COLTON CLIMATE VULNERABILITY ASSESSMENT

2021

W.M. Keck Science Department
Claremont McKenna College • Pitzer College • Scripps College

Robert Redford
CONSERVANCY
for Southern California Sustainability
PITZER COLLEGE

COLTON
INCORPORATED • 1887

Prepared by
EA100 Global Climate Change, Fall 2021
Professor Branwen Williams, Evie Andrade, Caitlyn Arce, Anna Bagley, Hava Chishti, Sophia Cook, Kate DeMarsh, Lily Fillwalk, Mason Hernandez, Simone Henry, Kelly Keene, Olivia Klein, Nhi Phan, Max Proctor, Kati Tuemmler, Tate Tussing, Niklas Ugalde Recarte, Melia Waring, and Bryan Williams
In partnership with
Jessica Sutorus, City of Colton

Supported by
Professor Susan Phillips and Teresa Sabol Spezio
Robert Redford Conservancy for Southern California Sustainability, Pitzer College

Contents

Introduction

City Background and Demographics

The City of Colton, San Bernardino County, California has a population of 54,828, of which approximately 70% of the population is Hispanic (as of 2018) (Southern California Association of Governments 2019). The City of Colton has served as a hub of activity since the 1700s in the Inland Empire (History of Colton | Colton, CA - Official Website). Beginning as an agricultural city supplying the Los Angeles area with citrus fruits, the City of Colton transformed into a center of transportation with the introduction of the Southern Pacific Railroad in 1875. In the first decades of the 21st century, it has become a crucial part of the transportation and logistics industries with two freight railroad lines, eight trucking routes, and two freeways. The surrounding county has three major airports, six Interstate Highways, two U.S Highways, and eighteen State highways, which provides the infrastructure to make the City of Colton a distribution center point.

The 2018 median household income in the City of Colton was $47,256, which places it below the mediun income for San Bernardino and the broader region, including Imperial County, Los Angeles County, Orange County, Riverside County, San Bernardino County, and Ventura County (Southern California Association of Governments 2019). Furthermore, air pollution related to the influx in the transportation and logistics industries impacts community member health (Bluffstone and Ouderkirk 2007). Combined, these factors identify the City of Colton as a SB 535 Disadvantaged Community, calling upon the State of California to improve air quality and economic conditions ("Disadvantaged Communities" n.d.).

Climate Change

Human activities including greenhouse gas emissions (GHGs) and land use changes are warming our planet (IPCC 2014). Projected impacts of this climate change in California are summarized in California's Fourth Climate Change Assessment (Bedsworth et al. 2018). Briefly, annual average maximum daily temperatures are projected to warm 5.6 °F to 8.8 °F with the current rate of GHG emissions. While California experiences high variability in year-to-year precipitation, models suggest that rainfall events will become more extreme while the number of dry years will increase (Swain et al. 2018). The higher temperatures combined with the dry years will stress California's freshwater reservoirs while simultaneously increasing wildfire risk (Bedsworth et al. 2018). The rainfall events may encounter drier soil caused by drought conditions and/or wildfires could increase the risk of flash flood events (Modrick and Georgakakos 2015; Guilinger et al. 2020).

The Inland Empire's climate is hot and dry, with geographic variability in the region largely related to elevation and distance from the ocean. Climate change will increase both the number of extremely hot weather days (defined as temperature > 95 °F) and the average nighttime low temperature extremes (Hopkins 2018). Inland areas such as Colton will warm faster than areas that are closer to the ocean. Model projections suggest little change in average annual rainfall by the end of the century, but significant increases in year-to-year variability, such that drier years will become drier and wetter years will become wetter (Hopkins 2018). Higher temperatures will also increase evaporation, leading to decreasing soil moisture and amplify drought conditions.

Climate Vulnerability and Resilience

The City of Colton has progressively proposed measures to reduce its own environmental footprint, such as water efficient landscaping, green building ordinances, smart bus technologies, and urban tree planting (City of Colton 2015). Despite this, with projected future climate change, the residents of the City of Colton will experience dramatically different environmental conditions than today, impacting their quality of life (“San Bernardino County Community Indicators Report” 2020). In this report, we consider the vulnerability and resilience of the City of Colton to these future changes. Vulnerability describes the susceptibility of harm imposed by stresses associated with climate change and the absence of capacity to adapt. Resilience considers the capacity to recover and adapt to the changes. Climate resilience not only represents the ability to recover from heat, drought, or extreme weather events, but also to anticipate and create frameworks so everyone in the community is supported and educated about the systems in place to act and respond. This climate vulnerability assessment creates a framework for the City of Colton to anticipate, learn from, and plan for the future. The document outlines the current, pressing issues affecting the environmental and public health of City of Colton residents. Ultimately, the main objective is to increase resilience to the risks that greenhouse gas concentrations present throughout the region through current and future impacts on temperature, rainfall, winds, and extreme weather and storms.

Chapter 1: Climate Impacts

Atmospheric pollution

Greenhouse gases (GHGs) and air pollution are primarily emitted in the City of Colton from transportation sources and land use changes (City of Colton 2015). Air pollutants released include lead, ozone, carbon monoxide, nitrogen dioxide, sulfur dioxide, and particulate matter (PM). In the City of Colton, the main atmospheric pollutants are $PM_{2.5}$ and ground-level ozone. $PM_{2.5}$ is particulate matter that is roughly 2.5 micrometers, and is emitted through various sources, such as trucks and automobiles, coal-fired power plants, and other industry sectors, as well as reactions between chemicals such as nitrates, sulfates, and volatile organic compounds (VOCs) (Marshall 2013). Ground-level ozone is a secondary pollutant created by reactions between oxides of nitrogen, methane, and VOCs (Sicard et al. 2017). Air pollutants can lead to health impacts including cardiovascular and lung issues, and in extreme cases can lead to mortality (Dominici et al., 2000). Due to the transportation and logistics industry, some California communities are disproportionately burdened by air pollution, include the City of Colton (

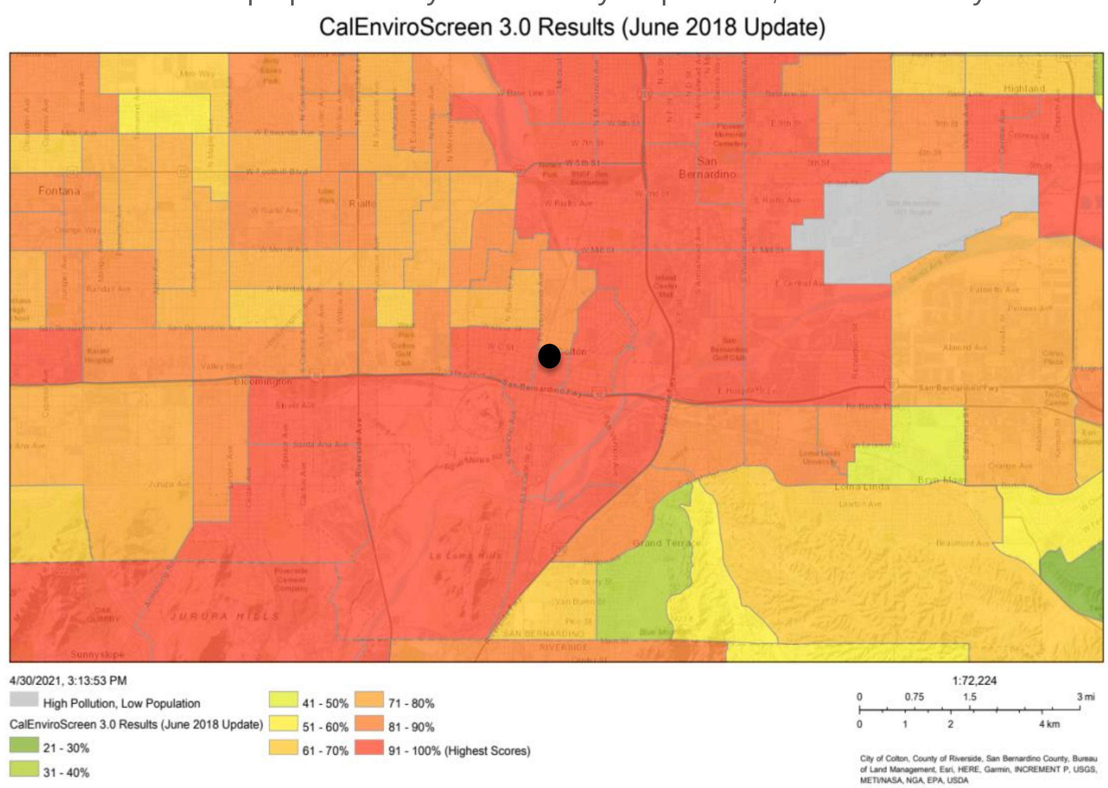

Figure 1).

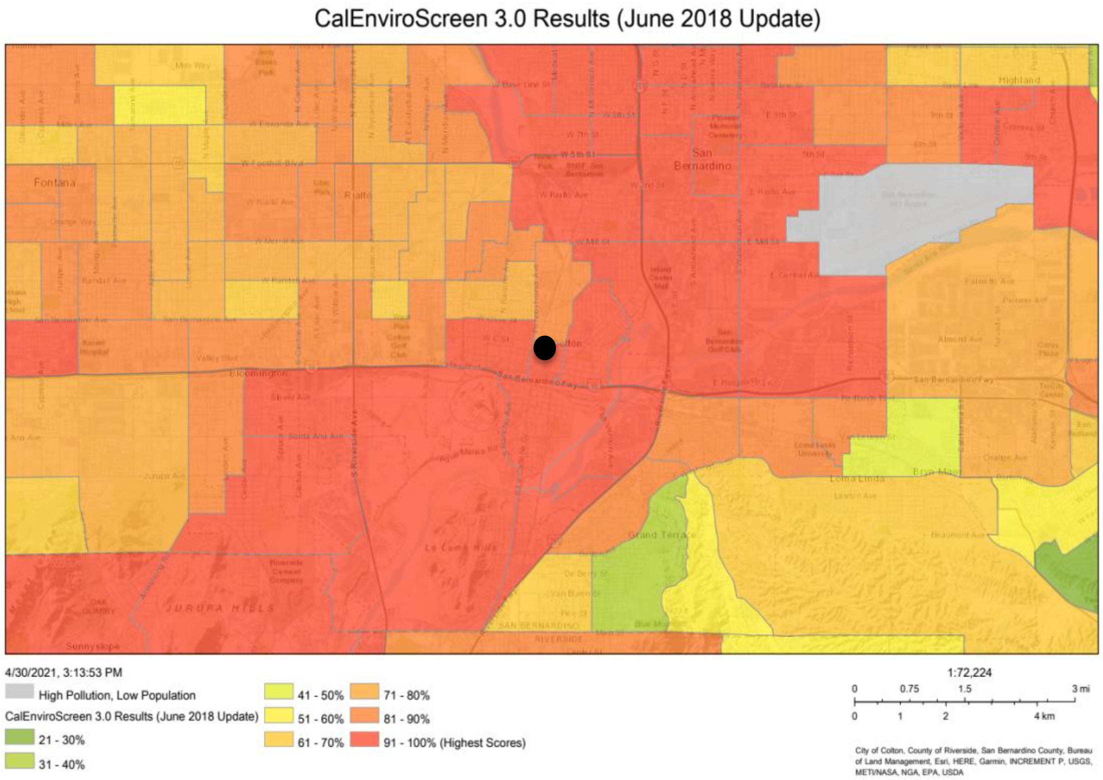

Figure 1. CalEnviroScreen 3.0. (Rodriquez and Zeise 2017). The black circle marks the approximate location of the City of Colton.

GHG emission mitigation also reduces air pollution, benefitting the health of residents (West et al. 2013). In the Inland Empire, vehicle emission policies since the 1960s have reduced ozone concentrations (Figure 2) (Garcia et al. 2019; Rowan 2019; Schwarzman et al. 2021). Even with these improvements, San Bernardino County has some of the worst ozone pollution in the United States: approximately 172.8 high ground-level ozone days a year placing over two million citizens in San Bernardino at high risk for conditions such as asthma, chronic obstructive pulmonary disease, lung disease, and cardiovascular disease (American Lung Association 2021).

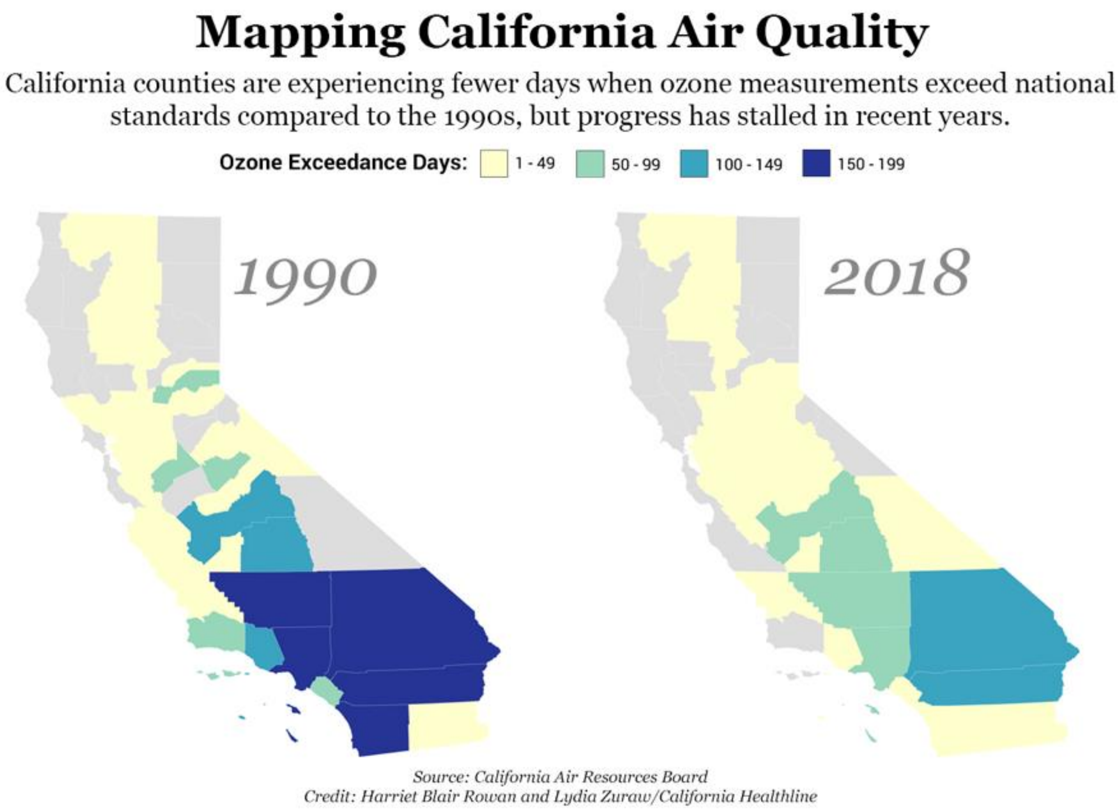

Figure 2. Ozone exceedance days in California from 1990 to 2018 (Rowan 2019).

Climatology

Historical temperatures in the City of Colton range from average low temperatures in the low 40s during the winter months and increase to average high temperatures in the 90s in August. The 30-year average temperature from 1961 to 1990 was 79.4°F (California Energy Commission 2021). The 30-year annual average rainfall (1961 to 1990) was 12.0 inches, with average daily maximum rainfall of 1.283 inches and maximum length of dry spell within a given year was 121 days (California Energy Commission 2021). Prevailing winds are typically the westerlies, bringing winds from the Pacific Ocean onshore, which carries the winter rains onshore. Thus, rainfall is most prevalent in the winter months. However seasonally during the fall and winter, the Santa Ana winds may dominate, which carry extremely dry air into Southern California. Occasionally, the North American Monsoon brings summer rains from the Pacific Ocean, the Gulf of California and the Gulf of Mexico into the region.

Due to the increased levels of atmospheric greenhouse gases, there has been a modern, post-industrial trend of increasing global temperatures (IPCC, 2014). This warming will lead to heatwaves, changed precipitation and wind patterns, which will in turn impact flooding/drought and wildfires (Guzman-Morales and Gershunov 2019).

Water Quality, Flooding, and Security

The City of Colton relies on local groundwater drawn from the San Bernardino Basin Area, the Rialto-Colton sub-basin, and the Riverside North sub-basin. Emergency water supply can also be accessed through the cities of Riverside and San Bernardino, Riverside Highland Water Company, and West Valley Water District, respectfully. The drinking water is safe for consumers in City of Colton, passing federal and state requirements for the level of contaminants (City of Colton Water Department 2019).

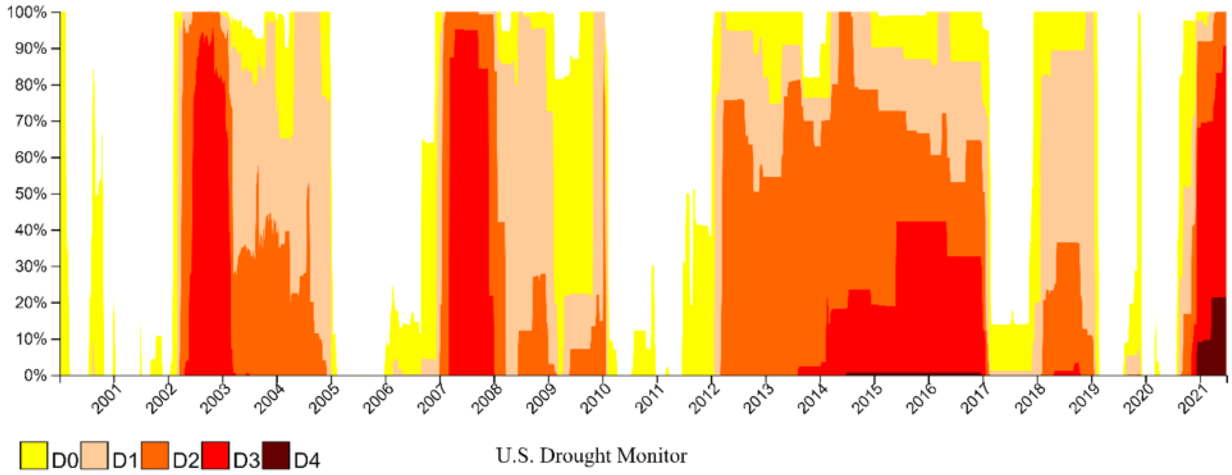

Figure 3. Historical drought conditions of San Bernardino County and the city of Colton since 2000 ("Conditions for Colton, CA (San Bernardino County)" n.d.). From 2012 to 2017, there is a trend of prolonged and intensive drought conditions.

San Bernardino naturally experiences multiple consecutive years of low rainfall leading to drought conditions (Figure 3). In 2015, in accordance with California's Executive Order B-29-15, the City of Colton enacted Ordinace O-09-14 to implement a water conservation plan (City of Colton, 2014). The purpose of the ordinance is to preserve water resources for the necessities of "human consumption, sanitation, and fire protection". Efforts to reduce water consumption include rebate programs, usage restrictions, and penalty fees for violators. Currently, the City of Colton is adapting a Water Shortage Contingency Plan that identifies shortage response actions when water supply is insufficient to meet expected water use ("Water / Wastewater | Colton, CA - Official Website" n.d.). Furthermore, the City of Colton worked with other water suppliers to develop an updated integrated regional urban water management plan to identify long term strategies to maintain sufficient groundwater (Water / Wastewater | Colton, CA - Official Website (coltonca.gov)). This plan considers water security under future climate projections (including drought scenarios) largely by balancing water use from the groundwater basins with recharge.

Chapter 2: Model Projections

Over the next few decades, the City of Colton faces four main climate stressors – these are the climatic changes that the City of Colton will face in the future: (1) temperature, (2) rainfall, (3) winds, and (4) extreme weather/storms. In addition, six main climate risks – adverse impacts that may result from these stressors – include (1) heatwaves, (2) wildfires, (3) flooding, (4) drought, (5) strain on energy grids, and (6) air quality. To understand how to respond and prepare for these changes, the report details two potential response scenarios. The high emissions scenario (RCP 8.5) presents a future with no climate change mitigation. The medium emissions scenario (RCP 4.5) presents a future with some mitigation resulting in a stabilization of atmospheric CO_2 concentrations of ~ 650 parts per million (ppm) CO_2-equivalents by the year 2100 (Thomson et al. 2011).

Stressors

Stressor 1: Temperature

Due to anthropogenic (human-caused) land surface changes and increased greenhouse gas emissions, the Earth's atmosphere is increasingly retaining more of the energy re-emitted from the earth, which is experienced as increases in average temperatures. Without any changes in our current activities, the RCP 8.5 model projects the City of Colton to experience a 5.0 – 5.6°F increase in mean temperatures by 2050, and up to a 9.1°F increase by 2100 (Figure 4). While these projections assume a "worst case" climate scenario that is consistent with our current trajectory, more ambitious scenarios that reflect human mitigation activities still indicate a significant warming trend. For instance, under a moderate climate mitigation scenario (RCP 4.5 model), average temperatures in the City of Colton are expected to increase 4.0 - 4.7°F by 2050 and 5.2 - 5.8°F by 2100 (California Energy Commission 2021). Even with mitigation efforts, a substantial increase in average temperatures in the City of Colton over the next decades is projected. The effects of increasing temperatures include higher risk of wildfires (Risk 1), droughts (Risk 3), energy grid strain (Risk 5) and heat-related illnesses.

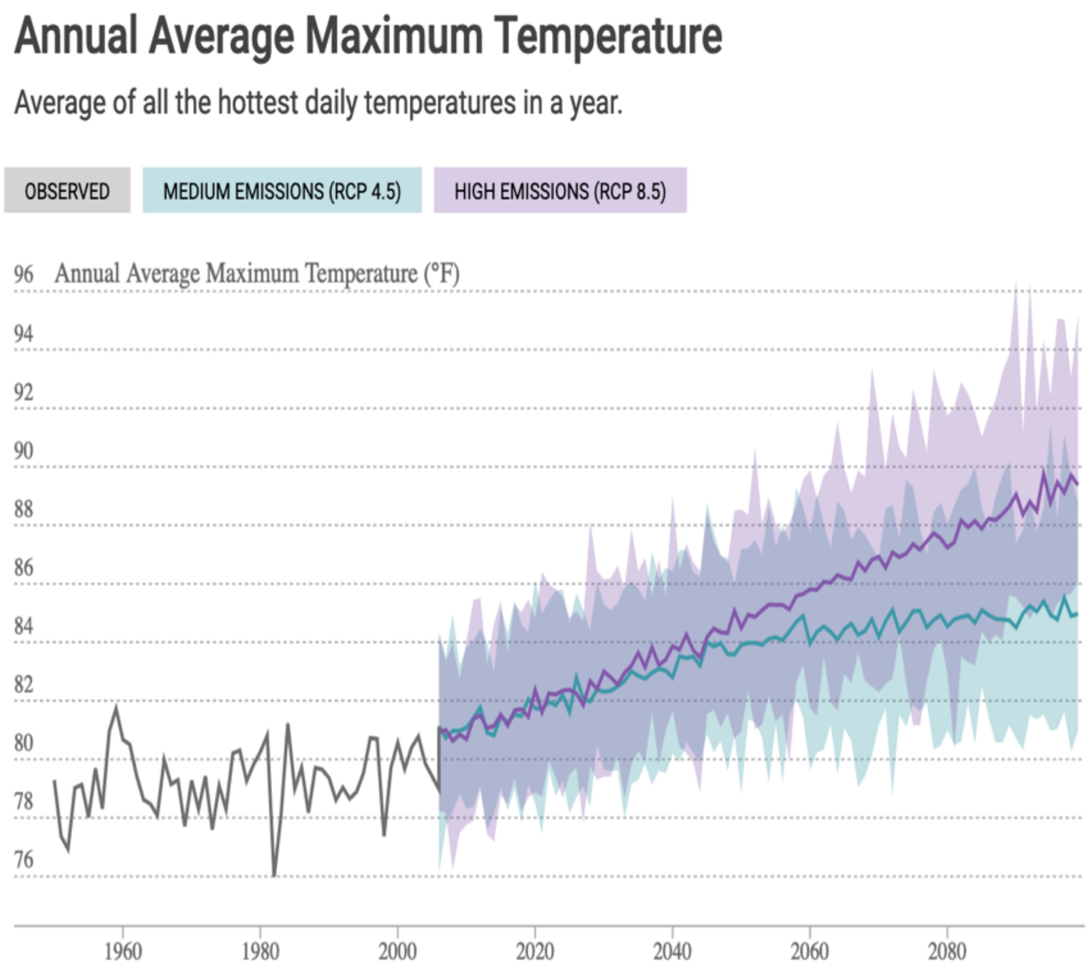

Figure 4. Annual average maximum temperatures in the City of Colton from recorded data from 1950 to projected data up to 2100. High emissions (purple) represents projections for temperatures without any climate change mitigation. Medium emissions (blue) represent projection temperatures with some mitigation.

Stressor 2: Rainfall

Human-induced alterations to the Earth's climate system also cause changes to precipitation patterns as water evaporates more easily under higher temperatures. Although average annual precipitation may increase with higher mean temperatures, the changes in rainfall are irregular across regions, which cause some areas to become wetter and others drier. Under a "business-as-usual" emissions scenario (RCP 8.5) and under emissions mitigation scenarios (RCP 4.5), the City of Colton is projected to receive slightly less annual precipitation, which could decrease by approximately 0.4 - 0.6 inches per year by mid-century and the end of century (Figure 5). However, significant uncertainty exists around those projections. In contrast, greater certainty exists with respect to future changes in precipitation intensities and dry spell periods. Maximum rainfall in a day is projected to increase up to 12.7% (+0.125 inches) by mid-century and up to 20.6% (+0.244 inches) by 2100 ("Cal-Adapt", 2021). Similarly, the maximum length of dry spells will increase from the current average of 121 days per year up to an average of 129 days by mid-century. In 2100, the average dry spell period in the City of Colton will reach between 130 to 140 days per year (California Energy Commission 2021). The prolonged dry spell periods may exacerbate wildfire risk and increase the risk of flooding events during storms due to reduced capacity of soils to absorb water.

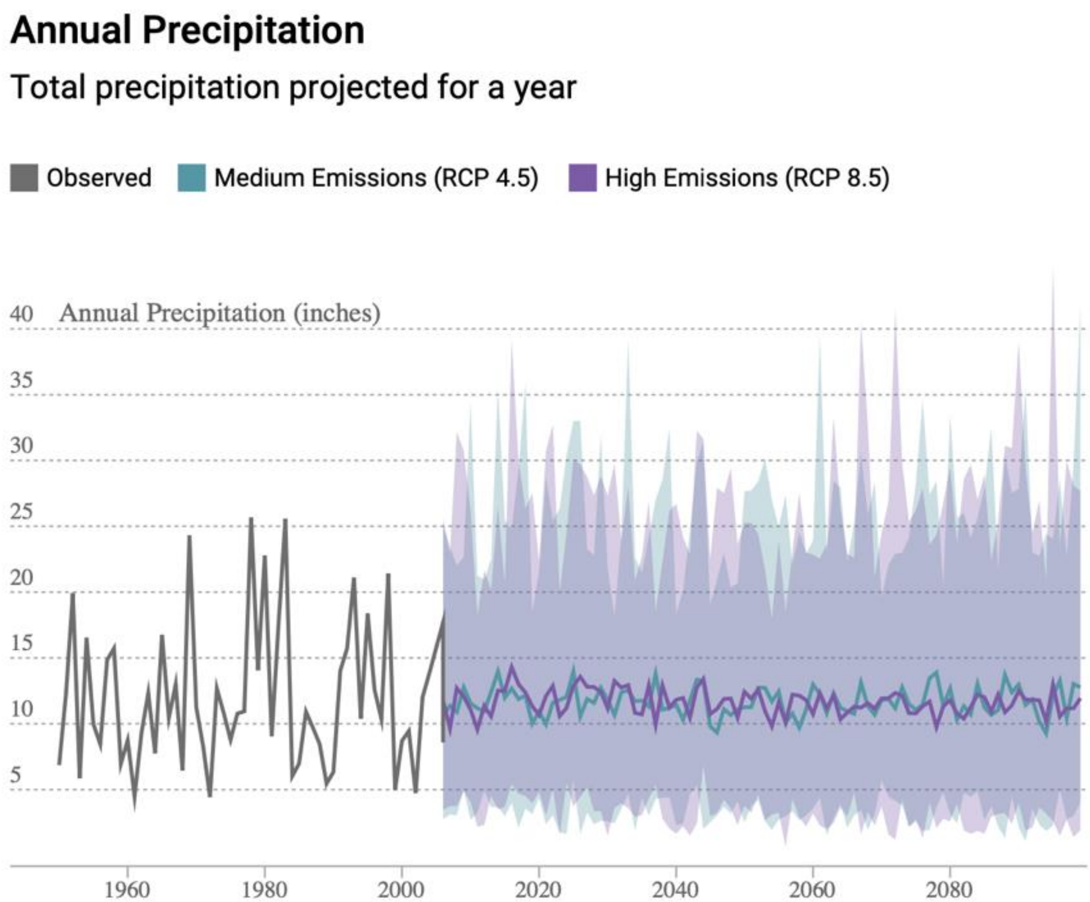

Figure 5. Annual average Precipitation in the City of Colton from recorded data from 1950 to projected data up to 2100 (California Energy Commission 2021).

Stressor 3: Winds

Changes in global climate, especially temperatures, alter the circulation of air in the atmosphere. As glaciers increasingly melt with rising temperatures, faster warming at high latitudes is expected, which reduces temperature differences between warm, tropical regions (low latitudes) and cold, glacial regions (high latitude). By reducing temperature differences, the atmospheric pressure gradient decreases, which causes winds to slow down on a global scale. More locally, both in the City of Colton and California, wind speeds are expected to decrease by approximately 2 - 8% from current averages (Pierce, Kalansky, and Cayan 2018). By 2050, the average number of extreme wind days in the City of Colton is projected to decrease by 2 - 3 days per year compared to current averages (Western Riverside Council of Governments 2021). While the slowing of wind speeds will reduce the risks of wildfires, it will also contribute to greater warming throughout the greater Los Angeles area since winds circulate cool air into cities. Reduced wind speeds may also have implications on air quality in the City of Colton and energy generation from wind power in California.

Stressor 4: Extreme Weather/Storms

Despite uncertainty in projections for wind speeds and annual precipitation in the City of Colton over the coming decades, extreme weather conditions are expected to intensify and become more frequent. By the end of the century, atmospheric cloud events with heavy rainfall are expected to double in frequency while also increasing by 40% in severity across Southern California (Hall, Berg, and Reich 2018). Similarly, the greater Los Angeles area is expected to experience a 60% to 100% increase in extreme dry-to-wet “whiplash” events by the end of the century (Swain et al. 2018). This leads to increased conditions of droughts followed by heavy precipitation events that cause floods.

Risks

Risk 1: Heat waves

With climate change, the City of Colton is at risk for intensive heat waves and short-term events of extremely hot temperatures (e.g., Figure 6). Historically, these events have become more humid and affected nighttime temperatures at a higher intensity than daytime temperatures (Gershunov and Guirguis 2012). From the baseline 1961 - 1990, the City of Colton experienced an average of 4 days per year that exceeded 104.9 °F. Going forward, model projections indicate between 16 and 55 extreme heat days by mid-century under the high GHG emissions scenario (RCP 8.5) (California Energy Commission 2021). Heat-related deaths are predicted to increase in the future as a result, particularly in concentrated urban areas (Weinberger et al. 2017). Under an emission mitigation scenario (RCP 4.5), extreme heat days may increase to roughly 22 and 31 days per year by mid-century and end of century, respectively. Similarly, the average number of warm nights (above 69.1° F) in the City of Colton per year are projected to spike under both business-as-usual and mitigation scenarios. We project warm nights to increase six to seven-fold by mid-century from current averages of 5 days per year, and nine to eighteen-fold by the end of the century (California Energy Commission 2021). Hence, warm nights might exceed 35 days per year by 2050 and 90 days per year by 2100.

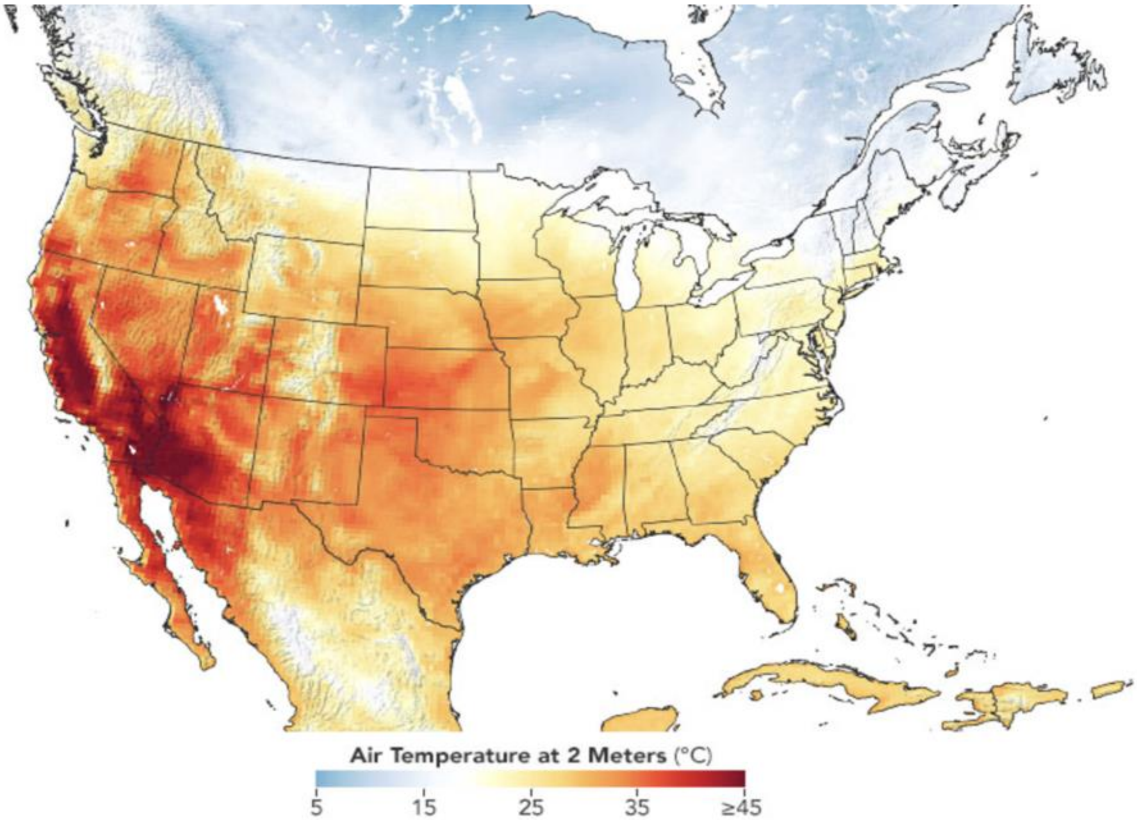

Figure 6. United States of America air temperature from September 6th, 2020 during a prevalent heatwave ("California Heatwave Fits a Trend" 2020).

Heat related days in cities are expected to double by 2050 (Figure 7), and triple or quadruple by 2090 as a result of increasing average temperatures (under both RCP 4.5 and 8.5 models), disproportionately impacting vulnerable populations (Weinberger et al. 2017). Elderly people and outdoor workers are at highest risk of potentially deadly heat-related illnesses, although other populations are also vulnerable. Associated illnesses include heat stroke, heat exhaustion, rhabdomyolysis, heat syncope, heat cramps, or heat rash. The symptoms of the illnesses can be as minimal as dehydration, but as extreme as death or permanent disability ("Heat Stress Related Illness" 2020). Elderly people without social networks and those with high blood pressure tend to be at highest risk for these illnesses. Additional information on impacts on health can be found below in the section: Human Health and Welfare.

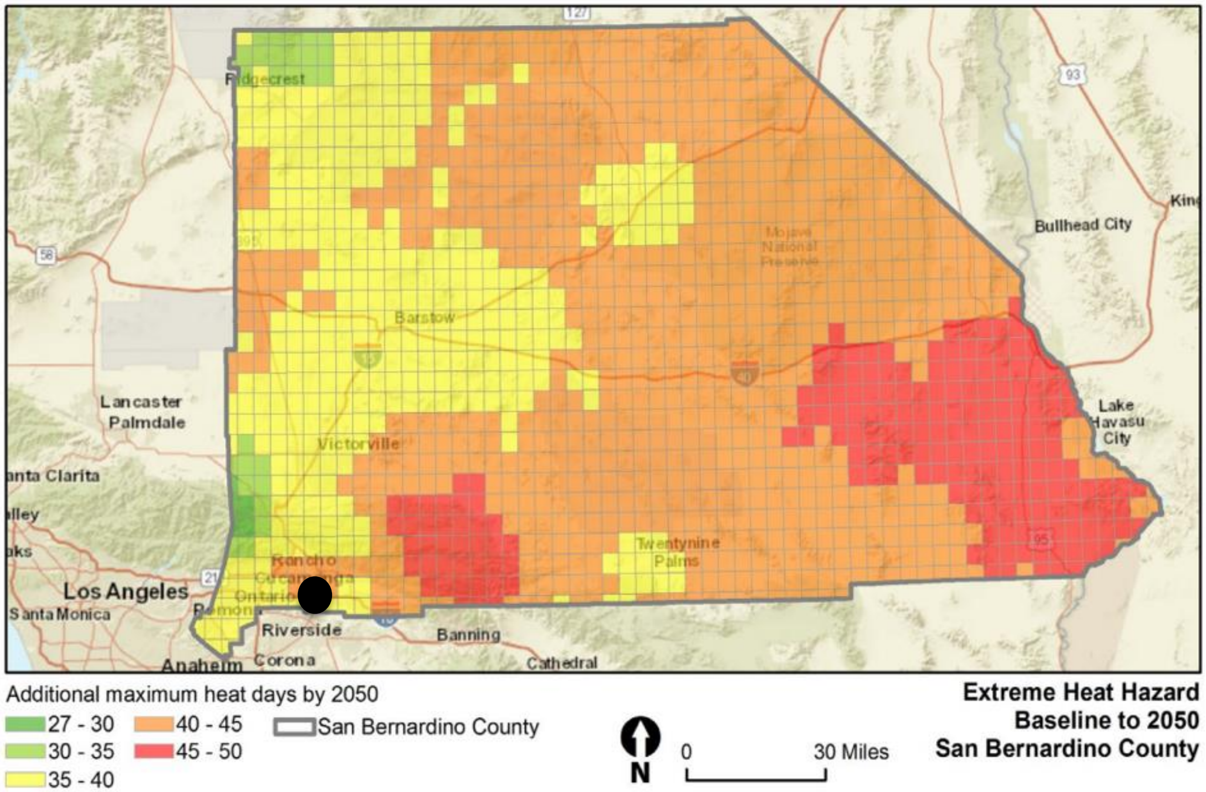

Figure 7. Expected change in number of extreme heat days to 2050 (California Energy Commission 2021). The black circle marks the approximate location of the City of Colton.

Risk 2: Wildfires

Wildfires can occur frequently in the western United States, with fires ignited both naturally by lightning and by human causes including smoking, arson, downed or sparking powerlines, and vehicles (Keeley and Syphard 2018). Wildfire risk is increasing due to higher average temperatures and prolonged droughts which extends the wildfire season length and increases frequency of events (Sun et al. 2019; Westerling 2018). The Inland Empire including San Bernardino is sometimes excluded from projected wildfire analysis (Keeley and Syphard 2018; Williams et al. 2019). In southern California, wildfire risk relates to temperature, vapor pressure deficit, grass and shrub cover, and the distance to roads and housing (Faivre et al. 2016; Li and Banerjee 2021). The City of Colton has already identified that increases in drought conditions and the amount of dry vegetation can act as fuel for wildfires (Colton Electric Department 2019b). For San Bernardino County, models project an increase in area burned from an annual average of 9.5 acres to 12.3 acres by the end of the century. However, these models project a decrease in area burned for the City of Colton from an annual average of 48.5 acres to 6.8 acres (Figure 8) (California Energy Commission 2021), potentially as a reflection of land use changes and reduced vegetation. In the City, only the Reche Canyon area is at substantial wildfire risk.

Air pollution from wildfires affects communities locally and regionally. As wildfires increase across the West Coast, air quality issues will increase in the City of Colton in the coming decades. Smoke from wildfires contains particulate matter, carbon monoxide, nitrogen oxides, and methane that affect human health and contributes to the formation of ozone. Wildfire pollutants lead to 339,000 additional deaths annually (Di Liberto 2018). The economic value of U.S. health impacts from short-term exposures to wildfire smoke is between $11 billion and $20 billion (2010 US dollars) per year and the value of long-term exposures is between $76 billion and $130 billion (2010 US dollars) per year (Neal Fann et al. 2018). Therefore, while wildfire risk in the City of Colton may be minimal, the secondary effects from regional fires will continue to be a risk for the local community.

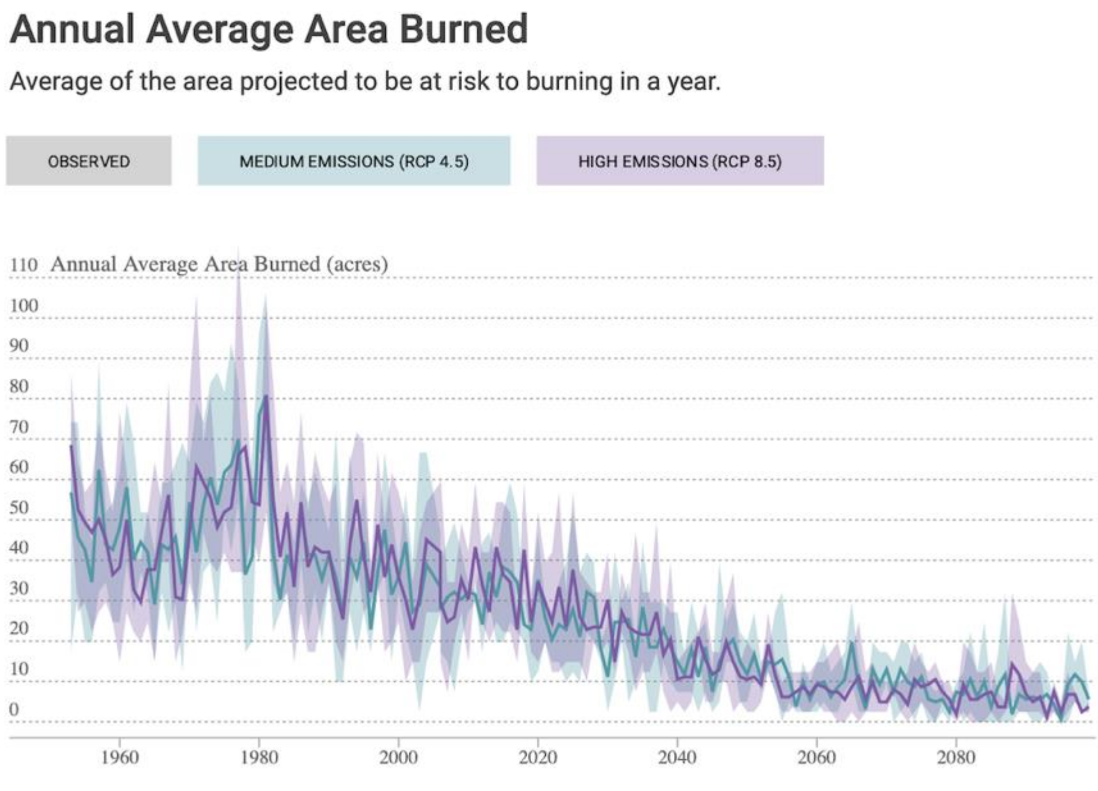

Figure 8. Annual average area burned in acres from 1950 to projected 2100 in the city of Colton area (California Energy Commission 2021).

Risk 3: Flooding

Higher intensity precipitation and more extreme storms are expected to cause increased flooding events, especially in urban areas without sufficient natural water retention capacities. Furthermore, drier soil and soil in wildfire-burned areas is less absorbent, causing more water to glide over the soil surface before it begins to be absorbed. Significant flooding events will occur more frequently in the Santa Ana River area while the flow rate will increase to more than 100,000 cfs (cubic foot per second) (Blickenstaff et al. 2013). Santa Ana River flooding will become more frequent and stronger. Within the City of Colton, 428 people and several key facilities including a Fire Station and the city's Water Reclamation Facility are in the 100-year flood plain and additional 7,700 people live in the 500-year flood plain (

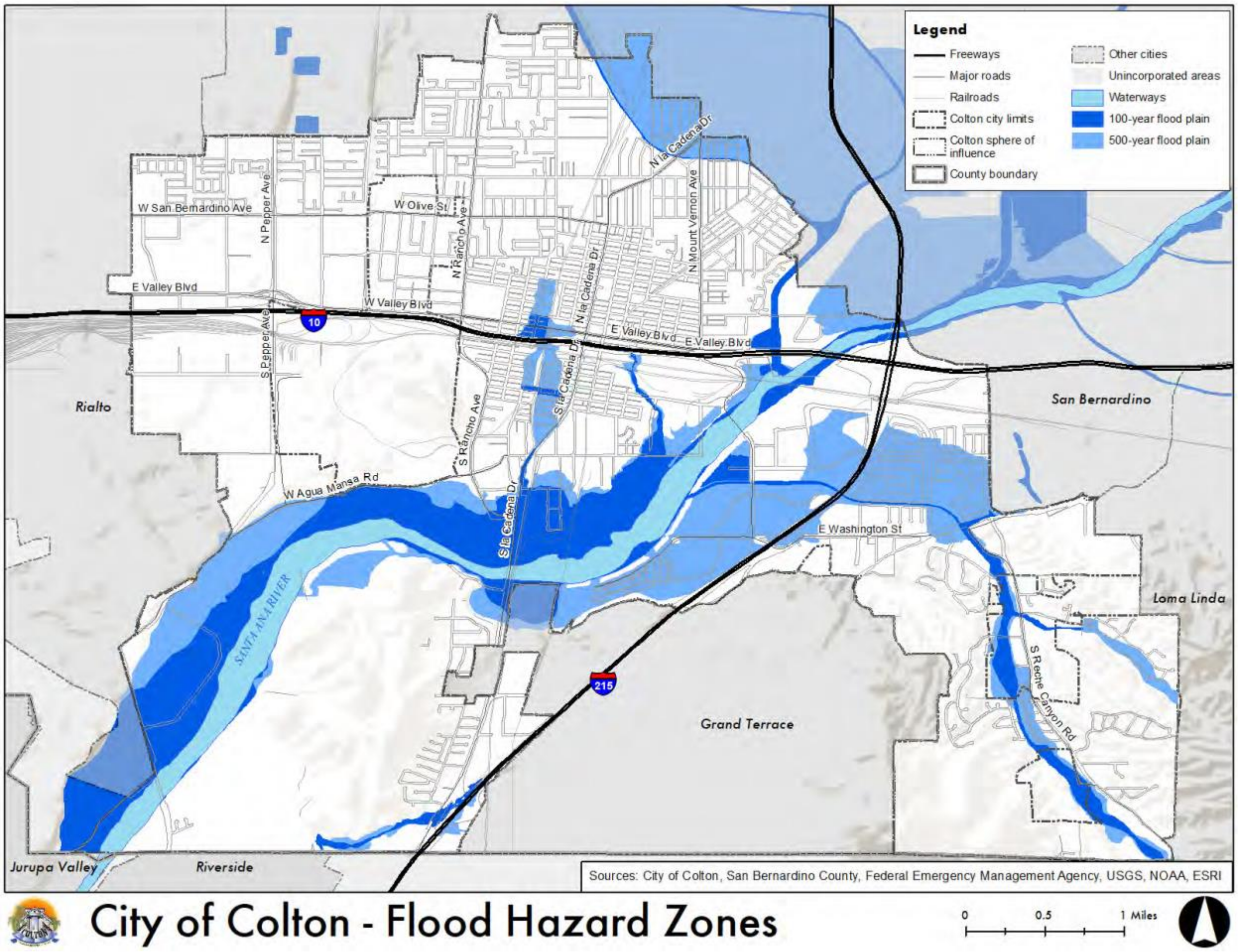

Figure 9) (City of Colton 2019b). Most importantly, the City of Colton faces a significant inundation risk if the Seven Oaks Dam were to fail due to increased water retention behind the dam (City of Colton 2019b).

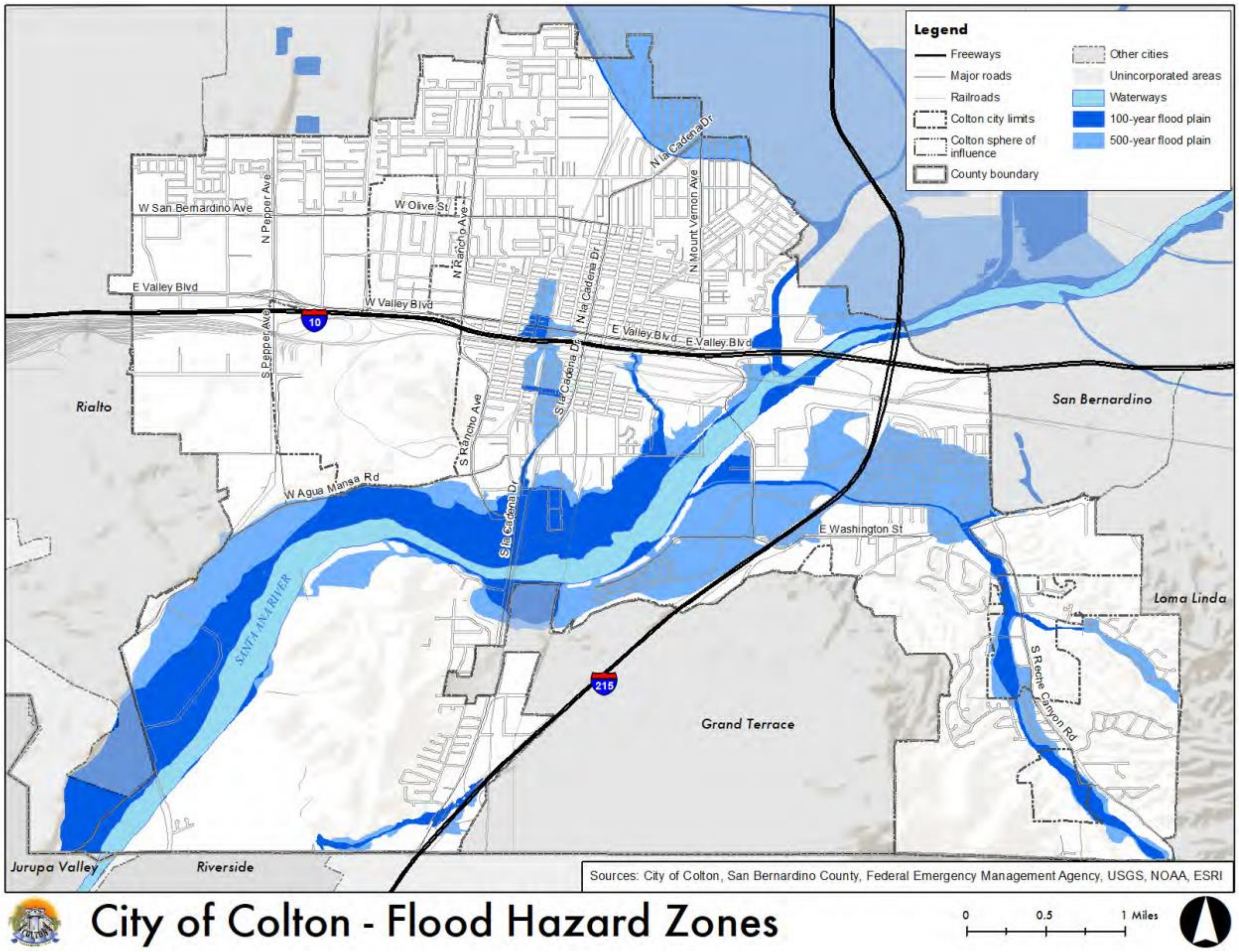

Figure 9. 100-year and 500-year flood plan marked in the City of Colton. Figure from (City of Colton 2019b)

Risk 4: Drought

Longer dry seasons, coupled with increased average temperatures are suspected to increase severity and longevity of droughts. Warmer temperatures decrease relative humidity and soil moisture and reduce snowpack. California has recently experienced the most intense drought conditions in California history from 2012 to 2017. This period led to a $1.7 billion crop loss, loss of 102 million forest trees, and inadequate water management (Howitt et al. 2015; Lund et al. 2018; U.S. Department of Agriculture 2016). The latest drought outlook for July 2021 puts San Bernardino County in severe to exceptional drought (National Drought Mitigation Center at the University of Nebraska-Lincoln, United States Department of Agriculture, and National Oceanic and Atmospheric Administration n.d.).

Climate change will intensify the impacts and increase the frequency of future droughts. The projected mid-century drought will bring more extreme heat days, low snowpack, increased soil drying, and forest loss (Ullrich et al. 2018). These conditions increase risk of poor drinking water, decreased air quality, inadequate nutrition, reduced sanitation, and disease. Drought may cause water shortages, urban forest loss (in part due to increased vulnerability of vegetation to disease), and an increased risk of poor air quality from wildfires within the City of Colton.

Risk 5: Strain on energy grids

Increasing temperatures are expected to drive up energy demand in Southern California due to increased use of air conditioning. By the end of the century, electricity demand is projected to exceed the peak load (highest power demand) for almost every summer days in California (Sathaye et al. 2011). A mean temperature increase of 5.0°F will decrease the capacity of transmission lines by 7.5% (Sathaye et al. 2011). Similarly, during extreme heat waves, electricity deficits as high as 17% are projected (Miller et al. 2008). The increase in heat days will drive a higher demand for electricity, increasing the stress on energy grids. However, the transmission line capacity will also decrease due to the increase in temperature causing further outages. Wildfires are projected to increase within San Bernardino County. This will lead to an increase in transmission lines exposure to wildfires, which is an issue in Colton's Reche Canyon area. To address this risk, the City of Colton has adopted a fire mitigation plan and insulated its transmission lines.

Risk 6: Air Quality

Assessment of air quality includes factors such as pollution from burning of fossil fuels or greenhouse gas content to ozone density. Poor air quality has adverse effects on human health. Based on 2002 data, the Centers for Disease Control and Prevention estimated that poor air quality-related health issues cost $6.5 billion nationwide. Air pollution can cause respiratory and cardiovascular damage; diabetes, obesity, and reproductive, neurological, and immune system disorders. For San Bernardino County to meet the federal 8-hour ozone National Ambient Air Quality Standard, a reduction from over 250 ppm to below 150 ppm of NO_x by 2023 is required (N. Fann et al. 2016). With the current pollution output of trucks, rail, and factories, increases in temperature, and possible slowing of winds, the City of Colton will encounter worsening air quality in the future.

Chapter 3: Social systems

Social Vulnerabilities

To assess the City of Colton's overall climate vulnerability, it is essential to consider the city's social systems and their vulnerabilities in relation to the effects of climate change. Social vulnerability factors include age, socioeconomic status, race, and disability status. Although the effects of climate change will be felt by everyone, racial-ethnic and socioeconomic disparities in climate change vulnerability are prevalent. Approximately 52% of households in the City of Colton earn less than $50,000 annually and about half of the city's residents rent their homes. The majority of residents live in single-family detached homes that account for an average of 36.7% of their total household income (Southern California Association of Governments 2019). Lower income households often have limited access to emergency services and health care, which can be essential when faced with a natural disaster or extreme weather event. Generally, the inability to spend money on rebuilding, fixing damages, or replacing essential items will be disproportionately faced by lower income communities and increase with more frequent and extreme natural disasters or weather events.

With over 80% of the population traveling to work via car and with a commute greater than 30 minutes, the City of Colton's residents are both creators and recipients of local air pollution due to transportation (Southern California Association of Governments 2019). The reliance on cars for long commutes has become more prevalent in recent years, and residents are carpooling 7.8% less than they did at the start of the 21st century. More environmentally conscious transportation choices such as biking may not be an option for many City of Colton residents, who have long distance commutes to their jobs. Often only those with short commutes can partake in sustainable alternatives to their normal transportation habits, and residents that rely on time-consuming or long-distance commutes to work usually have constraints that prohibit change.

Elderly populations are the most vulnerable to degraded air quality, often struggling with chronic health problems, or limited mobility. Additionally, elderly people are more likely to live alone, which decreases their ability to receive care in the event of a natural disaster or extreme weather event. Many elderly residents live on a fixed income with limited social networks. Natural disasters pose several other risks to the elderly due to greater difficulties they may have with finding adequate shelter or methods to evacuate.

Human health and welfare

The effects of climate change will negatively impact human health and welfare in many ways. In Southern California, heat, fire, and drought will contribute to increasing heat-related illnesses, breathing troubles, heart issues, contamination of food and water, injuries, mental health challenges, and the spreading of infectious diseases (Constible 2019). In the City of Colton, the most relevant impacts to human health may be heat waves and poor air quality.

As the number of hot days increases, heat cramps, heat stroke, and heat-related heart attacks will become more common (Constible 2019). Heat also contributes to the photochemical reactions that produce smog and increased ground-level ozone and particulate matter ($PM_{2.5}$). In urban areas, hotter temperatures are exacerbated by the urban heat island effect (Maizlish et al. 2017). The populations most vulnerable to heat are young children, older adults, people experiencing poverty, people with chronic illnesses, people experiencing homelessness, and people who work outdoors (Constible 2019).

Southern California wildfire smoke contributes to particulate matter which can worsen air quality hundreds or thousands of miles from the burn site. This particulate matter can lead to respiratory infections, cardiac arrests, low birth weight, poor mental health, asthma, and chronic obstructive pulmonary disease (Constible 2019). Wildfire smoke may compound health effects on very hot days and the existing poor air quality already present in the Inland Empire.

Economic Impacts

The impacts of climate change will impact the City of Colton's economy in several ways. Generally, increasing temperatures lead to a decrease in worker's productivity, leading to economic losses and a reduction in overall social welfare (Heal and Park 2016). This impact is significant: high temperatures (defined as over 78°F) slow global economic growth roughly 0.25 percentage points per year and is expected to increase to 0.28 percentage points in future years (Hsiang et al. 2016). Economic impacts on businesses depend on the sector. For instance, transportation, retail, manufacturing, and wholesale industries comprise 28.5% of jobs in the City of Colton (Southern California Association of Governments 2019). These four sectors are vulnerable to climate changes that will negatively affect transportation infrastructure. These impacts to infrastructure can disrupt supply chains across the country and incur economic losses to businesses. Some sectors, like retail (13%) and construction (4.2%), may benefit from an increase in warmer days in winter, although workers who work outside in the heat may also experience a decrease in productivity and suffer health impacts. The increased strain on energy grids and more frequent power outages in California will negatively affect businesses and production that are unable to operate without reliable power sources. The economic losses of businesses in a variety of sectors will impact city tax revenues.

The economic costs of climate change will also be felt at an individual level. The health impacts of climate change increase healthcare costs and affect individuals' ability to work. Households can remain comfortable in higher temperatures using air-conditioning units, which increase energy costs or increases health risks for those who cannot afford to use it. Infrastructure damage as a result of wildfires and floods place an economic burden on homeowners, landlords, and renters, and increase insurance rates (Roland-Holst and Kahrl 2008). With over 80% of the population relying on cars to get to work (Southern California Association of Governments 2019), damage to road infrastructure will be critical to worker economic productivity.

Chapter 4. Built Environment

Systems Infrastructure

Energy Plants

Energy in the City of Colton is distributed by local infrastructures, such as the City of Colton's Electricity Utility and by regional utilities, SoCalGas and Southern California Edison. Maintaining the infrastructure (power plants, power lines, pipelines, etc.) to distribute these energy sources is critical to City of Colton's residents. This becomes crucial, especially moving forward, as future energy usage is expected to increase with a warming climate. The City of Colton outlines their planning efforts to deal with future power supply issues in their 2019 Integrated Resource Plan (Colton Electric Department 2019a).

Electricity

Electric power infrastructure is comprised of transformers, power lines, and substations (Burillo et al. 2019). The components are spread across the City of Colton and they are exposed to a variety of climate change-induced hazards. Heat and wildfires in a semi-arid environment have multiple impacts on electric power infrastructure. The infrastructure is vulnerable to rising temperatures since warming reduces the components' safe operating capacities and overusing air conditions or other cooling devices produces strain its capacity (Burillo et al. 2019). The Local Hazard Mitigation Plan (City of Colton 2018) reports that none of the City of Colton's eight key electric facilities are in high risk wildfire areas; however, power lines are present in these areas. Wildfires can destroy the power line infrastructure or make it inoperable by ionizing the surrounding air (Burillo 2018). The power lines located in Reche Canyon are in an area prone to wildfires and the area has a track record of high severity burns, such as the 1981 fire that burned 4,051 acres (City of Colton 2018). Infrastructure in Reche Canyon, Loma Linda, parts of the Grand Terrace, and an area contained within the Santa Ana River/Highway 215/Riverside are risk from wildfire (Figure 10).

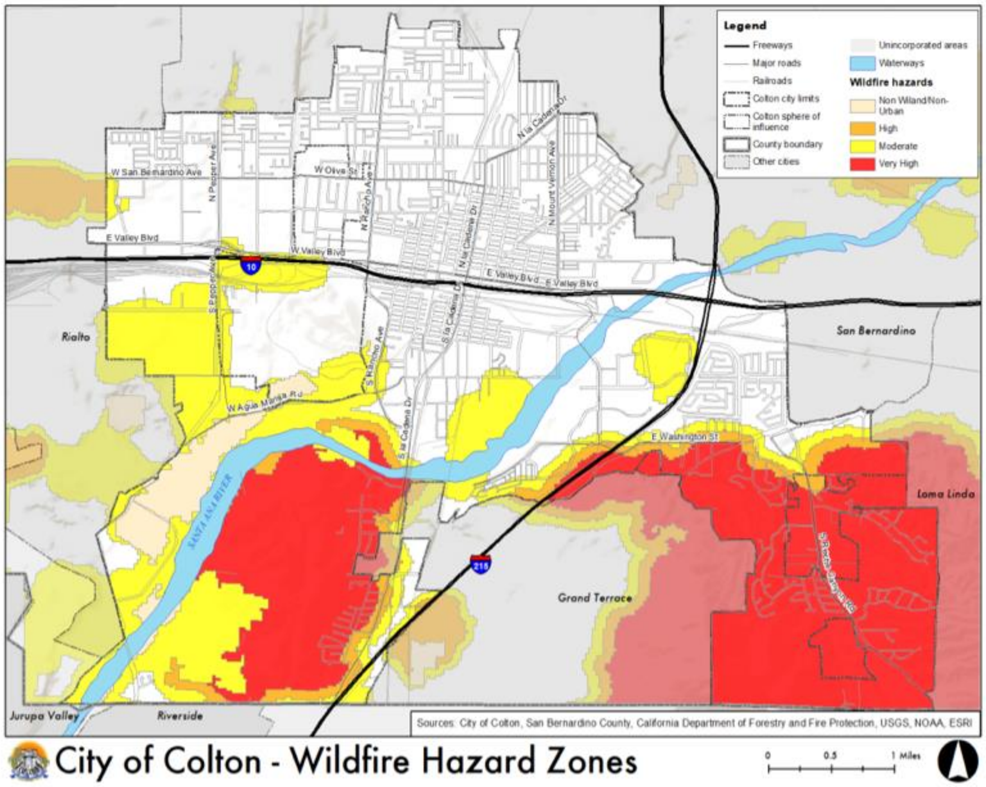

Figure 10. Wildfire risk for the City of Colton. Figure from (City of Colton 2018)

Three of the eight key electric facilities may be in 500-year flood plains in Northern Colton, around East Washington, or along Agua Mansa Road/Santa Ana River. Though the Southern California region is arid and current warming trends are projected to decrease precipitation, flash flooding is a climate change hazard facing the City of Colton (Modrick and Georgakakos 2015). Excessive flooding and high rainfall impairs electrical infrastructure by damaging towers/lines through soil erosion, interfering with electrical delivery, and flooding components that are underground (Burillo 2018).

To maintain its electrical infrastructure, the City of Colton must meet high-electrical demand, regulate system temperatures, protect more dispersed components, and develop a blockage or drainage system to divert excessive water. In the City of Colton, equipment failures can occur when temperatures at night do not cool down enough to cool equipment causing power faults in the system. Distributed generation, such as solar photovoltaics (PVs) with smart inverters and storage, can efficiently help electric plants meet high demands (Burrilo et al., 2019). Moreover, planning the placement of air chillers and generators may prevent the components from overheating (Burillo 2018; City of Colton 2018).

Natural Gas

Though natural gas generates electricity, it is also used for heating and cooling. The thermoregulatory infrastructure is composed of wells, processing plants, pipelines, storage, and liquid natural gas (LNG) facilities. However, external sources reveal that there are pipelines distributed across the City of Colton. For the purpose of this study, the SoCalGas pipelines will be used to explore potential climate related risk on Natural Gas Infrastructures.

Natural gas is a flammable substance, making it an extreme heat and wildfire risk if it were to leak from pipelines (both high pressure and transmission) or from storage. By taking account of the Local Hazard Mitigation Plan (City of Colton 2018) and related pipeline maps, natural gas transmission are located in the City of Colton wildfire regions. For example, high pressure SoCalGas pipelines intercept at high-risk areas such as South La Cadena Drive and Loma Linda. Potential climate change risks include combustion-related damage to the surrounding infrastructure and power failure (City of Colton 2018).

A major transmission pipeline in northern part of the City of Colton crosses waterways and 100/500-year-flood plains. The location of the transmission pipeline, along with other high-pressure pipelines in northern Colton, makes natural gas facilities vulnerable during excessive precipitation and flooding events. Climate change-intensified rainfall can loosen soil surrounding the pipeline, which weakens the pipeline's stability (AghaKouchak et al. 2020). The pipeline can also be weakened by direct influx from flooding, and runoff following excessive precipitation (AghaKouchak et al. 2020; Moftakhari and AghaKouchak 2019). Thus, protecting dispersed infrastructure is a strategy that can be applied for wet seasons and flooding. Constructing storm water drainage system and guards around transmission areas or pipelines may be a solution to protect them from flooding or intense precipitation (AghaKouchak et al. 2020; Moftakhari and AghaKouchak 2019).

Water

The City of Colton operates water retrieval facilities for the Rialto-Colton Basin, one of the largest potable aquifers in the State of California. The infrastructure that extracts water from the aquifer includes ten wells, four main booster pumping plants, six water storage reservoirs, two pressure reducing facilities, and over 120 miles of water transmission and distribution pipelines. Insufficient water, flooding and potentially dam failure are the largest risks to water infrastructure. Approaches to mitigate these risks are outlined in the Water Shortage Contingency Plan (draft - 2021) and the Integrated Regional Urban Water Management Plan (2020).

Wastewater

Risk of floods due to more frequent extreme wet weather events will increase the risk of damage to wastewater systems. Floods can cause system overflows which damage pipelines, treatment plants and increase risk of unintended wastewater release. The City of Colton is prepared for accidental wastewater release, and outlined an Overflow Emergency Response Plan, with specific steps for the containment of released wastewater and for the control of crowds and transportation. Floods can cause damage to storage sites for sanitation chemicals, leading to toxic release into municipal waterways. Under extreme rainfall conditions the City of Colton is permitted to discharge secondary treated wastewater directly to the Santa Ana River (https://www.ci.colton.ca.us/653/Wastewater-Information).

Solid Waste
The biggest threats to landfills are floods, which can rapidly transport large amounts of solid waste and contaminants and lead to leaching. The City of Colton’s primary waste collection facility, the Inland Regional Material Recovery Facility, located near the crossing of I-10 and I-215, is not in the 100- or 500-year floodplain nor in a wildfire risk area.

Buildings

Housing
Extreme heat poses one of the largest threats to housing. Extreme temperatures will put a strain on electrical supplies through increased reliance on air-conditioning and heating systems. The Colton Electric Utility department provides rebates for upgrades and replacements for air conditioning units (Air Conditioning Program | Colton, CA - Official Website 2021). Housing and air-conditioning play an especially important role for senior members of the community, because of their increased vulnerability to extreme heat. Twelve percent (1,929) of the City of Colton’s households are elderly households (City of Colton 2014). The city has been working with San Bernardino County’s Senior Home Repair Program to help rehabilitate the homes of senior community members (City of Colton 2014). Weatherization programs have been developed to assist every homeowner in improving their household energy efficiency (City of Colton 2014). This not only reduces the energy bills for households, but also promotes the continued function of home energy systems in the face of increased extreme weather conditions.

Flood risk also has the potential to damage housing infrastructure. A relatively low number of City of Colton residents live within the 100-year floodplain, while thousands are in the 500-year floodplain. The City of Colton is a participating community in the National Flood Insurance Program (NPIP), which provides flood insurance for homeowners, renters and businesses (City of Colton 2018). The NPIP follows the City of Colton's Floodplain Management Regulations, with residences and businesses in the floodplains mapped in the City Code of Ordinances Chapter 15.22, are eligible. NPIP also allows the City of Colton's infrastructure to become more resilient against floods by regulating building construction in the 100-year floodplain and updating standards for new homes.

Other threats to housing include wildfires, landslides, and earthquakes. A little under one-fifth of City of Colton residents live in wildfire hazard zones, with the highest risk occurring in the La Loma Hills and the Reche Canyon areas (City of Colton 2018). The City of Colton Electric Department has developed plans for fighting fires in both areas in the 2019 Wildfire Prevention and Mitigation Plan (City of Colton 2019a). The La Loma Hills and Reche Canyon areas are also in areas of elevated landslide risk. A number of homes along the Alquist-Priolo fault zones in Northeast Colton are at elevated risks for earthquakes (City of Colton 2018).

Municipal Buildings

The City of Colton's Capital Improvements Program prioritizes public works projects, including the retrofitting and maintenance of government buildings (City of Colton 2021). In the case of future hazardous climatic events, the city can include projects to improve building resilience in the improvement program. The City of Colton's Building Maintenance Department is equipped to maintain and update the infrastructure of government buildings. The Building Maintenance Department maintains buildings housing fire departments, libraries, police departments, community centers, and other municipal services. Fire Station 3 is in the dam failure hazard zone (City of Colton 2018). Since the Emergency Operations center is located in Firehouse 3, this is an especially important community asset. The City of Colton already identified in the 2018 Local Hazard Mitigation Plan that developing a backup location for the Emergency Operations Center is a priority (City of Colton 2018). Fire Station 4 is in the Alquist-Priolo fault zone which is a moderate wildfire risk zone (City of Colton 2018). The relocation of these two facilities outside the hazard zones was discussed as a mitigation strategy. Similar to the Reche Canyon neighborhoods, the Reche Canyon Elementary school is at high wildfire risk.

Hospitals

Among several healthcare centers, one key hospital facility exists in the City of Colton: the Arrowhead Regional Medical Center. A hospital's primary function is to provide medical services to their patients. Tasks to run an efficient facility include water and medicine distribution, waste disposal, treating wounds or infectious diseases, and generating enough power to run crucial equipment, such as life support (Watts et al. 2015). When climate change related risks impair hospital infrastructure, it impedes the facility from carrying out its tasks. The Arrowhead Regional Medical Center is not present in any of the flood plains or wildfire severity zones; however, it is susceptible to extreme temperatures or weather events. Hospitals require a constant supply of energy for their operations (Benjamin 2016). The Arrowhead Regional Medical Center relies on an efficient and constant flow of energy. Heat waves and high temperature can impair hospital energy use and equipment, given its impacts on electricity infrastructure. Heat-related effects include limited access to cooling units and decreased energy supply for life support and similar medical technology (Cooley et al. 2012; Wilbanks and Fernandez 2014).

Various solutions exist to adjusting hospital infrastructure for extreme temperature and weather events. Infrastructure adaptations to heat events include installing air conditioners and natural ventilation, developing thermal insulation to limit temperature fluctuations, and adjusting building features (ex. windows) to maximize shading (Loosemore, Chow, and McGeorge 2014). Similar to energy infrastructures, providing solar panels with batteries can ensure hospitals maintain technological support during heat-related power outages and limit the refueling process required for back-up generators.

Transportation

The City of Colton has a wide array of transportation infrastructure, including roadways, railways, public transit options, and walkways. It has two major freeways, Interstate 10 running east-west and Interstate 215 running north-south (City of Colton, 2018). Omnitrans which provides the primary public transit option in City of Colton maintains seven bus routes within the city that also connect to hubs in surrounding communities. Railways are of major significance to the City of Colton's history, serving as important industry in the community. The two major railways in the City of Colton include the Union Pacific railroad tracks running east-west alongside Interstate 10 and the BNSF railroad tracks running north-south alongside La Cadena Drive. Rail is also a key contributor to pollution, and as Colton faces increased expansion through the Intermodal Transfer Facility, this problem may worsen into the future.

The US Environmental Protection Agency articulates that burning fossil fuels such as gasoline and diesel releases carbon dioxide into the atmosphere, making the transportation industry the largest source of U.S. greenhouse gas emissions (28 percent of total U.S. greenhouse gas emissions). The City of Colton provides several public options for transportation that reduce overall pollution, such as busing and biking, decreasing its overall volume of carbon emissions that cause poor air quality and climate change. However, the use of these amenities in place of private automobiles is low. Furthermore, air pollution associated with the logistics and transportation industry contributes to local greenhouse gas emissions and air pollution, placing a disproportionate burden on sensitive communities.

Chapter 5. Pathways to resilience

City officials can take measures to anticipate, prepare, and lessen climate impacts in the future, especially on vulnerable populations. When combined with physical risk indicators like proximity to floodplains, socioeconomic factors can identify the populations most in need of support and critical preparedness infrastructure. Intentional measures involving multiple stakeholders throughout the city will help equitably combat the projected impacts of climate change. Intervention plans should be tailored to local needs, and require coordination between local health agencies, social services, voluntary agencies, school districts, ministries, universities, professional bodies, trade associations, and the National Weather Service. Engaging a wide range of stakeholders is crucial to accomplishing proper climate change mitigation. The City of Colton should consider the following recommendations based on these current risks: heat waves, flooding, drought, energy grid strain, and air quality.

Heatwaves

Review: The average number of extreme heat days (above 104.9°F) in the City of Colton are expected to increase over the next century. The rise in heatwaves and/or extreme weather events disproportionately impacts vulnerable populations and puts electrical systems at risk (refer to Models and Projections section for more information). Investing in emergency heatwave management and heatwave prevention will pay long-term dividends for the City of Colton and its residence. The recommendations will prove critical so people, businesses, and the power grid can withstand extreme heat in the near future. The following recommendations address these issues. Recommendations were gathered from the Heatwave Planning Guide from the City of Victoria (Department of Health & Human Services 2012). The recommendations were selected based on their alignment with the City of Colton's specific impacts:

Recommendations

1. Strengthen emergency management capacity to respond to extreme heat.
    a. Develop spatial maps of heat risk to maximize effectiveness of emergency management to respond to the most vulnerable people;
    b. Create a heatwave response plan;
    c. Further develop cooling centers;
    d. Develop cool routes such as shaded walkways and promote awareness.
2. Improve capacity of the community to respond to extreme heat.
    a. Identify most vulnerable populations and the local temperature threshold at which heat becomes a threat;
    b. Communicate with the public and businesses to raise awareness of heatwave risks and mitigation tools;

    c. Invest in equity and social networks projects.
3. Enhance reliability of the grid during high heat events.
    a. Enhance modeling and analytics for forecasting impacts and facilitating response to grid conditions;
    b. Expand grid automation to automatically respond to heat conditions;
    c. Build redundancy into the communication network;
    d. Regularly test primary and backup communications capabilities to control and monitoring points on the grid.
4. Decrease Urban Heat Island effect.
    a. Construct cool roofs, painted white or with highly reflective paint to absorb less heat;
    b. Use lighter color paving options of roads and surfaces;
    c. Plant and maintain trees to shade the ground and surrounding structures.

Flooding

Extreme weather conditions in the City of Colton are expected to intensify and occur more often, with the amount of heavy rainfall to double in frequency and nearly double in severity. Additionally, the amount of extreme dry-to-wet conditions are expected to increase by at least 60% by the end of the century. Due to the higher intensity and frequency of storms and precipitation, flooding events are expected to increase in the City of Colton. Its location near the foothills of the San Bernardino mountains and proximity to the Santa Ana River makes the city at high risk for flooding. Although many of these recommendations require upfront costs, the payoffs in the future will be substantial with worsening weather. Resilient infrastructure, business, and energy will serve the City of Colton and its residents far into the future. Recommendations were gathered from the *Comprehensive Flood Management Plan* from the city of Sacramento, Ca (Perkins et al. 2017) and the Organization for Economic Cooperation and Development *Climate Resilient Infrastructure* policy perspectives (Organisation for Economic Co-operation and Development 2018). The recommendations were selected based on their alignment with the City of Colton's specific impacts:

<u>Recommendations</u>

1. Improve local infrastructure to withstand the increase in storms.
    a. Build a strong foundation and maintain building infrastructure;
    b. Favor designs that support flexibility instead of robustness and redundancy;
    c. Ensure city buildings are flood proof;
    d. Consider buffer zones of habitat, tree belts, or urban agriculture;
    e. Increase climate change and extreme weather research.
2. Enhance resilience of local businesses to extreme weather.
    a. Implement standard building codes that will withstand severe weather.
    b. Increase insurance coverage.

    c. Create a disaster recovery plan.
    d. Encourage distributed generation with back up storage.
3. Increase the resilience of natural and built systems to adapt to increased time frames between precipitation and increased drought conditions
    a. Provide tools and equipment so local officials can be informed of hazardous conditions as soon as possible;
    b. Encourage local land use decisions to maximize local recharge and reduce run off.
4. Strengthen emergency management capacity to respond to flood-related emergencies;
    a. Ensure those located in floodplains understand the risk;
    b. Develop evacuation plans and practice evacuation scenarios regularly;
    c. Invest in emergency supply kits and shelter locations.
5. Increase the resilience of the natural and built environment to more intense rain events and associated flooding
    a. Increase awareness of the importance of cleaning debris from gutters and downspouts.
    b. Regularly inspect and monitor floodgates, drainage canals and basins, and clean drainage systems regularly.
6. Enhance resilience to fuel disruptions in transportation and mobility
    a. Plan to provide personnel and resources for road closures and traffic diversion.
    b. Provide damage access for roads and bridges.
    c. Open and close specific flood gates to channel the flooding and mitigate damage.
    d. Securely anchor fuel tanks to a foundation to prevent movement and flotations

Drought

As a result of increasing average temperatures due to climate change, the impacts of drought on the City of Colton are expected to intensify. These impacts include water shortages, forest loss, and an increased wildfire risk within the Colton community. The City of Colton receives freshwater from their deep-water wells. Because of climate change and the increases in temperature, serious action needs to be taken to conserve water. Droughts will continue to last longer as temperatures continue to rise. Water basins will be depleted faster than they are capable of being replenished. Optimizing the City of Colton's groundwater resources and management strategies will reduce the risk that droughts have on the city. Implementing city-wide or state-wide government policies will have long term benefits for the City of Colton. immediately. The timeframe of these recommendations will be dependent on systems' quality and efficiency. After a review of the system, the city should have a clearer understanding of which problems should be targeted and the length of time the process should take. Water conservation relies heavily on the compliance of residents and providing the proper incentives will increase cooperation. Recommendations were gathered from the climate assessments from the cities of Berkeley and Tacoma (deBoer, McNeilly, and Riordan 2017; Environment Services Department 2016) and from EPA *Water Reuse* and *Groundwater Management* from the Water Education Foundation (US EPA 2019; "Groundwater Management" n.d.). The recommendations were selected based on their alignment with the City of Colton's specific impacts:

Recommendations

1. Increase the resilience of cities water supply in drier summers
    a. Update codes and ordinances to support water sustainability;
    b. Choose water- and energy-efficient options for capital improvements;
    c. Adopt a water waste ordinance and penalties;
    d. Provide incentives for water conservation and water-use efficiency.
2. Improve groundwater management
    a. Review groundwater management and improve sustainability of basins;
    b. Limit pumping in normal and wet years to ensure enough water in drought years.
3. Reduce water use and improve groundwater management
    a. Implement pre-impact government programs and take actions that encourage groundwater supply management and continued water use reductions
4. Develop monitoring and early warning systems
    a. Improve seasonal forecasts;
    b. Establish comprehensive early warning and information systems;
    c. Improve knowledge of the landscape and expand access to reliable and timely data;
    d. Increase the emphasis on water conservation and raise awareness.
5. Strengthen risk mitigating measures
    a. Prevent contamination of water sources.
    b. Expand the structure for local agencies to implement plans to manage groundwater resources sustainably.
    c. Develop a system that prioritizes and addresses groundwater basins in need of the most restoration.
6. Promote water recycling
    a. Educate businesses and homeowners on the benefits of water recycling;
    b. Increase City of Colton's capacity to use recycled water at municipal facilities including for irrigation and other uses;
    c. Consider investment, policy and/or subsidies for water catchment, graywater, composting toilets, etc. at residential, industrial, and municipal levels.
7. Investigate water systems expansion
    a. Examine the feasibility of alternative water producing systems such as Atmospheric Water Generators

Strain on Energy Grid

The strain on energy grids is expected to rise due to a higher demand for electricity driven by an increase in heat days. Transmission line capacity is projected to decrease while the probability of exposure is expected to increase. This puts the residents of the City of Colton at risk for more frequent blackouts and power outages. Creating long term plans to ensure the reliability of the local power grids is a realistic first step toward reducing the likelihood of large outage events. It is important to maintain and monitor the balance of electricity demand while integrating energy from renewable sources. While these potential long-term solutions can take time to implement, residents can apply simple energy-saving measures at home for short term energy conservation practices. Recommendations were gathered from California's *Desert Renewable Energy Conservation Plan* (Commission 2021).The recommendations were selected based on their alignment with the City of Colton's specific impacts:

<u>Recommendations</u>

1. Develop a Desert Renewable Energy Conservation Plan
    a. Increase awareness of the need to transition to renewable energy;
    b. Identify areas appropriate for the utility-scale development of wind, solar, and geothermal energy projects.
2. Plan for increased energy demand
    a. Develop estimates of energy demand while taking heatwaves and unexpected outages into account.
3. Upgrade regular maintenance activities on the grid and transmission lines
    a. Resources should be maintained and managed accordingly to proactively plan for unexpected situations.
    b. Depending on the current condition of the grid, prepare for the integration of more renewable energy sources.
4. Increase awareness of surrounding risks
    a. Determine high-risk areas for wildfire threats and prepare to temporarily shut off transmission lines to reduce the chances of sparking a new blaze.

Air Quality

Decreased air quality stems from transportation and increased land use for logistics in the City of Colton. Failing to reduce air pollution impacts for residents may result in greater health consequences, including an increase in cardiovascular and lung issues. The following table lists several interventions that the City of Colton can encourage or incentivize so individuals and companies can reduce their pollutant emissions. These recommendations require research to determine their effectiveness for the City of Colton. Recommendations were gathered from the climate assessments from the City of Bloomington, Indiana, and the City of Minneapolis, Minnesota (City of Bloomington

2020; City of Minneapolis 2015). The recommendations were selected based on their alignment with the City of Colton's specific impacts:

Recommendations

1. Reduce pollution from automobiles, trains, and trucks
    a. Reduce auto-generated particulate matter, tailpipe pollutants, waste heat, and ozone formation by investing in clean powered vehicles and fuel technologies,
    b. Implement toll roads in high trafficked areas near disadvantaged populations to reduce local air pollution effects
    c. Develop alternative industries to reduce transportation impacts
2. Apply for government subsidies
    a. Use subsidies to invest in air conditioning systems for lower income housing to reduce air pollution levels inside homes
3. Increase citizen and business awareness to change behaviors
    a. Through education or displaying information around the city to promote clean energy use
    b. Calculate the costs of GHG emissions and health impacts associated with polluting infrastructure; calculate the benefits of land conservation, habitat preservation, and nature-based solutions to climate change;
4. Develop green infrastructure
    a. Trees and greenbelts can contribute to phytoremediation, which is the nature-based reduction of air pollutants as well as promoting other benefits.
    b. Community garden and urban agriculture projects can also contribute to remediation of air and water, while building soil and producing food, thus increasing local vulnerability to food insecurity.
5. Continue to move away from polluting infastructure
    a. Continue to limit or eliminate warehouse growth and the expansion of logistics infrastructure;
    b. Continue to advocate for the electrification of rail and trucking;
    c. Ensure that newer buildings adhere to high efficiency standards;
    d. Take steps regulate unregulated polluters, such as top-offender businesses, medium-duty trucks, implement ban of two-stroke leaf blowers, etc.

Additional Recommendations

The City of Colton can utilize the information within this assessment to advocate for a larger budget. In addition, the local government can adopt strategies and implement policies that work toward climate mitigation. Local governments as energy consumers have the potential to shift supply in favor of renewable energy, shifting demand toward more sustainable choices. This can be supported by regulatory and other financial instruments, such as renewable energy portfolio standards, feed-in tariffs, and energy subsidies, grants and loans (de Schio 2013). We also advise using climate vulnerability assessments or related documents from other cities as a reference for future policy recommendations.

Works Cited

AghaKouchak, A, N Berg, J Brouwer, A Hall, Z Heydarzadeh, H-Y Huang, Y-H Lin, et al. 2020. "Multihazard Investigation of Climate Vulnerability of the Natural Gas Energy System." California Energy Commission. ww2.energy.ca.gov/2020publications/CEC-500-2020-071/CEC-500-2020-071.pdf.

"Air Conditioning Program | Colton, CA - Official Website." 2021. 2021. https://www.ci.colton.ca.us/662/Air-Conditioning-Program.

"Air Pollution and Your Health." n.d. National Institute of Environmental Health Sciences. Accessed May 18, 2021. https://www.niehs.nih.gov/health/topics/agents/air-pollution/index.cfm.

American Lung Association. 2021. "State of the Air." https://www.lung.org/getmedia/17c6cb6c-8a38-42a7-a3b0-6744011da370/sota-2021.pdf.

Bedsworth, L, D Cayan, G. Franco, L Fisher, and S Ziaja. 2018. "Statewide Summary Report. California's Fourth Climate Change Assessment." SUM-CCCA4-2018-013. California Governor's Office of Planning and Research, Scripps Institution of Oceanography, California Energy Commission, California Public Utilities Commission.

Benjamin, Georges C. 2016. "Shelter in the Storm: Health Care Systems and Climate Change." *The Milbank Quarterly* 94 (1): 18–22. https://doi.org/10.1111/1468-0009.12174.

Blickenstaff, K, S Gangopadhyay, I Ferguson, L Condon, and T Pruitt. 2013. "Climate Change Analysis for the Santa Ana River Watershed: Santa Ana Watershed Basin Study, California Lower Colorado Region." Technical Memorandum No. 86-68210-2013-02. U.S. Department of the Interior, Bureau of Reclamation. https://www.usbr.gov/lc/socal/basinstudies/OWOWReferences/index.html.

Bluffstone, R.A., and B. Ouderkirk. 2007. "Warehouses, Trucks, and PM2.5: Human Health and Logistics Industry Growth in the Eastern Inland Empire." *Contemporary Economic Policy* 25 (1): 79–91. https://doi.org/10.1111/j.1465-7287.2006.00017.x.

Burillo, Daniel. 2018. "Effects of Climate Change in Electric Power Infrastructures | IntechOpen." In *Power System Stability*, doi: 10.5772/intechopen.82146. https://www.intechopen.com/books/power-system-stability/effects-of-climate-change-in-electric-power-infrastructures.

Burillo, Daniel, Mikhail V. Chester, Stephanie Pincetl, and Eric Fournier. 2019. "Electricity Infrastructure Vulnerabilities Due to Long-Term Growth and Extreme Heat from Climate Change in Los Angeles County." *Energy Policy* 128 (May): 943–53. https://doi.org/10.1016/j.enpol.2018.12.053.

"California Ambient Air Quality Standards | California Air Resources Board." n.d. Accessed May 18, 2021. http://ww2.arb.ca.gov/resources/california-ambient-air-quality-standards.

California Energy Commission. 2021. "Cal-Adapt." 2021. https://cal-adapt.org/tools/local-climate-change-snapshot/.

City of Bloomington. 2020. "City of Bloomington Climate Risk and Vulnerability Assessment." https://bloomington.in.gov/sites/default/files/2020-08/Bloomington%20Climate%20Risk%20and%20Vulnerability%20Assessment%20May%202020.pdf.

City of Colton. 2014. "City of Colton General Plan 2013-2021 Housing Element." Resolution No. R-12-14. https://www.ci.colton.ca.us/DocumentCenter/View/2220/Colton-2013-2021-Housing-Element_2014-02-04_CC-Final?bidId=.

———. 2015. "Climate Action Plan." https://www.ci.colton.ca.us/DocumentCenter/View/2774.

———. 2018. "City of Colton General Plan: 2018 Safety Element." https://coltonca.gov/DocumentCenter/View/4275/Safety-Element_Adopted-December-18-2018?bidId=.

———. 2019a. “City of Colton Wildfire Prevention and Mitigation Plan.” www.ci.colton.ca.us/DocumentCenter/View/6551/110619-Wildfire-Prevention-2019?bidId=.

———. 2019b. “Local Hazard Mitigation Plan.”

———. 2021. “Capital Improvement Projects | Colton, CA - Official Website.” 2021. https://www.ci.colton.ca.us/742/Capital-Improvement-Projects.

City of Colton Water Department. 2019. “Consumer Confidence Report.” 2019. https://www.ci.colton.ca.us/512/Water-Reliability.

City of Minneapolis. 2015. “Climate Change Vulnerability Assessment.” 2015. https://www2.minneapolismn.gov/government/programs-initiatives/climate/preparing-for-climate-change/vulnerability-assessment/.

Colton Electric Department. 2019a. “Integrated Resource Plan.”

———. 2019b. “Wildfire Prevention and Mitigation Plan.” https://coltonca.gov/DocumentCenter/View/6551/110619-Wildfire-Prevention-2019?bidId=.

Commission, California Energy. 2021. “Desert Renewable Energy Conservation Plan.” California Energy Commission. California Energy Commission. 2021. https://www.energy.ca.gov/programs-and-topics/programs/desert-renewable-energy-conservation-plan.

Constible, J. 2019. “Climate Change and Health in California.” IB: 18-10-A. Natural Resources Defense Council. www.nrdc.org/sites/default/files/climate-change-health-impacts-california-ib.pdf.

Cooley, H, E Moore, M Heberger, and L Allen. 2012. “Social Vulnerability to Climate Change in California.” CEC-500-2012-013. California Energy Commission. Pacific Institute.

deBoer, A, L McNeilly, and B Riordan. 2017. “Climate Vulnerability: An Initial Assessment for the University of California, Berkeley.” University of California, Berkeley. https://sustainability.berkeley.edu/sites/default/files/climate_vulnerability_initial_assessment_for_uc_berkeley_deboer.pdf.

Department of Health & Human Services. 2012. “Heatwave Planning Guide: Development of Heatwave Plans in Local Councils in Victoria.”

Di Liberto, T. 2018. “Wildfires Burn through Southwestern Colorado in June 2018.” 2018. https://www.climate.gov/news-features/event-tracker/wildfires-burn-through-southwestern-colorado-june-2018.

“Disadvantaged Communities.” n.d. Accessed July 1, 2021. https://www.cpuc.ca.gov/discom/.

Environment Services Department. 2016. “Tacoma Climate Change Resilience Study.” https://cms.cityoftacoma.org/Sustainability/Climate_Resilience_Study_Final_2016.pdf.

Faivre, N. R., Y. Jin, M. L. Goulden, and J. T. Randerson. 2016. “Spatial Patterns and Controls on Burned Area for Two Contrasting Fire Regimes in Southern California.” *Ecosphere* 7 (5): e01210. https://doi.org/10.1002/ecs2.1210.

Fann, N., T. Brennan, P. Dolwick, J. L. Gamble, V. Ilacqua, L. Kolb, C. G. Nolte, T. L. Spero, and L. Ziska. 2016. “Air Quality Impacts.” *The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment*. U.S. Global Change Research Program, Washington, DC. air-quality-impacts.

Fann, Neal, Breanna Alman, Richard A. Broome, Geoffrey G. Morgan, Fay H. Johnston, George Pouliot, and Ana G. Rappold. 2018. “The Health Impacts and Economic Value of Wildland Fire Episodes in the U.S.: 2008–2012.” *Science of The Total Environment* 610–611 (January): 802–9. https://doi.org/10.1016/j.scitotenv.2017.08.024.

Garcia, E, K.T. Berhane, T Islam, R McConnell, R Urman, Z Chen, and F.D. Gilliland. 2019. “Association of Changes in Air Quality With Incident Asthma in Children in California, 1993-2014.” *JAMA* 321 (19): 1906–15. https://doi.org/10.1001/jama.2019.5357.

Gershunov, Alexander, and Kristen Guirguis. 2012. "California Heat Waves in the Present and Future." *Geophysical Research Letters* 39 (18). https://doi.org/10.1029/2012GL052979.
"Groundwater Management." n.d. Water Education Foundation. Accessed May 19, 2021. https://www.watereducation.org/aquapedia/groundwater-management.
Guilinger, James J., Andrew B. Gray, Nicolas C. Barth, and Brandon T. Fong. 2020. "The Evolution of Sediment Sources Over a Sequence of Postfire Sediment-Laden Flows Revealed Through Repeat High-Resolution Change Detection." *Journal of Geophysical Research: Earth Surface* 125 (10): e2020JF005527. https://doi.org/10.1029/2020JF005527.
Guzman-Morales, Janin, and Alexander Gershunov. 2019. "Climate Change Suppresses Santa Ana Winds of Southern California and Sharpens Their Seasonality." *Geophysical Research Letters* 46 (5): 2772–80. https://doi.org/10.1029/2018GL080261.
Hall, A, N Berg, and K Reich. 2018. "Los Angeles Summary Report. California's Fourth Climate Change Assessment." SUM-CCCA4-2018-007. University of California, Los Angeles.
Heal, Geoffrey, and Jisung Park. 2016. "Reflections—Temperature Stress and the Direct Impact of Climate Change: A Review of an Emerging Literature." *Review of Environmental Economics and Policy* 10 (2): 347–62. https://doi.org/10.1093/reep/rew007.
"Heat Stress Related Illness." 2020. November 13, 2020. https://www.cdc.gov/niosh/topics/heatstress/heatrelillness.html.
Hopkins, F. 2018. "Inland Deserts Summary Report. California's Fourth Climate Change Assessment." SUM-CCCA4-2018-008. University of California, Riverside.
Howitt, R, D MacEwan, J Medellin-Azuara, J Lund, and D Sumner. 2015. "Economic Analysis of the 2015 Drought For California Agriculture." Center for Watershed Sciences, University of California – Davis, Davis, CA.
IPCC. 2014. "Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change." IPCC. Geneva, Switzerland.
Keeley, Jon E., and Alexandra D. Syphard. 2018. "Historical Patterns of Wildfire Ignition Sources in California Ecosystems." *International Journal of Wildland Fire* 27 (12): 781–99.
Li, Shu, and Tirtha Banerjee. 2021. "Spatial and Temporal Pattern of Wildfires in California from 2000 to 2019." *Scientific Reports* 11 (1): 8779. https://doi.org/10.1038/s41598-021-88131-9.
Loosemore, Martin, Vivien Chow, and Denny McGeorge. 2014. "Managing the Health Risks of Extreme Weather Events by Managing Hospital Infrastructure." *Engineering, Construction and Architectural Management* 21 (1): 4–32. https://doi.org/10.1108/ECAM-10-2012-0060.
Lund, Jay, Josue Medellin-Azuara, John Durand, and Kathleen Stone. 2018. "Lessons from California's 2012–2016 Drought." *Journal of Water Resources Planning and Management* 144 (10): 04018067. https://doi.org/10.1061/(ASCE)WR.1943-5452.0000984.
Maizlish, N, D English, J Chan, K Dervin, and P English. 2017. "Climate Change and Health Profile Report: San Bernadino County. Sacramento, CA." Office of Health Equity, California Department of Public Health.
Marshall, Jessica. 2013. "Pm 2.5." *Proceedings of the National Academy of Sciences* 110 (22): 8756–8756. https://doi.org/10.1073/pnas.1307735110.
Miller, Norman L., Katharine Hayhoe, Jiming Jin, and Maximilian Auffhammer. 2008. "Climate, Extreme Heat, and Electricity Demand in California." *Journal of Applied Meteorology and Climatology* 47 (6): 1834–44. https://doi.org/10.1175/2007JAMC1480.1.

Modrick, Theresa M., and Konstantine P. Georgakakos. 2015. “The Character and Causes of Flash Flood Occurrence Changes in Mountainous Small Basins of Southern California under Projected Climatic Change.” *Journal of Hydrology: Regional Studies* 3 (March): 312–36. https://doi.org/10.1016/j.ejrh.2015.02.003.

Moftakhari, Hamed, and Amir AghaKouchak. 2019. “Increasing Exposure of Energy Infrastructure to Compound Hazards: Cascading Wildfires and Extreme Rainfall.” *Environmental Research Letters* 14 (10): 104018. https://doi.org/10.1088/1748-9326/ab41a6.

National Drought Mitigation Center at the University of Nebraska-Lincoln, United States Department of Agriculture, and National Oceanic and Atmospheric Administration. n.d. “Current Map | U.S. Drought Monitor.” Accessed July 14, 2021. https://droughtmonitor.unl.edu/.

Organisation for Economic Co-operation and Development. 2018. “Climate-Resilient Infrastructure.” 14. OECD ENVIRONMENT POLICY PAPER. https://www.oecd.org/environment/cc/policy-perspectives-climate-resilient-infrastructure.pdf.

Perkins, C, K Sherfey, A Akhtar, J McDonald, R Mendoza, P Ghelfi, and J Sirney. 2017. “Comprehensive Flood Management Plan City of Sacramento Department of Utilities.” https://www.cityofsacramento.org/-/media/Corporate/Files/DOU/Flood-Ready/2017-CFMP-2.pdf?la=en.

Pierce, D.W., J.F. Kalansky, and D.R. Cayan. 2018. “Climate, Drought, and Sea Level Rise Scenarios for California’s Fourth Climate Change Assessment: A Report for California’s Fourth Climate Change Assessment.” CCCA4-CEC-2018–006.

Roland-Holst, D, and F Kahrl. 2008. “California Climate Risk and Response.” UC Berkeley. https://are.berkeley.edu/~dwrh/CERES_Web/Docs/ClimateRiskandResponse_ES.pdf.

Rowan, Harriet Blair. 2019. “California Air Quality: Mapping The Progress.” *California Healthline* (blog). November 5, 2019. https://californiahealthline.org/multimedia/california-air-quality-mapping-the-progress/.

“San Bernardino County Community Indicators Report.” 2020. https://indicators.sbcounty.gov/income/food-security/.

Sathaye, Jayant, Larry Dale, Peter Larsen, Gary Fitts, Kevin Koy, Sarah Lewis, and Andre Lucena. 2011. “Estimating Risk to California Energy Infrastructure from Projected Climate Change.” LBNL-4967E. Lawrence Berkeley National Lab. (LBNL), Berkeley, CA (United States). https://doi.org/10.2172/1026811.

Schio, N de. 2013. “Stimulating Renewable Energy through Public and Private Procurement.” International Renewable Energy Agency. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2013/Jan/IRENA-cities-case-4-Austin.pdf?la=en&hash=5CA7BE4EE96400839F694C8AD485297039D0C789.

Schwarzman, Megan, Samantha Schildroth, May Bhetraratana, Álvaro Alvarado, and John Balmes. 2021. “Raising Standards to Lower Diesel Emissions.” *Science* 371 (6536): 1314. https://doi.org/10.1126/science.abf8159.

Sicard, Pierre, Alessandro Anav, Alessandra De Marco, and Elena Paoletti. 2017. “Projected Global Ground-Level Ozone Impacts on Vegetation under Different Emission and Climate Scenarios.” *Atmospheric Chemistry and Physics* 17 (19): 12177–96. https://doi.org/10.5194/acp-17-12177-2017.

Southern California Association of Governments. 2019. “Profile of the City of Colton.” www.ci.colton.ca.us/DocumentCenter/View/4311/Colton_2019-Local-Profile?bidId=.

Sun, Qiaohong, Chiyuan Miao, Martin Hanel, Alistair G. L. Borthwick, Qingyun Duan, Duoying Ji, and Hu Li. 2019. “Global Heat Stress on Health, Wildfires, and Agricultural Crops under Different Levels of Climate Warming.” *Environment International* 128 (July): 125–36. https://doi.org/10.1016/j.envint.2019.04.025.

Swain, Daniel L., Baird Langenbrunner, J. David Neelin, and Alex Hall. 2018. "Increasing Precipitation Volatility in Twenty-First-Century California." *Nature Climate Change* 8 (5): 427–33. https://doi.org/10.1038/s41558-018-0140-y.
Thomson, Allison M., Katherine V. Calvin, Steven J. Smith, G. Page Kyle, April Volke, Pralit Patel, Sabrina Delgado-Arias, et al. 2011. "RCP4.5: A Pathway for Stabilization of Radiative Forcing by 2100." *Climatic Change* 109 (1): 77. https://doi.org/10.1007/s10584-011-0151-4.
Ullrich, P. A., Z. Xu, A. M. Rhoades, M. D. Dettinger, J. F. Mount, A. D. Jones, and P. Vahmani. 2018. "California's Drought of the Future: A Midcentury Recreation of the Exceptional Conditions of 2012–2017." *Earth's Future* 6 (11): 1568–87. https://doi.org/10.1029/2018EF001007.
U.S. Department of Agriculture. 2016. "New Aerial Survey Identifies More Than 100 Million Dead Trees in California." 2016. https://www.usda.gov/media/press-releases/2016/11/18/new-aerial-survey-identifies-more-100-million-dead-trees-california.
US EPA, OW. 2019. "Basic Information about Water Reuse." Announcements and Schedules. US EPA. August 13, 2019. https://www.epa.gov/waterreuse/basic-information-about-water-reuse.
"Water / Wastewater | Colton, CA - Official Website." n.d. Accessed July 1, 2021. https://coltonca.gov/180/Water-Wastewater.
Watts, N, D Campbell-Lendrum, M Maiero, L Fernandez Montoya, and K Lao. 2015. "Strengthening Health Resilience to Climate Change: Technical Briefing for the World Health Organization Conference on Health and Climate." World Health Organization.
Weinberger, Kate R., Leah Haykin, Melissa N. Eliot, Joel D. Schwartz, Antonio Gasparrini, and Gregory A. Wellenius. 2017. "Projected Temperature-Related Deaths in Ten Large U.S. Metropolitan Areas under Different Climate Change Scenarios." *Environment International* 107 (October): 196–204. https://doi.org/10.1016/j.envint.2017.07.006.
West, J. Jason, Steven J. Smith, Raquel A. Silva, Vaishali Naik, Yuqiang Zhang, Zachariah Adelman, Meridith M. Fry, Susan Anenberg, Larry W. Horowitz, and Jean-Francois Lamarque. 2013. "Co-Benefits of Mitigating Global Greenhouse Gas Emissions for Future Air Quality and Human Health." *Nature Climate Change* 3 (10): 885–89. https://doi.org/10.1038/nclimate2009.
Westerling, Anthony Leroy. 2018. "California's Fourth Climate Change Assessment." *California's Fourth Climate Change Assessment, Rep. CCCA4-CEC-2018-014*, 57.
Western Riverside Council of Governments. 2021. "San Bernardino County Vulnerability Assessment." http://www.wrcog.cog.ca.us/DocumentCenter/View/7477/San-Bernardino-County-Vulnerability-Assessment.
Wilbanks, T.J., and S.J. Fernandez. 2014. *Climate Change and Infrastructure, Urban Systems, and Vulnerabilities*. NCA Regional Input Reports. Washington, DC: Island Press.
Williams, A. Park, John T. Abatzoglou, Alexander Gershunov, Janin Guzman-Morales, Daniel A. Bishop, Jennifer K. Balch, and Dennis P. Lettenmaier. 2019. "Observed Impacts of Anthropogenic Climate Change on Wildfire in California." *Earth's Future* 7 (8): 892–910. https://doi.org/10.1029/2019EF001210.