6. *Climate Change*

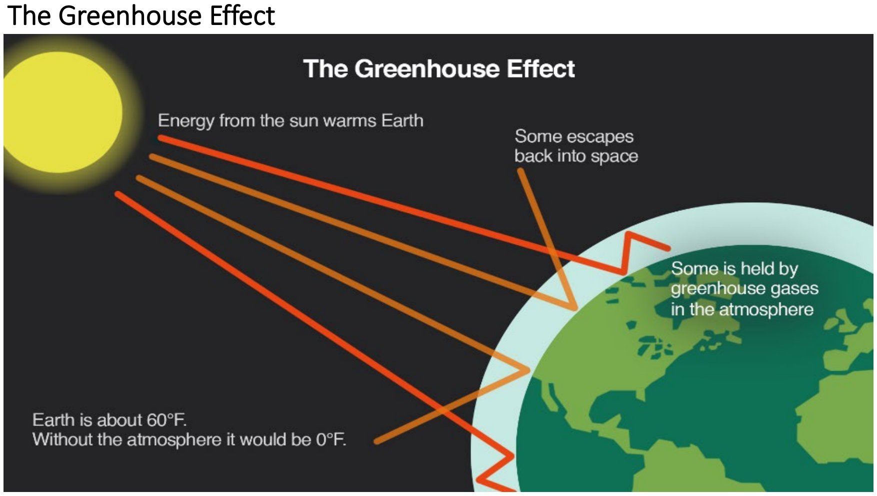
This chapter provides an overview of climate change, the applicable regulatory framework, and how the City of Livermore contributes to and is affected through presentation of the anticipated effects of climate change to the City of Livermore; the City's past, current, and predicted future greenhouse gas (GHG) emissions; actions that the City has taken to mitigate and respond to the effects of climate change; and implications for the General Plan Update. This chapter uses the term "Livermore" to cover the City of Livermore together with the immediately surrounding area within the Urban Growth Boundary (UGB) and Sphere of Influence (SOI). See the Introduction for more information on these boundaries.

6.1 WHAT IS CLIMATE CHANGE?

Climate is the long-term average of weather conditions, such as temperature and precipitation. While it is normal for Earth's climate system to experience long-term shifts in these average conditions, human activity is causing global climate change at a much more rapid pace than has occurred in the past. These activities, predominately the burning of fossil fuels, emit heat-trapping gases called greenhouse gases (GHGs) that build up in the atmosphere. As GHG levels increase, Earth's atmosphere traps more heat, triggering changes in the global climate system that may have serious and potentially catastrophic impacts on people, physical assets, and natural systems.

To fully understand global climate change, it is important to recognize the naturally occurring "greenhouse effect" and to define GHGs that contribute to this phenomenon. The temperature on Earth is regulated by this greenhouse effect, which is so named because the Earth's atmosphere acts like a greenhouse, warming the planet in much the same way that an ordinary greenhouse warms the air inside its glass walls. Like glass, the gases in the atmosphere let in light yet prevent heat from escaping. This process is shown on Figure 6-1.

Figure 6-1 The Greenhouse Effect



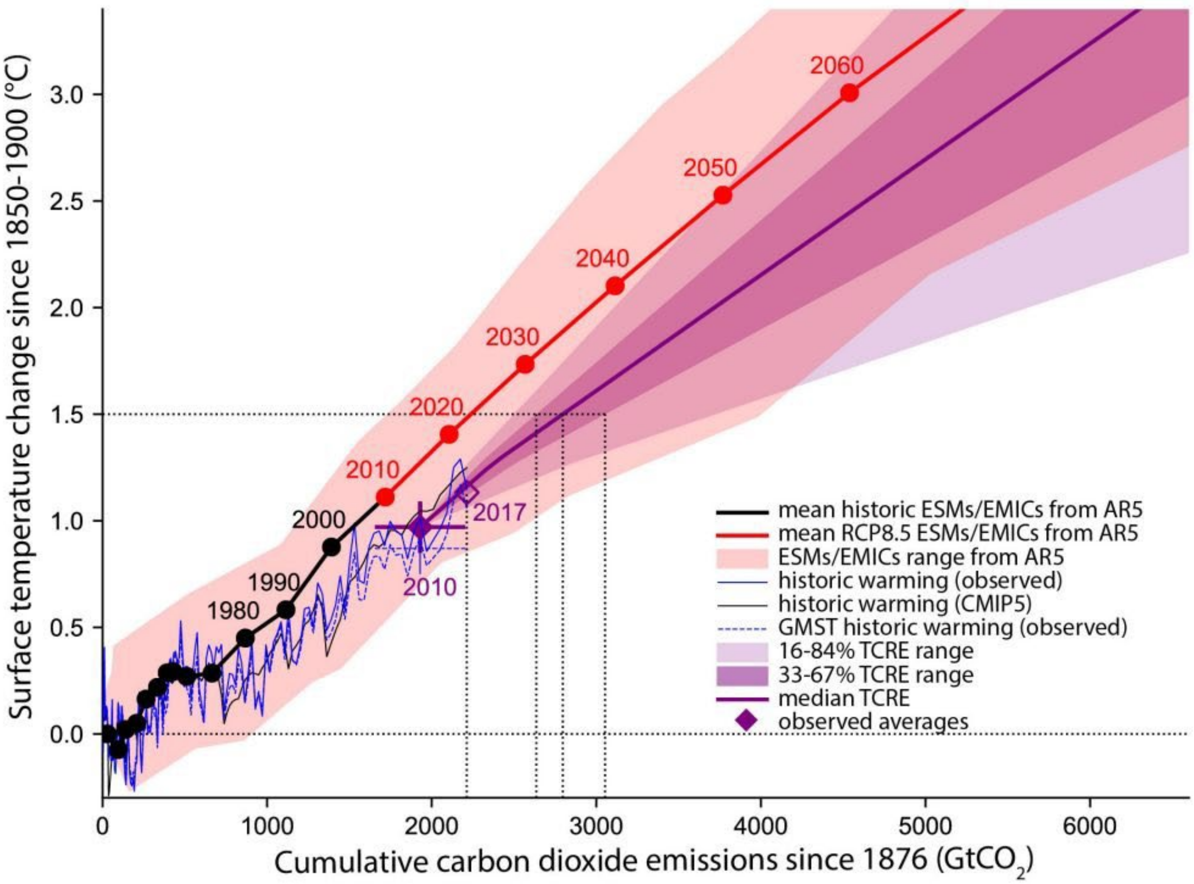
Source: Climate Central.

The most common GHGs are naturally occurring gases, such as water vapor, carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) that absorb heat radiated from the Earth's surface. GHGs are transparent to certain wavelengths of the sun's radiant energy, including visible light, allowing sunlight to penetrate deep into the atmosphere or all the way to Earth's surface. Clouds, ice caps, and particles in the air reflect about 30 percent of this energy, but oceans and land masses absorb the rest (70 percent of the energy received from the sun) before releasing it back toward space as heat. GHGs and clouds effectively prevent some of the heat from escaping; they trap the heat near Earth's surface where it warms the lower atmosphere. If this natural barrier of atmospheric gases was not present, the heat would escape into space, and Earth's average global temperatures could be as much as 61 degrees Fahrenheit (°F) cooler.

In addition to natural sources, human activities are exerting a major and growing influence on the climate by changing the composition of the atmosphere and by modifying the land surface. Particularly, the increased consumption of fossil fuels (e.g., natural gas, coal, gasoline) has substantially increased atmospheric levels of GHGs. The Intergovernmental Panel on Climate Change's (IPCC's) Sixth Assessment Report summarizes the most recent scientific understanding of global climate change and projects future conditions using the most comprehensive set of recognized global climate models. The report, released in 2021, considers impacts that human activities have on global temperature and states that there is at least a 95-percent probability that "human influence has warmed the climate at a rate that is unprecedented in at least the last 2,000 years." The Sixth Assessment Report projects five different temperature scenarios based on future GHG emission levels and rates of change, all of which project 2021–2040 temperatures 0.54 to 1.26°F warmer than the 1986–2005 average temperature, and potentially over 8.5°F by 2100 under the scenario with the largest volume of future GHG emissions.

As noted in the IPCC Sixth Assessment Report, if trends remain unchanged, continued GHG emissions will induce further warming changes in the global climate system and pose even greater risks than those currently witnessed. Figure 6-2 shows the effects of additional warming on global temperatures. Given the scientific basis of climate change and projected trends, preparing for and mitigating the effects of climate change through deliberate global and local action is imperative.

Figure 6-2 Global Temperature Increase



Source: Intergovernmental Panel on Climate Change, 2019.
The information presented in Figure 6-2 includes information from ESMs and EMICs, which are various types of climate models, of which, includes the CMIP5. This figure also includes reference to Transient Climate Response to Cumulative Carbon Emissions (TCREs) ranges, which indicates how much temperatures could change per unit of emissions.

In order to help demonstrate the effect that human actions can have on climate change's ultimate trajectory; the IPCC's fifth Assessment Report introduced four Representative Concentration Pathways (RCPs) to represent four different potential climate futures. The four RCPs, RCP2.6, RCP4.5, RCP6, and RCP8.5, are named after a possible range of radiative forcing[1] values in the year 2100 (2.6, 4.5, 6, and 8.5 W/m^2), respectively.

RCP is a "very stringent" pathway, requiring that carbon dioxide emissions start declining by 2020 and reach zero by 2100. IPCC describes RCP 4.5 as an intermediate scenario, in which emissions peak around 2040 and then begin to decline. RCP4.5 requires that carbon dioxide emissions start declining by approximately 2045 to reach roughly half of 2050 levels by 2100. In RCP6, emissions peak around 2080,

[1] Radiative forcing is the change in energy flux in the atmosphere caused by natural or human-caused factors, such as climate change. It is measured in watts/square meter. It is a scientific concept used to quantify and compare the external drivers of change to Earth's energy balance.

then begin to decline. In RCP8.5, emissions continue to rise throughout the 21st century and is considered to the worst case of climate scenarios.

6.1.1 CLIMATE CHANGE IN CALIFORNIA

In California and western North America, observations of the climate have shown:

- A trend toward warmer temperatures with an increase in extremely hot days and nights.
- Increase in the area burned by wildfires.
- A smaller fraction of precipitation falling as snow.
- An increase in frequency of drought and an increase in consecutive dry years.
- A shift (5 to 30 days earlier) in the timing of spring flower blooms.

Overall, California has become drier over time, with five of the eight years of severe to extreme drought occurring between 2007 and 2016, and unprecedented dry years in 2014 and 2015. Statewide precipitation has become increasingly variable from year to year, with the driest consecutive four years occurring from 2012 to 2015.

The IPCC Sixth Assessment Report estimates that even with aggressive global action to dramatically reduce GHG emissions by 2025 and achieve net-zero GHG emissions by 2055, global surface temperatures at the end of the twenty-first century are likely to result in 2.5 °F) of warming relative to the timeframe between 1850 and 1900. With less aggressive global action, temperatures at the end of the twenty-first century are likely to be warmer, potentially as high as 7.9°F if no significant action is taken. Consequently, some impacts from climate change are now considered unavoidable. Global climate change risks to California are summarized in Table 6-1.

TABLE 6-1 SUMMARY OF GHG EMISSIONS RISK TO CALIFORNIA

Impact Category	Potential Risks
Land use and population growth	Increased property damage/destruction, injury, and loss of life in hazard-prone areas. Economic impacts from increased insurance and reconstruction costs.
Equity and social vulnerability	Increased air pollution in frontline communities. Higher costs of water. Compounded risk from existing inequities.
Public health and wellbeing	Increased risk of harm from extreme heat. Air quality impacts from wildfire smoke. Increased spread of vector-borne diseases. Higher stress and mental trauma from extreme events, economic disruption, and residential displacement.
Water infrastructure	Reduced water availability from drought and low snowpack levels. Loss of reservoir capacity from higher runoff. Damage to water systems from natural hazards.
Energy systems	Higher energy demand placing stress on delivery infrastructure. Damage to electrical grid from natural disasters. Reduced hydropower from drought. Damage to fossil fuel refineries and pipelines.

TABLE 6-1 SUMMARY OF GHG EMISSIONS RISK TO CALIFORNIA

Impact Category	Potential Risks
Transportation infrastructure	Increased damage to roads and railways, causing delays and reducing safety. Inundation of transportation infrastructure in low-lying areas. Greater wildfire impacts on transportation infrastructure.
Agriculture	Water shortages and higher temperatures make some crops and livestock less viable. Increased development pressure from relocation.
Biodiversity and ecosystems	Increased levels of water pollution from higher runoff and warmer temperatures. Population decline and shifts in distribution. Increased physiological stress on plants and animals. Interruptions in life cycles. Greater spread of invasive species.
Forest health	Increased heat and drought stress. Damage from wildfire, increasing risk of forest ecosystems transitioning to shrubs or grasslands. Increased pest activity.
Ocean and coast	Damage to fisheries from warmer temperatures and ocean acidification. Loss of coastal ecosystems from sea-level rise. Potential loss of nutrient upwelling.

Sources: California's Fourth Climate Change Assessment, Statewide Summary Report: 2018 [2]

6.1.2 CLIMATE CHANGE IN LIVERMORE

Although much of the attention to the topic of climate change is global in scale, climate change affects every community at the local level, including the City of Livermore. The impacts and risks associated with climate change are expected to affect economic, social, and ecological systems in Livermore. Potential consequences of climate change for Livermore include the following:

- Air temperature increases
- Changes in precipitation patterns
- Increased occurrence of agricultural pests and diseases
- Increased frequency and severity of drought conditions
- More frequent and severe extreme heat events
- Greater risk of inland flooding
- Elevated risk of landslides and debris flows
- Higher risk of severe weather
- Greater frequency and severity of wildfire

[2] Bedsworth, Louise, Dan Cayan, Guido Franco, Leah Fisher, Sonya Ziaja. (California Governor's Office of Planning and Research, Scripps Institution of Oceanography, California Energy Commission, California Public Utilities Commission). 2018. Statewide Summary Report. California's Fourth Climate Change Assessment. Publication number: SUMCCCA4-2018-013.

Some of these changes are direct or primary stressors such as increased temperature, while others are indirect changes or secondary effects, such as changes to heat wave frequency, resulting from these direct changes. These primary and secondary impacts may then result in impacts on human and natural systems.

6.2 PROTOCOLS AND REGULATORY FRAMEWORK

Responding to climate change requires two, complementary process: reduction of GHG emissions and adaptation to changing conditions, as illustrated in Figure 6-3. Each process follows best practice protocols and guidance, which is further shaped by regulatory requirements as further described in this section.

Figure 6-3 Illustration of Climate Change Mitigation and Adaptation

Source: California Adaptation Planning Guide, 2020.

6.2.1 GREENHOUSE GAS EMISSIONS PROTOCOLS AND GUIDANCE

Local governments estimate and report on community GHG emissions through GHG inventories. A GHG inventory estimates the quantity of GHG emissions and removals associated with community sources and activities taking place during a chosen analysis year. By conducting additional inventories every three to five years and presenting data over time, local governments can use community GHG inventory reports to provide information on trends in GHG emissions associated with a given community. Community GHG inventory reports typically focus on selected GHG emissions occurring within the jurisdictional boundary of the community. GHG removals may also occur, particularly in the land sector.

GHG accounting represents an emerging field of science that continually benefits from refinements in best practice and emergence of new information. Organizations in California and throughout the United States have established protocols to assist and guide communities in assessing GHG emissions from government operations and community activities. While these protocols are not regulatory, they identify relevant sources or activities, recommended methods to estimate GHG emissions from each source, and provide consistency in the identification, assessment, and presentation of emission results across multiple jurisdictions.

6.2.1.1 U.S. COMMUNITY PROTOCOL

The U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions is designed to inspire and guide U.S. local governments to account for and report on GHG emissions associated with the communities they represent. The U.S. Community Protocol establishes requirements and recommended best practices for developing community GHG inventories. The Protocol provides guidance to local governments on the process of selecting or scoping what GHG emissions sources and activities to include in their community GHG inventories and outlines a set of five basic GHG emissions generating activities that must be included in an inventory to comply with the Protocol: 1) the use of electricity by the community, 2) use of fuel in residential and commercial stationary combustion equipment, 3) on-road passenger and freight motor vehicle travel, 4) use of energy in potable water and wastewater treatment and distribution, and 5) generation of solid waste by the community. The Protocol also provides optional reporting frameworks to help local governments scope their inventories in a manner appropriate to their goals and capacity.

6.2.1.2 LOCAL GOVERNMENT OPERATIONS PROTOCOL (LGOP)

Developed by a partnership between the California Air Resources Board, Climate Action Reserve, The Climate Registry, and ICLEI, the LGOP provides guidance on how to inventory GHG emissions resulting from government buildings and facilities, government fleet vehicles, wastewater treatment and potable water treatment facilities, landfill facilities, and other operations.

The Protocol is divided into several parts.

- Part I provides background on the origin and development of the Protocol, and an overview of its purpose and audience.
- Part II provides guidance on determining the specific emission sources to include in an inventory and how emissions data should be categorized and consolidated for reporting purposes.
- Part III provides the methodologies for quantifying emissions from various emission sources.
- Part IV provides guidance on how to report emissions in a standardized and consistent manner once they have been quantified using the methodologies explained in Part III.

6.2.1.3 GLOBAL PROTOCOL FOR COMMUNITY-SCALE GREENHOUSE GAS EMISSION INVENTORIES (GPC)

The GPC requires cities to measure and disclose a comprehensive inventory of GHG emissions and to total these emissions using two distinct but complementary approaches. One approach captures emissions from both production and consumption activities taking place within the city boundary, including some emissions released outside the city boundary. The other approach categorizes all emissions into "scopes," depending on where they physically occur.

The GPC is divided into three main parts:

- Part I introduces the GPC reporting and accounting principles, sets out how to define the inventory boundary, specifies reporting requirements and offers a sample reporting template.
- Part II provides overarching and sector-specific accounting and reporting guidance for sourcing data and calculating emissions, including calculation methods and equations.
- Part III shows how inventories can be used to set mitigation goals and track performance over time and shows how cities can manage inventory quality.

6.2.1.4 CAPCOA'S HANDBOOK FOR ANALYZING GREENHOUSE GAS EMISSION REDUCTIONS

The California Air Pollution Control Officers Association (CAPCOA) have prepared the Draft Handbook for Analyzing Greenhouse Gas Emission Reductions, Assessing Climate Vulnerabilities, and Advancing Health and Equity: Designed for Local Governments, Communities, and Project Developers (the "Handbook"). This draft document, released in August 2021, updates the 2010 CAPCOA Quantifying Greenhouse Gas Mitigation Measures Handbook, which is widely used by local governments across California to reduce GHG emissions from new land use development projects and to create climate action plans, master plans, and general plans.

The Handbook provides methods to quantify GHG emission reductions from a specified list of measures, primarily focused on project-level actions. The Handbook also includes a method to assess potential benefits of different climate vulnerability reduction measures, as well as measures that can be implemented to improve health and equity.

CAPCOA included a wide range of measures in the Handbook that are frequently used to reduce GHG emissions, bolster communities against expected climate impacts, and enhance community health and equity. Measures were screened according to the feasibility of quantifying emissions reductions or benefits; availability of robust and meaningful data; and ability of measures (alone or in combination with other measures) to appreciably reduce GHG emissions, reduce climate vulnerabilities, and improve health and equity.

6.2.2 CLIMATE ADAPTATION AND RESILIENCE GUIDANCE

Climate vulnerability describes the degree to which natural, built, and human systems are at risk of exposure to climate change impacts. Vulnerable communities experience heightened risk and increased sensitivity to climate change and have less capacity and fewer resources to cope with, adapt to, or recover from climate impacts. These disproportionate effects are caused by physical (built and environmental), social, political, and/ or economic factor(s), which are exacerbated by climate stressors[3].

To fully understand the level of vulnerability a community may experience, it is important to first consider climate risk, which includes assessing both the degree of exposure and sensitivity to climate impacts, as well as an individual or community's level of adaptive capacity. A vulnerability assessment considers both a community's degree of climate stress and level of adaptive capacity in order to identify populations, assets, and infrastructures that are most vulnerable to the impacts of climate change. The results of a vulnerability assessment can be used to guide climate change mitigation and adaptation policy and to direct resources for building community resilience.

6.2.2.1 THE CALIFORNIA ADAPTATION PLANNING GUIDE

In 2020, the California Governor's Office of Emergency Services updated the *California Adaptation Planning Guide* (APG), which recommends steps for local governments to follow while identifying and reducing climate change hazards. The APG suggests that vulnerability assessments follow a four-step process:

Identify Exposure: In a vulnerability assessment, *exposure* is the presence of people; infrastructure; natural systems; and economic, cultural, and social resources in areas subject to harm. A *hazard,* or climate hazard*,* is an event or physical condition that has the potential to cause types of harm or loss. This phase includes scoping the process and project, such as identifying the potential climate change effects and important physical, social, and natural assets in the community, as well as the key stakeholders in the local government and throughout the community.

Analyze Sensitivity and Potential Impacts: *Sensitivity* is defined as the level to which changing climate conditions affect a species, natural system, community, government, etc. Potential *impacts* are the effects of a climate change hazard, or the combination of *exposure* and *sensitivity*. This phase includes analysis of potential impacts and adaptive capacity to determine the vulnerability of populations, natural systems, and community assets to the impacts of climate change.

Evaluate Adaptive Capacity: *Adaptive capacity* is the ability of people and assets to adjust to potential damage from climate change hazards, to take advantage of existing opportunities such as funding, tools, and resources, or to respond to the impacts of climate change. This phase includes analysis of existing policies, community assets, and infrastructures that can mitigate the impacts of climate change and/or help the community recover after perturbation.

[3] Governor's Office of Planning and Research, 2018. Defining Vulnerable Communities in the Context of Climate Adaptation, https://opr.ca.gov/docs/20180723-Vulnerable_Communities.pdf, accessed on September 23, 2021.

Conduct Vulnerability Scoring: *Vulnerability* is defined as the combination of impact and adaptive capacity as affected by the level of exposure to changing climate conditions. This phase brings together the analyses of exposure, sensitivity, and adaptive capacity to develop a score of the overall vulnerability of each key population, asset, and type of infrastructure within the community.

6.2.2.2 CAL-ADAPT

California has invested significant resources in developing climate change information for the entire state at a resolution that is useful for planning at both a statewide and regional scale. These data are called downscaled climate data. Downscaling is an analytical tool that starts with data from global climate models and then makes adjustments using statistical techniques and/or numerical models to provide projections of climate impacts at a finer scale. California has developed a set of downscaled climate data for the State using the Localized Constructed Analogs, or LOCA, statistical downscaling technique. All data are available through Cal Adapt, an online tool that displays climate impacts in a spatial format. The platform also includes a web Application Programming Interface (API) to allow users to build their own applications. Accessible data includes annual averages, extreme heat, sea level rise, snowpack, wildfire, cooling degree days and heating degree days, downscaled climate projections, and more[4].

6.2.2.3 THE CITY OF LIVERMORE'S CLIMATE CHANGE VULNERABILITY ASSESSMENT

In 2020, the City of Livermore conducted a climate change vulnerability assessment. This vulnerability assessment was intended to help develop an understanding of the primary impacts of climate change on Livermore and the degree to which physical, socioeconomic, and natural factors are susceptible to, or unable to accommodate, the effects of climate change. The assessment considered community exposure to changes in temperature, precipitation, and wildfire; sensitivity of community structures, community functions, and populations; potential impacts of each hazard on community structures, functions, and populations; Livermore's ability to adapt to climate change impacts; and the likelihood and projected timing of hazard exposure. The assessment concluded that:

- Maximum and minimum temperatures are expected to increase.
- Precipitation variability is expected to increase.
- Intense rainstorms and changes in seasonal patterns are expected to occur within the next several years and decades.
- The City of Livermore has a low to medium adaptive capacity rating because, while the City has developed an extensive suite of sustainability and adaptation measures, the implementation rate of these measures has been low.

[4] Governor's Office of Planning and Research, 2018. Defining Vulnerable Communities in the Context of Climate Adaptation, https://opr.ca.gov/docs/20180723-Vulnerable_Communities.pdf, accessed on September 23, 2021.

6.2.3 STATE REGULATIONS

California law first directly addressed climate change in 1988, when AB 4420 directed state agencies to prepare a GHG inventory and study the impacts of climate change. Since then, California has adopted several laws to assess climate change, analyze GHG emissions and their effects, reduce emissions, and prepare for the impacts of climate change. Many of these laws and associated regulations affect local governments, although only some create specific requirements for individual communities. Key laws and associated regulations are briefly summarized here, please note that this list is not comprehensive.

6.2.3.1 EXECUTIVE ORDER S-03-05 AND ASSEMBLY BILL 32 – CALIFORNIA GLOBAL WARMING SOLUTIONS ACT OF 2006

In 2005, Governor Arnold Schwarzenegger issued Executive Order S-03-05, which established the first statewide GHG reduction goals for California: reduce emissions to 2000 levels by 2010, reduce emissions to 1990 levels by 2020, and reduce emissions 80 percent below 1990 levels by 2050.

AB 32, the California Global Warming Solutions Act, was approved by the Legislature and signed by Governor Schwarzenegger in 2006. The landmark legislation required the California Air Resources Board (CARB) to develop regulatory and market mechanisms to reduce GHG emissions to 1990 levels by 2020, codified in Executive Order S-03-05. AB 32 also directed CARB to identify early action items that could be quickly implemented, to develop a scoping plan to identify the most technologically feasible and cost-effective strategies to achieve the 2020 target, and to create and adopt regulations requiring major emitters to report and verify their emissions.

The Climate Change Scoping Plan (Scoping Plan), adopted in 2008 and updated in 2014 and 2017, employs a variety of GHG reduction strategies that include direct regulations, alternative compliance mechanisms, incentives, voluntary actions, and market-based approaches like a cap-and-trade program. The plan identifies local governments as strategic partners to achieving the state goal and translates the reduction goal to a 15-percent reduction of “existing” emissions by 2020. Although “existing emission levels” is not formally defined by the Scoping Plan, state, regional, and local agencies interpreted it as referring to emissions occurring between 2005 and 2008.

The 2014 and 2017 Scoping Plan Updates introduce a GHG reduction target of 40 percent emissions reductions below 1990 levels by 2030 and 80 percent below 1990 levels by 2050. As of September 2021, the Scoping Plan was undergoing an update for 2022. The 2022 Scoping Plan Update will assess progress towards achieving the Senate Bill 32 2030 target and lay out a path to achieve carbon neutrality by mid-century[5].

[5] California Air Resources Board. AB 32 Climate Scoping Plan, https://ww2.arb.ca.gov/our-work/programs/ab-32-climate-change-scoping-plan, accessed on September 23, 2021.

6.2.3.2 EXECUTIVE ORDER S-01-07

On January 18, 2007, the state set a new Low Carbon Fuel Standard (LCFS) for transportation fuels sold in California. Executive Order S-01-07 sets a declining standard for GHG emissions measured in CO_2e gram per unit of fuel energy sold in California. The LCFS requires a reduction of 2.5 percent in the carbon intensity of California's transportation fuels by 2015 and a reduction of at least 10 percent by 2020. The LCFS applies to refiners, blenders, producers, and importers of transportation fuels and would use market-based mechanisms to allow these providers to choose how they reduce emissions during the "fuel cycle," using the most economically feasible methods.

6.2.3.3 SENATE BILLS 1078, 107, AND X1-2, AND EXECUTIVE ORDER S-14-08

A major component of California's Renewable Energy Program is the renewable portfolio standard (RPS) established under Senate Bills 1078 (Sher) and 107 (Simitian). Under the RPS, certain retail sellers of electricity were required to increase the amount of renewable energy each year by at least 1 percent in order to reach at least 20 percent by December 30, 2010. Executive Order S-14-08, signed in November 2008, expanded the RPS to 33 percent renewable power by 2020. This standard was adopted by the legislature in 2011 (SB X1-2). Renewable sources of electricity include wind, small hydropower, solar, geothermal, biomass, and biogas. The increase in renewable sources for electricity production will decrease indirect GHG emissions from development projects because electricity production from renewable sources is generally considered carbon neutral.

6.2.3.4 SENATE BILL 375 – SUSTAINABLE COMMUNITIES AND CLIMATE PROTECTION ACT OF 2008

In 2008, SB 375, the Sustainable Communities and Climate Protection Act, was adopted to connect the GHG emissions-reductions targets established in the 2008 Scoping Plan to local land use decisions that affect travel behavior. Its intent is to reduce GHG emissions from light-duty trucks and automobiles (excludes emissions associated with goods movement) by aligning regional long-range transportation plans, investments, and housing allocations to local land use planning to reduce VMT and vehicle trips.

Specifically, SB 375 required CARB to establish GHG emissions-reduction targets for each of the 18 metropolitan planning organizations (MPOs). The Metropolitan Transportation Commission (MTC) is the MPO for Alameda County and its jurisdictions. Pursuant to the recommendations of the Regional Transportation Advisory Committee (RTAC), CARB adopted per-capita reduction targets for each of the MPOs rather than a total magnitude reduction target. The reduction targets for MTC/ABAG are 10-percent reduction in per-capita vehicle-related emissions for 2020 and 19 percent for 2035, relative to 2005 levels[6].

[6] California Air Resources Board. Regional Plan Targets, https://ww2.arb.ca.gov/our-work/programs/sustainable-communities-program/regional-plan-targets, accessed September 23, 2021.

6.2.3.5 EXECUTIVE ORDER B-30-15

Executive Order B-30-15, signed April 29, 2015, sets a goal of reducing GHG emissions within California to 40 percent of 1990 levels by year 2030. Executive Order B-30-15 also directs CARB to update the Scoping Plan to quantify the 2030 GHG-reduction goal for the State and requires State agencies to implement measures to meet the interim 2030 goal as well as the long-term goal for 2050 in Executive Order S-03-05. It also requires the Natural Resources Agency to conduct triennial updates of the California adaption strategy, Safeguarding California, to ensure climate change is accounted for in state planning and investment decisions.

6.2.3.6 SENATE BILL 32 AND ASSEMBLY BILL 197

In September 2016, SB 32 and AB 197 were signed into law, making the Executive Order goal for year 2030 into a statewide mandated legislative target. AB 197 established a joint legislative committee on climate change policies and requires CARB to prioritize direct emissions reductions rather than the market-based cap-and-trade program for large stationary, mobile, and other sources. Executive Order B-30-15 and SB 32 required CARB to prepare another update to the Scoping Plan to address the 2030 target for the state. On December 14, 2017, CARB adopted the 2017 Climate Change Scoping Plan Update (2017 Scoping Plan) to address the 2030 target for the state. The 2017 Scoping Plan establishes a new emissions limit of 260 $MMTCO_2e$ for the year 2030, which corresponds to a 40-percent decrease in 1990 levels by 2030.

6.2.3.7 EXECUTIVE ORDER B-55-18

In 2018, Governor Brown issued Executive Order B-55-18, which established an additional statewide goal of achieving carbon neutrality (no net GHG emissions) by 2045 and to achieve and maintain net negative emissions thereafter. Under this goal, any GHGs that are emitted by California must be fully offset by other activities by 2045. While this goal does not yet have the force of law, it does indicate the direction that the state is moving in and may be a reference point for future legislative action.

6.2.3.8 SENATE BILL 100

On September 10, 2018, Governor Brown signed SB 100, which raises California's RPS requirements to 60 percent by 2030, with interim targets, and 100 percent by 2045. The bill establishes a state policy that eligible renewable energy resources and zero-carbon resources supply 100 percent of all retail sales of electricity to California end-use customers and 100 percent of electricity procured to serve all state agencies by December 31, 2045. Under the bill, the state cannot increase carbon emissions elsewhere in the western grid or allow resource shuffling to achieve the 100 percent carbon-free electricity target.

6.2.3.9 EXECUTIVE ORDER N-79-20

In 2020, Governor Gavin Newsom issued Executive Order N-79-20, which set new statewide goals for the phasing out of gasoline-powered vehicles in California. This Executive Order sets the following zero emissions goals and directs the CARB to develop regulations and strategies to achieve these goals.

- 100 percent of in-state sales of new passenger cars and trucks will be zero-emission by 2035.
- 100 percent of medium- and heavy-duty vehicles in the state be zero-emission by 2045 for all operations where feasible.
- The state will transition to 100 percent zero-emission off-road vehicles and equipment by 2035 where feasible.

6.2.3.10 ASSEMBLY BILL 1493

Also known as Pavley I, AB 1493 is a clean-car standard that reduces GHG emissions from new passenger vehicles (light-duty auto to medium-duty vehicles) from 2009 through 2016 and is anticipated to reduce GHG emissions from new passenger vehicles by 30 percent in 2016. California implements the Pavley I standards through a waiver granted to California by the USEPA. In 2012, the USEPA issued a Final Rulemaking that sets even more stringent fuel economy and GHG emissions standards for model years 2017 through 2025 light-duty vehicles (see also the discussion on the update to the CAFE standards under the heading for Federal Regulations, above). In January 2012, CARB approved the Advanced Clean Cars program (formerly known as Pavley II) for model years 2017 through 2025. The program combines the control of smog, soot, and GHGs with requirements for greater numbers of ZE vehicles into a single package of standards. Under California's Advanced Clean Car program, by 2025, new automobiles will emit 34 percent less global warming gases and 75 percent less smog-forming emissions.[7]

6.2.3.11 CALIFORNIA BUILDING CODE: BUILDING ENERGY EFFICIENCY STANDARDS

Energy conservation standards for new residential and non-residential buildings were adopted by the California Energy Resources Conservation and Development Commission (now the CEC) in June 1977 (Title 24, Part 6, of the California Code of Regulations). Title 24 requires the design of building shells and building components to conserve energy. The standards are updated periodically to allow for consideration and possible incorporation of new energy efficiency technologies and methods. The 2019 Building Energy Efficiency Standards, which were adopted on May 9, 2018, went into effect starting January 1, 2020.[8] The 2019 standards move toward cutting energy use in new homes by more than 50 percent and will require installation of solar photovoltaic systems for single-family homes and multifamily buildings of three stories and less. The 2019 standards focus on four key areas: 1) smart residential photovoltaic systems; 2) updated thermal envelope standards (preventing heat transfer from the interior to exterior and vice versa); 3) residential and nonresidential ventilation requirements; and 4) nonresidential lighting requirements.[9] Under the 2019 standards, nonresidential buildings will be 30

[7] See also the discussion on the update to the CAFE standards under Federal Laws, above. In January 2012, CARB approved the Advanced Clean Cars program (formerly known as Pavley II) for model years 2017 through 2025. The program combines the control of smog, soot and global warming gases and requirements for greater numbers of zero-emission vehicles into a single package of standards. Under California's Advanced Clean Car program, by 2025, new automobiles will emit 34 percent fewer global warming gases and 75 percent fewer smog-forming emissions.

[8] California Energy Commission. Building Energy Efficiency, https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards, accessed on September 23, 2021.

[9] California Energy Commission, 2018. Energy Commission Adopts Standards Requiring Solar Systems for New Homes, First in Nation. News Release.

percent more energy efficient compared to the 2016 standards, and single-family homes will be 7 percent more energy efficient. When accounting for the electricity generated by the solar photovoltaic system, single-family homes would use 53 percent less energy compared to homes built to the 2016 standards.[10]

6.2.3.12 SENATE BILL 1241

Passed in 2012, SB 1241 revises the safety element requirements for State Responsibility Areas (SRA) and Very High Fire Hazard Severity Zones (VHFHSZ) and requires the safety element, upon the next revision of the housing element on or after January 1, 2014, to be reviewed and updated as necessary to address the risk of fire in SRAs and VHFHSZs.

6.2.3.13 SENATE BILL 379

Passed in 2016, SB 379 requires all cities and counties to include climate adaptation and resiliency strategies in the safety elements of their general plans upon the next revision beginning January 1, 2017. The bill requires the climate adaptation update to include a set of goals, policies, and objectives for their communities based on the vulnerability assessment, as well as implementation measures, including the conservation and implementation of natural infrastructure that may be used in adaptation projects. Specifically, the bill requires that upon the next revision of a general plan or local hazard mitigation plan, the safety element is to be updated as necessary to address climate adaptation and resiliency strategies applicable to the city or county.

6.2.3.14 ASSEMBLY BILL 747

Passed in 2019, AB 747 requires that, upon the next revision of a local hazard mitigation plan on or after January 1, 2022, or beginning on or before January 1, 2022, if a local jurisdiction has not adopted a local hazard mitigation plan, the safety element to be reviewed and updated as necessary to identify evacuation routes and their capacity, safety, and viability under a range of emergency scenarios.

6.2.3.15 CALIFORNIA ENVIRONMENTAL QUALITY ACT

CEQA requires that many proposed development projects conduct an environmental review to identify how the project may impact the environment. SB 97 directed the Governor’s Office of Planning and Research to amend the CEQA Guidelines to address GHG emissions, requiring proposed projects to analyze their GHG emissions and contribution to climate change. The Office of Planning and Research adopted the CEQA Guidelines in December 2009, and they went into effect March 18, 2010. The guidelines include provisions for local governments to use adopted plans for the reduction of GHG emissions to address the cumulative impacts of individual future projects on GHG emissions (see CEQA Guidelines Section 15183.5(b)(1)).

[10] California Energy Commission, 2018. 2019 Building Energy and Efficiency Standards Frequently Asked Questions. http://www.energy.ca.gov/title24/2019standards/documents/2018_Title_24_2019_Building_Standards_FAQ.pdf, accessed September 23, 2019.

Consistent with the CEQA Guidelines, lead agencies may use adopted GHG reduction plans to assess the cumulative impacts of discretionary projects on climate change. In addition, the guidelines provide a mechanism to streamline development review of future projects.

Specifically, lead agencies may use adopted plans consistent with CEQA Guidelines Section 15183.5 to analyze and mitigate the significant effects of GHGs under CEQA at a programmatic level by adopting a plan for the reduction of GHG emissions. Later, as individual projects are proposed, project-specific environmental documents may tier from and/or incorporate by reference that existing programmatic review in their cumulative impact analysis. Project-specific environmental documents prepared for projects consistent with the General Plan and the 2012 CAP may rely on the programmatic analysis of GHGs in this document.

A project-specific environmental document that relies on the 2012 CAP for its cumulative impact analysis must identify specific GHG reduction strategies applicable to the project and demonstrate the project's incorporation of the strategies. Project applicants and City staff will identify specific strategies applicable to each project during project review. If applicable strategies are not otherwise binding and enforceable, they must be incorporated as mitigation strategies for the project. If substantial evidence indicates that the GHG emissions of a proposed project may be cumulatively considerable, notwithstanding the project's compliance with specific strategies in the 2012 CAP, an environmental impact report (EIR) must be prepared for the project.

6.2.4 LOCAL REGULATIONS

6.2.4.1 LIVERMORE 2003-2025 GENERAL PLAN

In 2009, the City of Livermore adopted the Climate Change Element of its General Plan. Goals and objectives of the Climate Change include reducing greenhouse gas emissions to 15 percent of 2008 levels by 2020 and adopting a Climate Action Plan by 2010. The Climate Change Element's objectives and policies address a diversity of climate change mitigation and adaptation strategies, including high-density development and alternative transportation to reduce transportation related GHG emissions, energy and water efficiency and conservation, tree planting, and waste reduction. Table 6-2 lists the Climate Change Element's goals, objectives, and policies.

TABLE 6-2 LIVERMORE 2003-2025 GENERAL PLAN GOALS AND POLICIES RELATED TO CLIMATE CHANGE

Goal CL1-1	By 2020, the City of Livermore shall seek to reduce greenhouse gas emissions under the control of the City to a level 15% less than 2008 levels in order to support state implementation of the global warming solution act of 2006 (ab 32).
Objective CL1-1.1	Adopt a Climate Action Plan by 2010 that will help the City address climate change.
Policy CL1-1.1-P1	CLIMATE ACTION PLAN – The City will prepare and adopt a Climate Action Plan (CAP) by 2011. The CAP shall include an inventory of the 2008 level of GHG emissions within the City. The CAP shall set out specific policies and actions to be undertaken by the City to reduce GHG emissions under the control of the City to a level 15% less than 2008 conditions in order to support State implementation of AB 32. The policies and actions will include incentives, actions, and requirements to reduce the City's GHG emissions, the GHG emissions of the private sector, and actions that the City will take in concert with public agencies, the private sector, and other stakeholders to reduce GHG emissions. Development of the CAP will include a public and stakeholder process.
Policy CL1-1.1-P2	CLIMATE ACTION PLAN – Include mechanisms to ensure regular review of progress toward the GHG emission reduction targets established by the CAP, report progress toward the GHG emission reduction targets established by the CAP, report progress to the public and responsible officials, and revise the plan as appropriate, using principles of adaptive management.
Policy CL1-1.1-P3	CLIMATE ACTION PLAN – Work with other local and regional governments to assess federal and state programs and their impact on GHG emissions and mitigation efforts.
Policy CL1-1.1-P4	DEVELOPMENT PROJECT FRAMEWORK – Evaluate the GHG emissions impacts of proposed developments through the CEQA process. Require preparation of project level GHG emissions inventories. Establish requirements for tiered significance thresholds for the evaluation of projects and identification and application of mitigation.
Objective CLI-1.2	Encourage and provide greater support for infill, mixed use, and higher density development in order to reduce GHG emissions associated with vehicle travel.
Policy CL1-1.2-P1	MIXED USE INTENSIFICATION – Conduct a survey of sites that currently do not permit any residential or residentially mixed uses in order to identify additional sites that have the potential for mixed-use development as follows: ▪ Site-selection efforts should be focused on areas located near to the Downtown area in or near commercial corridors, shopping centers, and mixed use areas. ▪ For each identified use, analyze current zoning and development standards to identify constraints that may limit mixed-use development. ▪ Develop criteria for site identification, such as proximity to transit, availability of commercial services, compatibility with surrounding land uses and scale of development, lack of land use conflicts, and applicability of CEQA Section 15332 ("Infill Development Projects").
Policy CL1-1.2-P2	BASELINE DENSITIES - Expand allowable baseline densities of mixed-use designations located within close proximity and/or within activity centers that can be served efficiently by public transit and alternative transportation modes. Update the zoning code accordingly.
Policy CL1-1.2-P3	DENSITY - Investigate feasibility of establishing minimum residential densities and parking maximums in areas designated for transit-oriented, mixed use development to ensure higher density in these areas.
Policy CL1-1.2-P4	DENSITY - Promote infill, mixed use, and higher density development located in close proximity to existing public transportation corridors by providing incentives for these projects.
Policy CL1-1.2-P5	FORM BASED CODE - The City shall update the Livermore Planning and Zoning Code (LPZC) to include Form Based Code Principles and application areas, which helps to create a more predictable public realm primarily by controlling physical form, with a lesser focus on land use, through City regulations.
Policy CL1-1.2-P6	HOUSING ELEMENT UPDATE - As part of the Housing Element update, the City shall reiterate/reinforce policies that promote infill, mixed use, and higher density development.
Objective CLI-1.3	Support measures that encourage alternative modes of transportation and alternative fuels in order to reduce emissions associated with vehicle travel.
Policy CL1-1.3-P1	ALTERNATIVE FUEL VEHICLE INFRASTRUCTURE/ PUBLIC - Provide the necessary facilities and infrastructure to encourage the use of City-owned low or zero-emission vehicles such as electric vehicle charging facilities and conveniently locate alternative fueling stations.

TABLE 6-2	LIVERMORE 2003-2025 GENERAL PLAN GOALS AND POLICIES RELATED TO CLIMATE CHANGE
Policy CL1-1.3-P2	ALTERNATIVE FUEL VEHICLE INFRASTRUCTURE/ PRIVATE - Promote the necessary facilities and infrastructure to encourage the use of privately owned low or zero-emission vehicles such as electric vehicle charging facilities and conveniently locate alternative fueling stations.
Policy CL1-1.3-P3	ALTERNATIVE FUELS - Collaborate with local and regional governments and businesses to support expanded use of renewable fuels by, for example, helping to coordinate and leverage the purchasing power of multiple jurisdictions/businesses and to properly site alternative fuel infrastructure.
Policy CL1-1.3-P4	VMT REDUCTION - Evaluate the feasibility of a VMT reduction target in concert with other Alameda County municipalities. Evaluate the feasibility of a VMT target for new development below “business as usual” VMT levels. If determined feasible, adopt a VMT reduction target in conjunction with adoption of the Climate Action Plan. Part of the evaluation of a VMT reduction target would require an analysis of the City’s existing multi-modal circulation infrastructure such as pedestrian routes, bicycle lanes, and transit services and operations. Monitor VMT every two years to evaluate the effectiveness of VMT reducing strategies in this element.
Policy CL1-1.3-P5	TRANSIT PROMOTION - Evaluate and consider multi-modal transportation benefits to all City employees, such as free or low-cost monthly transit passes. Encourage employer participation in similar programs. Encourage new transit/shuttle services and use. Encourage appropriate use of telecommuting for municipal employees.
Policy CL1-1.3-P6	BICYCLE USE - Evaluate and consider free bicycles for public use and/or charge a nominal fee for their use
Policy CL1-1.3-P7	CAR SHARE - Encourage community car-sharing and carpooling.
Policy CL1-1.3-P8	PARKING - Build upon the City’s Downtown Parking Study and adopt a comprehensive parking policy for the entire City that encourages carpooling and the use of alternative fuel vehicles and transportation. The feasibility of potential use of parking fees/parking maximums shall also be evaluated.
Policy CL1-1.3-P9	TRAFFIC SIGNALING - –Evaluate potential efficiency gains from further signal synchronization and transit signal priority.
Policy CL1-1.3-P10	ANTI-IDLING REQUIREMENTS - Limit idling of municipal, community, and/or commercial vehicles for new development through the CEQA process. Support CARB anti-idling requirements and provide signage in key areas where idling that is not consistent with CARB requirements might occur.
Policy CL1-1.3-P11	NEW ROAD WIDTHS - To reduce heat gain from pavement, consider reducing street pavement in new developments.
Policy CL1-1.3-P12	CONGESTION PRICING - Work with regional partners to analyze and develop potential congestion road pricing scenarios for the I-580 HOT (High Occupancy Toll) lanes and address any legal and implementation issues. Report findings and recommendations on pricing options as well as mechanisms for applying part or all of the road-pricing revenues to fund transit and other alternatives to single occupancy vehicles.
Policy CL1-1.3-P13	TRANSPORTATION PLANNING - Work with county, regional, and state governments to account for greenhouse gas emissions in evaluations of land use and regional transportation infrastructure investments.
Policy CL1-1.3-P14	TRANSPORTATION FUNDING - Consider a public transportation impact fee on new development in order to provide additional capital improvements to support increased public transit service.
Policy CL1-1.3-P15	TRIP REDUCTION ORDINANCE - The city shall evaluate the feasibility of implementing a voluntary trip reduction ordinance that promotes the preparation and implementation of a trip reduction plan (TRP) for large employers (100 employees or more) in the City. The TRP should include, at a minimum, performance of annual employee commute surveys, marketing of commute alternatives, ride matching assistance, telecommuting, and transit information. The suggested performance target for the TRPs is a reduction of the vehicle trips per employee by 15% in five years and 25% in ten years.
Policy CL1-1.3-P16	CARBON FOOTPRINT FEE - Explore and consider a carbon footprint fee on new developments to fund transit, other alternatives to single occupancy vehicles, and alternative fuel infrastructure
Policy CL1-1.3-P17	TRANSIT REAL-TIME INFORMATION - Promote real-time information for transit and ridesharing.

TABLE 6-2 LIVERMORE 2003-2025 GENERAL PLAN GOALS AND POLICIES RELATED TO CLIMATE CHANGE

Objective CLI-1.4	Enhance existing water efficiency and conservation measures and adopt new programs that encourage recycled water use and water efficiency in order to reduce energy and GHGs associated with water use.
Policy CL1-1.4-P1	RECYCLED WATER - Update the Recycled Water Master Plan to establish additional areas and uses that could also be required to use recycled water.
Policy CL1-1.4-P2	RECYCLED WATER USE - Assess the feasibility of using advance treatment of recycled water with microfiltration or reverse osmosis for future potable water use. Assess associated energy/GHG tradeoffs vs. out of basin water supply.
Policy CL1-1.4-P3	WATER EFFICIENCY - Review and update the City's water efficient landscape ordinance.
Policy CL1-1.4-P4	WATER EFFICIENCY - Promote water audit programs that offer free water audits to single family, multi-family and commercial customers.
Policy CL1-1.4-P5	Policy P5. WATER EFFICIENCY - Participate in and support regional programs and projects that target the improvement and conservation of the region's groundwater and surface water supply. Also consider programs to collect stormwater for landscape watering.
Objective CLI-1.5	Expand and adopt new policies and programs that will help to provide energy efficiency alternatives to fossil fuel use and reduce consumption in order to reduce greenhouse gas emissions.
Policy CL1-1.5-P1	ALTERNATIVE ENERGY DEVELOPMENT PLAN - Explore possibilities for alternative energy production and establishing City-wide measurable goals. Develop an Alternative Energy Development Plan to identify the allowable and appropriate alternative energy facility types (i.e., solar photovoltaic (PV) on urban residential and commercial roofs and wind farms on the edge of town or in rural areas) and locations within Livermore as well as propose phasing and timing of alternative energy facility and infrastructure development. Continue to identify and remove regulatory or procedural barriers to producing renewable energy in building and development codes, design guidelines, and zoning ordinances. Work with related agencies such as fire, water, and health that may impact the use of alternative technologies. Develop protocols for alternative energy storage such as biodiesel, hydrogen, and/or compressed air. Establish a protocol for reviewing a proposed alternative energy project against existing City policies and ordinances. The Alternative Energy Development Plan shall identify optimal locations and best means to avoid noise, aesthetic, and other potential land use compatibility conflicts (e.g., installing tracking solar PV or angling fixed solar PV in a manner that reduces glare to surrounding land uses.)
Policy CL1-1.5-P2	RENEWABLE ENERGY PROMOTION - Expand incentives and goals for incorporating energy reducing practices into existing and proposed public and private developments and alternative energy vehicles. Consider potential public and private funding partnerships for solar roofs through a solar power loan program that would pay for the installation of solar panels and solar hot water systems for any homeowner or commercial building owner. For example, the owners of the home or the business building could retain ownership of the solar systems, by paying back the cost through an assessment on their annual property tax bill.
Policy CL1-1.5-P3	RENEWABLE ENERGY FOR MUNICIPAL FACILITIES - Explore using renewable energy and clean generation technologies such as solar, wind, biogas, or fuel cells to power City facilities where appropriate.
Policy CL1-1.5-P4	RENEWABLE ENERGY/ REGIONAL COLLABORATION - Explore regional collaborations among local governments, special districts, nonprofits, and other public organizations to share resources, achieve economies of scale, and develop renewable energy policies and programs that are optimized on a regional scale.
Policy CL1-1.5-P5	ENERGY MANAGEMENT - Use Geographic Information Systems (GIS) to map and assess local renewable resources, the electric and gas transmission and distribution system, community growth areas anticipated to require new energy services, and other data useful to deployment of renewable technologies.
Policy CL1-1.5-P6	GREEN BUILDING ORDINANCE EXPANSION - City departments will work together to periodically review (approximately every five years) the City's Green Building Ordinances in order to expand LEEDTM (Leadership in Energy and Environmental Design) or GreenPoint Rating System (or other) certification requirements to all new construction of private and public buildings.

TABLE 6-2 LIVERMORE 2003-2025 GENERAL PLAN GOALS AND POLICIES RELATED TO CLIMATE CHANGE

Policy CL1-1.5-P7	ALTERNATIVE BUILDING MATERIALS - Encourage the use of cement substitutes and recycled building materials for new construction.
Policy CL1-1.5-P8	GREEN BUSINESSES - The City shall support green businesses through the efforts of the Alameda County Green Business Program to recognize and assist businesses to operate in an environmentally friendly manner.
Objective CLI-1.6	Expand the number of trees in Livermore in order to provide a larger carbon sink or area containing natural sources that retain more carbon than what those sources emit.
Policy CL1-1.6-P1	URBAN FORESTRY - Evaluate feasibility of expanding tree planting within the City during preparation of the Climate Action Plan including evaluation of potential carbon sequestration as well as GHG emissions associated with irrigation.
Policy CL1-1.6-P2	AGRICULTURAL LAND MANAGEMENT - Support the voluntary efforts of the wine industry and other agricultural businesses to promote land management activities that reduce GHG emissions and promote sequestration of carbon in agricultural soils.
Objective CL1-1.7	Expand methods to increase waste diversion and recycling goals in order to reduce GHGs associated with waste disposal.
Policy CL1-1.7-P1	WASTE REDUCTION - Research, evaluate and report to the Council on best practices, innovations, trends and developments in waste-to-energy, climate friendly building materials and waste reduction practices, as relevant to greenhouse gas emissions reduction. Promote regional development and use of new waste-to-energy technologies, waste reduction and climate-friendly materials as relevant to greenhouse gas emissions reduction.
Policy CL1-1.7-P2	WASTE REDUCTION - Expand educational programs to inform residents about reuse, recycling, composting, waste to energy, and zero waste programs.
Policy CL1-1.7-P3	WASTE REDUCTION - Support State legislative or regulatory efforts that will aid in achieving zero waste.
Policy CL1-1.7-P4	WASTE MANAGEMENT - Work with public and private waste disposal entities to reduce methane emissions released from waste disposal and promote methane recovery for energy production from other sources.

6.2.4.2 LIVERMORE CLIMATE ACTION PLAN

In November 2012, the Livermore City Council adopted the Livermore Climate Action Plan (CAP). The City of Livermore prepared the 2012 CAP to outline strategies and activities the City and community can take to reduce GHG emission levels produced within Livermore. The CAP implements General Plan policy, adopted in 2009 via the Climate Change Element of the Plan, to reduce GHG emissions to 15 percent below 2008 conditions by 2020 in accordance with AB 32.

The 2012 CAP includes an inventory of all GHG emissions resulting from community activities in 2005 and projected for 2020, then identifies an emissions reduction target and measures for reducing future GHG emissions. Successful implementation of the CAP would require commitment and action throughout the community including government, residents, businesses, and employers. Based on the City's GHG emission inventory, the CAP identifies opportunities for emissions reductions in the building energy, transportation and land use, water conveyance, wastewater treatment, solid waste generation, and urban forest and conservation sectors. The CAP provides a roadmap for successfully implementing the emissions reduction measures selected by the City.

Chapter 4 of the CAP contains implementation steps and strategies to ensure that measures in the CAP are being implemented effectively and efficiently. Topics pertaining to successful implementation discussed include administration and staffing, financing and budgeting, timelines for measure implementation, community outreach and education, and opportunities for regional involvement. The CAP also outlines supporting strategies for each GHG reduction measure.

As of September 2021, the CAP was undergoing a comprehensive update. The updated CAP will create a roadmap to achieve carbon neutrality (also known as net zero carbon emissions) by 2045. It will also include adaptation strategies toto prepare Livermore for a changing climate. The CAP update began in early 2020 and is anticipated to be adopted by the Livermore City Council in Spring 2022.

The City of Livermore has implemented a number of climate change and sustainability initiatives, including[11]:

- **Use of Hybrid Vehicles and city charging stations.** The City operates seven hybrid vehicles and has installed charging stations at both City Hall and the Maintenance Service Center for electric City trucks and employees with electric cars.
- **Use of recycled water and materials.** The City has implemented a recycled water system that contains a pump station, 1.9-million-gallon reservoir, and over 14 miles of pipeline. The City uses recycled water for irrigation and fire protection. Through its Recycled Product Procurement Policy, City staff also purchase and use recycled materials for City operations such as office supplies, furniture, park benches, picnic tables, and school and park playground structures.
- **Use of Rubberized Asphalt Concrete (RAC) on City major arterial road paving projects.** This practice reduces the stockpile of waste tires statewide.
- **Damaged asphalt recycling.** The City has been using a cold milling machine since 2003 to remove and recycle damaged asphalt, eliminating landfill waste and high disposal fees.
- **Livermore's Green City Hall.** In 2002, the Livermore City Hall was renovated using salvaged and recycled materials from the original building. The renovated building includes a Photovoltaic System generating 13.5% of the facility's annual electricity.
- **Street-Level imagery project** allows staff to inspect City streets via photo files thereby reducing City vehicle trips for on-site inspections.
- **Spare the Air Program.** On declared "Spare the Air" days, City maintenance crews curtail turf mowing, paving work, and use of two-cycle engines.
- **Tree City USA Program (National Arbor Day Foundation).** The City was recently awarded the Sterling Tree City USA designation for urban forestry achievements in education and public relations, planning and management, partnerships, and tree planting and maintenance.
- **Electronic Waste Recycling events.** The City conducts annual Electronic Waste Recycling events and free E-waste and cell phone drop-off at City Hall.
- **Community Recycling.** Livermore began Community Recycling more than 30 years ago.

[11] City of Livermore. Livermore Climate Action Plan, https://www.cityoflivermore.net/government/community-development/planning/climate-action-plan, accessed September 23, 2021.

6.3 GREENHOUSE GAS PROFILE

A GHG inventory is a summary of the GHG emissions generated by activities that take place within a community. Inventories help elected officials, City staff, and members of the public to understand what activities generate GHG emissions. The GHG emissions inventory guides the creation of GHG reduction policies and initiatives, such as those included in a Climate Action Plan or General Plan, and helps the community track its progress towards GHG reduction targets.

An inventory of GHG emissions requires the collection of information from a variety of sectors and sources. The inventory assesses the GHG emissions from activities within Livermore or associated with the activities of Livermore community members, as opposed to strictly the GHGs emitted within the City Limits. For example, although the electricity used by Livermore's residents and businesses is mostly produced elsewhere, the GHG emissions associated with electricity use appear in Livermore's inventory. The decision to calculate emissions in this manner reflects the general philosophy that a community should take ownership of the impacts associated with its resource use and behavior, regardless of whether the emissions occur within the geographical limits of the community.

6.3.1 COMMUNITY-WIDE INVENTORY

GHG emissions inventories have been completed for the years 2005, 2010, 2015, and 2017. The 2005 inventory which was originally completed as part of the 2012 CAP development was re-inventoried in 2020 using current methodologies consistent with that used for the 2010, 2015, and 2017 inventories to allow for comparison between all years.

In 2017, Livermore GHG emissions were estimated to be 534,334 metric tons (MT) of carbon dioxide equivalent (CO_2e) (Table 6-3).

TABLE 6-3 2017 LIVERMORE GHG EMISSIONS INVENTORY SUMMARY

Sector	Activity Data	Emissions Factors	Units	MT CO_2e
Residential Electricity (kWh)	205,232,521	0.00009635	MT CO_2e/kWh	19,775
Nonresidential Electricity (kWh)	288,894,815	0.00009635	MT CO2e/kWh	27,836
Direct Access Electricity[4] (kWh)	32,283,926	0.0002027	MT CO_2e/kWh	6,545
Residential Gas (therms)	12,408,537	0.00531	MT CO_2e/therms	65,896
Adjusted Nonresidential Gas (therms)	10,820,445[1]	0.00531	MT CO_2e /therms	57,462[1]
Passenger On-Road Transportation (VMT)	538,932,050	0.000338	MT CO_2e /mile	181,900
Commercial On-Road Transportation (VMT)	96,824,903	0.001366	MT CO_2e /mile	132,254
Off-Road Transportation	N/A[2]	N/A[2]	-	16,770
Waste (tons)[5]	81,766	0.2860	MT CO_2e /Ton	23,052
Wastewater (kWh)	N/A[3]	N/A[3]	MT CO_2e /kWh	1,366
Water (kWh)	15,344,462	0.00009635	MT CO_2e /kWh	1,479
Total Emissions				**534,334**

MWh: megawatt hours; kWh: kilowatt hours; CO_2e: carbon dioxide equivalent; MT: metric tons; VMT: vehicle miles traveled; ADC: Alternative Daily Cover
1 No natural gas usage was reported by PG&E for large industrial users after 2013 due to California Public Utilities Commission privacy rules. Natural gas emissions reported by the Lawrence Livermore National Laboratory to the California Air Resources Board as a part of the Cap-and-Trade program were added to allow for accurate comparison of emissions from nonresidential gas in previous inventory years. Data reported as a part of the Cap-and-Trade program can be found here: https://ww2.arb.ca.gov/mrr-data. All natural gas data has been provided through the EBEW inventories.
2 Off-road emissions calculated as a proportion of total emissions in Alameda County based on local population and does not have activity data.
3 Wastewater is a combination of stationery and process emissions.
4 Direct access service is retail electric service where customers purchase electricity from a competitive provider called an Electric Service Provider instead of from a regulated electric utility. An Electric Service Provider is a non-utility entity that offers electric service to customers within the service territory of an electric utility.
5 Includes 8,329 tons of Alternative Daily Cover Waste for which a different emission factor was used (.246 $MTCO_2e$/ton). This emissions factor was calculated using data from the CARB California Landfill Emissions Tool Version 1.3
Source: Rincon, 2020.

Between 2005 and 2017, the City of Livermore experienced a 26 percent reduction in total GHG emissions. During this same period, Livermore's population increased 16 percent, meaning that per-capita[12] emissions declined by 36 percent.

A 26 percent community GHG emissions reduction from 1990 levels exceeds the AB 32 target of a 15-percent reduction from 2005 levels by 2020. Table 6-4 summarizes GHG emission changes in Livermore from 2005 to 2017, and Table 6-5 summarizes changes in activity data.

Between 2005 and 2017, Livermore reduced GHG emissions in every sector except for nonresidential gas, which likely increased due the addition of Lawrence Livermore National Laboratory and Sandia National Laboratory to the City boundary in 2012. Major GHG emissions reductions were achieved in the waste and wastewater sectors, although these sectors make up smaller proportions of the Livermore's overall emissions. It is worth noting that large GHG emissions reductions from electricity usage were driven

[12] Per each person; in relation to people taken individually. In the context of GHG inventories, per-capita emissions are total community emissions divided by the total number of community residents, or an estimate of the average emissions produced by each person.

largely by PG&E's electricity fuel mix, which saw a significant decrease in carbon intensity[13] from 2005 to 2017. Although there was an increase in commercial vehicle-miles traveled (VMT), GHG emissions associated with the commercial on-road transportation sector declined because of the increased fuel efficiency of vehicles as detailed in Table 6-5 and Table 6-6.

TABLE 6-4 SUMMARY OF LIVERMORE GHG EMISSIONS CHANGES FROM 2005 TO 2017

	2005 (MT CO_2e)	2017 (MT CO_2e)	Percentage Change
Residential Electricity	49,822	19,775	-60%
Nonresidential Electricity	65,872	27,836[1]	-58%
Direct Access Electricity	15,192	6,545[2]	-57%
Residential Gas	71,139	65,896	-7%
Nonresidential Gas	29,771	57,462[1]	+93%
Solid Waste	35,008	21,006	-40%
Alternative Daily Cover Waste	3,487	2,046	-41%
Water	4,680	1,479	-68%
Wastewater	1,839	1,366	-26%
On-Road Passenger Transportation	218,684	181,900	-17%
On-Road Commercial Transportation	134,636	132,254	-2%
Off-Road Transportation[3]	88,179	16,770	-81%
Total Emissions	**718,358**	**534,334**	**-26%**
Emissions Per Capita	9.21	5.91	-36%

MT CO_2e: metric tons of carbon dioxide equivalent
1 PG&E did not report data for industrial natural usage in Livermore for 2015 and 2017 due to the CPUC's 15-15 privacy rule. Industrial natural gas usage was estimated for these years using the reported GHG emissions from the Livermore Lawrence National Laboratory for those years as a part of California's Cap-and-Trade program.
2 PG&E did not report data for direct access electricity usage in Livermore for 2017 due to the CPUC's 15-15 privacy rule and was estimated using the average of 2015 and 2016 data as they were the closest available years.
3 Off-road emissions in 2005 calculated using CARB's OFFROAD 2007 model, while 207 emissions were calculated with the updated 2017 model.
Source: Rincon, 2020.

[13] Carbon intensity is the amount of carbon by weight emitted per unit of energy consumed. For example, as the percentage of renewable energy sources used to produce electricity increases, the carbon intensity of that electricity decreases.

TABLE 6-5 SUMMARY OF LIVERMORE ACTIVITY DATA CHANGES FROM 2005 TO 2017

	2005 Activity Data	2017 Activity Data	Percent Change
Population	78,019	90,454	+16%
Residential Electricity (kWh)	223,251,790	205,232,521	-8%
Residential Gas (therms)	13,395,923	12,408,537	-7%
Nonresidential Electricity (kWh)	295,174,279	288,894,815	-2%
Adjusted Nonresidential Gas (therms)	5,606,070	10,820,445[1]	+93%
Direct Access Electricity (kWh)	39,378,526	32,283,926[2]	-18%
Wastewater (kWh)	4,546,080	3,671,304	-19%
Water (kWh)	20,975,856	15,344,462	-27%
Solid Waste (tons)	119,384	73,437	-38%
Alternative Daily Cover Waste (tons)	14,193	8,329	-41%
Passenger VMT	548,153,828	538,438,400	-2%
Commercial VMT	91,610,896	95,769,686	+5%

MT CO_2e: Metric tons of carbon dioxide equivalent; kWh: Thousand-watt hours; MWh: Million-watt hours; ADC: Alternative Daily Cover
1 Includes activity data from Lawrence Livermore National Laboratory, calculated using reported emissions to CARB as a part of the Cap-and-Trade Mandatory GHG Reporting program and the natural gas emission factor from Table 6-1.
2 Activity data for 2017 direct access electricity unavailable from PG&E due to CPUC privacy rules and was estimated for consistency with other inventory years based on an average of 2015 and 2016 direct access electricity data.
Source: Rincon, 2020.

Changes in emissions factor between 2005 and 2017 are summarized in Table 6-6.

TABLE 6-6 EMISSION FACTOR CHANGES FROM 2005 TO 2017

Category	2005 Emission Factor	2017 Emission Factor	Percent Change
Passenger VMT Emission Factor (MT CO_2e/VMT)	0.000399	0.000338	-15%
Commercial VMT Emission Factor (MT CO_2e/VMT)	0.001470	0.001366	-7%
Off-Road Emission Factor (Effective Change in Service Population)[1]	-	-	-
PG&E Elec Factor (MT CO_2e/MWh)	0.000223	0.000096	-57%

1 Off-road emissions calculated as attributed percentage of total off-road emissions in Alameda County, by individual off-road emissions category, and thus there is no activity data or emission factor for Livermore.
Source: Rincon, 2020.

6.3.2 COMMUNITY-WIDE FORECAST

Future Livermore GHG emissions were forecasted using the 2017 inventory for five different years (2020, 2025, 2030, 2040, and 2045) for both a business-as-usual (BAU) scenario and an adjusted forecast scenario to quantify expected emissions through 2045.

6.3.2.1 BUSINESS-AS-USUAL FORECAST

A BAU future GHG emissions forecast provides a forecast of how GHG emissions would change over time if consumption and activity trends were to continue as they did in 2017 and if growth were to occur as projected in the Livermore 2003-2025 General Plan and Association of Bay Area Government's future demographic forecasts. This does not include emission reductions from any regulations which would reduce local emissions. Projected changes in population and jobs for 2020, 2025, 2030, 2035, 2040, and 2045 are summarized in Table 6-7. The corresponding business-as-usual forecast results are provided in Table 6-8.

TABLE 6-7 SUMMARY OF LIVERMORE FUTURE POPULATION AND JOBS

	2017	2020	2025	2030	2035	2040	2045
Population	90,454	91,474	96,699	105,967	113,218	120,925	129,158
Jobs	48,133	48,340	48,686	49,372	50,649	51,499	52,364

Source: Rincon, 2020.

TABLE 6-8 SUMMARY OF LIVERMORE BUSINESS-AS-USUAL FUTURE GHG EMISSIONS FORECAST BY SECTOR

	2017 (MT CO_2e)	2020 (MT CO_2e)	2025 (MT CO_2e)	2030 (MT CO_2e)	2035 (MT CO_2e)	2040 (MT CO_2e)	2045 (MT CO_2e)
Residential Electricity	19,775	19,998	21,140	23,167	24,752	26,437	28,237
Nonresidential Electricity	27,836	27,956	28,156	28,553	29,291	29,783	30,283
Direct Access Electricity	6,545	6,618	6,996	7,667	8,192	8,749	9,345
Residential Gas	65,896	66,639	70,445	77,197	82,479	88,094	94,091
Nonresidential Gas	57,462	57,709	58,123	58,941	60,465	61,481	62,513
Waste	23,052	23,256	24,183	25,839	27,257	28,681	30,194
Water	1,479	1,492	1,551	1,657	1,748	1,840	1,937
Wastewater	1,366	1,378	1,433	1,531	1,615	1,699	1,789
On-Road Passenger Transportation	181,900	184,250	191,175	198,101	201,095	204,090	207,084
On-Road Commercial Transportation	132,254	132,641	134,445	136,248	138,355	140,462	142,568
Off-Road Transportation	16,770	17,763	19,418	21,073	22,746	24,419	26,092
Total Emissions	**534,334**	**539,699**	**557,066**	**579,973**	**597,996**	**615,734**	**634,133**
Emissions Per Capita	5.91	5.90	5.76	5.47	5.28	5.09	4.91

MT CO_2e: metric tons of carbon dioxide equivalent
Note: VMT data are provided by the MTC traffic demand model that are based on a variety of factors besides only projected demographic changes
Source: Rincon, 2020.

The BAU forecast shows how Livermore's emissions would change without any changes to the current conditions. While this forecast provides useful information, it predominately acts as an upper bound on GHG emissions within the city. For a more accurate depiction of GHG emissions over time, an adjusted forecast which includes the impacts of current legislation was developed.

6.3.2.2 ADJUSTED FORECAST

California has enacted multiple regulations that will reduce future emissions throughout the State. The impact of these regulations on GHG emissions have been incorporated into an adjusted forecast, which provides a more accurate picture of future emissions growth and the emission reduction the City and community will be responsible for after State regulations have been implemented. These State regulations include SB 100 (which sets a goal for reaching 100 percent electricity from renewable energy and zero-carbon sources by 2045), Title 24 building efficiency standards, and California Air Resources Board (CARB) tailpipe emissions standards (Pavley Standards, Advanced Clean Cars Program).

Calculating the difference between the adjusted forecast and the reduction targets set by the City determines the gap to be closed through City CAP policy implementation. The adjusted forecast shows that Livermore's GHG emissions will decrease by approximately 9 percent (45,639 metric tons) between 2017 and 2030, decrease by approximately 15-percent (81,400 metric tons) between 2017 and 2040, and decrease by 19 percent (99,799 metric tons) between 2017 and 2045. The summary results of the adjusted future GHG emissions forecast are provided in Table 6-9.

TABLE 6-9 SUMMARY OF LIVERMORE ADJUSTED FUTURE GHG EMISSIONS FORECAST BY SECTOR

	2017 (MT CO_2e)	2020 (MT CO_2e)	2025 (MT CO_2e)	2030 (MT CO_2e)	2035 (MT CO_2e)	2040 (MT CO_2e)	2045 (MT CO_2e)
Residential Electricity	19,775	19,998	21,140	23,167	24,752	26,437	28,237
Nonresidential Electricity	27,836	27,956	28,156	28,553	29,291	29,783	30,283
Direct Access Electricity	6,545	6,618	6,996	7,667	8,192	8,749	9,345
Residential Gas	65,896	66,639	70,445	77,197	82,479	88,094	94,091
Nonresidential Gas	57,462	57,709	58,123	58,941	60,465	61,481	62,513
Waste	23,052	23,256	24,183	25,839	27,257	28,681	30,194
Water	1,479	1,492	1,551	1,657	1,748	1,840	1,937
Wastewater	1,366	1,378	1,433	1,531	1,615	1,699	1,789
On-Road Passenger Transportation	181,900	184,250	191,175	198,101	201,095	204,090	207,084
On-Road Commercial Transportation	132,254	132,641	134,445	136,248	138,355	140,462	142,568
Off-Road Transportation	16,770	17,763	19,418	21,073	22,746	24,419	26,092
Total Emissions	**534,334**	**539,699**	**557,066**	**579,973**	**597,996**	**615,734**	**634,133**
Emissions Per Capita	5.91	5.90	5.76	5.47	5.28	5.09	4.91

Source: Rincon, 2020.

6.4 CLIMATE CHANGE HAZARD PROFILES AND IMPACTS

The impacts of climate change can manifest across time and place in a variety of ways. Primary climate change impacts, or climate stressors, include the direct consequences of a warming climate, including increases in air temperature and changes in precipitation patterns. Secondary impacts, or secondary climate stressors, result from interaction of two or more primary stressors and include changes in the habitat and lifecycle of agricultural pests, drought, extreme heat, flooding, landslides and debris flow, severe weather, and wildfire. The following section profiles each of these stressors and how they are expected to impact the City of Livermore.

6.4.1 PRIMARY CLIMATE STRESSORS

6.4.1.1 AIR TEMPERATURE

Both national and local average temperatures have been steadily trending upward since 1901. Figure 6-4, which is taken from the recent Vulnerability Assessment prepared as part of the CAP, shows observed and projected annual average maximum temperature in Livermore created by four different climate models.[14] As can be seen in Figure 6-4, projected temperature trends in Livermore are expected to consistently increase over time. Compared to 1990, annual average maximum temperatures in Livermore are expected to rise between 4.5°F and 8.7°F by the end of the century, depending on the GHG emissions scenario.[15] Annual average minimum temperatures are expected to rise between 3.2°F and 8°F by the end of the century. Increasing annual average minimum temperatures trends also indicate less cooling off at night.

[14] Rincon Consultants, Inc., 2021. City of Livermore Climate Action Plan Update, Vulnerability Assessment, https://livermoreclimateaction.com/wp-content/uploads/2020/12/Livermore-Vulnerability-Analysis-Final-2020.pdf, accessed on September 23, 2021.

[15] Rincon Consultants, Inc., 2021. City of Livermore Climate Action Plan Update, Vulnerability Assessment, https://livermoreclimateaction.com/wp-content/uploads/2020/12/Livermore-Vulnerability-Analysis-Final-2020.pdf, accessed on September 23, 2021.

Figure 6-4 Historical and Projected Annual Average Maximum Temperature in Livermore[16]

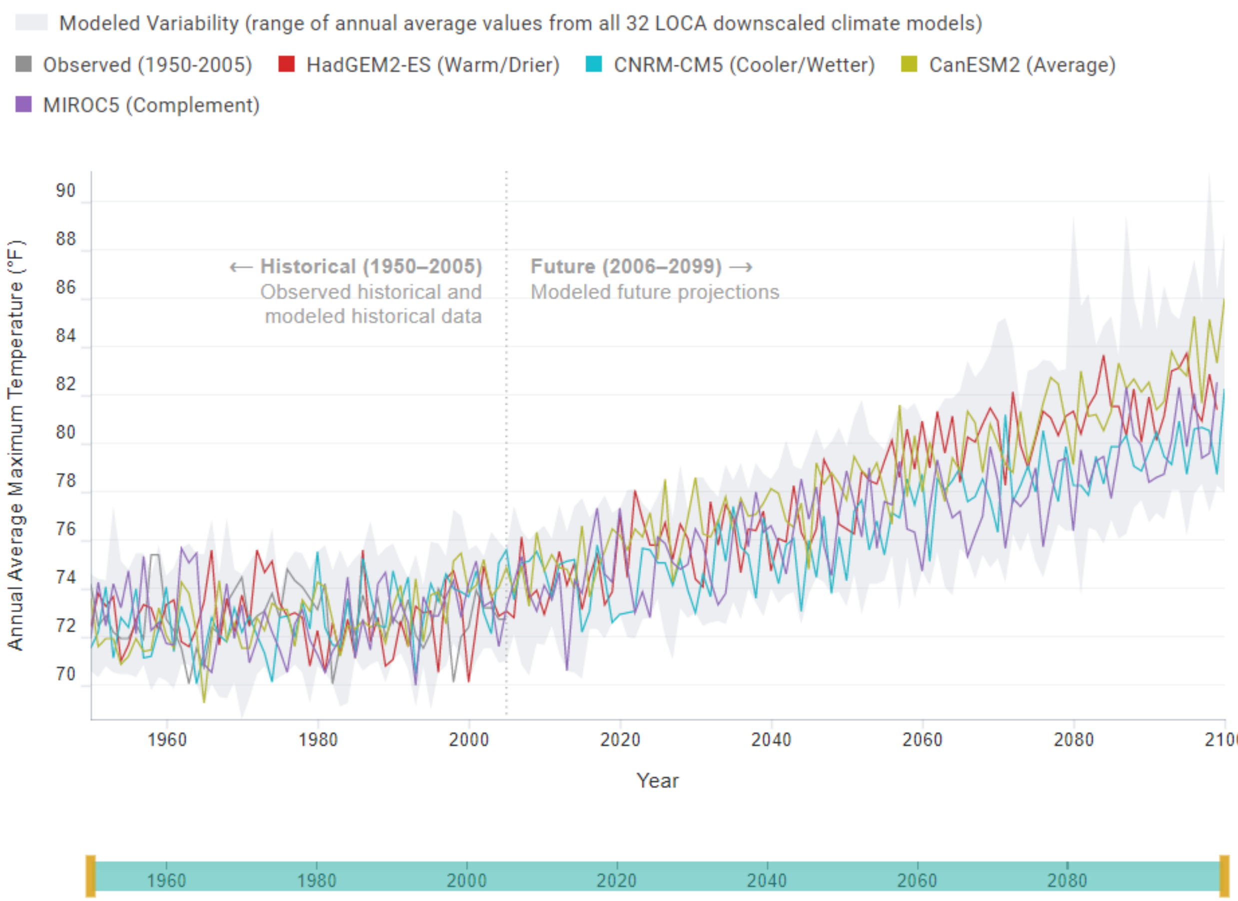


Table 6-10 depicts observed and projected temperature changes in Livermore for both RCP 4.5, the intermediate scenario,[17] and RCP 8.5, the high emissions scenario.[18] As can be seen in Table 6-10, the annual number of heat waves in Livermore, defined as four or more days over 102.7°F, is projected to increase from 0 to 3 heat waves by the end of the century, under the RCP 8.5 scenario.[19] The annual number of extreme heat days, defined as temperatures greater than 102.7°F, is projected to increase from 4 in 1990 to about 25 by the end of the century, under the RCP 8.5 scenario.[20]

[16] Chart shows annual average maximum temperature for Livermore under RCP8.5 (emissions continue to rise through the 21st century then level off)

[17] RCP 4.5: Scenario in which emissions peak around 2040 and then decline

[18] RCP 8.5: Scenario in which emissions continue to rise throughout the 21st century before leveling off

[19] Rincon Consultants, Inc., 2021. City of Livermore Climate Action Plan Update, Vulnerability Assessment, https://livermoreclimateaction.com/wp-content/uploads/2020/12/Livermore-Vulnerability-Analysis-Final-2020.pdf, accessed on September 23, 2021.

[20] Rincon Consultants, Inc., 2021. City of Livermore Climate Action Plan Update, Vulnerability Assessment, https://livermoreclimateaction.com/wp-content/uploads/2020/12/Livermore-Vulnerability-Analysis-Final-2020.pdf, accessed on September 23, 2021.

Warm nights, described as nights when daily minimum temperature is above the extreme heat threshold of 62.1°F, are expected to increase substantially from 11 in 1990 to about 101 annually by 2100 under the RCP 8.5 scenario.[21] Longer heat waves could occur due to the combination of temperature changes. Between 1950 and 1990, the longest stretch of consecutive extreme heat days per year in Livermore was 2.2 days. By the end of the century the average heat wave is projected to last just over seven days under the RCP 8.5 scenario.[22]

TABLE 6-10 TEMPERATURE CHANGES

Effect	1990 (Observed)	2030 (RCP 4.5)	2030 (RCP 8.5)	2050 (RCP 4.5)	2050 (RCP 8.5)	2099 (RCP 4.5)	2099 (RCP 8.5)
Annual average maximum temperature	73°F	76.1°F	75.9°F	77.1°F	77.1°F	77.5°F	81.7°F
Annual average minimum temperature	47.1°F	48.1°F	48.6°F	49.4°F	50.3°F	50.3°F	55.1°F
Average number of extreme heat days per year[1]	4	11	11	17	13	13	25
Average number of warm nights per year[2]	11	18	15	18	33	42	101
Average number of heat waves per year[3]	0	0.8	1.0	2.8	0.8	0.8	3.0
Max duration of heat waves (days)[4]	2	4.0	5.3	7.5	3.8	4.3	7.3

1. Number of days in year when daily maximum temperature is greater than heat threshold of 102.7°F
2. Number of nights in a year when daily minimum temperature is above extreme heat threshold of 62.1°F
3. Number of 4-day heat waves (daily maximum temperatures above extreme heat threshold of 102.7°F) by year
4. Longest stretch of consecutive extreme heat (> 102.7°F) days per year

Source: UG Berkeley & CED n.d.

6.4.1.2 PRECIPITATION

Total annual precipitation in the United States and globally has increased since 1901[23]. However, shifts in weather patterns have led to substantial decreases in precipitation in the Southwest of the United States.[24] Cal-Adapt projections are ambiguous regarding change in total annual precipitation in Livermore. Overall, the climate projection models show a slight to moderate increase in precipitation levels, although and different climate projection models predict different future precipitation patterns, as illustrated in Figure 6-5, which also comes from the Vulnerability Assessment. However, even small changes in

[21] Rincon Consultants, Inc., 2021. City of Livermore Climate Action Plan Update, Vulnerability Assessment, https://livermoreclimateaction.com/wp-content/uploads/2020/12/Livermore-Vulnerability-Analysis-Final-2020.pdf, accessed on September 23, 2021.

[22] Rincon Consultants, Inc., 2021. City of Livermore Climate Action Plan Update, Vulnerability Assessment, https://livermoreclimateaction.com/wp-content/uploads/2020/12/Livermore-Vulnerability-Analysis-Final-2020.pdf, accessed on September 23, 2021.

[23] Rincon Consultants, Inc., 2021. City of Livermore Climate Action Plan Update, Vulnerability Assessment, https://livermoreclimateaction.com/wp-content/uploads/2020/12/Livermore-Vulnerability-Analysis-Final-2020.pdf, accessed on September 23, 2021.

[24] Rincon Consultants, Inc., 2021. City of Livermore Climate Action Plan Update, Vulnerability Assessment, https://livermoreclimateaction.com/wp-content/uploads/2020/12/Livermore-Vulnerability-Analysis-Final-2020.pdf, accessed on September 23, 2021.

precipitation can cause significant impacts such as altered water availability throughout the year, decreased agricultural output in the region, and altered seasonal patterns, which could cause increased droughts and/or flooding.

Figure 6-5 Historical and Projected Annual Average Precipitation in Livermore[25]

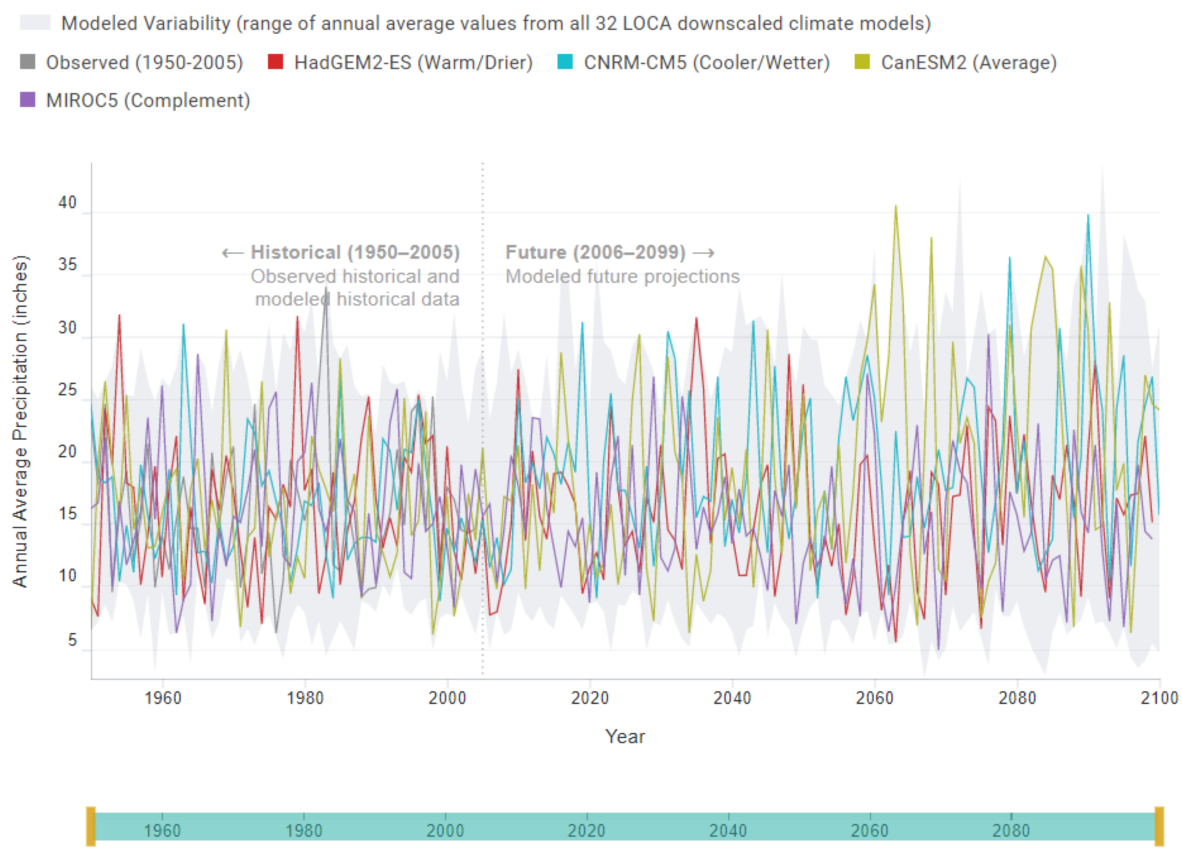


Table 6-11 summarizes projected changes in precipitation patterns in Livermore through 2099. As can be seen in Table 6-11, annual average precipitation is projected to increase somewhat by the end of the century, based on both RCP 4.5 and RCP 8.5.[26] However, as seen in Figure 6-5, considerable year-to-year variability in annual precipitation is also projected to occur the future.

Extreme precipitation events, defined as the number of days in a water year (October-September of the following year) with two-day rainfall totals above extreme threshold of one inch, is projected to increase from three in 1990 to about five mid-century, before dropping to 0 by the end of the century, under the

[25] Chart shows annual average precipitation for Livermore under RCP8.5 (emissions continue to rise through the 21st century then level off)

[26] Rincon Consultants, Inc., 2021. City of Livermore Climate Action Plan Update, Vulnerability Assessment, https://livermoreclimateaction.com/wp-content/uploads/2020/12/Livermore-Vulnerability-Analysis-Final-2020.pdf, accessed on September 23, 2021.

RCP 8.5 scenario.[27] The maximum duration of consecutive extreme precipitation events, defined as the longest stretch of consecutive days in a water year (October-September) with two-day rainfall totals above extreme threshold of 1 inch, is projected to increase slightly midcentury from 1 to 1.5 and decrease to 0 at the end of the century, under the RCP 8.5 scenario.[28]

TABLE 6-11 PROJECTED CHANGES IN PRECIPITATION PATTERNS

	1990	2030		2050		2099	
Effect	(Observed)	(RCP 4.5)	(RCP 8.5)	(RCP 4.5)	(RCP 8.5)	(RCP 4.5)	(RCP 8.5)
Annual average precipitation (inches)	9.7	15.9	17.3	23.2	21.0	17.6	19.8
Extreme precipitation events by water year[1]	3	5	5	7	5	0	0
Max duration of consecutive extreme precipitation events by year[2]	1	2	1.3	2.8	1.5	0	0

1 Number of days in a water year (Oct-Sep) with 2-day rainfall totals above extreme thresholds of 1 inch
2 Longest stretch of consecutive days in a water year (Oct-Sep) with 2-day rainfall totals above extreme threshold of 1 inch
Source: UC Berkeley & CEC n.d.

6.4.2 SECONDARY CLIMATE STRESSORS (HAZARDS)

In addition to the direct effects of climate change on people and the environment, a changing climate is expected to exacerbate a number of natural hazards that already impact Livermore. The section that follows focuses on the potential physical impacts of these hazards. It should be noted that environmental hazards and disasters may also negatively affect the physical and mental health of Livermore residents. Post-disaster recovery can cause anxiety, anger, depression, lethargy, hyperactivity, sleeplessness, and long-term anxieties that disasters and losses will reoccur again in the future.

6.4.2.1 AGRICULTURAL PESTS AND DISEASES

Livermore is home to a rich and diverse agricultural community. However, with prolific agricultural activity comes concerns about agricultural pests and diseases. As of 2002, approximately 1,640 acres of land within the Livermore City Limits were in agricultural uses. Contiguous agricultural resources are more extensive outside the City Limits. Unincorporated areas to the north, east, and west of Livermore are currently used for rangeland, dry farmland, irrigated cropland, and uncultivated farmland. Agricultural uses south of Livermore include extensive vineyards, orchards (mainly olives and nuts), rangeland, and uncultivated farmland.[29]

[27] Rincon Consultants, Inc., 2021. City of Livermore Climate Action Plan Update, Vulnerability Assessment, https://livermoreclimateaction.com/wp-content/uploads/2020/12/Livermore-Vulnerability-Analysis-Final-2020.pdf, accessed on September 23, 2021.

[28] Rincon Consultants, Inc., 2021. City of Livermore Climate Action Plan Update, Vulnerability Assessment, https://livermoreclimateaction.com/wp-content/uploads/2020/12/Livermore-Vulnerability-Analysis-Final-2020.pdf, accessed on September 23, 2021.

[29] City of Livermore, 2004. City of Livermore General Plan, 2003-2025, https://www.cityoflivermore.net/government/community-development/planning/2003-2025-general-plan, accessed on September 23, 2021.

Weeds of concern within Alameda County include hoary cresses, rush skeletonweed, white horsenettle, golden thistle, puna grass, Japanese dodder, Iberian thistle, purple star thistle, artichoke thistle, stinkwort, barb goatgrass, and medusahead. Pests of concern in include Mediterranean fruit fly, Mexican fruit fly, melon fruit fly, Oriental fruit fly, gypsy moth, light brown apple moth, Japanese beetle, European pine shoot moth, glassy-winged sharpshooter, and Asian citrus psyllid.

Climate Change Impacts on this Hazard

The elevated carbon dioxide concentrations and increasing temperatures associated with climate change will have substantial impacts on plant-insect interactions, integrated pest management programs, and the movement of nonnative insect species into California. Natural ecosystems will also be affected by the expected changes in insect diversity.

The warmer temperatures created by climate change influence insect ecology and encourage insect proliferation in a variety of ways. As temperatures rise in the Bay Area and across California, current insect pests are expected to extend their ranges into new areas. One reason for such range expansions is a change in frost patterns. As temperatures increase, the frequency of frost events declines, and the resulting extended frost-free periods increase the duration and intensity of insect outbreaks. These outbreaks can lead to substantial changes in ecosystem carbon and nitrogen cycling, biomass decomposition, and energy flows.[30] Higher temperatures will likely allow some insects to mature faster, decreasing the time between subsequent generations and enabling insects to spend more time flying around fields, reproducing, and feeding on crops[31].

Additionally, climate change, by changing atmospheric levels of CO_2, is projected to alter weed morphology such that some major weeds may become less sensitive to herbicide treatments[32].

Changes in weed and insect morphology, lifecycle, and behavior may trigger increased reliance on pesticides, which in turn can harm sensitive aquatic habitats. Increased pesticide application, coupled with extreme rainfall events that can efficiently flush agricultural cultures into rivers and streams, means that climate change can lead to high levels of chemical exposure among aquatic species.[33]

If local crop production in Livermore is to keep pace with growing demand, farmers will need new cultivars, major changes in integrated pest management (IPM) programs, and increased funding and improved response times to new pest outbreaks.

[30] University of California Office of the President, 2009. Climate change will exacerbate California's insect pest problems, http://calag.ucanr.edu/archive/?type=pdf&article=ca.v063n02p73, accessed on September 23, 2021.

[31] Gross, Lisa. In California's Farm Country, Climate Change is Likely to Trigger More Pesticide Use, Fouling Waterways. Inside Climate News, 2021 May 10, https://insideclimatenews.org/news/10052021/in-californias-farm-country-climate-change-is-likely-to-trigger-more-pesticide-use-fouling-waterways/, accessed on September 23, 2021.

[32] Varanasi, Aruna; Prasad, P.V. Vara; Jugulam, Mithila. Impact of Climate Change Factors on Weeds and Herbicide Efficacy. Abundances in Agronomy, 2016, https://www.agronomy.k-state.edu/people/faculty/jugulam-mithila/documents/A.%20Varanasi%20-%20AA%202016-review.pdf, accessed on September 23, 2021.

[33] Gross, Lisa. In California's Farm Country, Climate Change is Likely to Trigger More Pesticide Use, Fouling Waterways. Inside Climate News, 2021 May 10, https://insideclimatenews.org/news/10052021/in-californias-farm-country-climate-change-is-likely-to-trigger-more-pesticide-use-fouling-waterways/, accessed on September 23, 2021.

6.4.2.2 DROUGHT

As defined by the National Weather Service (NWS), drought is a deficiency in precipitation over an extended period, usually a season or more, resulting in a water shortage causing adverse impacts on vegetation, animals, and/or people. Drought is a normal, recurrent feature of climate that occurs in virtually all climate zones, from very wet to very dry. If the dry weather pattern lasts a short time (a few weeks or a couple of months), the drought is considered short-term. If the weather pattern becomes entrenched and precipitation deficits last for several months or years, the drought is a long-term drought. It is possible for a region to experience a long-term weather pattern that produces drought, and to have short-term changes in this long-term pattern that result in short-term wet spells. Likewise, it is possible for a long-term wet circulation pattern to be interrupted by short-term weather spells that result in short-term drought.

Determination of when drought begins requires knowledge of drought impacts on water users, including supplies available to local water users and stored water available to them in surface reservoirs or groundwater basins. Different local water agencies have different criteria for defining drought conditions within their jurisdictions. Determinations of regional or statewide drought conditions are usually based on a combination of hydrologic and water supply factors.[34]

The Sierra Nevada snowpack is the primary agent for replenishing water for much of California, including the city of Livermore. A reduction in spring snowpack runoff, whether due to drier winters or to increasing temperatures that lead to more rain instead of snow, can increase the risk of summer or fall water shortages throughout the region.[35]

Historic Conditions

In California, droughts typically occur after two or three years of below-average rainfall for the period from November to March, when about 75 percent of the State's average annual precipitation falls. Droughts are a cyclic part of the climate of the State and can occur at any time of the year, with an average recurrence interval between three and 10 years.[36] As described in Chapter 18, Utilities and Service Systems, the City of Livermore sources water from Zone 7 and the City and County of San Francisco's Hetch Hetchy supply system. As the City's water supplies rely at least in part on water supplied by the Sierra Nevada snowpack, local water supplies may be impacted by water shortages and changes in hydrological conditions occurring beyond Livermore City Limits. Recent drought periods that have affected the City of Livermore have occurred between 1976 and 1977, between 1987 and 1992, between 2007 and 2009, between 2012 and 2016, and from 2021 to the present.

[34] Tetra Tech, 2018. Tri-Valley Local Hazard Mitigation Plan, http://www.cityofpleasantonca.gov/civicax/filebank/blobdload.aspx?BlobID=35090, accessed on September 23, 2021.

[35] Tetra Tech, 2018. Tri-Valley Local Hazard Mitigation Plan, http://www.cityofpleasantonca.gov/civicax/filebank/blobdload.aspx?BlobID=35090, accessed on September 23, 2021.

In response to the drought emergency declared by Governor Brown on January 17, 2014, the Livermore City Council declared a water shortage emergency on February 24, 2014, and enacted Stage 1 Voluntary Water Conservation Measures. On April 28, 2014, the City Council enacted Stage 2 mandatory conservation measures. City Council later repealed the Stage 1 conservations measures following Governor Brown's declaration of the end of the drought emergency.

On September 27, 2021, the City of Livermore declared a State 2 Water Shortage Emergency and adopted mandatory water restrictions with the goal of reducing water use 15 percent citywide compared to 2020.[37]

Drought Impacts

Drought can have a widespread impact on the environment and the economy, although it typically does not result in direct loss of life or damage to property, as do other natural disasters. Nationwide, the impacts of drought occur primarily in the agriculture, transportation, recreation and tourism, forestry, and energy sectors. Social and environmental impacts are also significant, although it is difficult to put a precise cost on these impacts. The National Drought Mitigation Center uses three categories to describe likely drought impacts:

- Economic Impacts—Drought can cost people and businesses money: farmers' crops are destroyed; low water supply requires spending money on irrigation or to drill new wells; water-related businesses see drops in sales; water companies must spend money on new or additional water supplies.
- Environmental Impacts—Plants and animals depend on water, just like people. When a drought occurs, their food supply can shrink, and their habitat can be damaged
- Social Impacts—These impacts affect people's health and safety. Social impacts include public safety, health, conflicts between groups when there is not enough water to go around, and changes in lifestyle.

The severity of a drought depends on the degree of moisture deficiency, the duration, and the size and location of the affected area. The longer the duration of the drought and the larger the area impacted, the more severe the potential impacts. Reduced precipitation during a drought means that groundwater supplies are not replenished at a normal rate. This can lead to a reduction in groundwater levels and problems such as reduced pumping capacity or wells going dry. Shallow wells are more susceptible than deep wells. Reduced replenishment of groundwater affects streams. Much of the flow in streams comes from groundwater, especially during the summer when there is less precipitation and after snowmelt ends. Reduced groundwater levels mean that even less water will enter streams when steam flows are lowest.

[37] City of Livermore. Drought and Water Conservation, https://www.cityoflivermore.net/government/public-works/water-resources/drought-water-conservation. Accessed on September 29, 2021.

Climate Change Impacts on this Hazard

With a warmer climate, droughts could become more frequent, more severe, and longer lasting. Warming air temperatures throughout the 21st century will increase moisture loss from soils, which will lead to drier seasonal conditions even if precipitation increases. Warming air temperatures also amplify dryness caused by decreases in precipitation These changes affect both seasonal dryness and drought events[38]).

Because future changes in precipitation patterns are still uncertain, the potential impacts and likelihood of drought are uncertain. However, DWR has already noted the impact of climate change on statewide water resources by charting changes in snowpack and river flow. As temperatures rise and more precipitation comes in the form of rain instead of snow, these changes will likely continue or grow even more significant. DWR estimates that the Sierra Nevada snowpack, which provides a large amount of the water supply for the City of Livermore, will experience a 48- to 65-percent reduction from historic April 1 averages by the end of the century.[39] Increasing temperatures may also increase net evaporation from reservoirs by 15 to 37 percent[40] Increased incidence of drought may also cause a drawdown in groundwater resources without allowing opportunity for aquifer recharge.

Drought Management

California's 2005 Water Plan and subsequent updates indicate that water demand in the state will increase through 2030. The 2013 Plan Update predicts an increase in urban water demand ranging from 1 to 7 million acre-feet and a decrease in agricultural water demand ranging from 2 to 6 million acre-feet by 2050[41]. The 2018 Plan Update provides recommended actions, funding scenarios, and an investment strategy to bolster efforts by water and resource managers, planners, and decision-makers to address California's water resource challenges. It reaffirms State government's unique role and commitment to sustainable, equitable, long-term water resource management; it also introduces implementation tools to inform sound decision-making. The plan's broad and diverse portfolio of recommended actions address California's critical, systemic, and institutional challenges.

Zone 7 includes a water supply strategy in its 2020 Urban Water Management Plan to meet its planning objectives for water supply reliability, cost, water quality, environmental protection, and risk. It evaluates a range of water supply and water conservation options and recommends a strategy that includes desalination, recycled water, conservation, groundwater management and off-site banking/transfers. Zone 7 has projected water supply and demand through 2035 for normal-year, single-dry-year, and multiple-

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[38] Bedsworth, Louise, Dan Cayan, Guido Franco, Leah Fisher, Sonya Ziaja. (California Governor's Office of Planning and Research, Scripps Institution of Oceanography, California Energy Commission, California Public Utilities Commission). 2018. Statewide Summary Report. California's Fourth Climate Change Assessment. Publication number: SUMCCCA4-2018-013.

[39] Tetra Tech, 2018. Tri-Valley Local Hazard Mitigation Plan, http://www.cityofpleasantonca.gov/civicax/filebank/blobdload.aspx?BlobID=35090, accessed on September 23, 2021.

[40] Tetra Tech, 2018. Tri-Valley Local Hazard Mitigation Plan, http://www.cityofpleasantonca.gov/civicax/filebank/blobdload.aspx?BlobID=35090, accessed on September 23, 2021.

[41] California Department of Water Resources, 2018. California Water Plan Update 2018, https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/California-Water-Plan/Docs/Update2018/Final/California-Water-Plan-Update-2018.pdf, accessed on September 23, 2021.

dry-year conditions. Under normal-year conditions, the agency will have sufficient supply to meet the projected demand and to increase groundwater storage for later use in the service area.[42]

The City of Livermore first adopted a Water Shortage Contingency Plan in 1991 and updated the plan in 1996, 2005, and 2011. The Plan includes water conservation strategies in response to water shortages. During the recent droughts, Livermore Municipal Water customers followed both voluntary and mandatory conservation measures to achieve reductions in water use of 25 percent in 2014, 32 percent in 2015, and 28 percent in 2016, as compared to 2013 water use.[43] As described previously, on September 27, 2021, the City of Livermore declared a State 2 Water Shortage Emergency and adopted mandatory water restrictions with the goal of reducing water use 15 percent citywide compared to 2020.[44]

6.4.2.3 EXTREME HEAT

Extreme heat is unexpected, unusual, or unseasonable hot weather that can create dangerous situations. As defined by Cal-Adapt, an extreme heat day is a day when the daily maximum/minimum temperature exceeds the 98th historical percentile of daily maximum/minimum temperatures based on observed historical data from 1961–1990 between April and October. According to the California Climate Adaptation Strategy, heat waves have claimed more lives in California than all other declared disaster events combined.

Extreme Heat Impacts

Extreme heat is the primary weather-related cause of death in the U.S. over a 30-year average from 1987 through 2016. In 2016, heat claimed 94 lives, though none of them were in California.[45]

Community infrastructure and Livermore's transportation system may be impacted by increased temperatures. Long periods of intense heat may result in increased use of electricity for home cooling purposes that could tax the system and result in electricity restrictions or black-outs. In addition, cyclists and active commuters could be impacted by increased temperatures and could suffer from heat related illnesses making them less inclined to ride their bikes for transportation if the temperatures continue to rise. This would increase demand on other aspects of the transportation system including public transit and roadways, which may exacerbate worsening air quality conditions.

Increases in temperature could have a substantial impact on the city's economy. Vineyards and farms are an essential part of Livermore and could be affected by crop failure, transportation system issues, and decreased labor associated with extreme temperature and heat exposure.

[42] Tetra Tech, 2018. Tri-Valley Local Hazard Mitigation Plan, http://www.cityofpleasantonca.gov/civicax/filebank/blobdload.aspx?BlobID=35090, accessed on September 23, 2021.

[43] Tetra Tech, 2018. Tri-Valley Local Hazard Mitigation Plan, http://www.cityofpleasantonca.gov/civicax/filebank/blobdload.aspx?BlobID=35090, accessed on September 23, 2021.

[44] City of Livermore. Drought and Water Conservation, https://www.cityoflivermore.net/government/public-works/water-resources/drought-water-conservation. Accessed on September 29, 2021.

[45] Tetra Tech, 2018. Tri-Valley Local Hazard Mitigation Plan, http://www.cityofpleasantonca.gov/civicax/filebank/blobdload.aspx?BlobID=35090, accessed on September 23, 2021.

Climate Change Impacts

Climate change will likely exacerbate all of the existing negative impacts of extreme heat, and may place additional strain on public health, ecological, and economic systems as extreme heat becomes more frequent and intense.

High temperatures may contribute to a reduced water supply. Higher temperatures result in earlier melt of the Sierra snowpack and drive the snowline higher, resulting in less snowpack to supply water to California users.[46] With temperatures expected to increase and snowpack expected to decrease, there may be an increase in the reliance on the Livermore Valley Groundwater Basin, putting pressure on local water supply.

Prolonged and extreme high heat events could lead to increased incidence of heat-related health concerns, such as cardiovascular disease; exacerbation of asthma, allergies, and chronic obstructive pulmonary disease; premature death; cardiovascular stress and failure; and heat-related illnesses such as heat stroke, heat exhaustion, and kidney stones.[47]

Some communities and individuals are more vulnerable to the health impacts of heat than others. Those in Livermore without health insurance and living in poverty are particularly vulnerable. With anticipated increases in temperatures, economically disadvantaged residents may find it more difficult or impossible to afford the additional costs of cooling their homes. Consequently, many low-income households, especially those of seniors and individuals with disabilities will be particularly vulnerable to the effects of extreme heat events. Additional vulnerable groups include individuals with disabilities or compromised immune systems, children playing outdoors, tourists, farm workers, and others working outdoors.

Additionally, rising temperatures may indirectly impact human health through increases in the incidence of vector borne disease.[48] The distribution of insects may expand through increased reproductive rate, biting behavior, and survival. This is expected to result in pathogens developing and spreading more quickly; susceptibility to disease may increase.

As rising temperature impacts public health, community resources such as hospitals and various doctors' offices and medical entities may be impacted by an increased need for various health care services including heat and respiratory care.

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[46] Rincon Consultants, Inc., 2021. City of Livermore Climate Action Plan Update, Vulnerability Analysis, https://livermoreclimateaction.com/wp-content/uploads/2020/12/Livermore-Vulnerability-Analysis-Final-2020.pdf, September 23, 2021.

[47] Rincon Consultants, Inc., 2021. City of Livermore Climate Action Plan Update, Vulnerability Analysis, https://livermoreclimateaction.com/wp-content/uploads/2020/12/Livermore-Vulnerability-Analysis-Final-2020.pdf, September 23, 2021.

[48] Rincon Consultants, Inc., 2021. City of Livermore Climate Action Plan Update, Vulnerability Analysis, https://livermoreclimateaction.com/wp-content/uploads/2020/12/Livermore-Vulnerability-Analysis-Final-2020.pdf, September 23, 2021.

6.4.2.4 INLAND FLOODING

Flooding is a temporary overflow of water onto land that is normally dry. Floods are the most common natural disaster in the United States and may result in significant damage to infrastructure, ecosystems, and private property, as well as injury, illness, and death.

Types of Flooding

Existing flood hazards in Livermore are discussed and mapped in Chapter 14, Hydrology and Water Quality, which also summarizes relevant federal and State regulations regarding floodplain management and flood insurance.

Three main types of flooding may occur within the City of Livermore:

- Stormwater Runoff Flooding - Urban drainage systems are designed to remove surface water from developed areas as quickly as possible to prevent flooding on streets and in other urban areas. Traditionally, these conveyance systems channel water away from urbanized areas to surrounding arroyos and streams, bypassing natural processes of water filtration through the ground, containment, and evaporation of excess water. If stormwater runoff exceeds the capacity of the drainage system, then stormwater runoff flooding can result throughout the system's service area. Stormwater runoff flooding generally occurs in flat areas. Although new urban development is required to comply with federal, State, and local requirements to capture and retain stormwater, replacing undeveloped land with impervious surfaces risks increasing the amount and rate of stormwater runoff.
- Riverine Flooding- Riverine flooding is the overbank flooding of rivers and streams. Flooding in large river systems typically results from large-scale weather systems that generate prolonged rainfall over a wide geographic area, causing flooding in hundreds of smaller streams, which then drain into major rivers. Two types of flood hazards are generally associated with riverine flooding: Inundation and channel migration. Inundation occurs when there is floodwater and debris flowing through an area that is not normally covered by water. Such events cause minor to severe damage, depending on the velocity and depth of flows, the duration of the flood event, the quantity of logs and other debris carried by the flows, and the amount and type of development and personal property along the floodwater's path. Channel migration is erosion that results from the wearing away of banks and soils due to flowing water. This erosion, combined with sediment deposition, causes the migration or lateral movement of a river channel across a floodplain.
- Flash Flooding- The National Weather Service defines flash flooding as follows:[49] "[A] rapid and extreme flow of high water into a normally dry area, or a rapid water level rise in a stream or creek above a predetermined flood level, beginning within 6 hours of the causative event (e.g., intense rainfall, dam failure). However, the actual time threshold may vary in different parts of the country. Ongoing flooding can intensify to flash flooding in cases where intense rainfall results in a rapid surge of rising flood waters." Flash floods are capable of stalling or flipping vehicles, tearing out trees,

[49] Tetra Tech, 2018. Tri-Valley Local Hazard Mitigation Plan, http://www.cityofpleasantonca.gov/civicax/filebank/blobdload.aspx?BlobID=35090, accessed on September 23, 2021.

undermining buildings and bridges, and scouring new channels. In urban areas, flash flooding is an increasingly serious problem due to the removal of vegetation and replacement of ground cover with impermeable surfaces such as roads, driveways, and parking lots. The greatest risk from flash floods is that they occur with little to no warning. The major factors in predicting potential damage are the intensity and duration of rainfall and watershed and stream steepness.

Historic Flood Conditions

Flooding in Livermore typically occurs during the rainy season, between November and April. According to NOAA NCEI, Alameda County has experienced 122 flood and flash flood events since 1996.[50] Table 6-12 lists some of the most significant events.

TABLE 6-12 FLOOD EVENTS IN THE TRI-VALLEY AREA

Event Date	Location	Description
February 21, 2017	Alameda County - Countywide	Widespread rain caused flooding, debris flow, accidents, and overtopping of reservoir spillways. In Livermore and Pleasanton, there were multiple road closures including westbound 580, westbound Stanley Blvd, and Happy Valley Road. Ten people were stranded by flash flood in Livermore along Collier Canyon Road
February 9, 2017	Alameda County - Countywide	Strong wind and heavy rain produced road flooding and debris flows
November 30, 2014	Tri-Valley area	Rain and wind brought a few downed trees and minor urban flooding. Heavy rain produced flooding on Interstate 580 onramp in Dublin and two westbound lanes were flooded in Livermore
October 13, 2009	Northern and Central California	Heavy rain and wind downed numerous trees and power lines
March 29 – April 16, 2006	Alameda County – Countywide	Strong storms brought heavy rain to most of Alameda County causing landslides, eroding hillsides and cracked pavement. Oversaturated earth also caused landslide and/or erosion problems to private properties, which spilled over onto public rights-of-way
December 17, 2005 – January 12, 2006	Bay Area including Alameda County	Storms were blamed for two deaths from falling trees, around 50 businesses were declared damaged, and three homes were nearly wiped out by mudslides. The event included severe storms, flooding, mudslides, and landslides.
February 3, 1998	Tri-Valley area	A levee breach along Arroyo Mocha damaged roads and property in Dublin and Livermore
December 28, 1996 – April 1, 1997	48 counties including Alameda County	300 square miles in northern California were flooded and over 12,000 people were evacuated. Levee breaks were reported across the Sacramento and San Joaquin Valleys. Over 23,000 homes, businesses, agricultural lands, bridges, and roads were damaged. Eight deaths resulted from this event

[50] Tetra Tech, 2018. Tri-Valley Local Hazard Mitigation Plan, http://www.cityofpleasantonca.gov/civicax/filebank/blobdload.aspx?BlobID=35090, accessed on September 23, 2021.

TABLE 6-12 FLOOD EVENTS IN THE TRI-VALLEY AREA

Event Date	Location	Description
January 3, - February 10, 1995; and February 13 – April 19, 1995	42 counties including Alameda County	Winter storms, flooding and landslides impacted a large area of the state. Storms in the Sacramento River Basin resulted in small stream flooding due to drainage system failures. Over 100 stations recorded their greatest one-day rainfall in history. Thirty-eight deaths occurred
February 12 – March 10, 1996	Bay Area including Alameda County	The event damaged over 12,000 homes, destroyed over 1,300 homes, and caused 13 deaths and 67 injuries in California
January 21 – March 30, 1983	40 counties including Alameda County	Heavy rains, high winds, flooding, and levee breaks occurred across the state
February 10, 1970	Bay Area including Alameda County	Heavy winds, storms, and flooding impacted the Bay Area, including Alameda County,

Source: Tetra Tech, 2018.

Flood Impacts

The principal factors affecting flood damage are flood depth and velocity. The deeper and faster flood flows become, the more damage they can cause. Shallow flooding with high velocities can cause as much damage as deep flooding with slow velocity. This is especially true when a channel migrates over a broad floodplain, redirecting high velocity flows and transporting debris and sediment. Flood severity is often evaluated by examining peak flow.

The most problematic secondary hazard for flooding is bank erosion, which in some cases can be more harmful than actual flooding. This is especially true in the upper courses of rivers with steep gradients, where floodwaters may pass quickly and without much damage, but scour the banks, edging properties closer to the floodplain or causing them to fall in. Flooding is also responsible for hazards such as landslides when high flows over-saturate soils on steep slopes, causing them to fail. Hazardous materials spills are also a secondary hazard of flooding if storage tanks rupture and spill into streams, rivers, or storm sewers.

Floods and their aftermath present numerous threats to public health and safety, including food and water contamination, mosquito infestation, growth of mold and mildew, and carbon monoxide poisoning. When reentering and cleaning flooded homes and buildings, electrical power systems can become hazardous. Gas leaks can trigger fire and explosion. Flood debris—such as broken bottles, wood, stones, and walls—may cause injuries to those cleaning damaged buildings. People who live through a devastating flood can experience long-term psychological impacts. The expense and effort required to repair flood-damaged homes places severe financial and psychological burdens on the people affected.

During intense storms and precipitation events, the local economy may be impacted through more frequent disruption to community services, such as power outages. Additionally, a flooded structure or agricultural field could result in increased expenses and disruption to work.

The 2018 Tri-Valley Local Hazard Mitigation Plan identifies assets that are vulnerable to flood impacts, as summarized in Table 6-13.

TABLE 6-13 ASSETS VULNERABLE TO FLOOD DAMAGE WITHIN LIVERMORE

	10-year floodplain	100-year floodplain	500 year floodplain
Population	212 (0.2%)	212 (0.2%)	5,340 (6.0%)
Structures	80	80	1,698
Critical Facilities/Infrastructure	15	16	35

Source: Tetra Tech, 2018.

Additionally, the following major roads pass through the 100-year floodplain:

- State Highway 84 / Isabel Avenue
- East Stanley Boulevard
- First Street
- Murietta Boulevard
- Livermore Avenue
- Holmes Street
- P Street
- East Avenue
- Vasco Road
- Jack London Boulevard

Some of these roads are built above the flood level, and others function as levees to prevent flooding. Still, in severe flood events these roads can be blocked or damaged, preventing access to some areas.

Flooding is a natural event, and floodplains provide many natural and beneficial functions. Nonetheless, flooding can impact the environment in negative ways. Migrating fish can wash into roads or over dikes into flooded fields, with no possibility of escape. Pollution from roads, such as oil, and hazardous materials can wash into rivers and streams. During floods, these can settle onto normally dry soils, polluting them for agricultural uses. Human development such as bridge abutments and levees can increase stream bank erosion, causing rivers and streams to migrate into non-natural courses.

Climate Change Impacts on this Hazard

Climate change is already impacting water resources, changing precipitation and runoff patterns. Extreme climatic events will become more frequent, necessitating improvement in flood protection, drought preparedness and emergency response.

Use of historical hydrologic data has long been the standard of practice for designing and operating water supply and flood protection projects. This method of forecasting assumes that the climate of the future will be similar to that of the period of historical record. However, the hydrologic record cannot be used to predict changes in frequency and severity of extreme climate events such as major floods.

Scientists project greater storm intensity with climate change, resulting in more direct runoff and flooding. High frequency flood events (e.g., 10-year floods) in particular will likely increase with a changing climate. What is currently considered a 1-percent-annual-chance flood may strike more often, leaving many communities at greater risk. Going forward, scientists must develop flood models that take into account expected changes in flood frequency and intensity, adopting a standard of practice that explicitly considers climate change.

As stream flows and velocities change, erosion patterns will also change, altering channel shapes and depths, possibly increasing sedimentation behind dams, and affecting habitat and water quality. With potential increases in the frequency and intensity of wildfires due to climate change, there is potential for more floods following fire, which increase sediment loads and water quality impacts.

Critical facility exposure and vulnerability may increase as a result of climate change impacts on flooding hazard. Runoff patterns may change, resulting in risk to facilities that have not historically been at risk from flooding. Changes in the management and design of flood protection critical facilities may be needed as additional stress is placed on these systems. Planners will need to factor a new level of safety into the design, operation, and regulation of flood protection facilities such as dams and bypass channels, as well as the design of local sewers and storm drains.

Increased flooding may result in water and wastewater treatment plants being unable to handle increases in intense rainfall events and associated runoff. This could impede the proper functioning of on-site septic systems or overwhelm sewers and centralized sewage treatment plants. As a result, untreated water with a full load of toxics and organic waste could enter streams and the ocean.

Flooding may impact the city’s transportation network, inhibiting movement of people and goods. Emergency response systems would similarly be affected by flooding through restricted access to and from emergency response systems, increasing wait times for these crucial services. Emergency communication may be impacted if electricity transmission is interrupted or if water and other natural resources are unavailable.

6.4.2.5 LANDSLIDES AND DEBRIS FLOWS

Landslides and mudslides can be initiated by storms, earthquakes, fires, volcanic eruptions, or human modification of the land. They can move rapidly down slopes or through channels and can strike with little or no warning at avalanche speeds. According to the USGS, the term landslide includes a wide range of ground movement, such as rock falls, deep failure of slopes, and shallow debris flows. Landslide risk in Livermore is discussed in more detail in Chapter 11, Geology and Soils.

In and around the City of Livermore, landslides typically occur during and after major storms, so the potential for landslides largely coincides with the potential for sequential severe storms that saturate steep, vulnerable soils. As mapped and discussed in Chapter 11, Geology and Soils, the City of Livermore has a range of low to high susceptibility to deep-seated landslides; therefore, the frequency of landslide events in these areas is considered moderate to high.

Approximately 8,403 Livermore residents (approximately 10 percent of the City's population) live in a low landslide susceptibility zone, 2,911 (approximately 3 percent) live in a moderate landslide susceptibility zone, 2,641 (approximately 3 percent) in a high landside susceptibility zone, and 3 in a very high landslide susceptibility zone. Additionally, 25,790 Livermore structures are located within a low landslide susceptibility zone, 871 are located within a moderate landslide susceptibility zone, 876 in a high landslide susceptibility zone, and 2 within a very high landslide susceptibility zone.

Historical Context

Landslides in the Bay Area typically occur either as a result of an earthquake or during heavy and sustained rainfall events. The City of Livermore has sustained damage from landslides caused by storms, as seen in Table 6-14.

TABLE 6-14 LANDSLIDE EVENTS WITHIN AND AROUND THE CITY OF LIVERMORE

Event Date	Event Type	Location	Description
February 20, 2017	Slide	Livermore	Slide blocked at least one lane east bound 84 just west of Vallecitos and Tesla Road closed from mudslide
November 2, 2015	Mudslide	Livermore/ Unincorporated county	Heavy rain caused mudslide or Patterson Pass Road, Tesla Road and Corrall Hollow Road, east of Livermore
April 6-20, 2006	Heavy rain and debris flow	Alameda County	Heavy rains caused landslides, eroding hillsides and cracked pavement. Landslide or erosion problems or private properties spilled out onto county rights-of-way
December 17, 2005 – January 12, 2006	Winter storms	Alameda County	Severe storms brought flooding, mudslides, and landslides to most of Alameda County
February 1995	Late winter storms (severe winter storms, flood, landslide, mudflows)	Statewide	All California counties except Del Norte were affected by severe late winter storms.

Source: Tetra Tech, 2018.

Landslide and Debris Flow Impacts

Landslides destroy property and infrastructure and can take human lives. Landslides can pose a serious hazard to properties on or below hillsides. When landslides occur — in response to such changes as increased water content, earthquake shaking, addition of load, or removal of downslope support — they deform and tilt the ground surface. The result can be destruction of foundations, offset of roads, breaking of underground pipes, or overriding of downslope property and structures.

Landslides can cause several types of secondary effects, such as blocking access to roads and damaging bridges, which can isolate residents and businesses and delay commercial, public, and private transportation. This could result in economic losses for businesses. Other potential problems resulting from landslides are power and communication failures. Vegetation or poles on slopes can be knocked over, resulting in possible losses to power and communication lines. Landslides can also destabilize the foundation of structures, which may result in monetary loss for residents. They also can damage rivers or streams, potentially harming water quality, fisheries, and spawning habitat.

Climate Change Impacts on This Hazard

Climate change may impact storm patterns, increasing the probability of more frequent, intense storms with varying duration. Increase in global temperature is likely to affect the snowpack and its ability to hold and store water. Warming temperatures also could increase the occurrence and duration of droughts, which would increase the probability of wildfire, reducing the vegetation that helps to support steep slopes. These factors would increase the probability for landslides.

6.4.2.6 SEVERE WEATHER

Severe weather refers to any dangerous meteorological phenomena with the potential to cause damage, serious social disruption, or loss of human life. It includes thunderstorms, downbursts, tornadoes, waterspouts, snowstorms, ice storms, and dust storms. Severe weather can be categorized into two groups: systems that form over wide geographic areas are classified as general severe weather; those with a more limited geographic area are classified as localized severe weather.

Severe Storms

Severe storm conditions within and around the City of Livermore include heavy rain (atmospheric rivers and thunderstorms), lightning, and hail. Heavy rain refers to events where the amount of rain exceeds normal levels.

An atmospheric river is a common weather pattern that brings southwest winds and heavy rain to California. Atmospheric rivers are long, narrow regions in the atmosphere that transport water vapor carried away from the tropics. These columns move with the weather, carrying large amounts of water vapor and strong winds. When they make landfall, they often release the water vapor in the form of heavy rain or snow.

A thunderstorm is a heavy rain event that includes thunder and lightning. A thunderstorm is classified as "severe" when it contains one or more of the following: hail with a diameter of three-quarter inch or greater, winds gusting in excess of 50 knots (57.5 mph), or tornado. Three factors cause thunderstorms to form: moisture, rising unstable air (air that keeps rising when disturbed), and a lifting mechanism to provide the disturbance. Thunderstorms are usually short in duration (seldom more than two hours). Heavy rains associated with thunderstorms can lead to flash flooding during the wet or dry season.

Lightning is an electrical discharge that results from the buildup of positive and negative charges within a thunderstorm. When the buildup becomes strong enough, lightning appears as a "bolt." This flash of light usually occurs within the clouds or between the clouds and the ground. Lightning is a major threat during a thunderstorm.

Hail occurs when updrafts in thunderstorms carry raindrops upward into extremely cold areas of the atmosphere where they freeze into ice and then fall to the ground.

Damaging Winds

Damaging winds are classified as those exceeding 60 mph. Damage from such winds accounts for half of all severe weather reports in the lower 48 states and is more common than damage from tornadoes. Wind speeds can reach up to 100 mph and can produce a damage path extending for hundreds of miles.

Windstorms are generally short-duration events involving straight-line winds or gusts of over 50 mph, strong enough to cause property damage. Windstorms are especially dangerous in areas with significant tree stands and areas with exposed property, poorly constructed buildings, mobile homes (manufactured housing units), major infrastructure, and above-ground utility lines. A windstorm can topple trees and power lines, cause damage to residential, commercial, and critical facilities, and leave tons of debris in its wake.

Severe Weather Impacts

The most common problems associated with severe weather conditions are immobility and loss of utilities. Fatalities are uncommon but can occur. Roads may become impassable due to flooding, downed trees, or a landslide. Power lines may be downed due to high winds, and services such as water or phone may not be able to operate without power. Lightning can cause severe damage and injury. Physical damage to homes and facilities can be caused by wind or flooding. Atmospheric rivers or heavy precipitation, which in Livermore almost always takes the form of rain, can have significant impacts, including crop damage, soil erosion, and increased risk of flood. These events can drop up to 12 inches of rain over a few days and cause widespread flooding and disruption to road and air travel. Stormwater runoff from heavy rains can also impair water quality by washing pollutants into water bodies. Thunderstorms carry the same risks as heavy precipitation events, and depending on the type of storm, they can also result in tornados, lightning, and heavy winds, increasing risk of injury and property damage.

Lightning severity is typically associated with property damage, injuries, and fatalities. The number of reported injuries from lightning is likely to be low, but infrastructure losses can be up to thousands of dollars each year. Lightning also is associated with wildfire ignitions within and around Livermore.

Windstorms can be a frequent problem within and around Livermore and have been known to cause damage to utilities. Strong, hot, dry offshore winds locally known as “Diablo winds” can be particularly dangerous. These winds can occur at any time of year but are especially dangerous in the driest months of summer and fall when vegetation is at its driest and most flammable.

Incapacity and loss of roads are the primary transportation failures resulting from severe weather, mostly associated with secondary hazards. Landslides caused by heavy prolonged rains can block roads. High winds can cause significant damage to trees and power lines, blocking roads with debris, incapacitating transportation, isolating populations, and disrupting ingress and egress. Of particular concern are roads providing access to isolated areas and to the elderly. Prolonged obstruction of major routes due to landslides, snow, debris, or floodwaters can disrupt the shipment of goods and other commerce. Large, prolonged storms can have negative economic impacts for an entire region. Severe windstorms, downed trees, and ice can create serious impacts on power and above-ground communication lines. Freezing of power and communication lines can cause them to break, disrupting electricity and communication. Loss of electricity and phone connection would leave certain populations isolated because residents would be unable to call for assistance.

All critical facilities exposed to flooding are also likely exposed to severe weather. Additional facilities on higher ground may also be exposed to wind damage or damage from falling trees.

The environment is highly exposed to severe weather events. Natural habitats such as streams and trees are exposed to the elements during a severe storm and risk major damage and destruction. Prolonged rains can saturate soils and lead to slope failure. Flooding events caused by severe weather or snowmelt can produce river channel migration or damage riparian habitat.

Climate Change Impacts on this Hazard

Climate change impacts on severe weather events such as thunderstorms and high winds are still not well understood.

6.4.2.7 WILDFIRE

A wildfire is any uncontrolled fire occurring on undeveloped land that requires fire suppression. Wildfires can be ignited by lightning or by human activity such as smoking, campfires, equipment use, and arson. Wildfire risk in Livermore, as well as both primary and secondary effects of wildfire, are discussed and mapped in Chapter 19, Wildfire.

Climate Change Impacts on this Hazard

Wildfire conditions are influenced by climate variability, local topography, and human activity. Climate change has the potential to affect multiple elements of the wildfire system: fire behavior, ignitions, fire management, and vegetation fuels. Hot dry spells create the highest fire risk. Increased temperatures may intensify wildfire danger by warming and drying out vegetation.

Changes in climate patterns may impact the distribution and perseverance of insect outbreaks that create dead trees (increase fuel). When climate alters fuel loads and fuel moisture, forest susceptibility to wildfires changes.

The Cal-Adapt projections for wildfire risk in Livermore is projected to decrease over this century.

Research has shown that there is great spatial variability in wildfire risk based on climate variability and trends, and in some regions, vegetation may be reduced by drought conditions and thus reduce fuel available to burn[51] . It is unclear whether this is the scenario applicable to Livermore. Despite the

[51] Rincon Consultant, Inc., 2021. City of Livermore Climate Action Plan Update, Vulnerability Analysis, https://livermoreclimateaction.com/wp-content/uploads/2020/12/Livermore-Vulnerability-Analysis-Final-2020.pdf, September 23,2021.

projected decline in wildfire risk for the Livermore area, wildfire remains a serious hazard to public health and safety in other parts of the East Bat, that may increase with climate change.[52]

Although the direct impact of wildfire to community structures in the City is expected to remain low, secondary impacts of wildfire, such as decreased air and water quality, could indirectly affect the Livermore economy. Air pollution from wildfires could impact vulnerable workers, reduce tourism, and directly impact the health of community members. Vulnerable populations such as individuals with compromised immune systems, seniors, children, and outdoor workers are likely to be impacted most by these secondary impacts.

6.5 IMPLICATIONS FOR THE GENERAL PLAN UPDATE

Planning for climate change-related impacts can be difficult because of the inherent uncertainty in projected future impacts. Some impacts of climate change are poorly understood or can be hard to predict with high accuracy, such as potential impacts on the frequency and severity of severe weather, drought, and landslides.

Based on information contained in this chapter, the General Plan Update should consider the following:

- Identifying future water sources and water efficiency measures for agriculture and reducing hazards faced by agricultural workers.
- Identifying opportunities to proactively plan for drought, including identifying new water supplies.
- Monitoring the implementation of long-term reliable water supply strategy projects, Bay Area Water Supply and Conservation Agency Water Conservation Implementation Plan projects, and water system upgrades.
- Continuing to develop and implement diverse water conservation measures, even during non-drought periods.
- Addressing the disproportionate impacts of high temperatures on neighborhoods with limited green space.
- Exploring ways of increasing equitable access to cooling centers and other heat-relieving tools.
- Possible protections for workers whose health may be jeopardized by high heat.
- Providing public outreach and education regarding upcoming heat events, their health effects, and available resources for heat management.
- Monitoring climate change's impact on landslide activity and risks and exploring opportunities for designing hazard mitigation programs and policies that can address landslide, wildfire, and flood risk simultaneously.
- Providing protections for older structures that may be more vulnerable to severe weather impacts.

[52] Rincon Consultant, Inc., 2021. City of Livermore Climate Action Plan Update, Vulnerability Analysis, https://livermoreclimateaction.com/wp-content/uploads/2020/12/Livermore-Vulnerability-Analysis-Final-2020.pdf, September 23,2021.

- Ensuring redundancy of power supply and communication equipment as well as availability of backup power generation.
- Public education regarding preparation for severe weather events.
- Planning ahead for debris management.
- Defining the City's role in offering social and/or mental health services to community members affected by disasters. Continuing to support integrated efforts to monitor and evaluate GHG emission-reduction policies and programs, secure funding for implementing GHG reduction efforts, identify opportunities to collaborate with local stakeholders on GHG reductions, and help to identify and prioritize the needs of vulnerable communities and assets in climate change response.

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