	1,680	$126,659,625	$126,659,625	$253,319,250
	Industrial	67	123	$122,016,480	$183,024,720	$305,041,200
	Mixed Use	65	234	$35,097,200	$35,097,200	$70,194,400
	Residential	18,703	24,184	$10,220,467,349	$5,110,233,675	$15,330,701,024
	Vacant	19	25	$1,775,783	$1,775,783	$3,551,566
	Total	**21,083**	**29,927**	**$11,295,198,218**	**$6,245,972,784**	**$17,541,171,002**
	Grand Total	**115,726**	**124,243**	**$61,534,269,115**	**$37,834,241,893**	**$99,368,511,008**

Source: Boulder County Assessor's Office

Equity

Affordable housing continues to be a crisis of its own in Boulder County. Occupancy rates were affected by the 2013 flood and have only recently risen back to the 5% that indicates a balanced market (HUD 2020). However, housing prices in the major cities in Boulder County rose between 39% and 71% between 2008 and 2017 and continue to climb. Between 2000 and 2017, price inflation moved over 30,000 homes out of achievable reach for low to middle income earners (Boulder County Regional Housing Strategy 2017). More than 60% of Boulder County residents do not earn enough to buy a home in the County (TRENDS 2019).

Housing is a critical need during and after hazard events. If large numbers of homes are removed from the housing stock as happened during the 2013 flood, this could have a devastating impact on the ability of communities to recover. Loss of housing has a disproportionate impact on low-income families, especially mobile homeowners, as there are no affordable places to go if their original home is lost. As seen in prior disasters, people were priced out of Boulder County and unable to return (CoLab 2019). People with disabilities were likewise unable to find accessible housing due to very low occupancy limits in towns and cities throughout the County.

Future Development

Climate change is projected to increase the number of hot days as well as the intensity of precipitation events (RMCO 2016). This will have major impacts on low-income households, as they will incur more heating and cooling costs, as well as maintenance costs to cope with the shortened lifespan of building materials in extreme temperatures. Wildfire mitigation alone for existing housing stock is projected to cost over $20 million (Resilient Analytics 2018).

Figure 15. Apartment Rents and Vacancy Rates in the Boulder HMA

Source: *Apartment Insights*

Infrastructure

Background

Infrastructure assets include transportation, green infrastructure, water, wastewater, solid waste, energy, and communications facilities.

Hazard impacts to infrastructure may cause impacts to life safety during disaster response and can also be prohibitive to recovery. This may include but is not limited to impacts such as road or bridge washout from flooding; loss of potable water; and loss of communications systems to deliver warnings or information.

Critical Facilities

- Highways, bridges, and tunnels
- Railroads and facilities
- Airports
- Water treatment facilities
- Natural gas and oil facilities and pipelines
- Communications facilities
- Internet/Cellular data access

Other Facilities identified by the HMPC:

- Gross Dam
- Barker Dam
- Boulder Water Shed
- Button Rock Dam
- Betasso Water Treatment
- 63rd Street Water Treatment
- Longmont Treatment
- Nederland Treatment
- Lyons Treatment
- Superior Treatment
- Lafayette Treatment
- Louisville Treatment
- Public Service—63rd
- Longmont Gas and Electric
- Boulder Hydros
- Daily Camera
- AT&T Cable
- Channel 8
- KGNU

Equity

The digital divide has shrunk since 2015, but 17% of residents making under $20,000 per year lack access to any internet service, even on their phones, as do nearly 10% of those making between $20,000 and $75,000 per year. This indicates a curtailed access to early warning systems and reduced access to public health warnings and information. The lack of digital devices also impacts elderly residents' ability to access services such as transportation assistance (Nelson/Nygaard). Low-income families also experience more difficulty accessing transportation systems (Nelson/Nygaard) as do elderly residents in mountain communities.

Is transportation a challenge in the life of you or your family?

No	# of respondents	%	Yes	# of respondents	%
	27	35%		50	65%
Under $15,000	10	13%	Under $15,000	35	45%
$15,000-$24,999	4	5%	$15,000-$24,999	7	9%
$25,000-$34,999	3	4%	$25,000-$34,999	5	6%
$35,000-$49,000	1	1%	$35,000-$49,000	0	0%
$50,000-$74,999	1	1%	$50,000-$74,999	2	3%
$75,000 or more	8	10%	$75,000 or more	1	1%

Future Development

Future adaptation costs to mitigate the impacts of climate change on infrastructure are projected to be upwards of $157 million across Boulder County. This does not include increased cooling costs for buildings or urban drainage improvements, which are conservatively projected to add another $20 million in costs (Resilient Analytics, 2018) These costs do not include accounting for costs of installing heating or cooling systems in homes where they do not already exist, increasing water availability for droughts, removing dead trees from wildfires or pine beetle infestations, or rising health care costs for increased diseases and hospitalizations (Resilient Analytics, 2018).

4.4.10 Growth and Development Trends

Table 4-18 illustrates how Boulder County has grown in terms of population and number of housing units between 2005 and 2020.

Table 4-18 Boulder County's Change in Estimated Population and Housing Units, 2005-2020

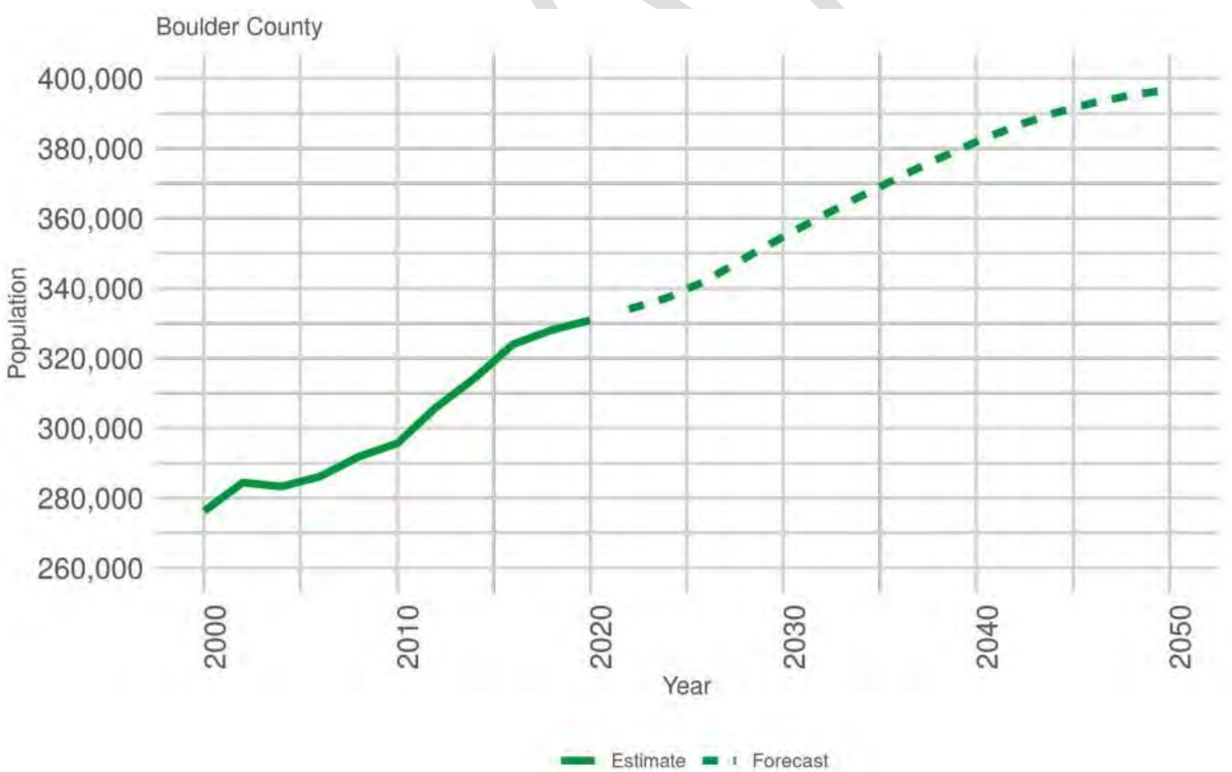
Jurisdiction	2005 Population Estimate	2020 Population	Percent Change 2005-2020	2005 # of Housing Units Estimate	2020 # of Housing Units	Percent Change 2005-2020
City of Boulder	95,088	108,250	12.16%	42,946	46,371	7.39%
Unincorporated Areas	43,261	42,263	-2.36%	20,751	20,973	1.06%
Erie (part)*	6,932	12,652	45.21%	2,500	4,221	40.77%
Jamestown	284	202	-40.59%	139	113	-23.01%

Jurisdiction	2005 Population Estimate	2020 Population	Percent Change 2005-2020	2005 # of Housing Units Estimate	2020 # of Housing Units	Percent Change 2005-2020
Lafayette	23,444	30,411	22.91%	9,714	12,482	22.18%
Longmont	81,415	98,885	17.67%	33,297	41,252	19.28%
Louisville	18,045	21,226	14.99%	7,631	8,934	14.58%
Lyons	1,642	2,126	22.77%	744	909	18.15%
Nederland	1,416	1,497	5.41%	735	772	4.79%
Superior	11,223	13,094	14.29%	4,573	5,043	9.32%
Ward	160	152	-5.26%	94	101	6.93%
Total County	**282,910**	**330,758**	**14.47%**	**123,124**	**141,171**	**12.78%**

Source: Colorado DOLA, State Demography Office
**Part of these municipalities are in another county.*

As indicated above, Boulder County has grown significantly in recent years, and growth is projected to continue through 2050. According to the Colorado Department of Local Affairs, the population of Boulder County is forecast to reach 381,850 by 2040. Overall, the growth rate for Boulder County is expected to decrease between 2020 and 2040, however growth is projected to remain positive through the mid-21st Century.

Figure 4-37 Population Projections for Boulder County, 2000-2050



Source: Colorado DOLA

4.4.11 Sets Vulnerability Mitigation Opportunities

The use of a combined social, ecological, and technological systems (SETs) framework allows for the identification of mitigation partners, projects, and strategies that will reduce fragility and increase flexibility and adaptive capacity throughout all systems. Examples of overarching mitigation strategies that can be used to increase system cohesion and capacity within Boulder County include the following:

1) Identify community critical facilities and put them in GIS database for future mitigation and adaptation.
2) Adapt first responder agencies for climate change.
3) Ensure warning systems and alerts are accessible for people with disabilities and limited English proficiency.
4) Ensure a variety of mental health services and therapies are available for all communities.
5) Provide preparedness material and hazard education for homeless, previously incarcerated, low-income, LEP households in culturally appropriate ways.
6) Create opportunities for community-led after-action reports.
7) Educate homeowners on green infrastructure, swales, etc. and encourage investment in permeable paving to reduce urban flooding.
8) Provide climate adaptation assistance for low-income families and homeowners.
9) Ensure continuity of operations planning includes climate adaptation.

4.5 Estimating Potential Losses

4.5.1 Air Quality

Background

Boulder County's air quality continues to suffer from high ozone levels and has recently been impacted by smoke from major fires across the western United States.

Community Impacts

Poor air quality impacts those with pre-existing conditions, children, and the elderly as well as sectors of the workforce that work in the outdoors.

Future Development

Climate change will contribute to air pollution in a variety of ways. Higher temperatures increase the production of ozone (LGC). The projected increase in wildfires and droughts will reduce ecosystem services that mitigate air pollution while increasing PM and ozone levels that are damaging to human health. Current estimates indicate 20,000 premature deaths per year due to chronic wildfire smoke exposure. That figure could double by the end of the year (LGC 2020).

Indoor radon pollution is also an ongoing concern in Colorado. Rising population numbers will increase the number of homes that require mitigation, and education about radon will be necessary for new residents.

4.5.2 Dam and Levee Failure

Background

Based on the information in the hazard profile the impacts to existing development from a dam failure in Boulder County could be catastrophic. Specific inundation maps and risk information is included with specific dam emergency action plans with the Boulder County OEM. Due to the sensitive nature of this information, it is not included in this plan. The impacts to the County and its municipalities from a dam failure will be similar in some cases to those associated with flood events (see the flood hazard vulnerability analysis and discussion). 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. Another difference is that dam failures could flood areas outside of mapped floodplains.

Community Impacts

The areas that could be significantly impacted by a dam failure include the City of Boulder, unincorporated Boulder County along Boulder Creek and South Boulder Creek, and Lyons, Longmont, and unincorporated area along St Vrain Creek. The reservoirs located in the foothills and Rocky Mountains could have the greatest potential impacts if they were to fail. These include the large reservoirs of Gross, Barker, and Button Rock. The overall dam inundation exposure of population, building counts, and estimated property value is broken out by jurisdiction in Table 4-19, and critical facility exposure is detailed in Table 4-20 below. Figure 4-38 shows the locations of dams throughout Boulder County.

Table 4-19 Dam Inundation Hazard by Jurisdiction and Property Type

Jurisdiction	Improved Parcels	Building Count	Improved Value	Content Value	Total Value	Population
Boulder	11,568	8,639	$9,657,092,858	$7,349,518,219	$17,006,611,077	14,480
Erie	94	123	$43,053,269	$22,458,685	$65,511,954	321
Jamestown	15	15	$5,061,899	$2,530,950	$7,592,849	25
Lafayette	2,883	2,926	$939,349,102	$597,138,104	$1,536,487,206	6,933
Longmont	4,609	5,531	$2,120,134,833	$1,494,255,178	$3,614,390,011	11,616
Louisville	198	286	$128,837,857	$96,158,196	$224,996,053	491
Lyons	291	351	$129,982,369	$69,494,685	$199,477,054	721
Nederland	-	-	-	-	-	-
Superior	651	363	$236,850,400	$118,596,100	$355,446,500	966
Ward	-	-	-	-	-	-
Unincorporated	2,893	4,236	$1,349,532,323	$778,007,684	$2,127,540,007	7,645
Total	**23,202**	**22,470**	**$14,609,894,910**	**$10,528,157,798**	**$25,138,052,708**	**43,198**

Source: Boulder County Assessor's Office, NID

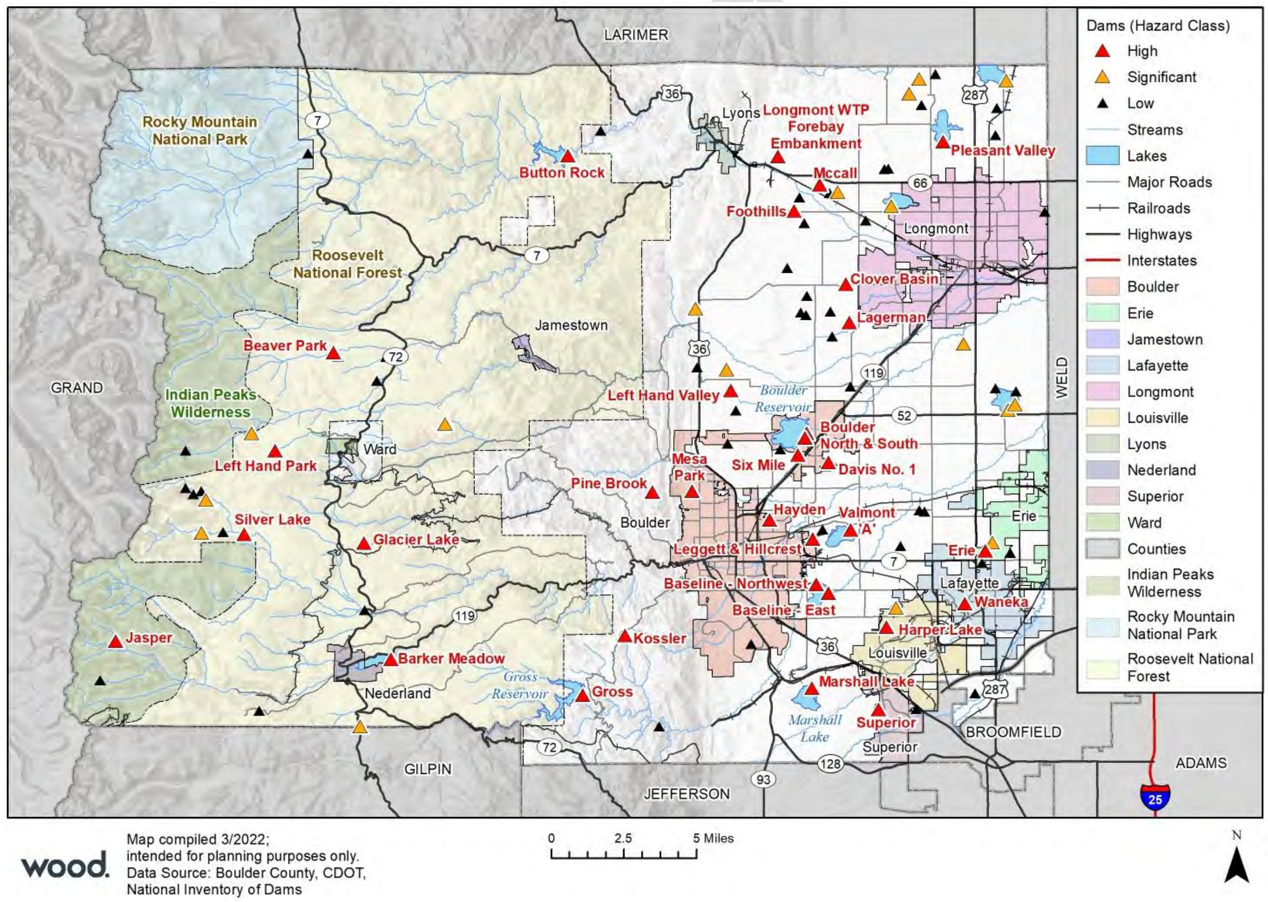
Table 4-20 Critical Facilities with Dam Inundation Risk by Jurisdiction and FEMA Lifeline

Jurisdiction	Communications	Energy	Food, Water, Shelter	Hazardous Material	Health and Medical	Safety and Security	Transportation	Total
Boulder	13	1	17	45	22	106	51	**255**
Erie	-	-	1	-	-	-	2	**3**
Jamestown	1	-	-	-	-	1	1	**3**
Lafayette	1	-	3	2	8	15	3	**32**
Longmont	-	-	2	12	14	31	22	**81**
Louisville	1	-	1	-	-	5	2	**9**
Lyons	1	-	1	-	-	4	6	**12**

Jurisdiction	Communications	Energy	Food, Water, Shelter	Hazardous Material	Health and Medical	Safety and Security	Transportation	Total
Nederland	-	-	-	-	-	-	-	0
Superior	-	-	1	-	-	1	-	2
Ward	-	-	-	-	-	-	-	0
Unincorporated	4	11	49	22	1	29	62	178
Total	**21**	**12**	**75**	**81**	**45**	**192**	**149**	**575**

Source: NID, Boulder OEM, HIFLD, National Bridge Inventory

Figure 4-38 Boulder County National Inventory of Dams



Losses from a dam failure will vary based on the dam involved, warning time, warning accessibility and time of day. However, the potential exists for property losses into the billions and multiple deaths and injuries. Impacts to critical facilities would be similar to those identified in the flood vulnerability analysis.

There are few levees within the County, mainly within the City of Boulder. While technically not a levee, a floodwall protects the Boulder County Justice Center (located within the City of Boulder) from flooding on Boulder Creek. This floodwall is designed to provide 100-year event protection and the structure has been mapped as providing 100-year protection.

Future Development

It is important that the County keeps the dam failure hazard in mind when permitting new development, particularly downstream of the high and significant hazard dams present in the County. There are currently 32 low hazard dams in the County. These could become significant or high hazard dams if development occurs below or downstream of them. Climate change is projected to increase the likelihood of dam failure due to increased variability in water availability, and more extreme temperature shifts that will strain infrastructure. In particular, precipitation events are projected to increase in variability and become more intense in the winter, while rising summer temperatures will increase evaporative potential (RMCO 2016). These fluctuations will strain the health and viability of existing infrastructure and may increase the possibility of dam failure.

4.5.3 Drought

Background

Based on Boulder County's recent multi-year droughts and Colorado's drought history, it is evident that all of Boulder County is vulnerable to drought. However, the impacts of future droughts will vary by region. The agricultural industry of the County will experience hardships, including agricultural losses, and livestock feeding expenses and deaths. The County will see an increase in dry fuels, beetle kill, and associated wildfires and some loss of tourism revenue. Water supply issues for municipal, industrial, and domestic needs will be a concern for the entire County during droughts. Most of Boulder County's water comes from snow melt runoff in the high country of the western County that is captured in reservoir storage. Vulnerability increases with consecutive winters of below average snowpack.

While widespread, the losses associated with drought are often the most difficult to track or quantify. While FEMA requires the potential losses to structures to be analyzed, drought does not normally have a structural impact. Drought can indirectly lead to property losses as a result of it contributing to extreme wildfire conditions (see discussion on wildfire vulnerability). This combined with the potential for significant impacts to water-intensive activities such as agriculture, wildfire suppression, municipal usage, commerce, tourism, and wildlife preservation, can lead to widespread economic ramifications.

Community Impact

Many residents in unincorporated Boulder County are vulnerable to the direct impacts of drought reducing the availability of groundwater and increasing pollutant levels in well water. This threat is exacerbated by the increased likelihood of wildfire that accompanies more numerous droughts. Paying for well improvements was a financial hardship for homeowners after the 2013 flood, and may price people out of the mountains if they must participate in successive recoveries from drought, landslide, wildfire, etc.

Drought has also been shown to negatively impact air quality. In addition to increased risk of wildfire, prolonged drought reduces the ability of trees to absorb pollutants and clean the air, causing increasing levels of ozone. Boulder County already has some of the highest ozone levels in the United States, and future droughts may contribute to its effects. Poor air quality has a larger effect on those with jobs in the outdoors, as well as those with pre-existing health conditions. In Boulder County, the Latinx population are subject to higher percentages of pre-existing conditions such as diabetes (POS 2020). Poor air quality will also impact recreational opportunities, which has repercussions for mental health as well as tourist-based economies, such as ski-towns in the mountains. Regions that are dependent on tourism often have a majority low-income population and loss of business will increase overall hardship and the ability to recover from the impacts of other hazards.

Future Development

Drought vulnerability will increase with future development as there will be increased demands for limited water resources. Future growth in the unincorporated areas will mean more wells and more demands on groundwater resources. Potential costs associated with this include monitoring drawdowns from local aquifers and springs to ensure long-term water availability. In Boulder County, models project that the number of drought months will increase sharply after 2030, and that the number of drought months characterized as "severe" and "extreme" will nearly double between 2020-2049 compared to historical events (Resilient Analytics, 2018). This will contribute to a variety of increased costs, including obtaining water supplies, compensating the agricultural industry for reducing water-intensive crops and incentivizing homeowners to choose drought resistant landscaping and perform fire mitigation (Resilient Analytics, 2018). Throughout the whole County, drought will increase vulnerability through increases in dry fuels, beetle kill, and associated wildfires and as well as loss of tourism revenue. Water supply issues for municipal, industrial, and domestic needs and air quality will also be concerns for the entire County during droughts.

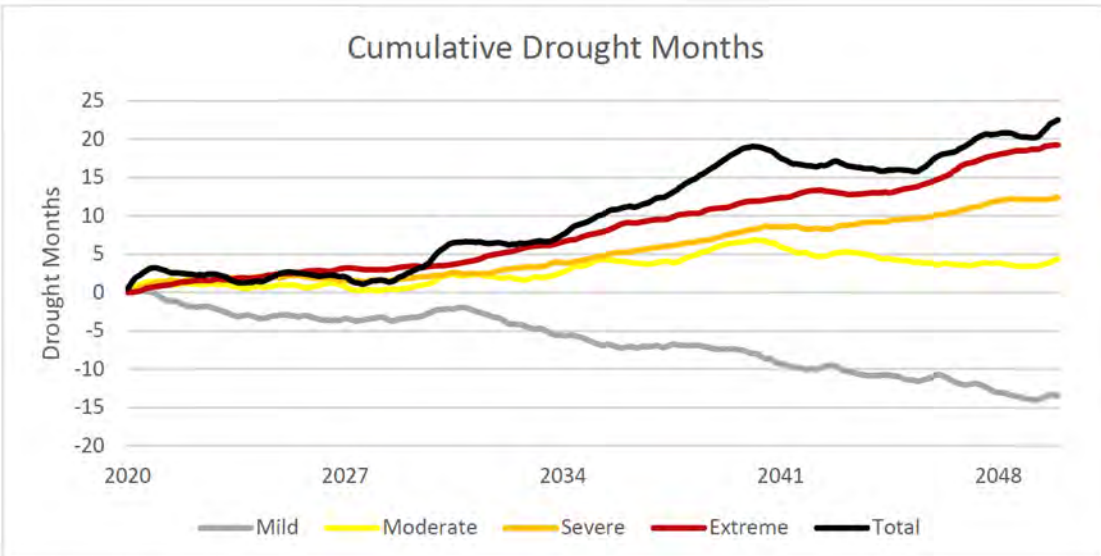


Figure10: Timeline of cumulative drought months by severity

4.5.4 Earthquake

Background

Earthquakes represent a low probability, high consequence hazard for Boulder County. Colorado has a relatively short historic record of earthquakes, which makes for a limited data set when making assumptions based on past events. A lot of unknowns remain about the earthquake potential in Boulder County and Colorado in general.

Based on the fact that there have been earthquake epicenters as well as potentially active faults inside the County boundaries, as well as in neighboring counties, earthquakes will likely occur in the future. Based on historic events, these will likely be in the range of Magnitude 5.5 or lower, which is strong enough to be felt and potentially cause damage.

According to the USGS, damage usually occurs with earthquakes in the Magnitude 4-5 range, but many variables affect damage such as building age, soil type, distance from the epicenter, etc. Older, historic buildings could suffer structural damage from a moderate sized event, but most impacts would likely be to non-structural items within the buildings such as light fixtures, toppling of shelves, cracked walls and chimneys. Falling items within buildings will likely pose the greatest risk to life safety.

The CGS has utilitized HAZUS-MH, FEMA's loss estimation software, to model earthquake risk from various faults in every county in the state. This information is included in Section 7.0 of the earthquake hazard identification and risk assessment chapter in the 2018 Colorado State Hazard Mitigation plan.

The CGS ran a series of deterministic scenarios for selected Colorado faults using HAZUS-MH to assess potential economic and social losses due to earthquake activity in Colorado. Deterministic analyses provide "what if" scenarios (e.g., determines what would happen if an earthquake of a certain magnitude occurred on a particular fault). The earthquake magnitudes used for each fault were the "maximum credible earthquake" as determined by the U.S. Geological Survey. The faults analyzed for Boulder County were Frontal, Golden, Mosquito, Ute Pass, Valmont, Walnut Creek, and Williams Fork (see Figure 4-9 in Subsection 4.2). Table 4-21 summarizes the results for Boulder County.

Table 4-21 Potential Earthquake Losses in Boulder County by Fault

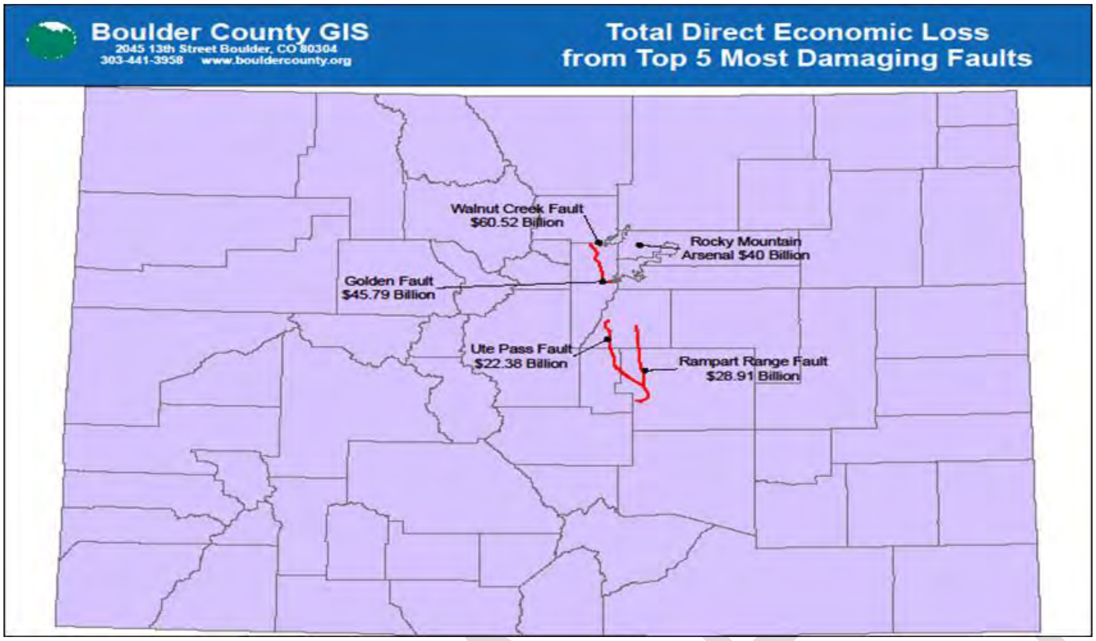
Fault/Magnitude	Fatalities at 2pm	Total Economic Loss (in millions)*	Loss Ratio (%)**
Frontal M7.0	0	56 Million	0.15%
Golden M6.5	20	1.27 Billion	3.78%
Mosquito M7.0	0	20 Million	0.04%
Ute Pass M7.0	0	45 Million	0.12%
Valmont M5	2	582 Million	1.92%
Walnut Creek M6.5	98	2.9 Billion	9.01%
Williams Fork M6.75	0	21 Million	0.05%

Source: HAZUS-MH models with depth of 2 km, attenuation function of West U.S. Extension 2008
**Direct and indirect losses*
***Percentage of the total building stock value damaged; the higher this ratio, the more difficult it is to restore a community to viability (loss ratios 10 percent or greater are considered by FEMA to be critical.)*
Note: County HAZUS-MH Inventory (HAZUS-MH 2000, including Broomfield): $25.46 billion

According to the CGS report, the Golden, Ute Pass, and Walnut Creek faults are considered among the top five potentially most damaging faults in the state (includes damage to other counties in the Denver Metropolitan Area). The top five, in order, are listed below and illustrated in Figure 4-39.

1) Rocky Mountain Arsenal
2) Golden
3) Rampart Range
4) Ute Pass
5) Walnut Creek

Figure 4-39 Total Direct Economic Loss from Top five Most Damaging Faults



During the development of this plan in 2022, a HAZUS-MH probabilistic earthquake scenario was run with the latest version of HAZUS-MH. This scenario involves a 2,500-year probabilistic 7.25 magnitude event occurring in Boulder County. The 2,500-year return period analyzes ground shaking estimates with a 2 percent probability of being exceeded in 50 years, from the various seismic sources in the area. The International Building Code uses this level of ground shaking for building design in seismic areas. Table 4-22 summarizes the results of the 2,500-year HAZUS-MH scenario. The total economic losses could exceed $824 million. Over 4 percent of the total number of buildings in the County will be at least moderately damaged.

Table 4-22 HAZUS-MH Earthquake Loss Estimation 2,500-Year Scenario Results

Type of Impact	Impacts to County
Total Buildings Damaged	Slight: 9,907 Moderate: 3,706 Extensive: 576 Complete: 24
Building and Income Related Losses	$606 million
	61% of damage related to residential structures
	17% of loss due to business interruption
Total Economic Losses (Includes building, income, and lifeline losses)	$824 million
Casualties	Without requiring hospitalization: 59
(based on 2 a.m. time of occurrence)	Requiring hospitalization: 7
	Life threatening: 0
	Fatalities: 1
Casualties	Without requiring hospitalization: 98
(based on 2 p.m. time of occurrence)	Requiring hospitalization: 13
	Life threatening: 1
	Fatalities: 2

Type of Impact	Impacts to County
Casualties (based on 5 p.m. time of occurrence)	Without requiring hospitalization: 75 Requiring hospitalization: 10 Life threatening: 1 Fatalities: 1
Displaced Households	230
Shelter Requirements	135

Source: HAZUS Global Probabilistic 2,500 Year model

Community Impacts

Given the lack of earthquake occurrence within the County, it is difficult to predict what the impact on key assets would be. Ensuring that community centers are built or retrofitted to withstand shocks will ensure that community services continue. This will be more difficult for low-income homeowners. It is also important to ensure that communications infrastructure can withstand earthquakes, including Spanish language services, and that warnings are accessible by disabled and limited English-speaking populations

Future Development

Any new construction built to modern building codes in the County should generally be able to withstand earthquakes. That said, the potential for non-structural damage will increase with new development. Continued growth of population in the County could potentially expose more persons to earthquakes and their related hazards.

4.5.5 Extreme Temperatures

Background

Extreme temperatures have not been considered for inclusion in the estimated losses section before. But with the increasing impacts of climate change, this hazard is projected to have a much more severe impact on residents and infrastructure within the County. Many homes in Colorado were built without cooling systems and it will be prohibitively expensive for many homeowners. The cost of adaptation and lack of preparedness may increase the impact of heat events across the County.

Community Impacts

Elderly populations, children, and those with pre-existing conditions are especially vulnerable to the impacts of extreme temperatures. Low-income families are less likely to be able to afford heating and cooling services and will be forced to rely on public institutions and services to escape extreme temperature events. Extreme temperatures will also preclude many from accessing the outdoors and will impact those that rely on the tourism sector for income.

Future Development

Extreme heat events are projected to become more common by the end of the century as climate change impacts intensify (RMCO 2016). In some models this would indicate that Boulder County's environment will come to resemble that of Phoenix, AZ by the end of the century. The County's infrastructure and homes require substantial mitigation costs to ensure that buildings can protect the population from extreme temperature impacts. As the median age of the population is rising, and as climate change impacts worsen, this hazard will create more substantial impacts in the County and throughout the region.

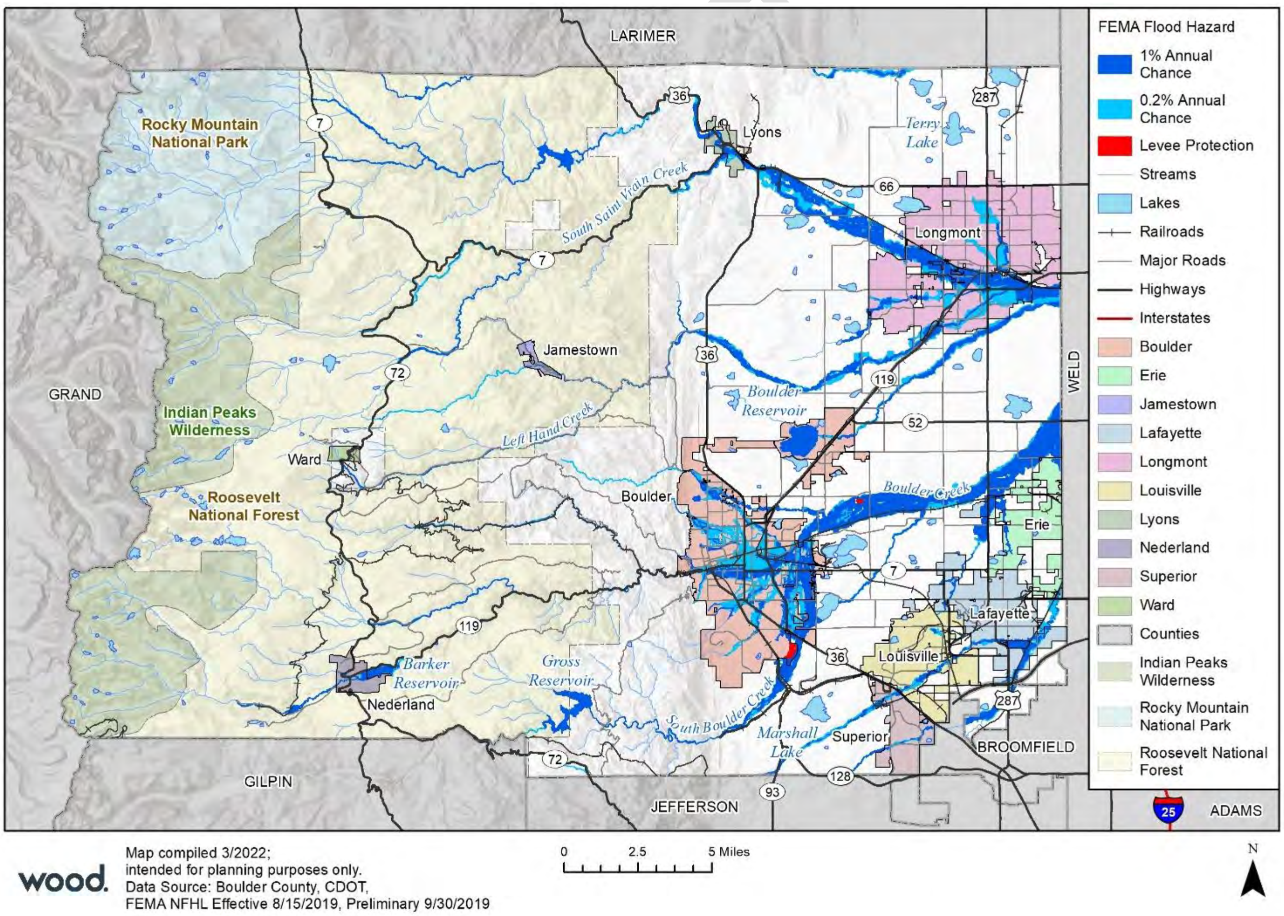
4.5.6 Flood

Background

Flooding and floodplain management are significant issues in Boulder County and some of the incorporated areas. The significance of this hazard, the requirements for Flood Mitigation Assistance plans, and the availability of digital hazard data in GIS drove the development of a detailed vulnerability assessment that is discussed in the following pages. The extent of the FEMA 1% and 0.2% Annual Chance Floodplains, as well as levee protected areas, are shown below in Figure 4-40.

It only takes three inches of rain over a few hours to trigger a 100-year flood. Those conditions are worsened by the lack of rain absorption caused by the Fourmile Canyon Fire in September 2010. Because of its large population and location at the mouth of the narrow Boulder Canyon, the City of Boulder has the greatest potential for loss of life from a flash flood of any community in Colorado. An estimated 6,000 people live and work in the floodplain of Boulder Creek, which runs through the heart of the City

Figure 4-40 Boulder County FEMA Flood Hazard



Methodology

The HMPC used GIS to quantify the potential flood losses to the County and cities within the mapped floodplain areas. The first step was to identify what is exposed to the various flood hazards. This entailed overlaying a countywide GIS layer of the 100- and 500-year floodplains (digitized by the City of Boulder based on the FEMA FIRM's) on parcels that contained data on structures. The flood layer for City of Boulder was determined to be the best available data countywide. The layer does not include changes associated with the recent restudy of South Boulder Creek. A separate countywide flood layer used for zoning purposes was not utilized because it did not differentiate between 100- and 500- year floodplains. A DFIRM is completed for the County.

Utilizing GIS, a hazard analysis was conducted on a 2020 pictometry building footprint layer provided by Boulder County. A separate parcel analysis was also conducted, where the parcel was used was used to create a centroid, or point, representing the center of each parcel polygon, in order to get the number of improved parcels, property types, and improved values. These two data sets were then merged together based on their property type and the jurisdiction in which they were located. This data was then analyzed in respect to the floodplain layer to find any parcel which intersected the floodplain, which in turn was assumed to be flooded. Another assumption with this model is that every parcel with an improved value greater than zero was assumed to be developed in some way. Only improved parcels, and the value of those improvements, were analyzed and aggregated by property type and flood zone. The parcels were segregated and analyzed for the unincorporated areas along with the following incorporated cities of Boulder, Erie, Jamestown, Lafayette, Longmont, Louisville, Lyons, Nederland, Superior and Ward.

The next step was to estimate potential losses to the properties located within a floodplain. The result of the exposure analysis summarizes the total values at risk in the floodplain. When a flood occurs, seldom does the event cause total destruction of an area. Potential losses from flooding are related to a variety of factors including flood depth, flood velocity, building type, and construction. Based on FEMA flood depth-damage curves, 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 of two feet. A damage estimation of 25 percent of the total value of the flooded property was used. This model does not account for structures within the 100-year floodplain that may be elevated above base flood elevation in accordance with local floodplain development requirements. While there are several limitations to this model, it does present a methodology to estimate potential damages.

In order to calculate potential losses, the improved property values were used to calculate content value based on FEMA formulas for building content value based on property type. For agricultural, commercial, exempt, and mixed-use properties the content value is estimated to be 100 percent of the improved value. For industrial properties the contents are valued at 150 percent of the improved value, and residential contents are valued at 50 percent of the improved value. The total value is then calculated by adding the improved value and content value.

The results of the vulnerability analysis are summarized in Table 4-23 and Table 4-24 showing loss by jurisdiction to the 100 year and 500-year events. A further $94.9 million in total property value is located in areas protected by levees in the City of Boulder. Table 4-25 contains an estimate of the population affected in each jurisdiction, by applying the 2020 Census average household size of each jurisdiction to the total count of residential structures affected in that jurisdiction.

Table 4-23 Boulder County 1% Annual Chance FEMA Flood Hazard by Jurisdiction and Property Type

Jurisdiction	Improved Parcels	Building Count	Improved Value	Content Value	Total Value	Estimated Loss
Boulder	2,228	2,481	$1,960,658,384	$1,406,373,770	$3,367,032,154	$841,758,039
Erie	7	8	$2,926,890	$1,742,895	$4,669,785	$1,167,446
Jamestown	22	32	$6,739,319	$3,369,660	$10,108,979	$2,527,245
Lafayette	74	76	$33,836,921	$37,116,511	$70,953,432	$17,738,358
Longmont	487	716	$194,598,433	$187,621,443	$382,219,876	$95,554,969
Louisville	16	16	$5,897,600	$2,948,800	$8,846,400	$2,211,600
Lyons	101	142	$31,828,315	$16,643,158	$48,471,473	$12,117,868
Nederland	17	28	$5,018,550	$3,268,725	$8,287,275	$2,071,819

Jurisdiction	Improved Parcels	Building Count	Improved Value	Content Value	Total Value	Estimated Loss
Superior	4	3	$481,227	$302,551	$783,778	$195,945
Ward	-	-	-	-	-	-
Unincorporated	652	1,279	$279,282,924	$167,996,856	$447,279,780	$111,819,945
Total	**3,608**	**4,781**	**$2,521,268,563**	**$1,827,384,367**	**$4,348,652,930**	**$1,087,163,233**

Source: Boulder County Assessor's Office, FEMA NFHL

Table 4-24 Boulder County 0.2% Annual Chance FEMA Flood Hazard by Jurisdiction and Property Type

Jurisdiction	Improved Parcels	Building Count	Improved Value	Content Value	Total Value	Estimated Loss
Boulder	5,689	4,060	$4,746,013,537	$3,432,192,563	$8,178,206,100	$2,044,551,525
Erie	-	-	-	-	-	-
Jamestown	6	16	$1,227,000	$949,150	$2,176,150	$544,038
Lafayette	39	30	$7,213,020	$5,849,970	$13,062,990	$3,265,748
Longmont	2,110	2,722	$956,811,845	$712,376,282	$1,669,188,127	$417,297,032
Louisville	101	125	$41,275,687	$25,306,586	$66,582,273	$16,645,568
Lyons	95	114	$38,939,594	$23,326,697	$62,266,291	$15,566,573
Nederland	-	-	-	-	-	-
Superior	27	43	$8,846,369	$4,548,635	$13,395,004	$3,348,751
Ward	-	-	-	-	-	-
Unincorporated	312	534	$130,770,936	$76,142,968	$206,913,904	$51,728,476
Total	**8,379**	**7,644**	**$5,931,097,988**	**$4,280,692,850**	**$10,211,790,838**	**$2,552,947,709**

Source: Boulder County Assessor's Office, FEMA NFHL

Table 4-25 Boulder County Population Affected by Flood

Location	Population Est. 100-year Flood	Population Est. 500-year Flood
Boulder	4,041	7,220
Erie	21	-
Jamestown	59	32
Lafayette	83	38
Longmont	1,069	5,764
Louisville	39	281
Lyons	261	215
Nederland	48	-
Superior	3	103
Ward	-	-
Unincorporated	2,092	918
Total	**7,714**	**14,569**

Source: U.S. Census Bureau, Boulder County Assessor's Office, FEMA NFHL

The results show an estimate of what the flood losses to structures would be if a 100-year or 500-year flood was to occur in any of the municipalities and unincorporated county.

Besides the City of Boulder, the highest losses to flood would be in Longmont, unincorporated areas, and Lafayette. However, the potential losses for Lyons and Jamestown are extremely high relative to their total building inventory and values. The analysis indicates that a 500-year flood in Longmont would be considerably more damaging than a 100-year event.

Critical Facilities

To estimate the potential impact of floods on critical facilities a GIS overlay was performed on the flood hazard layer to examine where it intersected with critical facility locations. The results are shown in Table 4-26 and Table 4-27. Any jurisdictions not included in the tables below do not have critical facilities located within the floodplain.

Table 4-26 Critical Facilities in within the FEMA 1% Annual Chance Flood Hazard by Jurisdiction

Jurisdiction	Communications	Energy	Food, Water, Shelter	Hazardous Material	Health and Medical	Safety and Security	Transportation	Total
Boulder	4	-	6	8	9	30	26	**83**
Erie	2	-	-	-	-	-	-	**2**
Jamestown	1	-	-	-	-	1	2	**4**
Lafayette	-	-	-	-	-	-	6	**6**
Longmont	-	-	1	9	-	6	17	**33**
Louisville	-	-	-	-	-	1	1	**2**
Lyons	-	-	-	-	-	-	3	**3**
Nederland	-	-	1	-	-	-	1	**2**
Superior	-	-	-	-	-	-	2	**2**
Unincorporated	2	-	6	7	1	1	52	**69**
Total	**9**	**0**	**14**	**24**	**10**	**39**	**110**	**206**

Source: FEMA NFHL, Boulder OEM, HIFLD, National Bridge Inventory

Table 4-27 Critical Facilities in within the FEMA 0.2% Annual Chance Flood Hazard by Jurisdiction

Jurisdiction	Communications	Energy	Food, Water, Shelter	Hazardous Material	Health and Medical	Safety and Security	Transportation	Total
Boulder	4	1	6	16	7	47	22	**103**
Lafayette	-	-	1	-	-	-	1	**2**
Longmont	-	-	2	1	3	19	6	**31**
Louisville	-	-	-	-	-	2	-	**2**
Lyons	1	-	1	-	-	-	3	**5**
Unincorporated	2	-	7	-	-	3	17	**29**
Total	**7**	**1**	**17**	**17**	**10**	**71**	**49**	**172**

Source: FEMA NFHL, Boulder OEM, HIFLD, National Bridge Inventory

Replacement values were not available with this data; thus, an estimate of potential monetary losses to critical facilities could not be performed. Impacts to any of these facilities could have wide ranging ramifications, in addition to property damage.

Life, Safety, Health, Procedures for Warning and Evacuation

Flooding has the potential to affect road conditions to the point where evacuation routes are disrupted, and first responder access is cut off from specific locations. This can be exacerbated in areas of the County where alternate routes are limited, most notably the roads in the mountain canyons. These roads generally serve as the only thoroughfare up and down the canyons which are poorly interconnected. As demonstrated by the September 2013 flood event, roads in the canyons built immediately adjacent to creek channels are subject to partial or complete local washouts. During this event, road washouts stranded significant portions of the mountain communities in their homes waiting for evacuation by helicopter.

Warning and evacuation procedures are vital to ensure life safety but are not delivered comprehensively or made accessible to all populations within Boulder County. Information about flood safety has failed to reach Spanish speakers within the County in the past.

Natural Floodplain Function

58% of the regulatory floodplain in Boulder County is protected as open space, thus, new development is not a threat to the natural floodplain functions within this area. Beyond these protected lands development of new structures within the flood fringe is possible on private property, but Boulder County Land Use Code places restrictions on total building footprint area on those properties. Together, the County's land use process and floodplain management regulations will minimize the effect of development on the natural functions of the floodplain.

National Flood Insurance Program/Community Rating System §201.6(C)(3)(Ii)

The NFIP is a federal program enabling property owners in participating communities to purchase insurance as a protection against flood losses. A jurisdiction's eligibility to participate is premised on their adoption and enforcement of state and community floodplain management regulations intended to prevent unsafe development in the floodplain, thereby reducing future flood damages. Thus, participation in the NFIP is based on an agreement between communities and the federal government. If a community adopts and enforces a floodplain management ordinance to reduce future flood risk to new construction in floodplains, the federal government will make flood insurance available within the community as a financial protection against flood losses.

The CRS was created in 1990 to recognize communities whose floodplain management activities go above and beyond the NFIP's minimum requirements. Under the CRS, if a community implements certain program activities, such as public information, mapping, regulatory, loss reduction, and/or flood preparedness activities, then its residents can qualify for a flood insurance premium rate reduction. Communities can have a classification of 1 through 10 with discounts of 45 percent discount to 0 respectively.

Table 4-28 provides detailed information on NFIP participation in NFIP participating communities in Boulder County.

Table 4-28 Community Participation in the NFIP and Community Rating System

Jurisdiction	Date Joined	Effective FIRM Date	Policies in Force 3/3/2022	Insurance in Force ($)	Number of Claims since 1978	Claims Totals ($)	Community Rating System Rating
Boulder County	2/1/1979	8/15/2019	631	185,872,800	434	15,461,284	5
City of Boulder	7/17/1978	8/15/2019	3,612	930,782,600	1,145	23,153,425	5
Town of Erie*	10/17/1978	8/15/2019	49	13,056,200	6	20,152	n/a
Town of Jamestown	7/18/1983	8/15/2019	12	3,300,700	16	1,809,791	n/a
City of Lafayette	3/18/1980	8/15/2019	69	22,456,300	6	4,716	n/a
City of Longmont	7/5/1977	8/15/2019	336	118,541,300	64	4,581,108	5
City of Louisville	5/4/1973	8/15/2019	58	17,504,900	4	123,189	6
Town of Lyons	8/1/1980	8/15/2019	71	18,602,400	81	4,447,267	n/a
Town of Nederland	8/1/1979	8/15/2019	12	3,421,700	2	7,463	n/a
Town of Superior	9/28/1979	8/15/2019	16	5,012,000	5	98,052	n/a

Source: Watershed and Flood Protection Section of the Colorado Water Conservation Board, Department of Natural Resources

**Includes Weld County*

According to data from the Colorado Water Conservation Board, as of January 2021 there were 14 repetitive loss properties in Boulder County. According to the data, three of the properties were mitigated. Seven of the properties are located in the City of Boulder, one in Erie, one possibly in Nederland, and five in the unincorporated County. Most are single family structures, but two in the City of Boulder are business-non residential. There are no severe repetitive loss structures.

Community Impacts

The highly variable terrain in Boulder County means that many communities are at risk of being isolated during large flood events. During the 2013 flood, the Town of Lyons was separated into six islands, and the Town of Jamestown required major air evacuation. This has resulted in piecemeal safety nets being developed through community liaisons and networks. These are dependent on a few community leaders and subject to disruption if individual community members drop out or move away. During the 2013 flood, food banks were especially important in the mountains, with the Old Gallery in Allenspark and food pantry in Nederland, for example, providing crucial food supplies for mountain residents. Without support for these lifeline services in situ, areas cut off from supplies in the plains for long periods of time will suffer. Without community engagement it will be impossible to successfully identify and mitigate facilities that are critical for local health and safety.

Other areas of community vulnerability in the mountains include difficulties in giving and receiving updates, including evacuation warnings; economic impacts from loss of transportation routes both from tourism and because major employment centers are located in the eastern half of the County; and ongoing impacts from debris cleanup and removal.

For the eastern half of the County, manufactured home parks remain a concern as many of them were built within the flood plain because land was cheaper. This population experienced an immense amount of difficulty recovering from the 2013 flood and were often unable to access assistance from FEMA due to claims of deferred maintenance on their homes. Other vulnerabilities throughout floodplains include a lack of income and knowledge to ensure positive drainage; homes which lack sump pumps and are not secured against groundwater flooding also increases risk. This has resulted in urban flooding and sewage backup into basements, which negatively impacts resident health and can put further pressure on available housing stock. Other income related vulnerabilities include lack of homeowners' insurance, and lack of assistance for older housing stock. Many reported that FEMA would not provide them with individual assistance because their homes were older and, during the damage assessment, they could not prove that damage was due to the flood and not deferred maintenance. Elderly homeowners have also struggled with debris removal from within their home, and mold growth.

Future Development

Any new construction in mapped flood hazard areas built in accordance with local floodplain management ordinances should be elevated at least 1 foot above the 100-year flood, at a minimum. Thus, vulnerability to flooding is not considered to be increasing with development. However, there are areas that are not mapped that could still be flood prone.

As a result of exacerbated urban flooding due to development in floodplains, the potential impact will include possible injury to individuals; damage to private property such as automobiles and residential, commercial, or industrial buildings; and degradation of natural floodplain functions due to excessive pollution from urban runoff.

Higher population density within the floodplain will put more individuals at risk of being affected by flooding. That risk could manifest itself as disrupted building access, disrupted services like electricity or plumbing, or even economic hardship due to disruption of local commerce. As a part of Boulder County's floodplain management regulatory policies, no new development within the floodplain will be permitted if it would cause a rise in base flood elevation for any other insurable structures. As such, the only impact to anthropogenic development within the floodplain beyond that which exists currently will be to those structures built anew. It should be noted, however, that these management restrictions do not cover all jurisdictions, and people may still be subject to flooding from their neighbors upstream, especially where county borders overlap with other municipalities. In 2013, neighbors in the area of North Boulder where the city and county meet, caused major flooding impacts to each other with building along dry creekbeds with no regard for hydrologic processes.

Climate change impacts are projected to include larger precipitation events interspersed with periods of severe drought. These will likely impose greater stress on people, property, and natural floodplain functions. With more intense events, private property and natural areas within the floodplain will suffer greater damage. Flood impacts will continue to be unpredictable as they are exacerbated by an accompanying increase in wildfires, erosion, and landslides. In addition to floodplain inundation, 62% of models project an increase in rainfall intensity during major storms. This will overwhelm storm drainage systems and cause urban flooding. Adaptive costs to meet EPA guidelines to limit runoff is estimated to be $16.25 million for the County as a whole (Resilient Analytics 2018).

Fluctuation in groundwater tables can also create unpredictable urban flooding, as seen during the 2013 flood. This poses a threat of inadequate recovery time, especially for the beneficial functions afforded by natural areas within floodplains, as well as increased stress on utility grids, transportations systems, and community assets. During the 2013 flood, many homeowner insurance policies were shown to be inadequate, as the definitions for flooding, mudslides, and landslides are confusing to homeowners and were written for coastal and not mountain hazards. Damages from heavy rain, landslides, and groundwater rise were often not covered.

It is difficult to estimate the amount of precipitation and runoff that will impact current bridge infrastructure, but best estimates include an average cost of roughly $478,000 to adapt vulnerable bridges for climate change (Resilient Analytics 2018). The cost of replacing private bridges after the flood in 2013 was eventually covered by Community Development Block Grant for Disaster Recovery funding from the federal government. It is questionable whether homeowners throughout the canyons will have the means to pay for bridge adaptation. This means that people will be forced to move elsewhere or live with reduced access to their homes for themselves and emergency services.

Larger precipitation events will likely impose greater stress on people, property, and natural floodplain functions. With more intense events, private property and natural areas within the floodplain will suffer greater damage. This poses a threat of inadequate recovery time, especially for the beneficial functions afforded by natural areas within floodplains. The goals, objectives, and action plan presented in this plan are in part meant to accommodate this expected shift in the dynamic flood hazard in Boulder County.

4.5.7 Landslide/Debris Flow/Rockfall

Background

Research in the hazard profile for Landslide/Debris Flow/Rockfall revealed sporadic impacts in western portions of the County, and repetitive debris flow issues in Jamestown and other areas that have had recent wildfire burns. Future property losses would likely be minor, based on patterns of previous events. Rockfall impacts on western Boulder County highways and county roads have the potential to cause significant indirect economic loss, in addition to the potential for serious injury or death. The most significant road that could be impacted by rockfall and related road closures is Highway 119 in Boulder County between Nederland and Boulder. Economic losses from this road closure and resulting detours could be estimated with traffic counts and detour mileage.

Critical facilities at risk include the Jamestown Fire Department which has been impacted by debris flows.

Community Impacts

Homeowners in the western half of the County will continue to be susceptible to landslides and debris flow. This is of high economic concern for the affordability of living in canyon areas in particular both for safety of housing stock as well as the transportation lifelines. During the 2013 flood, Boulder County set a new record for landslides within the interior United States (USGS 2014). This not only destroyed homes, but also highlighted gaps in insurance policies that created severe financial hardship for both renters and homeowners. Additionally, long delays in road repairs meant that canyon and mountain residents were forced to increase commute times by up to two hours in order to reach their place of employment. This created significant financial burdens and reduced economic recovery times for the County. Residents require stronger safety nets closer to their homes in case transportation is reduced.

Future Development

Steep slope regulations should limit problems from these hazards in the future, thus the exposure to this hazard is not anticipated to grow. Climate change is, however, likely to increase the occurrence of landslides, as fluctuations between wet and dry periods increase. As precipitation events become more intense, and wildfires also increase, rains will wash more soil downstream and may destabilize slopes. As foresters in Colorado have already noted, tree regrowth in Ponderosa pine forests has all but ceased in areas burned after the year 2000. These areas are converting into grasslands, which have higher erosion potential. If large wildfires occur within the canyons and tree regrowth does not occur, landslides and debris flow will increase and could threaten water availability and quality as well as the homes of residents. This will also impact open space access and reduce recreation activities.

4.5.8 Lightning

Existing Development

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, the County remains at risk and is vulnerable to the effects of lightning. Persons recreating or working outdoors during the months of April through September will be most at risk to lightning strikes. It is difficult to quantify future deaths and injuries due to lightning.

Critical facilities and infrastructure will have the greatest consequences if damaged by a lightning strike. The greatest losses from lightning could result from secondary hazards, such as wildfire.

Future Development

New critical facilities such as communications towers should be built with lightning protection measures. Community assets should also be assessed for lightning safety.

4.5.9 Communicable and Zoonotic Diseases

Background

Communicable (person to person diseases such as the flu) and Zoonotic (animal to human diseases such as West Nile Virus) diseases could result in serious human and economic losses.

The total County population of 330, 860 could potentially be exposed to various communicable and zoonotic disease outbreaks. Viruses/fungi/bacteria will be present in Colorado into the future, but the severity changes from year to year, depending on variables such as weather patterns, the mosquito population, the bird population, and immunity in humans. In a severe outbreak, approximately 30 percent of the state's overall population, 20 percent among working adults, and 40 percent among school-age children can be affected. Employee absenteeism, due to illness, the need to care for ill family members, and fear of infection, may cause government operations to be reduced by 30-49 percent of normal.

Community Impacts

The number of hospitalizations and deaths will depend on the virulence of the virus/fungi/bacteria. Risk groups cannot be predicted with certainty. During the annual influenza season, infants, the elderly, the chronically ill, and pregnant women are usually at higher risk. But, in contrast, in the 1918 pandemic, most deaths occurred among young, previously healthy adults. Despite these variabilities, certain populations within Boulder County continue to be more at risk for any outbreak. The availability of protective measures is not guaranteed for all populations as clean water access may be intermittent or inaccessible for low-income households.

The population of Boulder County has a high rate of health care coverage compared to the rest of the state, but 10% of the population is still not insured and could suffer financial as well as health impacts from an outbreak (CDPHE 2018). During the 2013 flood, residents in Lyons had problems getting prescriptions filled, and lack of transportation or a co-occurring hazard such as wildfire or flood could increase areas that are already underserved by health services such as communities along the Peak to Peak Highway. The digital divide within the County will also impact the accessibility of distributing public health information and warnings. Community partners and programs such as the Community Health Department's cultural broker outreach are important resources for increasing community self-sufficiency.

Future Development

As population trends continue to increase, more persons will be exposed to the communicable and zoonotic diseases, therefore increasing risk as well as pressure on local medical and emergency services. Climate change will also increase the number of disease outbreaks and introduce new diseases that may have a disproportionate impact on populations with pre-existing conditions.

4.5.10 Subsidence

Background

A 1986 study on land subsidence in southeastern Boulder County conducted by the State of Colorado Department of Natural Resources Mined Land Reclamation Division found that the major period of subsidence occurred within 30 to 40 years after the mining was completed. Since that time (around 1950), subsidence events have occurred on an erratic basis. It is not possible to predict the exact location where future subsidence may occur or the magnitude of subsidence events in terms of size or disturbance. This study found that subsidence-related damage to homes in the Louisville and Lafayette area was within a range of $700 to $2,900 per home ($1,549 to $6,438 in 20122 dollars). Losses from future subsidence events are predicted to be sporadic and relatively minor. Impacts to critical facilities are anticipated to be minor.

Future Development

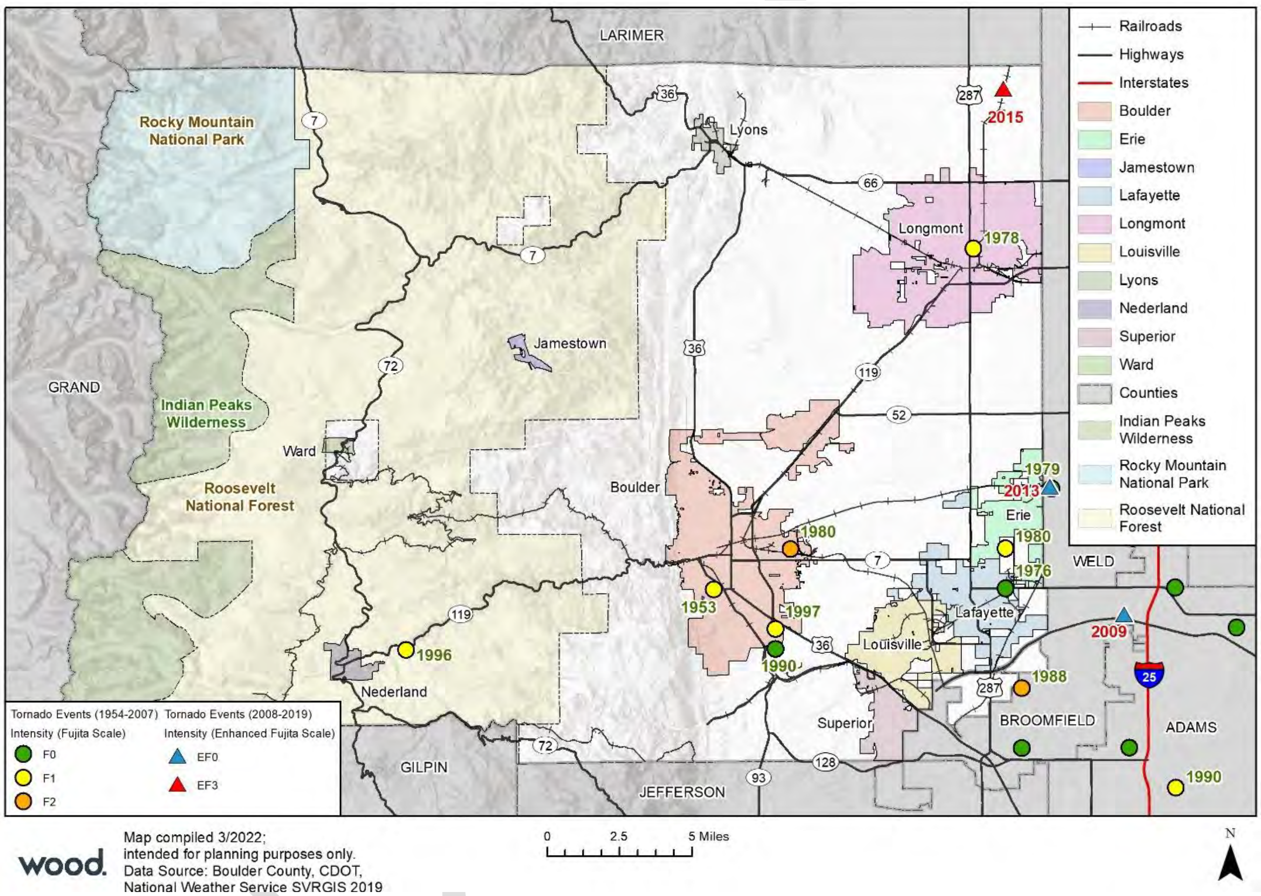
Land use and development controls should limit impacts to future development from subsidence. Lafayette's Comprehensive Plan recommends that no building occur on high hazard zones, and that pre-construction design considerations occur regardless of the hazard zone involved. Erie subdivision regulations have similar controls. The 1986 report recommends that utility lines installed in high hazard zones have special construction to minimize possible adverse effects of subsidence.

4.5.11 Tornado

Background

According to NOAA's Storm Prediction Center, based on national state-level tornado data from 1989 to 2019, Colorado averaged 49 tornadoes per year. This places Colorado 10th in the list of states with the most tornadoes per year. During a 71-year period (1950-2021), 11 tornadoes occurred in Boulder County, which equates to one tornado every 6.4 years, on average. Of these 11 tornadoes, two were magnitude F0, six were F1, two were F2, and one was EF3.

Figure 4-41 Boulder County Tornado Events, 1954-2019



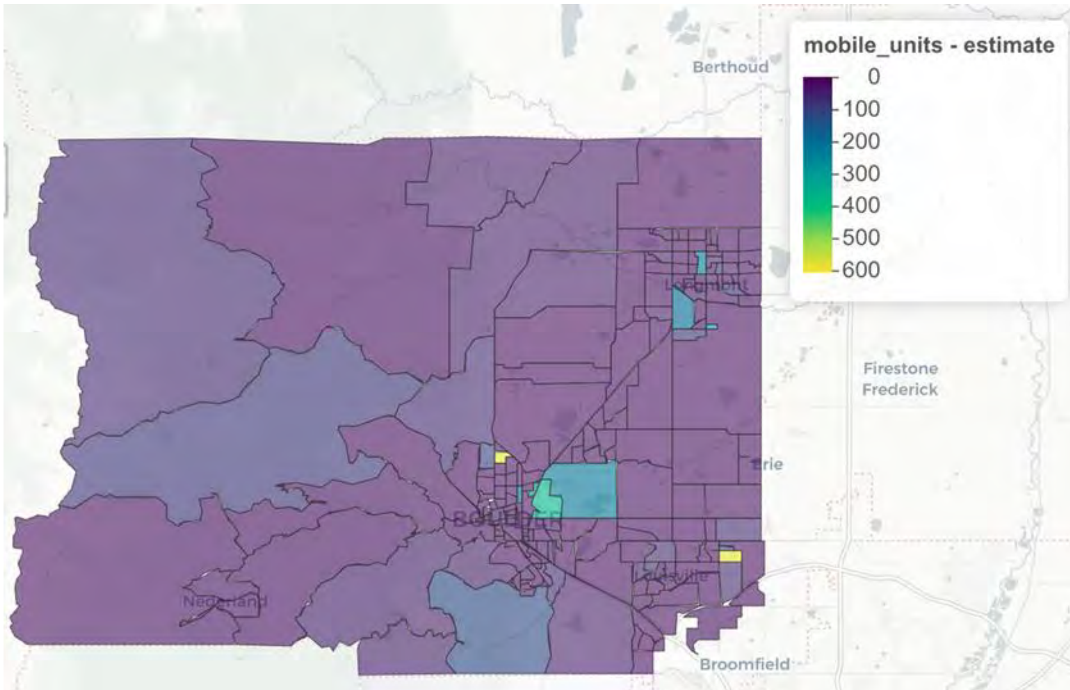
While tornadoes can occur anywhere, the likelihood of damaging tornadoes is highest in eastern Boulder County since it is further away from the foothills and closest to the eastern plains. The eastern Boulder County communities of Longmont and Erie have a higher risk than other communities in the planning area. The Weld County tornado in May 2008 occurred just east of Boulder County, damaging over 200 homes along a 10-mile path, and was an EF 3, so a damaging tornado is possible. Due to the random nature of tornadoes, it is difficult to quantify losses further or try to estimate impacts to critical facilities.

Community Impacts

Mobile home parks are especially vulnerable to the impacts of tornadoes, and many of these parks are clustered in Longmont and Boulder. Clear messaging on where and when to evacuate is critical, as are accessible shelters and education on where and how to shelter. This should include accommodations for low English proficiency households, as well as households without cars. Elderly residents represent a larger share of riders using public transportation and may need assistance in evacuating if necessary.

Future Development

Eastern unincorporated Boulder County, Erie, and Longmont are all experiencing population growth and associated residential and commercial development. This increase in population will expose more residents to tornado hazards. The scientific link between climate change and tornado activity has not yet been established and is difficult to quantify. There is some slight evidence that tornadoes may be appearing in more clusters and with slightly more force, but that has not yet been proven.



4.5.12 Wildfire

Background

Wildfire has the potential to cause widespread damage and loss of life in Boulder County. The significance of this hazard and the availability of digital hazard data in GIS drove the development of a detailed vulnerability assessment that is discussed in the following pages.

Methodology

The HMPC used GIS to quantify the potential wildfire losses to the County and cities within the mapped wildfire hazard areas. The first step was to identify what is exposed to the wildfire hazard. This entailed overlaying a countywide GIS layer of the wildfire hazard on parcels that contained data on structures. The hazard layer utilized was obtained from the Colorado State Forest Service. This layer was determined to be the best available wildfire hazard data countywide.

Boulder County's parcel layer was used as the basis for the inventory of developed parcels. GIS was used to create a centroid, or point, representing the center of each parcel polygon, upon which the wildfire layer was overlaid. In some cases, there are parcels in multiple wildfire hazard zones. For the purposes of this analysis, the wildfire hazard zone that intersected the centroid was assigned as the hazard zone for the entire parcel. Another assumption with this model is that every parcel with an improved value greater than zero was assumed to be developed in some way. Only improved parcels, and the value of those improvements, were analyzed and aggregated by property type and wildfire threat zone. Those parcels intersecting areas of moderate, high, or very high hazard were analyzed and aggregated by municipality. While wildfire risk is typically considered something that is limited to western Boulder County and the foothills and mountain communities of Nederland, Jamestown, Lyons, and Ward, recent events and shifting fire regimes may indicate that eastern Boulder County is at a much greater risk to fire than previously considered. Fast moving grassland fires, such as the Marshall Fire in late 2021, could rapidly impact developed areas adjacent to plains and open spaces, such as Louisville, Lafayette, and Superior.

The results of the analysis are displayed in Table 4-29 through Table 4-31 displaying the value of residential structures, estimated contents value, and population exposed to the moderate, high, and highest wildfire risk hazard areas. Additional data on lower wildfire risk areas and the WUI can be found in the respective community annexes.

Based on observations in WUI fires, structures and contents are often completely destroyed; thus the estimated total value also represents potential dollar losses. Note: a wildfire is not likely to burn all the WUI areas in Boulder County at once.

Table 4-29 Residential Structures and Population in Highest Wildfire Risk Hazard by Jurisdiction

Jurisdiction	Improved Parcels	Building Count	Improved Value	Content Value	Total Value	Population
Boulder	3	126	$4,985,000	$2,492,500	$7,477,500	273
Erie	-	-	-	-	-	-
Jamestown	32	150	$8,984,130	$4,658,665	$13,642,795	303
Lafayette	-	-	-	-	-	-
Longmont	-	-	-	-	-	-
Louisville	1	1	$322,500	$322,500	$645,000	-
Lyons	9	67	$5,753,900	$2,876,950	$8,630,850	159
Nederland	-	-	-	-	-	-
Superior	82	86	$58,352,091	$38,019,877	$96,371,968	199
Ward	-	-	-	-	-	-
Unincorporated	1,333	5,078	$927,522,851	$480,100,966	$1,407,623,817	9,406
Total	**1,460**	**5,508**	**$1,005,920,472**	**$528,471,457**	**$1,534,391,929**	**10,340**

Source: Colorado State Forest Service, Boulder County Assessor's Office, U.S. Census Bureau

Table 4-30 Residential Structures and Population in High Wildfire Risk Hazard by Jurisdiction

Jurisdiction	Improved Parcels	Building Count	Improved Value	Content Value	Total Value	Population
Boulder	76	4	$78,051,955	$39,025,978	$117,077,933	7
Erie	-	-	-	-	-	-
Jamestown	109	22	$33,829,926	$17,505,213	$51,335,139	18
Lafayette	-	-	-	-	-	-
Longmont	386	57	$246,400,086	$129,589,966	$375,990,052	126
Louisville	-	-	-	-	-	-
Lyons	43	42	$24,278,290	$12,544,695	$36,822,985	104
Nederland	-	-	-	-	-	-
Superior	30	30	$14,673,380	$7,450,440	$22,123,820	76
Ward	-	-	-	-	-	-

Jurisdiction	Improved Parcels	Building Count	Improved Value	Content Value	Total Value	Population
Unincorporated	2,709	239	$1,630,289,817	$912,593,903	$2,542,883,720	170
Total	**3,353**	**394**	**$2,027,523,454**	**$1,118,710,195**	**$3,146,233,649**	**501**

Source: Colorado State Forest Service, Boulder County Assessor's Office, U.S. Census Bureau

Table 4-31 Residential Structures and Population in High Wildfire Risk Hazard by Jurisdiction

Jurisdiction	Improved Parcels	Building Count	Improved Value	Content Value	Total Value	Population
Boulder	253	394	$203,203,616	$203,203,616	$406,407,232	794
Erie	411	494	$220,281,926	$220,281,926	$440,563,852	1,476
Jamestown	8	9	$3,564,420	$3,564,420	$7,128,840	20
Lafayette	45	112	$95,845,550	$95,845,550	$191,691,100	190
Longmont	292	286	$205,726,667	$205,726,667	$411,453,334	684
Louisville	13	34	$38,206,081	$38,206,081	$76,412,162	44
Lyons	41	55	$22,254,835	$22,254,835	$44,509,670	114
Nederland	28	37	$8,808,500	$8,808,500	$17,617,000	78
Superior	-	-	-	-	-	-
Ward	-	-	-	-	-	-
Unincorporated	2,656	4,895	$1,435,346,347	$1,435,346,347	$2,870,692,694	8,581
Total	**3,747**	**6,316**	**$2,233,237,942**	**$2,233,237,942**	**$4,466,475,884**	**11,982**

Source: Colorado State Forest Service, Boulder County Assessor's Office, US Census Bureau

To estimate the potential impact of wildfires on critical facilities a similar GIS overlay was performed of the wildfire hazard layer on existing critical facilities point locations. The results are shown in Table 4-32. Communities not listed had no critical facilities exposed to wildfire hazard. Bridges are included because wooden bridges could burn in a wildfire and result in a life safety issue both for evacuation and responders. A number of wastewater treatment facilities are potentially at risk. No replacement values are available, so a further estimate of potential losses was not possible. The critical facility layers provided were the best available, but may not be complete, especially for the mountain towns. Nederland, Ward, Jamestown and Lyons more than likely have fire departments, water treatment plants, and government buildings but they were not represented in the available data.

Table 4-32 Critical Facilities Located in Highest Wildfire Hazard Areas, by Jurisdiction and FEMA Lifeline

Jurisdiction	Communications	Energy	Food, Water, Shelter	Hazardous Material	Health and Medical	Safety and Security	Transportation	Total
Superior	-	-	1	-	-	-	-	**1**
Unincorporated	-	-	1	1	-	3	4	**9**
Total	**0**	**0**	**2**	**1**	**0**	**3**	**4**	**10**

Source: Colorado State Forest Service, Boulder OEM, HIFLD, National Bridge Inventory

Table 4-33 Critical Facilities Located in High Wildfire Hazard Areas, by Jurisdiction and FEMA Lifeline

Jurisdiction	Communications	Energy	Food, Water, Shelter	Hazardous Material	Health and Medical	Safety and Security	Transportation	Total
Jamestown	1	-	-	1	-	3	2	**7**
Unincorporated	-	3	12	22	-	13	17	**67**
Total	**1**	**3**	**12**	**23**	**0**	**16**	**19**	**74**

Source: Colorado State Forest Service, Boulder OEM, HIFLD, National Bridge Inventory

Table 4-34 Critical Facilities Located in Highest Wildfire Hazard Areas, by Jurisdiction and FEMA Lifeline

Jurisdiction	Communications	Energy	Food, Water, Shelter	Hazardous Material	Health and Medical	Safety and Security	Transportation	Total
Boulder	-	2	2	1	-	1	-	**6**
Erie	-	-	-	-	-	3	1	**4**
Longmont	-	-	-	-	2	1	-	**3**
Louisville	-	-	-	-	-	1	-	**1**
Unincorporated	2	1	19	14	-	15	13	**64**
Total	**2**	**3**	**21**	**15**	**2**	**21**	**14**	**78**

Source: Colorado State Forest Service, Boulder OEM, HIFLD, National Bridge Inventory

Community Impacts

The impacts to communities can be wide-reaching and severe. Wildfires, both nearby and further throughout the state and Western U.S., can negatively impact air quality in Boulder County, impacting the health of residents. Wildfires can drive up the cost of home insurance premiums. In addition to infrastructure costs, residents may experience loss of water supplies throughout Boulder County or increased costs due to wildfires. This includes impacts to well water viability. Septic systems should be considered as these critical utilities will be impacted by water quality and wildfire activity. New residents in the WUI are often not educated about community resources or safety precautions, and fire mitigation is still optional. The Wildfire Partners program provides important community outreach in mitigation, and the Parks and Open Space Department actively educates visitors as well. A remaining area of concern for community vulnerability includes warnings for non-English speaking populations and houseless populations that camp in the mountains. Transient populations are drawn to mountains during the summer months because there is often more space and privacy than at the homeless shelter in Boulder. Lack of knowledge of local fire danger, weather, and geography can increase individual and community vulnerability.

Future Development

Growth in the WUI has been significant in the past twenty years in Boulder County. While this growth has recently slowed, there still remains potential for development of primary and secondary residences in wildfire hazard areas in the unincorporated County. Wildfire risk to future development in these areas will be tempered by the County's land use regulations.

In all climate change projections, the number of wildfires and acres burned in the County will increase through the next century, potentially up to a 48% increase over the historical average. The current cost to

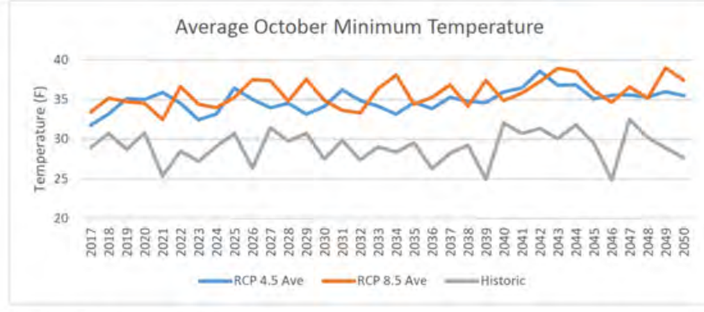


Figure 5: Fall temperature timeline

mitigate homes in wildfire areas is around $3399. This indicates costs could be up to $20.25 million to mitigate vulnerable homes within the County (Resilient Analytics 2018).

Rising temperatures are also increasing the populations of mountain pine beetles in Boulder County. The combination of increased drought conditions and higher minimum temperatures in the spring and fall mean that trees will be more stressed and pine beetle larvae more robust. This may lead to populations of pine beetles reaching epidemic proportions (Resilient Analytics 2018). This will increase fuels for fires and reduce air quality as well.

4.5.13 Windstorm

Background

Based on the hazard profile in Subsection 4.2, windstorms will continue to cause property damage annually in Boulder County. Due to the random and widespread nature of the hazard it is difficult to estimate future losses and where they will occur. Based on the NCEI data alone (see the windstorm profile in Section 4.0) between 1994 and 2005 the average annualized loss from wind is in the vicinity of $3.4 million. While that figure may include other losses from neighboring counties, it is likely to be a reasonable estimate. Communities in and along the base of the foothills are most susceptible to the hazard, including the City of Boulder, Louisville, Superior, Lyons, Jamestown, Nederland, and Ward, but high winds can damage communities in eastern Boulder County as well.

Windstorms can and will cause injury and even death in Boulder County. The highest risk demographic is to first responders who are dealing with emergency situations resulting from the windstorm. Those working or recreating outdoors will be susceptible to injury from wind borne debris. Winds can also be hazardous to hikers in areas of beetle or fire killed trees. This situation killed a hiker in Rocky Mountain National Park in 2007.

Impacts to critical facilities are difficult to estimate, but buildings could be susceptible to roof and window damage, as was witnessed at the Boulder County Jail in February of 1999. Backup power systems in critical facilities could help mitigate impacts from power outages associated with windstorms.

Future Development

Construction sites can be particularly vulnerable to windstorms. Wind borne construction materials can become hazards to life and property. New construction designed in accordance with the Boulder County wind load map should be able to withstand wind damage, if properly constructed.

4.5.14 Winter Storms (Severe)

Background

The threat to public safety is typically the greatest concern when it comes to impacts of winter storms. But these storms can also impact the local economy by disrupting transportation and commercial activities. Winter storms are occasionally severe enough to overwhelm snow removal efforts, transportation, livestock management, and business and commercial activities. Travelers on highways in Boulder County, particularly along remote stretches of road, can become stranded, requiring search and rescue assistance and shelter provisions. The County can experience high winds and drifting snow during winter storms that can occasionally isolate individuals and entire communities and lead to serious damage to livestock populations and crops. Winter storms contribute directly to other hazards in this plan: extreme temperatures (cold).

Research presented in Subsection 4.3.17 Severe Winter Storms yielded significant impacts from this hazard in the past. Structural losses to buildings are possible and structural damage from winter storms in Colorado has resulted from severe snow loads on rooftops. Older buildings are more at risk, as are buildings with large flat rooftops (often found in public buildings such as schools).

Community Impacts

The County's elderly population is a potentially vulnerable demographic during severe winter storms, especially considering that 60% of 65 and older individuals experience mental or physical disabilities compared with 7.8% of those under 65 (TRENDS 2019). The commuting population is another demographic potentially at risk during winter storm events. About half the workforce in the City of Boulder lives outside the County borders and causes heavy traffic during morning and afternoon commutes (TRENDS 2019). Mountain communities also have above average commute times as the major employment centers are located in the plains.

For those with low-income, or in manufactured homes, extreme temperatures and snow loads will cause problems if utilities are compromised through lack of payment or extra weight to unmaintained structures.

Smaller mountain communities such as Ward and Jamestown may become isolated during winter storm events, in addition to individuals living the foothills of unincorporated Boulder County. Persons that choose to live in these areas are generally self-sufficient, or should be, as government and emergency services may be limited during a severe winter storm.

Future Development

Future residential or commercial buildings built to code should be able to withstand snow loads from severe winter storms. Population and commercial growth in the County will increase the potential for complications with traffic and commerce interruptions associated winter storms. As building and population trends continue to increase, more persons will be exposed to winter storm hazards, therefore increasing pressure on local government snow removal and emergency services.

Climate change is projected to increase the variability and intensity of winter storms, with most years seeing more intense precipitation events within a shorter period of time (RMCO 2016). The increase in heavy precipitation will increase the burden on low-income households as houses will need to be maintained or retrofitted to accommodate heavier snow loads, and there may be increased day-to-day costs for warmer clothes, higher utility bills, and loss of revenue from business closures. Another major cost from heavy winter storms is likely to be childcare. If heavier precipitation events cause school closures, parents may be forced to miss work or pay for childcare, which will increase impacts on low-income populations.

5.0 Mitigation Strategy

44 CFR 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 Boulder County Multi-Hazard Mitigation Plan. This section describes how the County accomplished Phase 3 of FEMA's 4-phase guidance—develop the mitigation plan.

5.1 Goals and Objectives

Up to this point in the planning process, the 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 section. The resulting goals, objectives, and mitigation actions were developed based on this profile. In 2008, the HMPC developed this aspect of the plan based on a series of meetings and worksheets designed to achieve a collaborative mitigation planning effort as described further in this section. In the 2013 update, a second series of meetings and workshops was conducted to reevaluate and modify the goals of the plan as needed.

For the purpose of this mitigation plan, goals were defined 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 were defined before considering how to accomplish them so that the goals are not dependent on the means of achievement. Thus, implementation cost, schedule, and means are not considered in the goal statements which 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. During the 2022 plan update process, the HMPC reviewed the 2016 goals and objectives and concluded that the goals previously identified needed to be changed. A significant goal setting meeting developed new goals and the highlight is adding a climate change goal to the plan (Goal 5). The 2022 goals and objectives identified by the HMPC are listed below. The City of Boulder decided to keep their 2018 hazard mitigation goals, shown after the overall goals below and in the City's annex.

Goal 1: Reduce the Loss of Life and Personal Injuries from Hazard Events.

- Continue to manage development in areas, including property acquisitions to remove development from hazardous locations, pursuing relocation/elevation actions for flood- at risk properties, and providing enforcement measures following disasters to ensure that all redevelopment and recovery activities follow existing development codes. Continue programs to further identify hazards including incorporating future uncertain climate predictions.
- Continue programs to further identify hazards including but not limited to, flood after fire erosion, wildfire, wind, drought, debris flows, rock fall, etc. and assess risk associated. Provide timely notification and direction to the public of imminent and potential hazards.
- Provide timely notification and direction to the public of imminent and potential hazards, including installing rain gauges, soil saturation sensors and stream monitoring systems for early warning identification of pending flooding situations and debris flows. Continue public education programs to improve resident's ability to make informed decisions based on their hazard risks.
- Continue to manage development and mitigation efforts in hazard-prone areas.

- Add Inclusivity and Affordable Housing, list such areas, identify and prepare for impacts and enhancing early warning systems.
- Add resiliency component and expand beyond flooding situations i.e. tornado and differentiate between detections versus warning.

Goal 2: Reduce Impacts of Hazard Events on Property, Critical Facilities/Infrastructure, and the Environment

- Continue to manage development and placement of structures in hazard-prone areas, including applying land use regulations to minimize exposure to potential hazards and expanding current wildfire mitigation and defensible space programs on both public and private lands. Create incentives and continue to provide assistance for the public to mitigate hazards on their own property.
- Protect existing property to the extent possible through regulations, codes, education, cooperative agreements, hazard reduction projects, and other means. Continue to manage development and protect existing properties in hazard-prone areas through regulations to minimize exposure to potential hazards.
- Protect infrastructure and critical facilities to minimize loss of services following a hazard event including installation of backup generators and other vital infrastructure at critical county facilities.
- Create incentives for the public to mitigate hazards on their own property through education, cooperative land acquisitions, Elevation and relocation programs, Community Wildfire Protection Plans, TDRs and TDCs, and other means as they become available or are created. Restore natural function of environmental processes. Or restore natural function of environmental process.
- Continue to reduce flood losses through compliance with NFIP requirements; continue to comply with CRS requirements, where applicable (i.e., Boulder County, City of Boulder Longmont, and Louisville). NFIP is mandatory and CRS is not. Monitor progress and implement adaptive management as needed to incorporate new and improved best practices including those resulting from future uncertain climate predictions.
- Need to add environment bullet in title but not in objectives.

Goal 3: Strengthen Intergovernmental Coordination, Communication, and Capabilities Regarding Mitigating Hazard Impacts

- Promote planning efforts that foster cooperation and coordination among jurisdictions, agencies, and organizations involved in hazard mitigation.
- Establish and maintain processes and resources to incorporate mitigation and resiliency into recovery efforts following a hazard event.

Goal 4: Improve Public Awareness and Preparedness Regarding Hazard Vulnerability and Mitigation

- Enhance public education efforts regarding hazards and risk in Boulder County and the role of the public in mitigation.
- Continue engaging the public in hazard mitigation planning and implementation.
- Combine mitigation education efforts with existing governmental and nongovernmental outreach programs.
- Incorporate the most up to date climate predictions with all whole community mitigation programs and projects.

Goal 5: Address Hazard Identification in the Context of Climate Change

- Strive to identify and address common issues related to hazard mitigation and climate changes.
- Monitor the ever-changing environment and continue to identify new or changing hazards.
- Address hazard identification in the context of climate change.

5.1.1 City of Boulder Hazard Mitigation Goals

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

5.2 Identification and Analysis of Mitigation Actions

44 CFR 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.

This version of the Boulder County Hazard Mitigation Plan has two distinct points of focus. The first, is the update on the mitigation projects from the 2016 HMP plan as an indication of progress and revising to indicate current hazard mitigation priorities. The second, is the explanation of the new projects added to the revised plan during 2021-2022.

In order to identify and select mitigation measures to support the mitigation goals, each hazard identified in Section 4.0: Risk Assessment was evaluated. Only those hazards that pose a significant threat to the community were considered further in the development of hazard specific mitigation measures. Once it was determined which hazards warranted the development of specific mitigation measures, the HMPC analyzed the previous set of viable mitigation options and alternatives identified in 2015/16. The status of those actions was categorized as completed, deferred, ongoing, or in progress (which included projects with some work started as well as those not yet begun). Additional mitigation actions were also developed and are incorporated into this plan's jurisdictional annexes where appropriate.

5.3 Progress on Mitigation Actions

Based on the review of mitigation action progress it is clear that the County and participating jurisdictions are building resiliency through the implementation of specific mitigation actions or projects. Refer to the status notes in each jurisdictional annex's mitigation action strategy.

5.4 Prioritization Process

All participating agencies were involved in the first phase of hazard identification risk assessments based on an overall assessment of Boulder County. Using this data communities developed mitigation projects based on the updated 2021-2022 HMP goals. Each jurisdictional annex summarizes hazard significance to identify the local hazards and prioritize them form occurrence to impact. The assessment is then used to determine which hazard type is the most significant and likely to occur which then can be used to guide mitigation project creation and their relevance and priority. Communities assed values at risk based on life, structures and dollar loss. Once all the mitigation actions were identified, the HMPC members were asked to rank as high, medium, or low their mitigation actions related to their impact on reducing vulnerabilities to the communities' highest risks. In addition, prioritization of mitigation projects were based on considerations that include social, technical, administrative, political, legal, environmental and economic (cost effectiveness), using the guidelines recommended by FEMA that were used in the original development of this plan and subsequent updates.

5.5 Mitigation Action Plan

44 CFR Requirement §201.6(c)(3)(iv): The mitigation strategy shall include an action strategy describing how the actions identified in paragraph (c)(2)(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 benefits review of the proposed projects and their associated costs.

This section outlines the development of the final mitigation implementation 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. Each jurisdictional annex consists of their individual action plans.

Annex A contains the County's updated mitigation action strategy. Appendix G includes the yearly updates from the County for the 2016-2022 Hazard Mitigation Plan and at the end of each community annex hazard mitigation projects are listed in detail. Each project contains more detail about activities, actions, the entity responsible for implementation, any other alternatives considered, cost estimate, and a schedule for implementation.

6.0 Plan Adoption

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.

The purpose of formally adopting this plan is to secure buy-in from Boulder County and participating jurisdictions, raise awareness of the plan, and formalize the plan's implementation. This section is part one in part how the County accomplished Phase 4 of FEMA's 4-phase guidance—Step 9: Implement the Plan and Monitor Progress. Section 7.0: Plan Implementation and Maintenance is part two and will conclude the remainder of Phase 4. The governing board for each participating jurisdiction will need to adopt this local hazard mitigation plan by passing a resolution. A copy of the generic resolution and a sample resolution by community are included. The date on which each jurisdiction adopts this plan will be recorded.

Boulder County Board of County Commissioners	____________ MM/DD/YYY
Boulder City Council	____________ MM/DD/YY
Erie Town Council	____________ MM/DD/YYY
Lafayette City Council	____________ MM/DD/YYY
Longmont City Council	____________ MM/DD/YYY
Louisville City Council	____________ MM/DD/YYY
Lyons Town Council	____________ MM/DD/YYY
Nederland Town Council	____________ MM/DD/YYY
Superior Town Council	____________ MM/DD/YYY
Four Mile Fire Protection District Board	____________ MM/DD/YYY

7.0 Plan Implementation and Maintenance

Implementation and maintenance of the plan is critical to the overall success of hazard mitigation planning. This section outlines how this plan will be implemented and updated and is the final conclusion of Phase 4 of FEMA's 4-phase guidance—Implement the Plan and Monitor Progress.

Step 10: Implementation §201.6(c)(3)(vi) & §201.6(c)(3)(iii)

Once adopted, the plan faces the truest test of its worth: implementation. While this plan contains many worthwhile projects, the HMPC will need to decide which action(s) to undertake first. Two factors will help with making that decision. First, the priority assigned the actions in the planning process and funding availability. Second, Low or no-cost projects most easily demonstrate progress toward successful plan implementation.

Implementation will be accomplished by adhering to the schedules identified for each action and through constant, pervasive, and energetic efforts to network and highlight the multi-objective, win-win benefits of each project to the Boulder 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.

Simultaneously to the above-mentioned efforts, the HMPC will constantly monitor funding opportunities that could be leveraged to implement some of the more costly actions. This will include creating and maintaining a bank of ideas on how to meet required local match or participation requirements. 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, special district budgeted funds, state and federal earmarked funds, and other grant programs, including those that can serve or support multi-objective applications.

7.1 Role of Hazard Mitigation Planning Committee in Implementation and Maintenance §201.6(d)(3)

With adoption of this plan, the HMPC will be tasked with plan implementation and maintenance. The HMPC will be led by the Boulder OEM. The HMPC will act as an advisory body. Its primary duty is to see the plan successfully carried out and to report to the community governing boards and the public on the status of plan implementation and mitigation opportunities. The HMPC performed and will continue to perform the following duties:

- 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 Board of County Commissioners; and inform and solicit input from the public.
- Revise the plan to reflect changes in priorities as identified in mitigation actions / projects from the 2016 HMP.

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 County website and local newspapers.

7.2 Maintenance/Monitoring§201.6(C)(4)(Ii)

Plan maintenance implies an ongoing effort to monitor and evaluate plan implementation and to update the plan as required or as progress, roadblocks, or changing circumstances are recognized.

7.2.1 Maintenance/Monitoring Schedule

In order to track progress and update the mitigation strategies identified in the action plan, the HMPC will revisit this plan annually or after a significant hazard event or disaster declaration.

Boulder OEM is responsible for initiating this review and convening members of the HMPC on yearly basis, or more frequently as needed. The annual review will be held in February, prior to the traditional flood and wildfire season.

In addition to the annual review, this plan will be updated, approved and adopted within a five-year cycle as per Requirement §201.6(c)(4)(i) of the DMA of 2000. 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. With the initial approval of this plan occurring in June 2022, the plan will need to be updated, re-approved by FEMA Region VIII and re-adopted by all participating jurisdictions by no later than June 2027. The County maintains the options of submitting a planning grant application to the Colorado DHSEM/FEMA for funds to assist with the update. This grant should be submitted by 2024, as there is a three-year performance period to expend the funds, plus there is no guarantee that the grant will be awarded when initially submitted. This allows time to resubmit the grant in 2024 or 2025 if needed. Updates to this plan will follow the most current FEMA and DHSEM planning guidance.

7.2.2 List of Communities Adopting Boulder County's Plan Monitoring & Maintenance Schedule

Boulder County	Boulder County will schedule, conduct and record plan monitoring, revision and maintenance schedules for all HMPC members. The Boulder OEM will be the lead agency.
City of Boulder	The City of Boulder will be the lead agency support by Boulder OEM.
Erie	The Town of Erie will follow Boulder County's schedule for plan monitoring, revision and maintenance.
Lafayette	The City of Lafayette will follow Boulder County's schedule for plan monitoring, revision and maintenance.
Longmont	City of Longmont will continue to partner with Boulder County and work with their schedule on the monitoring, revision and maintenance of the plan.
Louisville	The City of Louisville will follow Boulder County's schedule for plan monitoring, revision and maintenance.
Lyons	The Town of Lyons will follow Boulder County's schedule for plan monitoring, revision and maintenance.
Nederland	The Town of Nederland will follow Boulder County's schedule for plan monitoring, revision and maintenance.
Superior	The Town of Superior will follow Boulder County's schedule for plan monitoring, revision and maintenance.

Four Mile FPD	The Four Mile Fire Protection District will follow Boulder County's schedule for plan monitoring, revision and maintenance.

7.2.3 Maintenance Evaluation Process

44 CFR 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.

Updates to this plan will follow the latest FEMA and DHSEM planning guidance. 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 because of implementing recommended actions,
- Increased vulnerability because of failed or ineffective mitigation actions, and/or
- Increased vulnerability because of new development (and/or annexation).

The HMPC will use the following process to evaluate progress and any changes in vulnerability because of plan implementation: §201.6(d)(3)

- Yearly HMP update meeting and process on existing projects will be facilitated and managed by the Boulder OEM.
- A representative from the responsible entity identified in each mitigation measure will be responsible for tracking and reporting on an annual basis to the HMPC on project status and provide input on whether the project as implemented meets the defined objectives and is likely to be successful in reducing vulnerabilities.
- If the project does not meet identified objectives, the HMPC will determine what alternate projects may be implemented.
- New projects identified will require an individual assigned to be responsible for defining the project scope, implementing the project, and 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.
- All updates and changes will be communicated and distributed to the HMPC members.

Updates to This Plan Will: §201.6(d)(3)

- 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 or increased hazard risk 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,
- Incorporate documentation of continued public involvement,
- Incorporate documentation to update the planning process that 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.

7.2.4 Incorporation into Existing Planning Mechanisms §201.6(C)(3)

Another important implementation mechanism that is highly effective and low-cost is incorporation of the hazard mitigation plan recommendations and their underlying principles into other County and City plans and mechanisms. Mitigation is most successful when it is incorporated into the day-to-day functions and priorities of government and development. Implementation through existing plans and/or programs is recommended, where possible. The County and participating entities already have existing policies and programs to reduce losses to life and property from natural hazards. These are summarized in this plan's capability assessment. 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. These existing mechanisms include:

- County Comprehensive Plan
- County Land Use Code
- County Capital Improvements Plan
- County Emergency Operations Plan
- Boulder Multiple Agency Coordinating System
- City of Boulder Comprehensive Plan
- Boulder Code of Ordinances
- Lafayette Comprehensive Plan
- Lafayette Code of Ordinances
- Longmont Area Comprehensive Plan
- Longmont Water Supply and Drought Management Plan
- Longmont Water Conservation Draft Master Plan
- Louisville Comprehensive Plan
- Louisville Municipal Code
- Lyons Comprehensive Plan
- Lyons Municipal Code
- Superior Comprehensive Plan
- Superior Municipal Code
- Four Mile Fire Protection District Plans

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 would be the Boulder Climate Adaptation Plan or the Boulder Community Wildfire Plan, and specifically linking duties of these types of plans with this plan.

7.2.5 Continued Public Involvement

44 CFR 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.

Continued public involvement is also imperative to the overall success of this plan's implementation. The update process provides an opportunity to publicize success stories from the plan implementation and seek additional public comment. A public engagement process to receive public comment on plan maintenance and updating will be held during the next update period. 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.

Social Media Strategy

Introduction

As with any civic effort, the process to revise and update the Boulder Multi-Hazard Mitigation Plan will benefit from broad public participation. The Boulder OEM will launch a virtual planning process to engage the community using social media and broaden the dialogue to include those members of our communities that, in the past, have been underrepresented in the planning process.

Goals

- Raise community awareness of the Boulder County Multi-Hazard Mitigation Plan revision process.
- Increase public participation in the revision process resulting in an increase the incorporation of public input and comments into the development of the Multi-Hazard Mitigation Plan.
- Increase engagement between the public and the Boulder OEM.
- Build relationships between the Boulder OEM and target audiences.

Target Audiences

All residents of Boulder County are our audience. However, to reach as broad an audience as possible we will actively engage several target audiences that can assist in pushing our message out to their constituencies and all residents of Boulder County.

- "Opinion leaders" (local journalists and traditional media, social media sites and the blogosphere, political/social activists)
- Business leaders (business owners, trade groups)
- Community organizations and leaders (churches, service clubs, chamber of commerce)
- Civic organizations and leaders that regularly engage with target constituencies (elected and government officials, schools and universities, service agencies)

Platforms

The Boulder OEM already maintains a presence on the following platforms. A separate Facebook page dedicated to the multi-hazard mitigation plan (MHMP) will be established. It will serve as the main platform for engagement and traffic will be directed there via the OEM website, twitter, and the general Facebook page.

- Facebook
- Twitter
- YouTube

We may utilize other platforms if we determine a need or potential benefit.

Strategies

- Target social media outreach to key "opinion leaders" to familiarize this group with the MHMP revision process and our goals of increasing public awareness and participation. Encourage this group to push our message through their outlets (re-tweets, link our site to their pages, shares on Facebook, etc.). This could have an added benefit of generating earned media if news sites, papers, radio, and TV pick up the content which will also reach our target audiences.
- Develop content aimed at interests of specific target audiences, i.e. "why small businesses in Boulder should participate in the MHMP revision process" etc. Push this content through key contacts in our target audiences.
- Engage target audiences through an active online presence (aggressively monitor social media sites, participate in online forums/conversations, share relevant content online).

Tactics

Increase our number of followers:

- Include links to OEM social media sites on all electronic correspondence, press releases, and on our static web presence with a tag line.
- "Like" and "Follow" key members of our target audiences, this encourages them to "Like" and "Follow" us.
- Comment on, reply to, link to, and re-tweet relevant content generated by key target audience members. This helps establish our presence and encourages them to follow us.

Engage Target Audiences

- Adopt the 70/20/10 rule:
  - 70% of the content we push will be information of significant interest and value to our target audiences (articles & stories that communicate our message of the value of the MHMP and its revision process and the importance of public participation)
  - 20% of the content we push will be through online interaction/conversation with our target audiences. Many people now expect to interact with organizations this way, relationships are built online. (Respond to and converse with commenters in a way that addresses their needs and communicates our message)
  - 10% of our content can be blatant promotion i.e. "Like us on Facebook!" or "Comment on the MHMP today!".

Observe and Analyze Social Media Activity

- Observation should guide any changes in the overall social media strategy.
- Keep basic records on who is talking about the OEM and the MHMP? What are they saying? Which platforms are they using? What content resonates generates interest and reaction? Have any new "opinion leaders" emerged with whom we should engage?
- Is our content/message pushing beyond our circles? i.e. have we generated any earned media?

Evaluation and Measures

- To measure the impact of our social media presence we will track the following metrics:
  - Number of comments per week
  - Number of followers on Twitter
  - Number of "Likes" on Facebook
  - Number of re-tweets
  - Number of click throughs on links posted on Twitter, Facebook, and other sites
- Compare levels of social media participation to levels of public participation in original MHMP planning process and traditional public meetings.
- Compare the quality of participation in virtual and traditional public participation using the following metrics:
  - Number of questions/comments per participant
  - Length and/or complexity of questions/comments
  - Length and/or complexity of discussion, i.e., number of follow up questions, number of back and forth with staff and public, number of additional outside comments/questions generated by the original
  - Satisfaction of staff and public that interaction was valuable and productive: this may require a survey at the conclusion of the process.