CLIMATE CHANGE VULNERABILITY ASSESSMENT

Administrative Review Draft

Prepared for:

Mono County
and
Town of Mammoth Lakes

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VULNERABILITY ASSESSMENT

Section 65302 of the California Government Code requires every general plan safety element to include a vulnerability assessment identifying the risks that climate change poses and the geographic areas at risk from climate change impacts. The research conducted for the Vulnerability Assessment (VA) summarized herein is the technical basis for informing policies in the Mono County General Plan Safety Element and Town of Mammoth Lakes General Plan Public Health and Safety Element.

The VA is a best estimate of likely future conditions, based on local demographic projections and the most recently available scientific projections of future climate conditions, given current trends. Like most long-range plans, the Mono County General Plan considers the expected changes to population and the economy, and the needs of the community as a result of these changes; these long-range projections are incorporated into this VA. The VA builds on baseline conditions and anticipated future conditions summarized in the General Plan.

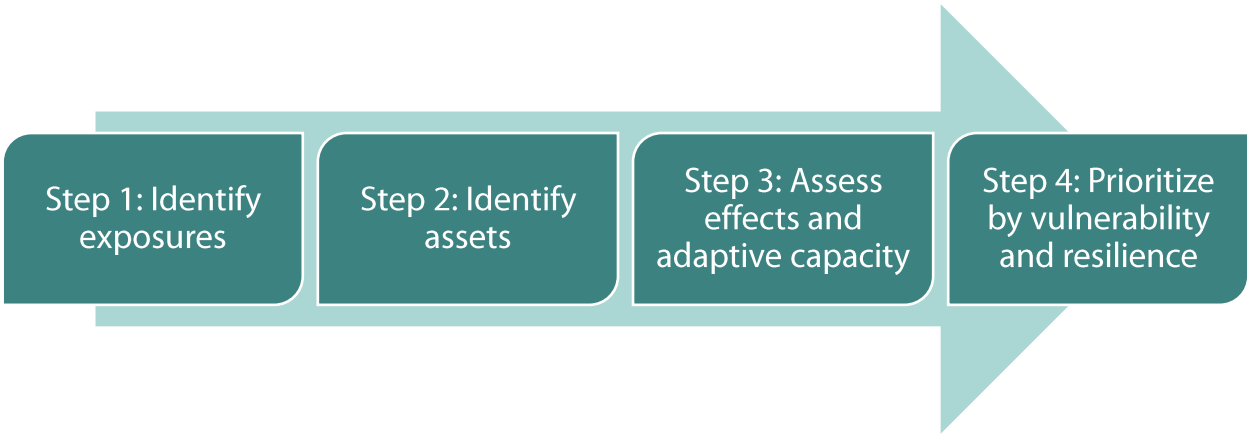
The VA includes a summary of the methods used in relation to the approach in the California Adaptation Planning Guide, a summary of future conditions and vulnerabilities as determined by the assessment, identification of vulnerable populations and assets, and recommended policies for the General Plan.

Method

This VA was completed using a four-part process consistent with the approach outlined in the California Adaptation Planning Guide (**Figure 1**). The process addresses the following questions:

- What **demographic conditions** or climate change-related hazards (known as exposures) could occur in the planning area?
- What **structures or populations** in the planning area (known as assets) could be affected by the exposures?
- How would changes to demographics, the economy, or climate change-related hazards **affect assets** (known as effects), and how are those assets currently prepared to deal with such impacts (known as adaptive capacity)?
- What topics should **adaptation strategies** address?

Figure 1: Vulnerability Assessment Process



This report uses information sources identified in the California Adaptation Planning Guide and assessments of existing conditions completed as part of the Multi-Jurisdictional Hazard Mitigation Plan update process to identify specific assets in the Mono County and Town of Mammoth Lakes planning area, which can include physical properties or structures, land uses, neighborhoods, key services and functions, natural resources, and specific populations. To identify vulnerability, this report first identifies how each exposure would affect each asset and how each asset might already be prepared to mitigate those effects. This analysis assesses how those exposures would affect assets in Mono County by considering existing and projected demographic and development patterns and then assigning a qualitative score for each. This report includes summaries and key outcomes from the vulnerability and resiliency assessment process.

Projected Conditions

As Mono County and the Town of Mammoth Lakes prepare for future natural hazard events, it is important to consider expected changes in socioeconomic and environmental conditions. This report uses information collected during the 2018 update to the Multi-Jurisdictional Hazard Mitigation Plan from sources including the US Census, the California Department of Finance, and Cal-Adapt. It also uses projected population, housing, jobs, and land use densities identified in County and Town General Plans as the best available demographic, economic, and climate change-related hazard projections for the Mono County communities. Since climate change-related hazard projections are based on uncertain future probabilities, many of these outputs are limited in granularity and results will be similar to that of the entire southeast Sierra region, which generally includes Alpine, Mono, and Inyo Counties.

Demographic Change

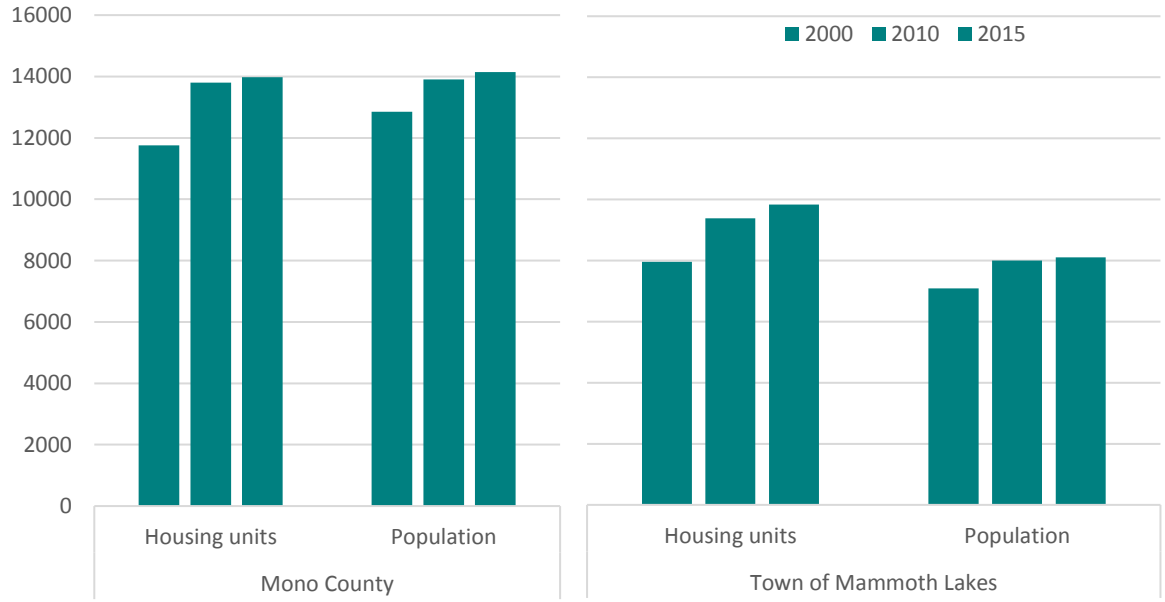
This section describes population and employment patterns, both current and projected, in the Mono County planning area using the Town and County General Plans, local studies, American Community Survey 2011–2015 data, US Census 2017 estimates, and California Department of Finance 2016 reports and projections. An understanding of expected demographic conditions absent changes to the existing planning framework (known informally as "business-as-usual" conditions) allows the County and Town to understand what changes could best shift development to reduce vulnerability to natural hazards in the future.

Population

The population of Mono County has grown very little since the last US Census. In 2010, the population for Mono County was 14,202, with 8,234 residents in the Town of Mammoth Lakes; in 2015, there were 14,146 residents in the county and 8,104 residents in the town. Future population projections also indicate an increase in the average age of residents, which means the County and Town will need to prepare for growing senior needs. In addition, Mono County hosts over 1.5 million people annually for seasonal recreation and tourist attractions.

The total number of housing units in Mono County for 2015 was 13,982, with 9,695 of them in the Town of Mammoth Lakes. Many of these units are only occupied seasonally. **Figure 2** displays population growth in Mono County and the Town of Mammoth Lakes between 2000 and 2015.

Figure 2: Mono County and Mammoth Lakes Population Growth (2000-2015)



Sources: Mono County 2009; Town of Mammoth Lakes 2007; US Census Bureau 2000, 2010; American Community Survey 2011-15

Employment

Employment in both Mono County and the Town of Mammoth Lakes is heavily based on outdoor recreation and tourism. Since much of this tourism season based, many jobs and residential units are also seasonal. Many residents must travel to other areas for consistent work. The primary employment centers are the Town of Mammoth Lakes and Bridgeport, with government positions, schools, and entertainment being the dominant employers.

Development Pattern

Most development is concentrated in the planning areas clustered along the main highways in the county. The General Plans for both Mono County and the Town of Mammoth Lakes accommodate reasonable growth within existing development boundaries.

The Mono County General Plan projects the greatest growth in certain urbanized communities including Antelope Valley, Bridgeport, Mono City, June Lake, and the Crowley Lake area, and nearly all new housing and commercial development within the Planning Areas defined by the General Plan Land Use Element. Most of the designated land in the county is planned for agricultural and open space uses. Slightly more concentrated residential and commercial development will be accommodated along the main corridors in more populated planning areas such as Bridgeport. The General Plan assumes a likely buildout of 13,930 housing units in the unincorporated area, a growth of just over 4,100 units from existing conditions established in the current General Plan.

The Town of Mammoth Lakes anticipates greater growth, establishing buildout at 52,000 residents, visitors, and workers on a winter weekend, with permanent residents making up 55 percent of that population. This could result in approximately 4,000 additional units for permanent residence. The Town anticipates all this growth will take place within its 12 existing Planning Districts.

Exposures

The following summarizes the exposures that may result from climate change effects predicted for Mono County and Mammoth Lakes. For purposes of this assessment, where predictive data exists, climate change effects are characterized for two milestone years: midcentury (2050) and end of century (2100). Historical data is used to set the baseline for describing the degree of change occurring by these two future dates.

The direct, or primary, effects of climate change summarized here are those identified as being of concern by Cal-Adapt. They include:

- Increased temperature
- Changes in precipitation
- Sea level rise

Secondary consequences, which could occur as a result of one or a combination of these primary effects, are also analyzed. These consequences include:

- Increased frequency, intensity, and duration of extreme heat days and heat waves/events
- Loss of snowpack and decreased water supplies
- Increased wildfire
- Increased flooding

Source data is primarily from Cal-Adapt. The Adaptation Planning Guide encourages communities to use Cal-Adapt as the primary source of information to forecast potential climate change impacts over time. Cal-Adapt is a climate change scenario planning tool developed by the California Energy Commission (CEC) and the University of California Berkeley Geospatial Innovation Facility. This data is supplemented by other state studies, academic research, and publications by the Intergovernmental Panel on Climate Change (IPCC). These projections do not apply solely to the community, but rather to a broader geographic region.

Table 1 summarizes Cal-Adapt projections for Mono County.

Table 1: Summary of Cal-Adapt Climate Projections

	Ranges
Temperature Change 1990–2099	January increase in average temperatures: 1.5°F to 2.5°F by 2050 and 5°F to 10°F by 2099. July increase in average temperatures: 3°F to 5°F by 2050 and 8°F to 10°F (*Modeled high temperatures; average of all models; high carbon emissions scenario)*
Precipitation	Potential precipitation decline is between 0 and 4 inches by 2050 and 1 and 15 inches by 2100. The range varies widely depending on location. Some areas receive less than 6 inches annually, with projected reductions bringing totals under 4 inches by 2090. In other areas, total rainfall exceeds 45 inches per year and is projected to decrease by roughly 15 inches by 2090. *(CCSM3 climate model; high carbon emissions scenario))*

	Ranges
Heat Wave	A heat wave is five consecutive days over temperatures in the 80s. By 2050, there will be 2 to 3 more heat waves per year, increasing to over 14 to 16 per year by 2100.
Snowpack	Snowpack levels are projected to decline dramatically by 2090 in some areas, with drops of over 50 percent. *(CCSM3 climate model; high emissions scenario)*
Wildfire Risk	By 2085, wildfire risk is projected to increase substantially (up to 19.1 times) over current levels in northern part of Mono County. The rest of Mono County is projected to have a wildfire risk between 1.1 to 4.8 times greater than current levels. (*GFDL model, high carbon emissions scenario)*

Source: Public Interest Energy Research 2011

Expected future climate conditions for Mono County and Mammoth Lakes, based on data from these sources, are summarized in the sections below.

Projected Conditions and Effects

Increased Temperature

Annual average temperatures in Mono County are projected to increase steadily. **Table 2** shows the historical and projected mean temperatures for both maximum and minimum temperatures in Mono County and Mammoth Lakes. Historical annual mean temperature is based on data from 1961 to 1990. According to Cal-Adapt, the County and Town are expected to experience an increase in annual mean temperature for both maximum and minimum temperatures. These increased temperatures are likely to result in the secondary climate impacts discussed below.

Table 2: Projected Mean Temperatures (2050–2099)

	Historical Annual	2050 High Emissions	2050 Low Emissions	2099 High Emissions	2099 Low Emissions
Mono County Max Temperature	56.8°F	60.8°F	60.5°F	63.6°F	62.0°F
Mono County Min Temperature	25.2°F	29.1°F	28.8°F	31.9°F	30.0°F
Mammoth Lakes Max Temperature	52.2°F	55.6°F	55.2°F	58.3°F	56.7°F
Mammoth Lakes Min Temperature	24.9°F	29.2°F	28.8°F	31.9°F	30.1°F

Source: Cal-Adapt 2018

Extreme Heat

Cal-Adapt defines the extreme heat day threshold for the Mono County area as 84.5°F or higher, and for Mammoth Lakes as 79.1°F or higher. An extreme heat day is defined as a day in April through October when the maximum temperature exceeds the location's extreme heat threshold, which is calculated as the 98th percentile of historical maximum temperatures between April 1 and October 31 based on observed daily temperature data from 1961–1990). Under this definition, the county has had a historical average of six extreme heat days per year since the 1960s, and Mammoth Lakes has had a historical average of four extreme heat days per year (Cal-Adapt 2018). Cal-Adapt data shows a projected average for the area of 32 to 38 days per year in 2050 and 35 to 85 extreme heat days by 2099.

While the extreme heat definition is tied to historic maximums, resulting in a threshold of 84.5°F Mono County and 79.1°F for Mammoth Lakes, significant real risk to human health and welfare does not generally occur until temperatures reach above 90 degrees in dry weather conditions, which are typical in Mono County and Mammoth Lakes. Neither the Town nor the County are projected to have any days over 90 degrees by 2099. However, generally higher temperatures contribute more broadly to other hazard vulnerabilities such as drought and wildfire, as discussed below.

Heat Waves

As defined by Cal-Adapt, when extreme temperatures (i.e., 79.1°F or higher for Mammoth Lakes and 84.5°F or higher for Mono County) are experienced over a period of five or more days, they are known as heat waves. Scientists expect climate change to lead to longer, more severe, and more frequent extreme heat events. Heat waves in Mono County occurred at a rate of about one to two per decade between 1950 and 2000. Over the next 50 years, Mono County is unlikely to experience a heat wave each year but may experience up to two or three heat waves per decade by the end of the century (Cal-Adapt 2018). Heat days may also manifest earlier in the year than historically recorded and continue to occur in later months.

Urban Heat Island Effect

Locations where development dominates the landscape experience higher temperatures due to the urban heat island effect (UHIE), compared to landscapes that support mostly landscaped or natural vegetation features (e.g., grass, trees). Human-made materials, such as asphalt and concrete, absorb heat and alter microclimate conditions by several degrees Fahrenheit, exacerbate emissions of air pollutants, and increase the rate of photochemical production of ozone. The California Environmental Protection Agency (CalEPA) has developed a study and an interactive map to track the effects of the UHIE throughout the state. This study shows that UHIE impacts are minimal in Mono County due to its predominantly rural nature.

Changes in Precipitation Patterns

Global climate change will affect physical processes and conditions beyond average temperatures. Historical precipitation patterns could be altered because of climate change. Depending on location, precipitation events may increase or decrease in intensity and frequency, and are difficult to predict. While projections generally show little change in total annual precipitation in the state and trends are not consistent, even modest changes could significantly affect California ecosystems that are conditioned to historical precipitation timing, intensities, and amounts. Reduced precipitation could lead to higher risks of drought, while increased precipitation could cause flooding and soil erosion (California Natural Resources Agency 2014:25).

Cal-Adapt cites a historical annual average rate of precipitation of about 21 inches for Mono County and 31 inches for Mammoth Lakes. Overall precipitation in Mono County is expected to increase slightly to 22 or 23 inches, and in Mammoth Lakes to 34 to 35 inches. That precipitation will likely occur with altered timing and intensities than has been the case historically. As discussed below, it is likely that much more of this precipitation will fall as rain rather than snow compared to historical averages. This could have additional secondary effects for flooding and water storage.

Shifts in precipitation across the state are likely to result in the secondary climate impacts discussed below as they relate to Mono County.

Snowpack

Changes in weather patterns resulting from increases in global average temperature could bring about a decreased proportion and total amount of precipitation falling as snow. This phenomenon is predicted to result in an overall reduction of snowpack in the Sierra Nevada. Based on historical data and modeling, the California Department of Water Resources (2008:4, 2013:3-64) projects that the Sierra Nevada snowpack will decrease by 25 to 40 percent from its historical April 1 average of 28 inches of water content by 2050, and decrease 48 to 65 percent by 2100. Runoff from precipitation and snowmelt from the Sierra Nevada is the main source of surface water supply in Mono County, as well as much of the rest of the state. As discussed further below, this will have secondary effects on both surface water and groundwater supplies, which both have important uses in the county and town.

Surface Water

Water in Mono County is provided through a variety of sources. For the Town of Mammoth Lakes, water and sewer service is through the Mammoth Community Water District. This supply is a mix of surface water and groundwater supplied through wells. County communities are served by a variety of public and private entities including utility districts, community service districts, mutual water companies, and

small private systems. Most unincorporated communities use a combination of surface and groundwater, with surface water being provided through local reservoirs and stream diversions by residents. Mono County also exports large amounts of water through the Los Angeles Aquaduct, supplying the majority of the water for the City of Los Angeles. In years of little snowpack, less water is delivered through the Los Angeles Aquaduct and the City of Los Angeles must purchase water from the Metropolitan Water District.

Major waterways in the planning areas include Mono Lake, Bridgeport Reservoir, Lake Crowley, June Lake, Grant Lake, Twin Lakes, and Topaz Lake, and several rivers and creeks. The flow regimes of these waterways depend on spring and summer snowmelt in the Sierra Nevada. The ability of snowpack to retain water and release it gradually is fundamental to water supply planning in Mammoth Lakes and Mono County, and throughout the watersheds of the Sierra Nevada.

Surface water flowing through Mono County comes through a series of 21 dams constructed to provide California with water security during droughts. Dams also provide flood protection for areas of the county located in floodplains.

Groundwater

Both Mono County and the Town of Mammoth Lakes are supplied partially by groundwater. Groundwater recharge occurs solely from precipitation in the form of rainfall and snowmelt; increased average temperatures and changes in the timing, amounts, and snow/rain form of precipitation will therefore affect local aquifer recharge for groundwater supplies. Groundwater use typically increases during droughts. Due to increased uncertainty in the amount and timing of water availability and the stress placed on aquifers during droughts, Mammoth Lakes and Mono County communities may face increased challenges in providing adequate groundwater supplies to meet future demand.

Groundwater levels are monitored through the California Statewide Groundwater Elevation Monitoring (CASGEM) program. The Owens Valley Groundwater Basin in southern Mono County is rated as a medium priority groundwater basin and therefore requires active monitoring, data collection, and reporting to ensure groundwater levels are adequately maintained (DWR 2015). The Owens Valley Groundwater Basin is monitored by the Tri-Valley Groundwater Management District.

Extreme Storms

Changes in precipitation patterns may result in less frequent but more extreme storm events. While the planning area is projected to experience an overall decrease in precipitation, the precipitation that will fall may have more intense characteristics, such as a high volume of rain falling over a shorter period with stronger and more destructive wind patterns. These storms may produce higher volumes of runoff

and/or snowmelt and contribute to an increased risk of flooding. Impacts associated with flooding are discussed in greater detail below under "Increased Flooding."

Increased Wildfires

Rising temperatures combined with changes in precipitation patterns and reduced vegetation moisture content can lead to a secondary impact of climate change: an increase in the frequency and intensity of wildfires. Changes in precipitation patterns and increased temperatures will alter the distribution and character of natural vegetation and the associated moisture content of plants and soils, according to the California Natural Resources Agency (2012b:11). Increased temperatures will increase the rate of evapotranspiration in plants, resulting in a greater presence of dry fuels in forests and creating a higher potential for wildfires.

Increased wildfire activity across the western United States in recent decades has contributed to widespread forest mortality, carbon emissions, periods of degraded air quality, and substantial fire suppression expenditures. Although numerous factors aided the recent decades' rise in fire activity, observed warming and drying have significantly increased fire season fuel aridity, fostering a more favorable fire environment across forested systems.

Mapping conducted by the California Department of Forestry and Fire Protection shows that all areas in Mono County are rated as having a very high fire hazard, with the exception of Bridgeport Valley (moderate fire hazard) and Antelope Valley (unrated). With the exception of the Antelope Valley, all privately owned lands in Mono County are within the State Responsibility Area. Cal-Adapt estimates an increase of 1,500 to 2,600 hectares of burn area by the year 2099. The estimated burn area in Mammoth Lakes is approximately double that of the annual mean burn area for the last several decades.

In addition to the direct impacts of fire, wildfires in the Sierra Nevada and areas outside the county affect air quality in the planning area. Wildland fires produce substantial emissions of particulate matter (i.e., smoke, soot), which may cause adverse health effects including restricted breathing and aggravation of existing respiratory and cardiovascular diseases in the short term, as well as alterations to immune systems and cancer from chronic exposure.

Increased Flooding

Climate change is likely to lead to changes in the frequency, intensity, and duration of extreme storm events, such as heavy precipitation amounts with increased rainfall intensity. Further, increases in annual temperature may result in earlier and more rapid melting of the Sierra Nevada snowpack, which could lead to an increase in flow rate of surface waters in the Mono County and Mammoth Lakes planning areas. These projected changes could lead to increased flood magnitude and frequency, and

could place more pressure on the communities as well as the entire region's systems and economy with higher risk of damage to land, buildings, roads, and crops (IPCC 2007:14). While it is uncertain precisely how and to what extent climate change will affect flooding events in the planning area, it is reasonable to expect that an increase in flooding could have serious ramifications because the area is already considerably vulnerable.

Flooding affects a large part of the county. The community areas most likely to be impacted by a 100-year flood include properties along the East and West Walker River, Reversed Creek, and Spring Canyon Creek. Small portions of the developed area in Antelope Valley, Bridgeport Valley, the June Lake Loop, and the Tri-Valley area are also impacted. The Town of Mammoth Lakes only has one potential source of flooding at Mammoth Creek, and generally maintains a low risk of flooding.

Sea Level Rise

Mono County is located approximately 185 miles inland from the California coast, and on the eastern side of the Sierra Nevada range. It is therefore unlikely to be directly affected by sea level rise.

Vulnerable Assets and Recommended Adaptive Capacity Policies and Actions

Increased Temperature

Vulnerable Assets

Population

Higher frequency of extreme heat conditions can cause serious public health impacts, increasing the risk of conditions directly related to heat such as heat stroke and dehydration (California Natural Resources Agency 2012:3). Exposure to excessive heat, generally temperatures over 90 degrees, may lead to heat-related illnesses such as heat cramps, heat exhaustion, and heat stroke. Although temperatures are not projected to reach over 90 degrees in Mono County, heat-related illnesses may still be a risk for specific vulnerable populations such as the elderly, those whose employment requires long hours outdoors such as agricultural laborers, and those without access to shelter, such as homeless people.

Higher temperatures, even at thresholds of 80 to 90 degrees, can also worsen air quality through increased air pollution, such as from ozone formation and particulate matter generation (e.g., wildfire smoke), which poses a health hazard to vulnerable populations. Children, the elderly, and persons with preexisting chronic diseases are particularly susceptible to respiratory and cardiovascular effects from air pollution. Further, elderly persons have a reduced ability to acclimatize to changing temperatures

and are more likely to live alone with limited mobility, which can exacerbate the risk of extreme heat. Those with Alzheimer's disease and dementia are particularly susceptible due to an inability to notice rising temperatures and failure to stay hydrated or turn on the air conditioning. Agricultural workers are particularly vulnerable to heat-related illnesses because of their unavoidable outdoor exposure during work hours. Disadvantaged communities may also face greater challenges in dealing with extreme heat. Low-income populations may live in aging buildings with poor insulation, leading to higher costs associated with air conditioning. Since lower-income and disadvantaged populations may overlap with populations that speak and read English as a second language, residents may face challenges in knowing what resources and refuges are available to them.

Functions and Structures

Roadway, bridge, and rail degradation is exacerbated by prolonged exposure to extreme heat, which may present unsafe road conditions for motorists, bicyclists, and pedestrians. Extended periods of extreme heat may lead to increased risk of power outages and blackouts. High temperatures decrease the efficiency of power transmission lines, while demand for electricity goes up as operation of air conditioners and cooling equipment increases. This results in more frequent blackouts and could affect the operation of infrastructure and the economic output of businesses, and further jeopardize vulnerable populations as they lose access to air conditioning and other key health technology requiring electric power.

Prolonged periods of high heat will also impact agricultural production, harming and/or killing crops and livestock. These impacts will harm the agricultural economy that is an important component of Mono County's community and economy, and at the regional level could raise the price of basic food goods.

Recommended Adaptive Capacity Policies and Actions

- *Develop a guide of County procedures in the event of severe weather conditions such as excessive heat, including the deployment of emergency services, opening of local cooling shelters, and community notification procedures.*
- *Incorporate elements of "passive cooling" design elements such as cross ventilation, overhangs, and insulated walls and windows into building design standards.*
- *Establish coordination with health and social service providers from multiple sectors to identify data sources and strategies for community resilience and reaching out to vulnerable populations.*
- *Allocate funding to address anticipated additional repairs to damaged infrastructure that will be required due to increased stress from climate effects such as extreme heat and storms.*

Precipitation Patterns

Vulnerable Assets

Changes in precipitation in the Sierra Nevada may have the greatest impact on the community. Increasing temperatures in the mountains, which result in hastening snowmelt and less captured water runoff into local watersheds (e.g., Mono and Crowley Lakes, Upper Carson, Upper Stanislaus), are likely to cause an overall reduction snowpack. If runoff shifts to earlier in the year, which has already begun to occur, current practices for flood control and water storage may become less effective (California Department of Food and Agriculture 2013:20). As a result, even if precipitation increases slightly or remains the same, local water agencies could struggle in the future to provide adequate water supplies to local residents and businesses. Groundwater sources underlying the City may experience similar changes. Water users could face shortages in normal or dry years if demand increases.

Population

Reduced and altered timing of water flows from the Sierra Nevada, as described above, will likely affect the quality and quantity of water supplies. As water flow decreases, the temperature of the water generally increases, the concentration of pollutants and contaminants in water may increase, and algae blooms can occur, all of which would degrade water quality and can carry illness-producing bacteria. Residents of and visitors to both Mammoth Lakes and unincorporated Mono County rely partially or solely on wells or groundwater; the County and Town may face challenges in meeting increased water demands as rates of groundwater recharge decline (CalBRACE 2018). In years with especially low water flows and snowpack, Mono County and Mammoth Lakes may need to implement very strict restrictions on water usage by the community.

Fluctuations in surface water levels have occurred for the past hundred years, mostly from water diversions from the Owens River beginning in 1913 and Mono Basin beginning in 1941. In recent years, restoration and conservation efforts have allowed Mono Lake to regain much of its volume, but the decline in water level has already had severe impacts on the lake and riparian ecosystems in Mono County. Drought conditions in the past decade have worsened ecosystem impacts.

Coupled with higher temperatures, reduced levels of precipitation could also result in unseen stagnant pools of water that provide the right conditions for the breeding of mosquitoes and the spread of mosquito-borne illnesses, such as dengue fever, West Nile virus, and Zika virus. Vulnerable populations susceptible to these diseases include the elderly and people with compromised immune systems or chronic illness.

Functions and Structures

Hydropower, from dams along several water bodies fed by Sierra Nevada snowpack, supplies a portion of the electricity for the county, as well as other areas in the northeastern California region. A declining volume of snowmelt coupled with earlier periods of melting could have severe consequences for the region's hydroelectricity generation. Power loss associated with extreme storms may disrupt communications and information technology systems, as well as backup pumps and generators that power hospitals, drainage pumps, and other critical operations. Additionally, the potential loss of groundwater supplies could result in land subsidence wherein a gradual settling or sudden sinking of the earth's surface occurs. The effects of subsidence could impact houses and other structures such as transportation infrastructure, cause failure of water well casings, and result in changes to the elevation and gradient of stream channels, drains, and other water transport structures (California Natural Resources Agency 2014:235).

Watersheds and reservoirs located in Mono County and the Mammoth Lakes area offer an array of recreational opportunities and contribute to the predominantly recreation-supported economy. Reduced levels of river flow in watersheds near the planning areas could also affect lake- and river-based economic and recreational opportunities. Similarly, reduced water supplies may affect agricultural irrigation, stressing output and the agriculture-based economy that is essential to Mono County and the surrounding region.

Recommended Adaptive Capacity Policies and Actions

- *Enforce water conservation in Mammoth Lakes and unincorporated communities and encourage public reporting of violations.*
- *Protect groundwater resources from contamination and further overdraft through methods such as encouraging use of water-conserving farming practices, the use of treated wastewater for groundwater recharge and protecting important groundwater recharge areas.*
- *Ensure populated areas have alternative energy sources to supplement the potential reduction or loss of hydro-electrical energy.*

Increased Wildfires

Vulnerable Assets

Increased temperatures, changes in precipitation patterns, and reduced moisture content in vegetation during dry years associated with climate change are expected to increase the potential severity of wildland fire both within and beyond the boundaries of the county. As discussed in the section titled "Exposures," increased temperatures and reduced precipitation in the broader region are predicted to

lead to an increase in the total area burned by wildfire, especially in Mammoth Lakes, June Lake, and Walker areas. Typically, these fires are caused by lightning or human activity, and can result in substantial habitat loss and severe economic impacts.

A changing climate is also expected to subject forests outside the county to increased stress due to drought, disease, invasive species, and insect pests. These stressors are likely to make forests more vulnerable to catastrophic fire (Westerling and Bryant 2008:231). An increased rate and intensity of wildfire in coniferous forests in the Sierra Nevada could adversely impact populations, functions, and structures in Mammoth Lakes and unincorporated Mono County communities.

Population

Because most of Mono County is rural with sloped geography and fire-prone vegetation, most areas are at risk of wildfire. Public lands surrounding the communities are often highly flammable and not adequately thinned, and many residents live in rural areas that are directly in the path of potential fires. Higher temperatures, dryer weather, and high winds make firefighting difficult, as does a lack of highway access. These factors make it likely that human life will likely be at risk during a wildfire.

Another significant impact of wildfire on vulnerable populations is reduced air quality from fires burning elsewhere in the region that affect respiratory health. Particulate matter (i.e., soot, smoke), carbon monoxide, nitrogen oxides, and other pollutants are emitted during the burning of vegetation. It can cause acute (short-term) and chronic (long-term) cardiovascular and respiratory illness, especially in vulnerable populations such as the elderly, children, agricultural and outdoor workers, and those suffering from preexisting cardiovascular or respiratory conditions. Because of wind patterns, residents can be subjected to degraded air quality from both nearby and distant fires. It is anticipated that more frequent and intense wildfires would produce harmful respiratory conditions that could aggravate chronic illnesses in susceptible populations as well as cause acute illness in more resilient populations. Further, as future wildfires burn at higher intensity and for longer durations, periods of exposure to air pollutants will become more frequent and prolonged, causing increased rates of acute and chronic respiratory and cardiovascular illness, and increased emergency room visits and hospitalizations.

Functions and Structures

Although wildfires occur every year in Mono County, fatalities and damage to structures are generally minimal. However, the probability of a fire damaging people or structures has increased within the past 20 years, due to more residences being built at the urban-wildland interface and an increase in permanent residents. Fire activity in the Sierra Nevada region may also damage infrastructure. Much of the infrastructure that provides electricity for Mammoth Lakes and Mono County, such as transmission

lines and hydroelectric facilities, is located in areas predicted to be more frequently affected by wildfire as a result of climate change. Further, the transmission capacity of a power line can be affected by heat, smoke, and particulate matter, even if direct damage does not occur. Wildfire could also make it more difficult for residents to have water available for personal consumption, by affecting the magnitude and timing of snowmelt runoff, increasing sediment and nutrient load of reservoirs, and heightening metal content.

Recommended Adaptive Capacity Policies and Actions

- *Facilitate implementation of measures identified in the Mono County Community Wildfire Protection Plan (CWPP) to protect human life and property, critical infrastructure, and natural resources associated with wildfire.*
- *Update fire hazard mapping to reflect changing fuels and climate conditions. Upon release of updated hazard severity zones, incorporate revised mapping into the jurisdiction's General Plans and CWPPs.*
- *Distribute information from the Great Basin Air Pollution Control District to the public on the status of air quality on a daily basis, provide alerts on poor air quality days, and include educational materials on the health effects of air pollution.*

Increased Flooding

Portions of Mono County are vulnerable to flooding, including the communities of Benton, Hammil, and Chalfant. Over 50 percent of state land and 11 percent of privately owned land are vulnerable to flood risk, although no households in Mammoth Lakes are located in the 100-year flood zone. While it is uncertain exactly how climate change will affect flooding events in Mono County and to what extent, any increase in flooding is highly likely to occur and could have serious ramifications to households located in the 100-year flood zone.

Vulnerable Assets

Population

Populations in Mono County most likely to be directly adversely affected are those living in 100- or 500-year floodplains. Flooding-related impacts will likely disproportionately affect populations considered socially vulnerable, especially those of lower income. Low-income populations generally suffer higher mortality rates and their homes sustain greater damage due to the age of the housing stock and its location. Further, low-income households may not be able to afford structural upgrades or flood insurance to mitigate the effects of flooding associated with dam failure or levee collapse (Burton and Cutter 2008:144). Low-income households may also lack transportation and other resources to respond

to or evacuate during a flood event. These households may not have sufficient financial reserves to afford appropriate flood insurance or pay for the costs to recover from flooding.

Flood events also contribute to the spread of disease and illness. Floodwaters uplift substances including dirt, oil, animal waste, and lawn, farm, and industrial chemicals and carry them downstream, contributing to degraded water quality in receiving streams. Stagnant flood pools can become breeding grounds for mosquitoes, which may lead to an increase in vector-borne diseases.

Functions and Structures

An increase in the number of wildfires and severe storms and subsequent severe flood events may impact streamside land, buildings, roads, and crops. The most vulnerable structures are residential homes, which make up most of the structures in areas most at risk of flooding. Flash floods, stagnant (medium-length) floods, and deep-water (long-length) floods can result in unwanted submergence and/or excessive soil saturation of croplands (California Department of Food and Agriculture 2013). Flooding could also release sewage and hazardous and/or toxic materials if wastewater treatment plants are inundated, storage tanks are damaged, or pipelines are severed. Floods also cause economic losses through the closure of businesses and government facilities, disrupt communications, disrupt the provision of utilities such as water and sewer, result in excessive expenditures for emergency response, and generally disrupt the normal function of a community.

Flooding also presents problems for infrastructure through wear and tear. Localized flooding often damages roadways by "stripping," a process that separates the aggregates in pavement from the asphalt binder that holds them together. Another potential source of damage occurs when water infiltrates the pavement, either through voids or cracks in the surface, then becomes trapped between two layers of asphalt. Flooding may result in closed roads and reduced access to many people trapped in their homes.

Roadways can become clogged with vehicles, restricting transportation. Flooding may also inundate sewage systems, causing backup and release of hazardous materials and exposing people and animals to toxic substances. Furthermore, floods can exacerbate bridge scour, which makes bridges weaker and less safe, and may require repairs or replacement. Electrical boxes and other facilities may also be inundated, disrupting service to infrastructure such as traffic signals and light rail systems. Additionally, underground electrical infrastructure is considered more vulnerable to flooding as prolonged periods of inundation can delay repairs. During fall storms, leaves wash into the drainage systems, further aggravating localized flooding throughout the region.

Recommended Adaptive Capacity Policies and Actions

- *For jurisdictions with existing property in 100-year flood zones, establish programs to fund homeowners to lift existing structures out of the100-year flood plain.*
- *For jurisdictions with existing property in 100-year flood zones, establish programs to fund buyouts for repetitive loss structures.*
- *Develop plans for phased use and adaptation of infrastructure that can used differently as flood water levels rise over time due to climate change.*
- *Work with FEMA to ensure flood maps are kept up to date for all inhabited areas of the county, and participate in the FEMA National Flood Insurance Program.*
- *Continually update and revise applicable portions of the Mono County Emergency Operations Plan to remain consistent with the Multi-Jurisdictional Hazard Mitigation Plan and the most current scientific data.*

Sea Level Rise

The Mono County and Mammoth Lakes Planning Areas are not vulnerable to sea level rise, although some secondary impacts such as statewide economic prosperity and inland migration may occur.

Vulnerable Assets

Population

Direct impacts on population due to sea level rise are limited in Mono County. Secondary impacts, however, may impact the population. Reduced economic output in other parts of the state and country could impact the tourist-based economy. Inland migration could result in unplanned levels of growth that in turn stress existing services and resource management.

Functions and Structures

There are no areas in Mono County that will be affected by sea level rise, although the potential for increased flooding may occur due to rising oceanic levels pushing water further inland. Saltwater intrusion has the potential to occur in the freshwater aquifers as a result of sea level rise, but the probability and extent of this is unknown.

Recommended Adaptive Capacity Policies and Actions

Sea level rise will not directly affect Mono County or Town of Mammoth Lakes. Secondary impacts on flood levels can be adequately addressed by the recommended adaptation strategies to reduce flood impacts.

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