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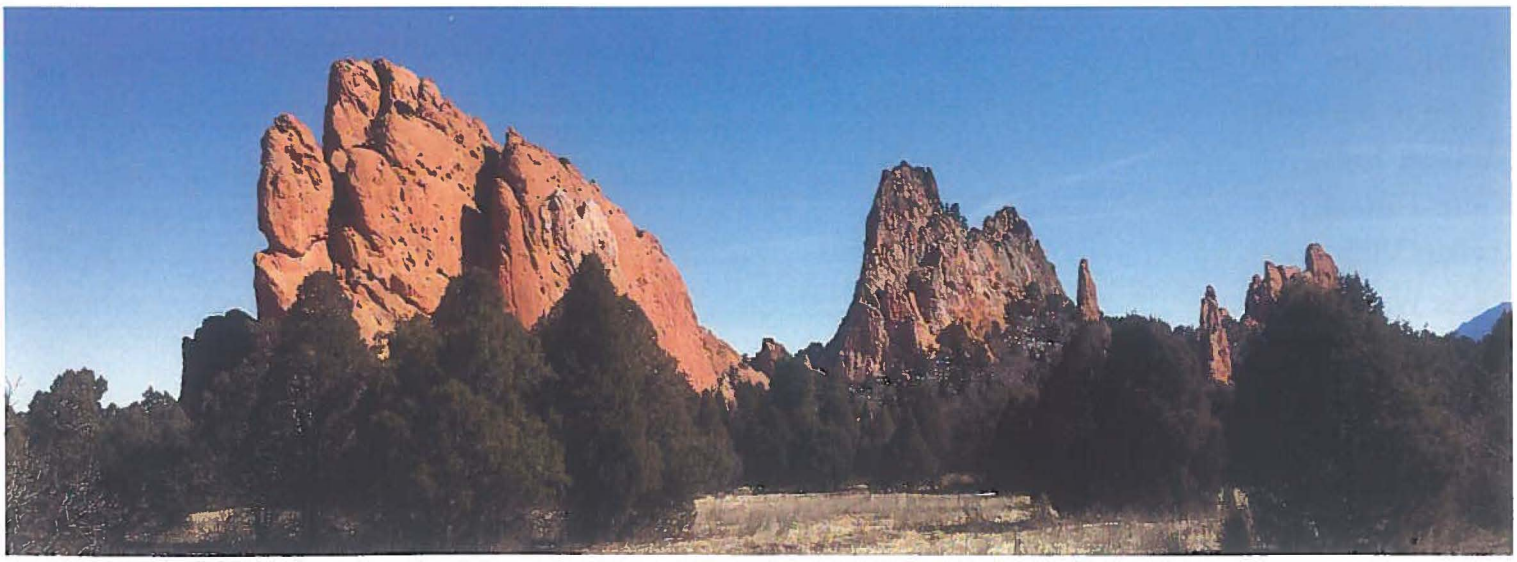


Executive Summary

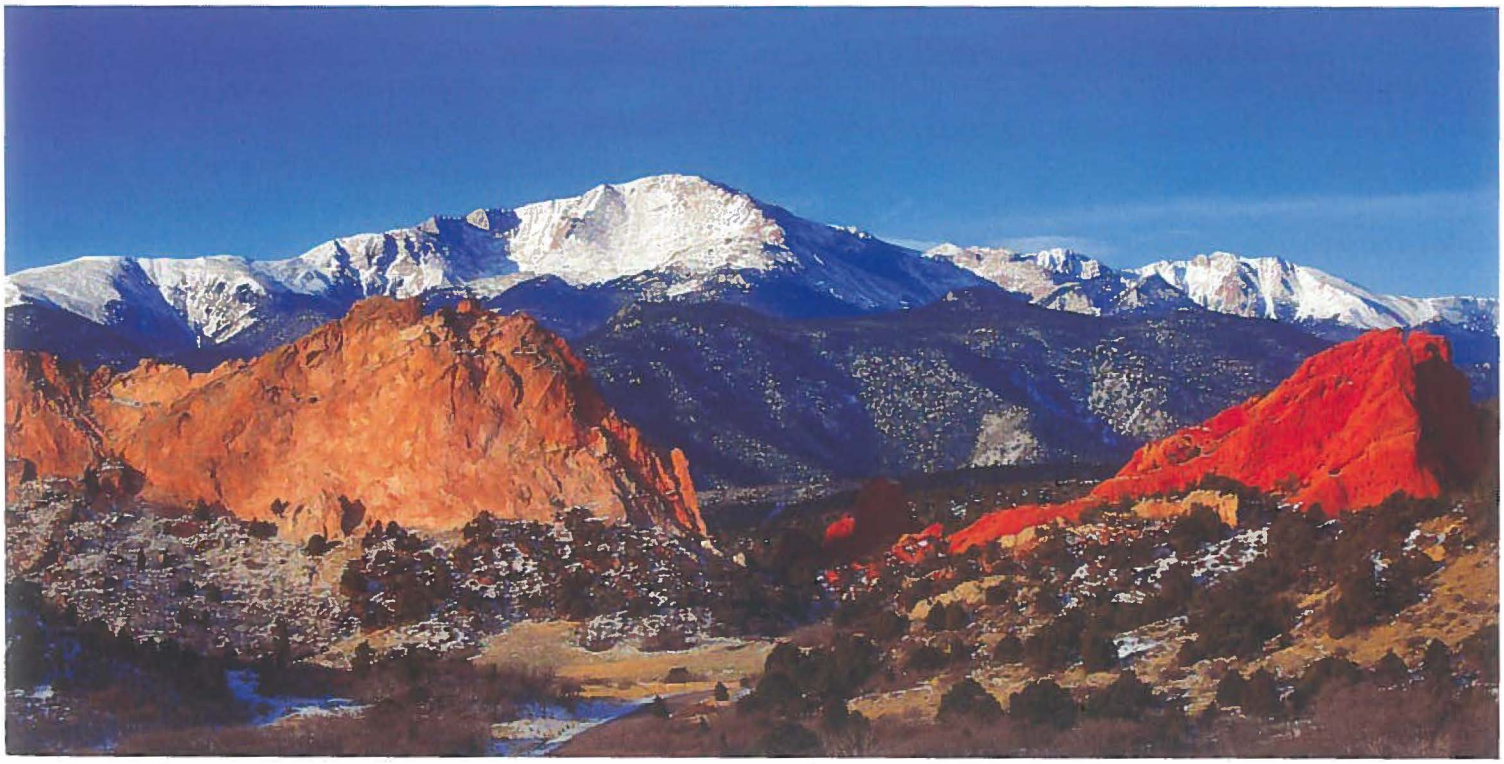
In recent years, shifts in global and local climate patterns have begun to impact the lives of people around the world, including those living in Colorado Springs. Though shifts in the climate occur naturally, human actions have intensified the pace and scale of these climatic changes. Quickly shifting climate regimes can pose serious risks, not only to the environment, but also to human health, well-being, and the built environments we call home. The City of Colorado Springs has acknowledged the need to address these risks in order to support a growing and thriving city.

The City's new master plan, PlanCOS, calls on the City to "Initiate an Adaptable Climate Response Plan that includes input from and guidance for private, non-profit, and public organizations" (Strategy ML-4.C-5). The plan elaborates:

> PlanCOS recognizes the differing perspectives of our citizens about the extent of global and regional climate change and the appropriate role of the City of Colorado Springs. The plan should be both informed and forward thinking, but primarily locally focused in planning for an adaptive and resilient city responsive to emerging trends in both the physical and regulatory environments. A full range of community stakeholders and experts should be involved in this ongoing, adaptive process, including Colorado Springs Utilities, our military and regional transportation partners, land and forest managers and emergency responders.[1]

This report strives to support this process by offering a preliminary climate change vulnerability and response assessment for Colorado Springs. The report focuses on the four major vulnerabilities facing Colorado Springs— urban heat, water scarcity, wildfire, and flooding.

These environmental phenomena should not be considered as isolated events. When considering the urban heat island, water scarcity, wildfire, and flooding, it is important to understand that each of these phenomena are complex and each exist as both catalysts and feedbacks to the others. As such, it is critical that Colorado Springs develop a comprehensive adaptation plan, which consider each of these vulnerabilities as contributing factors to climate change risk as a greater whole. The challenge for Colorado Springs is to approach climate adaptation in a holistic manner, recognizing not just the natural and environmental risks at hand, but the social vulnerabilities that have disparate impacts on various populations across the city. To this end, we propose a number of policies and strategies for the City to incorporate into its Adaptable Climate Response Plan. In creating this report, we hope to support the City's efforts to keep Colorado Springs safe, sustainable, and resilient for all people.



1. City of Colorado Springs. (2019). Plan COS Leading the Way to Our Future.Comphrensive Plan. Colorado Springs.

Urban Heat Island

Urban heat island effect (the UHI) is a localized meteorological phenomena that occurs when a city has a higher average temperature than surrounding rural areas. These higher temperatures are due to the abundance of urban infrastructure and industrialization present in city landscapes. Urban areas with dark-colored surfaces and structures—i.e. buildings, sidewalks, parking structures—typically have low albedos (surface reflectivity). In these urban areas there are also low levels of vegetation, and high concentrations of people and cars, which produce and trap heat close to the surface. An additional factor which contributes indirectly to the UHI effect is the prevalence of impermeable surfaces in the city drainwater. These surfaces remove water from the surface by sending it into the drainage system, preventing any evaporation that would have a cooling impact on the city. The combination and prevalence of these factors make Colorado Springs highly vulnerable to increased surface temperatures from the UHI effect. As global average temperatures are predicted to rise as a result of global anthropogenic climate change, this UHI effect will be further exacerbated.

This UHI effect is of particular concern for Colorado Springs. As a growing city that spans nearly 200 square miles, Colorado Springs' development is characterized by low-density residential communities and neighborhood zoning for just one type of land use. As Colorado Springs continues to grow, there will be a heightened necessity for roads and buildings to satisfy the needs of the increasing population. This will expand the urban built environment, further exacerbating the UHI and its area of effect. In Colorado Springs, green spaces are 1.6 degrees Fahrenheit (0.88 degree Celsius) cooler than nearby areas, illustrating that the impacts of the UHI already exists in the city (Figure 1).

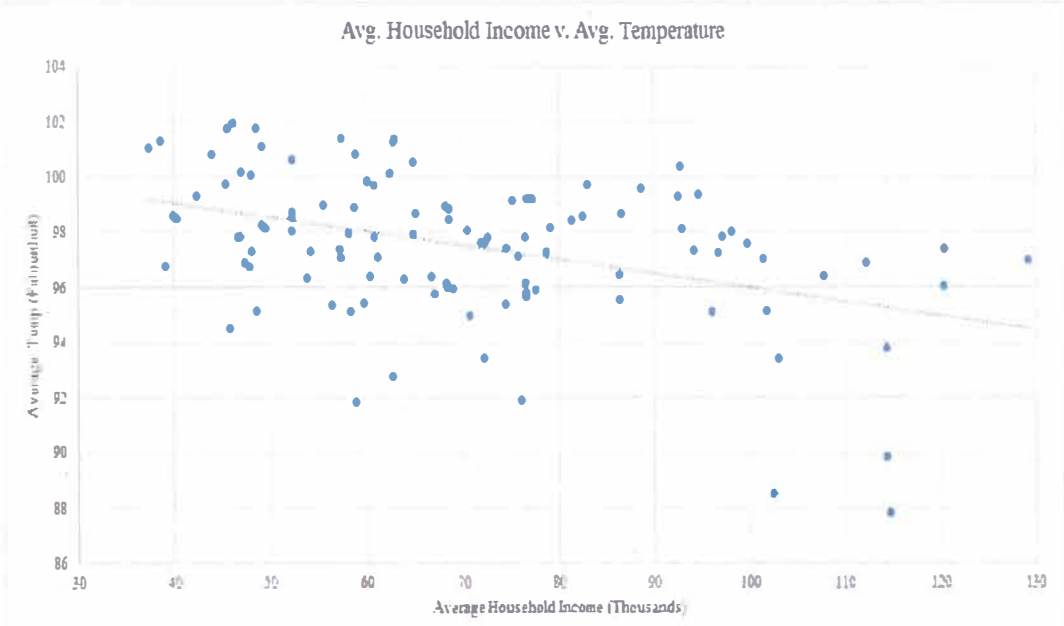


Figure 1: Average Household Income and Average Temperature Split by Census Tract

The effects of the UHI pose serious threats to the daily lives of Colorado Springs residents and can lead to detrimental public health impacts, such as increased risk of heat stroke and respiratory illnesses. Vulnerable populations, including low-income people, the elderly, homeless populations, communities of color, and people with pre-existing medical conditions, disproportionately suffer from health risks associated with heat[1]. For instance, low-income neighborhoods in Colorado Springs are on average 1.8 degree Fahrenheit (1 degree Celsius) warmer than neighborhoods with higher economic statuses. This shows that marginalized people will suffer disproportionately from extreme heat events.

Additionally, the economic impact of increased use of air conditioning in public buildings during hot summer months and the cost of providing healthcare to people suffering from heat-related health conditions will increase in the coming years. These economic impacts will prove costly for the city of Colorado Springs and its residents, unless action is taken to limit the impacts of heat risk in the city.

Through emergency response programs and city planning initiatives, Colorado Springs has taken steps to address heat risk. The Colorado Springs Public Health and CARES program, provide medical help to vulnerable populations during times of medical emergency. Additionally, PlanCOS, the city's long term comprehensive development plan, addresses some

aspects of climate vulnerability and extreme heat by planning for land-use changes that will eventually increase the prevalence greened landscapes.

Colorado Springs does, however, have a number of options available for further combating the consequences of the UHI effect. One option is to create education campaigns for the general public regarding the UHI and its dangers. These programs will inform the public about how to best protect themselves during extreme heat events. This could include education in schools, along with flyers and plaques placed in public areas around the city to outline available resources. Further, changes to city zoning and building codes would have a significant impact on the city and would ultimately benefit the greatest number of people. Changing the landscape and infrastructure of the built environment to include more green roofs, parks, and reflective, light-colored surfaces would both cool down and increase the albedo of the city, thus decreasing the overall impacts of the UHI. Creating new cooling centers or transitioning existing buildings into public spaces could help mitigate negative health impacts associated with the UHI. Lastly, changes that occur must primarily address the most vulnerable populations of Colorado Springs and we urge that these groups not be neglected or forgotten about during the decision-making process. Factors such as socioeconomic inequality and lack of access to education on heat dangers should be addressed concurrently with planning decisions. As these issues are appropriately addressed, further exacerbation of the UHI will be mitigated and the overall public health and economic prosperity of the region will improve.

Policy and Adaptation Recommendations:

- **Create heat advisory systems for extreme events**
- **Implement educational programs on heat dangers for the public and within school curriculums**
- **Expand emergency response programs, such as CARES**
- **Implement mixed-use zoning**
- **Increase the prevalence of green spaces, especially in the most vulnerable areas**
- **Increase the reflectivity of surfaces, especially in the Downtown and Southeast areas**
- **Implement infrastructure changes, such as increasing vegetation and adding cooling centers**

Drought and Water Scarcity

Average temperatures in Colorado Springs and the surrounding region have increased significantly over the last century. Warming temperatures in this and similar montane regions can have serious impacts on water drainage basins where municipalities store water. The most substantial impacts to long term water storage and availability result from warming during winter and spring months. Increasing temperatures during these cold seasons will lead to decreased snowpack, earlier snowmelt and declining water storage capacity. In conjunction with an increasing population, these climatic shifts will cause many challenges for Colorado Springs to balance an increase in demand for water with a smaller supply.

Colorado Springs Utilities (CSU) has already adopted an Integrated Water Resource Plan that outlines a plan on how Colorado Springs should move forward with planning for a drier climate. The report shows that CSU has taken positive steps for smart planning, however leaves room for further recommendations and improvements. CSU is currently raising water rates to help fund the replacement and repair of old infrastructure. While the current pricing is tiered, the most recent Water Case Report stated that there is an effort being made to flatten these tiers. Tier I prices were raised, while Tier II and III were lowered. Not only does this decrease incentive for conservation, but it also decreases access to reliable water for low income households. Currently there are programs to help low-income households increase water efficiency and conservation, but these services are not enough. Due to concerns about conservation and equity in water pricing, Colorado Springs Utilities should not attempt to completely flatten price differentials between the three different tiers and should consider expanding assistance programs for the most vulnerable populations.

Rain barrels can help lower personal homeowners' water bills. Using the water collected by these rain barrels, residential greenspaces, such as lawns, can be kept green without using potable water from the city. By maintaining residential greenspaces, neighborhoods are kept cooler and quality of life is increased.

The transfer of water to the Front Range for municipal use is a complex issue both in terms of acquiring water rights and transporting water. Colorado Springs sources its water primarily from the Arkansas River Basin and has worked over time

to acquire senior water rights from agricultural use. The city currently uses the "buy and dry" method, which is often seen as the most economically efficient method of water use. However, this method leads to significant economic and environmental externalities including harming rural economies, increasing dust storms and erosion, and decreasing Colorado's long term agricultural capacity. Colorado Springs has started to adopt innovative Alternative Transfer Methods, or ATMs, and these need to be expanded.

The implementation and maintenance of parks and greenspaces should also be considered an area of priority for the city of Colorado Springs. Not only do they bring in revenue through the large number of tourists that come to these spaces every year, they also provide areas of recreation and relaxation for community members and provide a cooling effect for the city. Rising temperatures and droughts continue to pose a threat to our city's water security. Our actions must reflect the gravity of the changing climate, thus it is vital to adapt to and mitigate such risks in order to uphold the community's quality of life in the long term.

Policy and Adaptation Recommendations:

- **Incentive program for rain barrel use in Colorado Springs**
- **Prioritize the maintenance of greenspaces by installing drought-tolerant plants, upgrading existing irrigation systems, and reducing water rates for park irrigation.**
- **Continue developing Alternative Transfer Methods for water sourcing**
- **Maintain some level of tiered pricing for water and consider expanding local assistance programs to help low-income households lower their water bills**

Wildfire

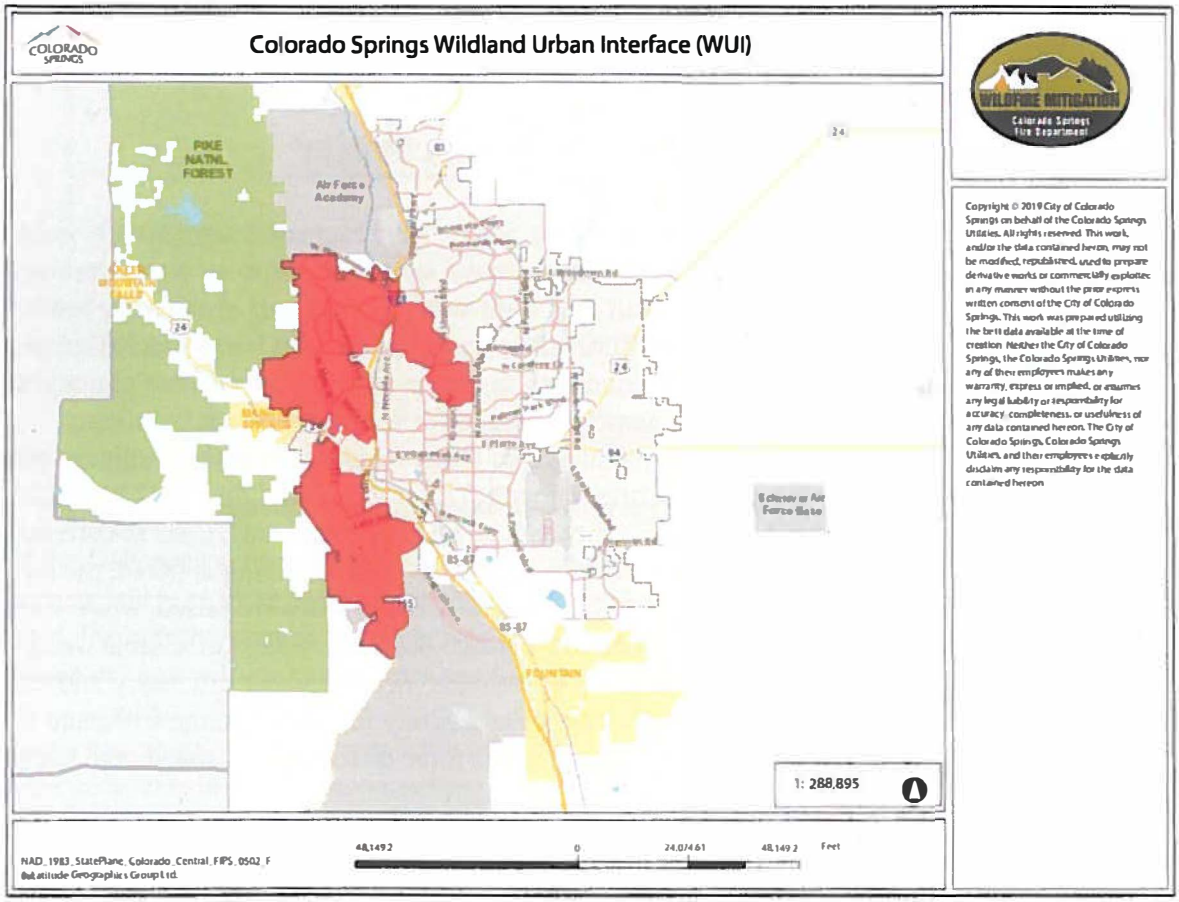


Figure 2: Map of Colorado Springs overlaid with a map wildland urban interface (WUI). The WUI is shown in red.

Vulnerability:

Wildfire risk in the Colorado Springs wildland-urban interface (WUI) has increased significantly as a result of warmer and drier climatic conditions and enhanced fuel abundance and aridity. The WUI is the area where homes, buildings, or other infrastructure are built close to or within the natural terrain of wildland and its vegetation. The population of those moving into the WUI in Colorado Springs is increasing and therefore more people and infrastructure are experiencing higher wildfire risks. The city's wildfire mitigation efforts are primarily focused on building codes in new developments, but many pre-existing structures in the WUI of Colorado Springs are still left vulnerable to wildfires.

Increasing WUI populations has also highlighted the vulnerabilities in emergency response and access. If a fire does spark, WUI fire stations are sparsely located which could limit response times to reports of smoke. For example, the Cheyenne Canyon region only has one fire station which is located on Broadmoor property.

More vulnerabilities arise for the city when examining the effects that a wildfire can have on a community. Flooding risk increases in burned areas due to a lack of vegetation to hold water and sediment in place. Without active programs to ensure proper post fire re-vegetation, many areas that have fire scars will be further susceptible to property damage and loss. In addition, communities that experience the effects of wildfire also face health risks such as respiratory problems and decreases in water quality which need to be addressed in restoration efforts..

Considering historical wildfires along Colorado's Front Range, Cheyenne Canyon and the area south of Highway 24 are zones at high risk of wildfire due to a variety of factors. The region has not experienced a high severity wildfire since 1894, and the coinciding effects of such long term fire suppression increase vulnerability. This area serves as a case study for the greater Colorado Springs WUI, due to its high risk and large population.

What is being done:

In response to these vulnerabilities, Colorado Springs has implemented wildfire mitigation, response, and recovery plans. The City of Colorado Springs, in conjunction with the Forest Service, already has comprehensive vegetative fuel management plans for properties in the WUI. Colorado Springs has updated its building code following the Waldo Canyon fire in 2012, however the majority of these codes apply only to newly constructed and redeveloped homes, leaving existing communities vulnerable. Voluntary community programs have also been implemented, such as the chipping program and tax breaks for implementing wildfire mitigation efforts.

In order to prepare residents of the WUI for a dangerous wildfire, evacuation drills take place multiple times a year in high risk areas utilizing social media, the emergency notification system, and first responder involvement. The next drill takes place in May of this year.

Recovery efforts have also been ongoing in Colorado Springs, as the city in partnership with the Forest Service has implemented policies to help restore the Waldo Canyon burn scar through revegetation and constructing sediment catchments and flood structures. In addition, many resources have been provided to aid with the aftermath of the Waldo Canyon fire. Despite this, there is still more that the city could be doing to increase wildfire resiliency and recovery.

Policy and Adaptation Recommendations:

- **Widespread implementation of vegetative fuel management on public and private lands inside and near the WUI. Both conducted through incentives and city programs.**
- **Annual fire season defensible space and vegetation thinning requirements for homes in the WUI.**
- **Place a growth limit on the number of additional buildings in the WUI.**
- **Implement policy that financially incentivizes individuals to update their buildings and homes to comply with current fire code standards.**
- **The City of Colorado Springs should evaluate what was successful with the Waldo. Canyon fire to be more prepared for wildfire recovery in the future and to share best practices with other cities.**
- **Increase number of fire stations in the WUI.**
- **Create a civilian training program for effective fire volunteer work.**
- **Improve cell phone coverage and create real-time update system for city officials and first responders.**
- **Push the state to obtain more large air tankers from the Air Force for fast fire suppression response.**

Flooding

Flooding is the most common natural disaster in Colorado Springs. In the next two decades, a projected $460 million is expected to be invested in strengthening the city's flood management and risk mitigation processes. As the city urbanizes, the cost of each subsequent flood continues to rise. Proactive risk mitigation will prevent billions of dollars in damage. Preventing devastation from flooding contains important implications with regards to social and economic policy. Three of Colorado Springs' socially vulnerable populations live in or adjacent to the floodplain, exposing some of the city's most defenseless population to the greatest risk.

Changing climatic conditions in coming years threaten communities and infrastructure. In the past three decades alone, the size of 2, 5 and 10-year floods have doubled along certain areas of Fountain Creek, one of the main contributors to flooding throughout the city. This increase in annual peak streamflows is a result of the extensive system of impervious surfaces that expedites water through the hydraulic system, as well as shifting environmental conditions, such as wildfire burn scars and extreme precipitation. Both the frequency and magnitude of extreme precipitation events has increased in past decades and are projected to continue increasing according to local and statewide climate predictions.3 These effects will exacerbate already visible changes within the watershed and further induce even more catastrophic flooding events that impact multiple communities in the city.

Colorado Springs acknowledges these issues and has drafted a constellation of city and regional reports, manuals, plans, and strategies. While they show much thought and action on behalf of the city, they fail to include adequate climate modelling and information about our most vulnerable populations. This report fills in both of these gaps and identifies the changing hydrology and climate of the region as well as the specific census tracts that intersects social and flood vulnerabilities.

Distinct policy recommendations are proposed concerning physical and social policies to ameliorate flood risk. They include: recodification of zoning laws to promote green infrastructure; increased interdepartmental and inter-jurisdictional communication; enhancing pre-, during, and post-disaster public outreach; creating water-smart parks; changing the development ordinances; and a variety of transparency and accountability measures for future planning. These substantive recommendations demonstrate a comprehensive framework of policies to better prepare and enhance the resiliency of Colorado Springs for future flood events. To supplement these recommendations, an amendment to the upcoming TOPS tax renewal has been proposed adding in a budget line for green infrastructure along with the existing maintenance, trails, parks, and open spaces categories.

Through enhanced maps and models identifying current and future risks for the city and its most vulnerable populations, this report adds to a large body of work from disparate departments. By adding to this work, a more holistic view of risk can be seen. It also serves to update some of the out of date data and models used today by the city to inform planning and zoning processes. This report should be a catalyst for enhanced adaptation planning at the city and regional levels. It by no means includes all possible information but rather shows a path for future reports and policies.

Policy and Adaptation Recommendations:

- **Enhance accountability and transparency measures in risk mitigation and disaster preparation.**
- **Engage the public in a multi-lingual, physical and online outreach strategy aimed to mitigate risk and inform disaster planning.**
- **Improve communication to effectively pool resources and prevent departmental/jurisdiction siloing.**
- **Add water-wise parks to our world-renown system to help curb stormwater runoff.**
- **Implement cost-effective zoning changes to adapt to a changing floodplain without overburdening the planning department.**
- **Encourage home/business owners to incorporate flood-resistant actions.**
- **Amend the Parkland Development Ordinance to include water-smart provisions.**
- **Create addition to the TOPS tax language in its upcoming renewal to add green infrastructure specifically for climate adaptation into the roster of TOPS properties.**