

2 EXISTING HAZARDS ASSESSMENT

This section provides an overview of local and regional plans, as well as a summary of existing hazards in the City that are anticipated to be affected by climate change. Plans and resources reviewed are the City's annex to the San Luis Obispo County Multi-Jurisdictional Hazard Mitigation Plan (HMP) (San Luis Obispo County 2019a), the current General Plan Safety Element (City of San Luis Obispo 2014), the California Governor's Office of Emergency Services' MyHazards mapping tool, Cal-Adapt, the California Heat Assessment Tool, the California Healthy Places Index (HPI), and geographic information system (GIS) data from the California Department of Transportation GIS Open Data and the City and County of San Luis Obispo Open Data Repository.

This section also includes background information on the overall climate and topography in the region and includes a detailed discussion of three existing hazards that may be exacerbated by climate change: flooding, extreme heat, long-term drought, and wildfire. Statistics and figures are provided to illustrate the extent of past impacts and geographic areas at risk for each hazard.

2.1 LOCAL AND REGIONAL PLANS

This section provides a general summary of local and regional plans related to existing hazards and describes how they can support increasing the City's resilience to the current and future impacts of climate change. The plans discussed in this section were used to develop this Report and help establish a planning framework to be used during various stages of the Resilient SLO development process.

2.1.1 San Luis Obispo County Multi-Jurisdictional Hazard Mitigation Plan

The HMP assesses all current human-made and natural hazards in San Luis Obispo County (County) and the incorporated cities in the County, including the City of San Luis Obispo. It also provides practical and cost-effective mitigation solutions to reduce the County's vulnerability to hazards and reduce both human and financial losses from hazardous events (San Luis Obispo County 2019a). The HMP, which was last updated in October 2019, includes community profiles for the incorporated cities, community services districts, and special districts in the County. The HMP and City specific Annex G acknowledges the role climate change will play in exacerbating future hazards and recognizes the importance of preparing climate-specific hazard mitigation strategies. Climate change considerations are discussed for each hazard. The following hazards discussed in the HMP specifically relate to climate change:

- ▶ adverse weather (e.g., thunderstorms, high winds, extreme heat);
- ▶ agricultural pest infestation, plant disease (e.g., tree mortality), and invasive species;
- ▶ naturally occurring biological agents (e.g., vector borne diseases);
- ▶ coastal storms, erosion, and sea level rise;
- ▶ dam failure;
- ▶ drought and water shortage;
- ▶ flooding;
- ▶ landslides and debris flow;
- ▶ soil hazards and land subsidence; and
- ▶ wildfires.

Annex G of the HMP (San Luis Obispo County 2019b), a community profile specific to the City, supersedes the City's previous Local Hazard Mitigation Plan (LHMP), which was first published in 2006 with an update in 2014. Annex G provides an in-depth discussion of the City's climate, economy, and demographics and presents an assessment of the City's vulnerability to natural and human-made hazards. Annex G also includes a capability assessment that provides an inventory of existing regulatory tools (e.g., ordinances, plans), personnel resources, financial resources (e.g., grants, fees), and partnerships that are currently used or could be used in the future to implement hazard mitigation activities. A mitigation action plan was developed, based on the capability assessment, and identifies mitigation strategies for each of the hazards discussed in the HMP.

Annex G of the HMP includes a detailed description of the planning process used to produce the plan, background information about the City, a hazard risk assessment, a capability assessment, mitigation strategies, and an implementation and monitoring plan. Annex G of the HMP also includes the following goal specific to preparing for climate impacts in the City. The Resilient SLO planning process supports objectives 3.A and 3.B.

GOAL 3: Prepare for and adapt to the impacts of climate change.

- ▶ **Objective 3.A:** Use, and update as needed, the best available science to estimate exposure, vulnerability, and risk of hazards as the result of climate change.
- ▶ **Objective 3.B:** Use the climate change exposure, vulnerability, and risk assessments to ensure mitigation investments, capital projects, and programs actively mitigate climate impacts.

2.1.2 City of San Luis Obispo General Plan Safety Element

The City's current General Plan Safety Element (City of San Luis Obispo 2014), which was adopted in 2000 and last revised in 2014, identifies goals and policies to avoid or minimize the loss of life, property, and prosperity that can result from disasters and to help the City and its residents recover quickly from unavoidable disaster events. The Safety Element identifies the level of risk for various hazards by evaluating the probability of loss, the City's capacity to reduce risks, the potential severity of loss, and the adequacy of knowledge about the hazard.

Hazards discussed in the Safety Element include flooding, fire, earthquakes and geologic hazards, hazardous materials, electromagnetic fields, airport hazards, and hazardous trees. The Safety Element also identifies programs and policies to aid the City in avoiding and preparing for emergencies, such as investing in City staff training, implementing the Standardized Emergency Management System, engaging citizens in preparedness education, and maintaining an Emergency Operations Center Plan. Although the City's current Safety Element does discuss climate-related hazards (e.g., wildfire, flooding), it does not include a discussion of climate change or assess how various hazards will be affected or exacerbated by climate change.

2.1.3 Urban Water Management Plan

In 2015, the City adopted the Urban Water Management Plan (UWMP) which evaluates the City's current and projected water supplies through the year 2035. The UWMP was prepared in accordance with the Urban Water Management Planning Act (Act), and; accordingly, will be updated every 5 years and submitted to the California Department of Water Resources. Goals in the UWMP related to this Report include the following:

- ▶ assess current and future water use trends in the community;
- ▶ summarize the water supply and the water system;
- ▶ assess water supply reliability;
- ▶ document the water demand;
- ▶ manage measures in place to balance supply and demand; and
- ▶ demonstrate compliance with SB X7-7 which requires the City to develop urban water use targets to help meet the goal of a 20 percent reduction goal by 2020.

2.1.4 Waterway Management Plan

In 2003, the City developed and adopted its current Waterway Management Plan in coordination with the San Luis Obispo County Flood Control and Water Conservation District Zone 9 Advisory Committee. The purpose of this plan is to adopt an approach and schematic plans to address flooding, erosion, water quality, and ecological issues in the San Luis Obispo Creek Watershed that can be implemented with approval from various regulatory agencies. The plan includes five key components to achieve the plan's objective. These include the following:

- ▶ Stream Maintenance and Management Program and guidance document for routine stream maintenance;
- ▶ new Drainage Design Manual for storm water, flood control, and bank repair design;
- ▶ Flood Management Plan that outlines the conceptual flood control alternatives;
- ▶ Bank Stabilization Program that provides a management framework and conceptual plans for addressing current and future bank instability problem areas; and
- ▶ Habitat Enhancement and Restoration Program that provides a conceptual plan and framework for stream resource enhancement, restoration, and protection.

2.1.5 Community Wildfire Protection Plan

The City of San Luis Obispo adopted the Community Wildfire Protection Plan (CWPP) in 2019. The purpose of the CWPP is to collaboratively address fire protection planning efforts occurring in the City, minimizing wildfire risk to watershed lands, assets, firefighters, and the public. The CWPP includes the following:

- ▶ the City's physical and social characteristics,
- ▶ wildfire history and landscape-scale fire hazard variables in the City,
- ▶ an evaluation of wildfire risk in priority areas, and
- ▶ strategies for reducing structural ignitability, conducting public education and outreach; and, reducing fuel loads, and minimizing wildfire risk in the community.

2.2 PLANNING RESOURCES

This section includes a brief summary of resources available to the public that will be used in the vulnerability assessment, some of which were used in this Report to identify baseline conditions for the assessment of future climate-related risk.

2.2.1 California Governor's Office of Emergency Services MyHazards Mapping Tool

The California Governor's Office of Emergency Services MyHazards mapping tool is an interactive map that displays information about earthquake, liquefaction, tsunami, flood, and fire hazards throughout the state. MyHazards also provides general information about each hazard and links to other resources for more detail about specific hazards and preparedness measures.

2.2.2 California Adaptation Planning Guide

In August 2020, the Governor's Office of Emergency Services completed an update to the *California Adaptation Planning Guide* (APG) (Cal OES, 2020). The California Adaptation Planning Guide (APG) is designed to support local government, regional organizations, and climate collaborative groups to integrate best practices and current science into their adaptation planning efforts. Guidance from the APG was used to develop this report and will be used as one of the primary guidance documents during the Resilient SLO planning process.

2.2.3 Federal Highway Administration’s Vulnerability Assessment and Adaptation Framework

The Federal Highway Administration’s (FHWA’s) Vulnerability Assessment and Adaptation Framework is a guidance document developed to support transportation agencies and their partners assess the vulnerability of their transportation systems to extreme weather and the impacts of climate change. The document also helps agencies integrate climate adaptation considerations into transportation decision-making and provides an in-depth process for conducting a vulnerability assessment. Relevant sections of this document were used to develop this report and will be used as one of the primary guidance documents during the Resilient SLO planning process.

2.2.4 Cal-Adapt

Cal-Adapt is a tool developed by the University of California, Berkeley’s Geospatial Innovation Facility, California Energy Commission, and California Strategic Growth Council that uses global climate simulation model data to provide a view of how climate change might affect California. Climate datasets on Cal-Adapt include historical observations, as well as downscaled climate projections, which are used to create charts and maps that display climate variables through time. Cal-Adapt includes climate variables, such as temperature, precipitation, sea level rise, snowpack, wildfire, streamflow, and drought.

2.2.5 California Heat Assessment Tool

The California Heat Assessment Tool is a tool developed by the California Natural Resources Agency as part of the state’s Fourth Climate Change Assessment. The tool provides information for local and state health practitioners to better understand dimensions of heat vulnerability driven by climate changes and where action can be taken to mitigate the public health effects of extreme heat in the future.

2.2.6 CalEnviroScreen

CalEnviroScreen, a web-based tool developed by the California Office of Environmental Health Hazard Assessment (OEHHA), uses a science-based method for evaluating multiple pollution sources in a community while accounting for local vulnerabilities. The purpose of the tool is to identify which communities are most burdened by pollution from multiple sources and which are most vulnerable to its effects, taking into account the socioeconomic and health status of people living in those communities. The tool provides a set of indicator data that will help to identify portions of the City particularly vulnerable to climate-related hazards.

2.2.7 California Healthy Places Index

The California HPI, developed by the Public Health Alliance of Southern California, provides an interactive map, graphs, data tables, and a policy guide to examine local health factors and compare local conditions to those across the state. Climate health vulnerability indicators are built into the HPI by incorporating climate-related hazards data layers into the mapping (e.g., air conditioning access, public transit access); incorporating select climate-resiliency metrics into the HPI score, which combines 25 community characteristics into a single indexed score to describe a community’s overall health; and addressing climate challenges in the policy guide.

2.3 EXISTING HAZARDS ASSESSMENT

This section provides an overview of existing climate-related hazards in the community and serves as a comparative baseline for assessing future climate conditions and the magnitude of changes that are projected to occur through the 21st century.

2.3.1 Geography and Climate

The City is located west of the Santa Lucia Mountains and 8 miles east of the Pacific Ocean in the Central Coast region of California. It occupies approximately 10.7 square miles and is surrounded primarily by protected open space and agriculture. Although the City itself is on average 300 feet above sea level, much of the terrain surrounding the City is mountainous, with prominent peaks such as Cerro San Luis and Bishop Peak at 1,292 and 1,559-feet above sea level, respectively (San Luis Obispo County 2019b).

San Luis Obispo experiences a Mediterranean climate, which is characterized by dry summers and mild, wet winters. Although this is the general trend, the region has historically experienced both unseasonably warm and cold periods. The City has an annual average temperature of 70.2 degrees Fahrenheit (°F) and average precipitation of 19 inches per year, occurring primarily in the winter and spring months. The City's climate is influenced by the proximity of the ocean, resulting in weather events including dense fog, offshore wind, and coastal storms (San Luis Obispo County 2019b).

2.3.2 Flooding

This section provides a summary of the San Luis Obispo Creek watershed and describes existing flooding issues in the City and the surrounding region. Two interchangeable, technical terms that characterize flood frequency are used throughout the section and are defined as follows:

- ▶ **Recurrence Intervals:** A common way to describe floods is by stating their recurrence intervals, which refer to how often, on average, a given flood may occur. A 100-year event, for example, is described as an event that may occur about once in every 100 years, on average. However, this terminology can be misleading because flood events are statistical occurrences, and events may occur more frequently than their recurrence interval suggests.
- ▶ **Exceedance Probability:** The exceedance probability of a given flood event is the percent chance that a larger flood will occur in any given year, and it is calculated by dividing the number 1 by the recurrence interval. Thus, the "100-year event" becomes the "1-percent exceedance event," or a flow rate that has a 1-percent chance in any given year of being equaled or surpassed by a larger flow rate. This representation, although interchangeable with the recurrence interval, provides a more helpful way to think about flood risk.

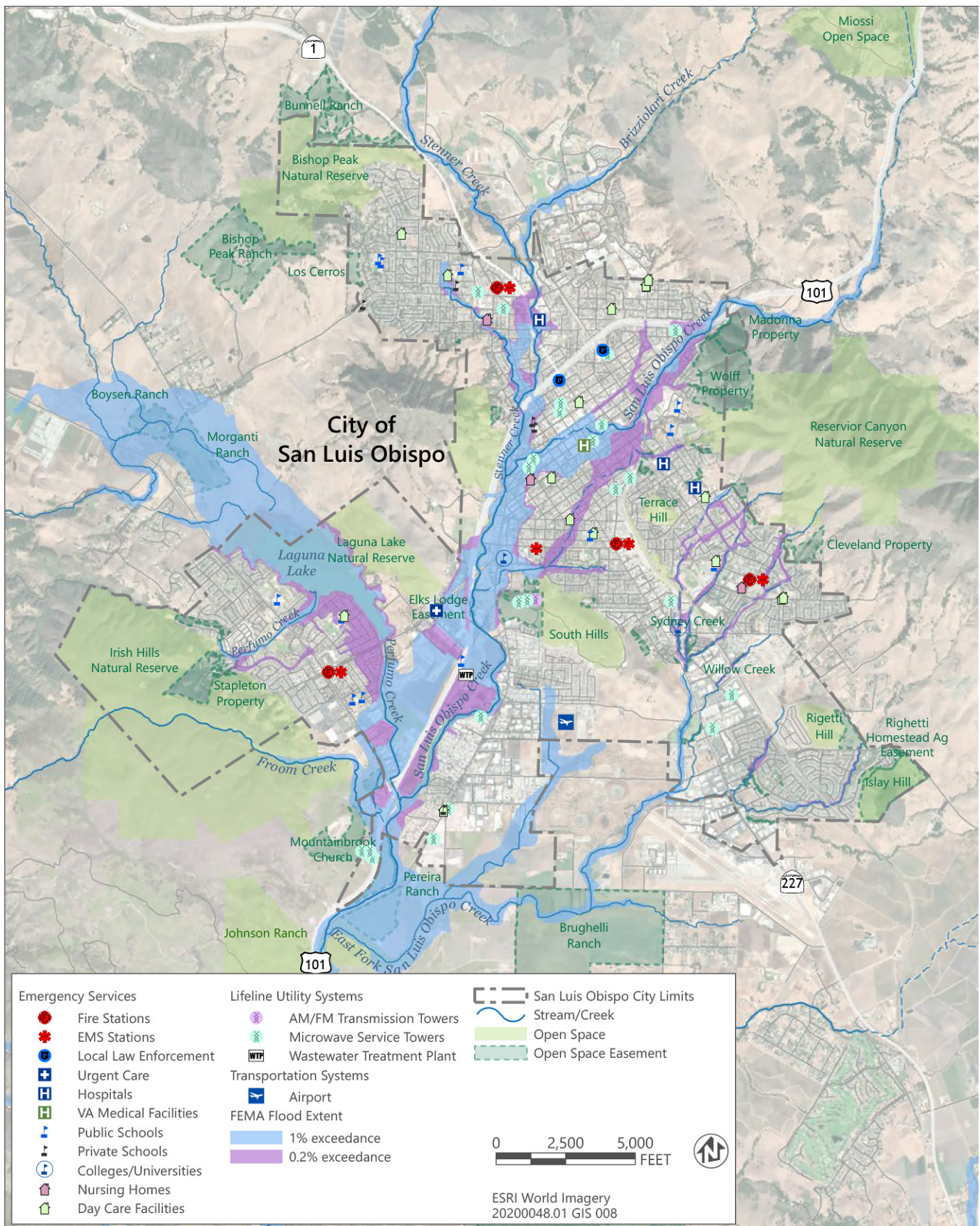
There are several overall mechanisms by which flooding can occur:

- ▶ dam inundation flooding, in which impounded water is released because of dam breaching;
- ▶ localized flooding, which occurs when intense rainfall overwhelms the capacity of local drainage infrastructure, causing the ponding of water; and
- ▶ riverine flooding, which occurs when channels (i.e., the relatively deep, narrow sections of creeks and rivers) cannot contain the flow volume moving through them, causing water to spill out into the overbank areas (i.e., the relatively wide, flat regions on one or both sides of the channel, also called "floodplains").

According to the HMP, the City is not at risk of dam inundation flooding, and localized flooding is considered a minimal risk. The highest flooding concern for the City is riverine flooding, which may include "flash" flood risks (San Luis Obispo County 2019b).

SAN LUIS OBISPO CREEK WATERSHED

As shown in Figure 2-1, San Luis Obispo Creek flows through the City in a northeast to southwest direction, passing through the downtown area and generally following U.S. Highway (U.S.) 101 on its way to the Pacific Ocean at Avila Beach. The watershed for San Luis Obispo Creek, the land area that captures rainfall and contributes water directly to the creek system, covers an area of approximately 84 square miles, ranging in elevation from approximately 2,460 feet in the upper watershed near the Cuesta Grade to its outlet into the Pacific Ocean. Along its main flow path, it transitions from steep canyons to the gently sloping alluvial plain underlying the City, descending more than 2,230 feet to downtown. In the City's downtown, San Luis Obispo Creek flows through the "under-city culvert," consisting of a system of covered, constructed channels between Osos Street and Chorro Street that is more than 1,000 feet long and 18–23 feet wide (Questa Engineering Corporation 2003, 2015), before emerging into Mission Plaza.



Sources: Data downloaded from City of San Luis Obispo in 2020 and County of San Luis Obispo in 2020 and processed by cbec eco engineering in 2020.

Figure 2-1 Waterways and Floodplain Areas in the City of San Luis Obispo with Critical Facilities

Further downstream, near the intersection of Marsh Street and Higuera Street, San Luis Obispo Creek is joined by a major tributary, Stenner Creek, which in turn receives flow from Brizzolara and Old Garden Creeks. San Luis Obispo Creek then continues south along the alluvial plain, intercepting Prefumo Creek as it exits Laguna Lake and joining East Fork San Luis Obispo Creek near the Higuera Street/U.S. 101 interchange by the Johnson Ranch Open Space. Near the confluence of San Luis Obispo Creek with Davenport Creek, the channel enters “the Narrows” (Questa Engineering Corporation 2003), passing through a steep, confined canyon before being joined by See Canyon Creek and discharging to the Pacific Ocean. Flows in the watershed are “flashy,” meaning that water moves quickly through the system and that stream levels rise and recede rapidly in response to rainfall events. This is a result of the steep topography of the upper watershed and the relatively shallow soils, land cover, and rainfall characteristics for the region (Questa Engineering Corporation 2003).

HISTORICAL FLOODING

The San Luis Obispo Creek watershed has a long history of flooding, with a series of storms over the last 50 years that have caused millions of dollars’ worth of damage.¹ Damaging flood events have occurred in 1868–1872, 1884, 1897, 1911, 1948, 1952, 1962, 1969, 1973, 1995, 1998, and 2001 (Questa Engineering Corporation 2003; City of San Luis Obispo 2014). The flooding events in January and March 1995 occurred during one of the wettest periods on record, causing the watershed to be relatively saturated for long periods, which prevented soils from absorbing incoming precipitation. The 1995 flooding events followed the 1994 Highway 41 fire, which burned major areas of the Stenner Creek and upper San Luis Obispo Creek watersheds and caused increased runoff and sediment delivery to channels. Flow spilled out of the San Luis Obispo Creek channel in the region around Marsh and Higuera Streets, causing extensive damage, and remained out of the creek banks for nearly 3 miles downstream. The events, for which the peak flow was estimated to be the 17-year flood event² (6-percent exceedance probability), caused \$2.3 million in damage (Questa Engineering Corporation 2003). Prior events were even more damaging: The 1969 flood caused \$6.92 million in damage, and the 1973 flood caused \$13.6 million in damage. During the 1973 flood, depths of inundation over U.S. 101 exceeded 4 feet near the Madonna Inn and were up to 3 feet near the Prefumo Creek confluence (Questa Engineering Corporation 2003).

FLOOD RISK

Following the 1973 flood, watershed studies and plans were developed and updated, including the 1974 U.S. Army Corps of Engineers floodplain study of San Luis Obispo Creek (USACE 1974), 1977 Nolte & Associates study (George S. Nolte & Associates 1977), and 1978 Federal Emergency Management Agency (FEMA) flood insurance study. The extent of 100-yr and 500-yr flood zones, based on these studies, is shown in Figure 2-1.

In 2003, the City’s WMP was completed, which relied on updated analyses for flow frequency. In general, the flow estimates provided by the WMP for a given recurrence interval are higher than those reported in the prior studies, leading to the recommendation that the WMP be used for design considerations for projects in the City, as a conservative assumption, as well as the adoption of the updated flow frequency estimates by the City. However, the FEMA inundation extents, shown in Figure 2-1, were generally validated by the 2003 WMP for the 100-year event despite the slightly higher depths reported by the WMP (Questa Engineering Corporation 2003). The FEMA inundation extents further indicate the 500-year flood hazard area, which was not assessed as part of the WMP, and they are still provided on the City’s website and serve as an important reference. According to the WMP, nearly all streams in the San Luis Obispo Creek watershed have less than a 25-year (4-percent exceedance probability) flood capacity, with some experiencing flooding in the 10- to 15-year range (Questa Engineering Corporation 2003).

¹ Storm damages were normalized to reflect costs in the year 2000.

² According to the flood frequency analysis conducted for the 2003 Waterway Management Plan (Questa Engineering Corporation 2003), which represent updated flood frequency information compared to the Federal Emergency Management Agency study (1978).

Flood Risk Factors

For the San Luis Obispo Creek watershed, factors that may directly contribute to flooding are infrastructure-induced flow constrictions, wildfire, and degraded riparian corridors (Questa Engineering Corporation 2003). In terms of flooding from infrastructure, bridges often serve as flow constrictions because the abutments, or structures connecting the bridge deck to the ground, may occupy part of the floodplain for a channel in order to reduce the span width of the deck. In addition, bridge piers can intercept transported debris, particularly woody vegetation, and reduce conveyance through the structure. The U.S. 101 and Santa Rosa Street bridges over Stenner Creek were upgraded following the highly damaging 1973 flood to prevent these occurrences and reduce future flood risk (Questa Engineering Corporation 2003). The Marsh Street Bridge in the City's downtown, first built in 1909, is currently being replaced and is scheduled to be completed in January 2021. One of the greatest flow constrictions in the watershed is the undercity culvert. The capacity of the culvert was estimated in the 1977 publication *Flood Control and Drainage Master Plan for the San Luis Obispo Creek Watershed* (George S. Nolte & Associates 1977) at 4,500 cubic feet per second. This flow rate is below the 25-year event (4-percent exceedance probability) according to FEMA flood insurance studies (FEMA 1978), indicating that the culvert is unable to manage water flow during the 25-year flood event. The 2003 WMP, which provided updated estimates for flood frequency, estimated the capacity of the culvert to be close to the 15-year event (7-percent exceedance probability), Questa Engineering Corporation 2003). Flows exceeding the undercity culvert capacity may exit the channel at Osos Street or further upstream at the Santa Rosa or Marsh Street bridges and cause overland flooding within downtown, particularly along the Marsh Street corridor and areas surrounding the creek channel.

Post-wildfire runoff represents another risk for flooding because burned areas in the watershed will contribute more runoff and higher sediment loads than vegetated areas. As previously mentioned, the 1995 floods, which caused approximately \$2.3 million in damages, followed the 1994 Highway 41 fire and the loss of vegetation on hillslopes contributed to high runoff volumes. Overall, about one third of the San Luis Obispo Creek watershed is considered by the California Department of Forestry and Fire Protection (CAL FIRE) to be in Very High Fire Hazard Severity Zones, based on an analysis of publicly available GIS data (CAL FIRE 2020). Wildfire impacts are further discussed in Section 2.2.4.

Finally, degradation of riparian corridors, the thin strips of trees and other vegetation lining the creeks, may contribute to flooding within the San Luis Obispo Creek watershed. Historically, riparian zones would have been composed of tall, single-trunk sycamores, cottonwoods, and willows, but these areas are now characterized by shrubby willow growth (Questa Engineering Corporation 2003). This results in more low-hanging branches coming into contact with flowing water, which increases the roughness of the creek channels and consequently reduces flow velocities. When the water is slowed, water levels in the channel are increased and overflow into surrounding lands becomes more likely.

Urbanization, the conversion of land to impervious surfaces as a result of urban development, has indirectly affected flood risk by altering the shape and function of the creek channels within the watershed. Overall, the San Luis Obispo Creek watershed is about 10 percent urbanized, meaning that 10 percent of the land area within the basin³ that drains to the outlet of San Luis Obispo Creek at Avila Beach is covered by urban development. However, when considering only the portion of the watershed upstream of Los Osos Valley Road, the drainage basin is 15 percent urbanized (Questa Engineering Corporation 2003). Conversion to impervious surfaces accompanying urban development results in higher runoff rates because rainfall cannot be absorbed by the underlying soil from these surfaces. This causes water to enter the creek channels more quickly and leads to higher flow volumes and faster channel velocities on a more frequent basis. However, this effect may be reduced for increasingly large flood events. For periods of sustained, heavy rainfall, the watershed soils may be highly saturated at the time of peak rainfall and the watershed may, therefore, have a limited ability to absorb the incoming precipitation, even if the impervious surfaces had not been in place. The WMP concluded that while urban development since the 1960s has not had a large effect on increasing runoff volumes for large events (increases of less than 2 percent for the 100-yr/1-percent exceedance probability flood), notable increases in runoff for more frequent events were determined. Specifically, flows associated with the 2-yr (50 percent exceedance probability) event were shown to increase by up to 10-12 percent in the Mid-Higuera area as a result of urbanization trends from the 1960's to the early 2000's. Impacts from additional urbanization of the San Luis Obispo Creek

³ Basin, or drainage basin, is another term for watershed.

watershed will need to be determined, as a result of build-out according to the general plans for the City, County, and the California Polytechnic State University at San Luis Obispo (Cal Poly). The County is currently progressing an update to the hydrologic study of East Fork San Luis Obispo Creek to further understand flood risk in key locations and impacts of urbanization on that region of the San Luis Obispo Creek watershed.

Although urban development from the 1960s to early 2000's has not had a large effect on directly increasing runoff volumes from large events (e.g., 100-year/1-percent exceedance probability) in the San Luis Obispo Creek watershed, it has greatly affected incision, or the deepening of channels through erosion (Questa Engineering Corporation 2003). The San Luis Obispo Creek watershed is vulnerable to erosion because the underlying Franciscan Complex is extensively fractured through tectonic forces and includes highly erodible layers (Questa Engineering Corporation 2003). Over time, incision can lead to a suite of flooding problems by altering the form and function of channels. Incision often results in the disconnection of creeks and rivers from their natural floodplains, as the channel cuts deeper and more narrowly into the land surface. This tends to increase flood risk downstream as the pulse of water moving through the basin following a rainfall event is concentrated in channels and accelerated, instead of flowing more slowly and shallowly over larger areas of land. As a result, the storage capacity of the watershed is minimized. Further, incision can lead to bank failure, in which the sloped sides of the channel become undercut by erosion related to frequent, fast-moving water and collapse inward, introducing large quantities of sediment and vegetation into the channel. This can in turn reduce flow capacity as the debris blocks portions of the channel, thereby causing localized flooding as water spills out of the channel and into surrounding areas. In some areas of the watershed, incision has been on the order of 6–10 feet, meaning that the channel bottoms are 6–10 feet lower than they have been historically (Questa Engineering Corporation 2003). So, while urbanization since the 1960s had not been shown by the WMP to greatly increase runoff volumes for large events, the effects of channel incision over long periods of time can still result in complex flood behavior that may ultimately worsen flooding from large storm events regardless of whether or not the runoff, and therefore the flow within the channel, is increasing markedly.

In addition to urbanization, there are several other causes of this widespread incision problem. The historic presence of small dams in the upper watershed (near Stagecoach Road, which has been removed, and the larger Reservoir Canyon facility) prevented large sediments (cobble and large gravels) from being transported downstream. Naturally, these eroded sediments would have continuously filled in the channels, but instead they became trapped behind the dams and filled in the small reservoirs. The creek channels continued to erode the underlying material, and with reduced incoming sediment to offset this erosion, the channels cut deeper into the landscape. While no longer occurring at historical levels, intensive livestock grazing in the late 1800's and early 1900's is a legacy factor that continues to affect incision (Questa Engineering Corporation 2003). As sheep, cattle, and other hooved animals walk across a landscape, their hooves can compress the soil and reduce its ability to absorb incoming precipitation, especially if grazing in high densities. Reduction in vegetation associated with grazing can also increase runoff rates as incoming precipitation encounters the land surface more quickly and directly. In the upper San Luis Obispo Creek watershed, intensive turn-of-20th century grazing has permanently increased runoff rates, which can subsequently drive channel incision by increasing flow rates for frequent (e.g., 2-yr) events. Further, changes to the creek channels themselves, from reducing the amount of mature vegetation along the creeks to straightening and relocating the channels for road construction, have caused water to move more quickly into and through the channel, increasing the erosive strength of the creeks and contributing to incision (Questa Engineering Corporation 2003).

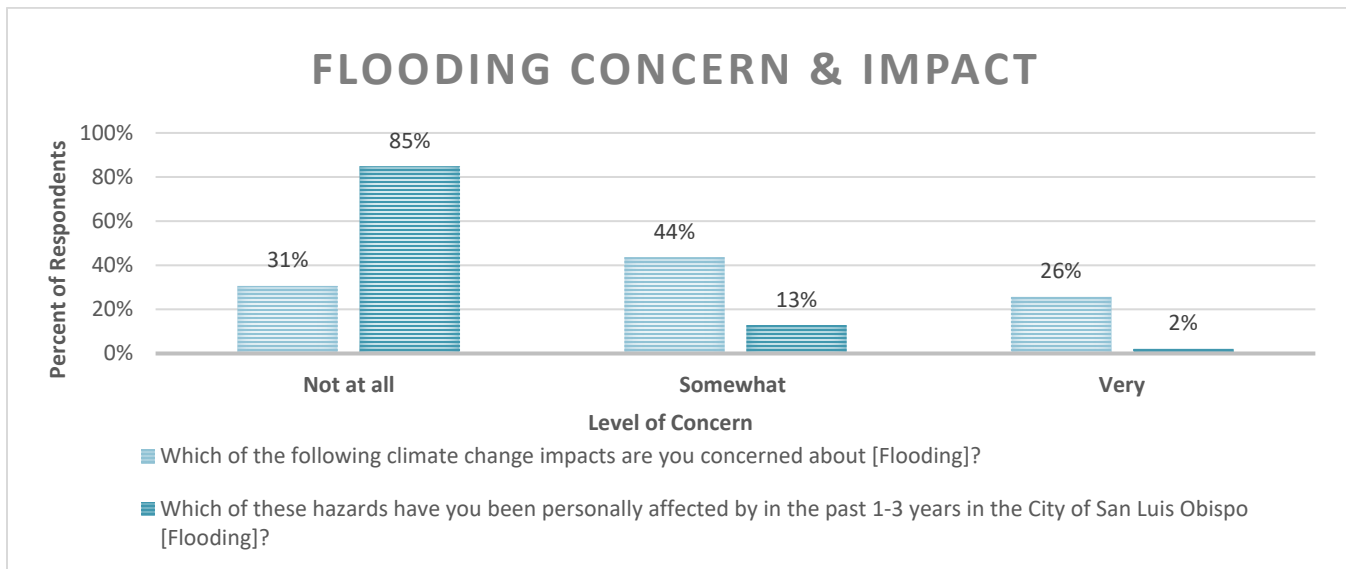
FLOOD MANAGEMENT

Flood management continues to be a high priority for the City, but there are several important barriers that can make management more difficult. First, much of the creek corridor that runs through the City along San Luis Obispo Creek and its tributaries is not owned by the City. Although the City has some authority under the City's Municipal Code for emergency removal of vegetation and other debris, general maintenance of the creeks falls upon the owners of property adjacent to the creek (City of San Luis Obispo 2015). Additionally, the creek corridor is highly confined in areas, particularly through downtown, making projects such as channel widening infeasible. Following the 1973 flood, the George S. Nolte & Associates study, completed in 1977, identified proposed flood control projects, but few were adopted because of the environmental effects associated with channel widening and other alternatives (Questa

Engineering Corporation 2003). Several areas of the City, including downtown areas along San Luis Obispo Creek, the intersection of U.S. 101 and Los Osos Valley Road, the Johnson Avenue railroad underpass, and areas surrounding Laguna Lake, have been at a high risk for frequent flooding (City of San Luis Obispo 2011). To address these issues, large projects have been proposed to manage flood risk in the increasingly urbanized City. One such proposed project is the Mid-Higuera Bypass Project, which would increase conveyance capacity of San Luis Obispo Creek between Marsh Street and Madonna Road. This area, downstream of the confluence of Stenner and San Luis Obispo Creeks, has flooded and received extensive damage in some of the historical floods previously mentioned. The planned removal of sediment and Arundo stands from San Luis Obispo Creek south of Los Osos Valley Road will also serve to reduce local flood risk.

COMMUNITY FLOODING CONCERNS

As part of the community priorities survey, when participants were asked to report on their level of concern for flooding, as shown in Figure 2-2, 70 percent of respondents indicated that they were “Somewhat” or “Very Concerned” about the issue. When asked about whether they had been impacted by flooding in the last 1-3 years, only 15 percent of respondents indicated “Somewhat” or “Very”. Additionally, individuals with a household income of less than \$50,000 and individuals aged 18 to 24 reported the highest level of concern for flooding. Individuals who identify as all other races and ethnicities, compared to individuals who identify as white or caucasian, also expressed a higher level of concern for flooding (i.e., 36 percent v. 24 percent, respectively).

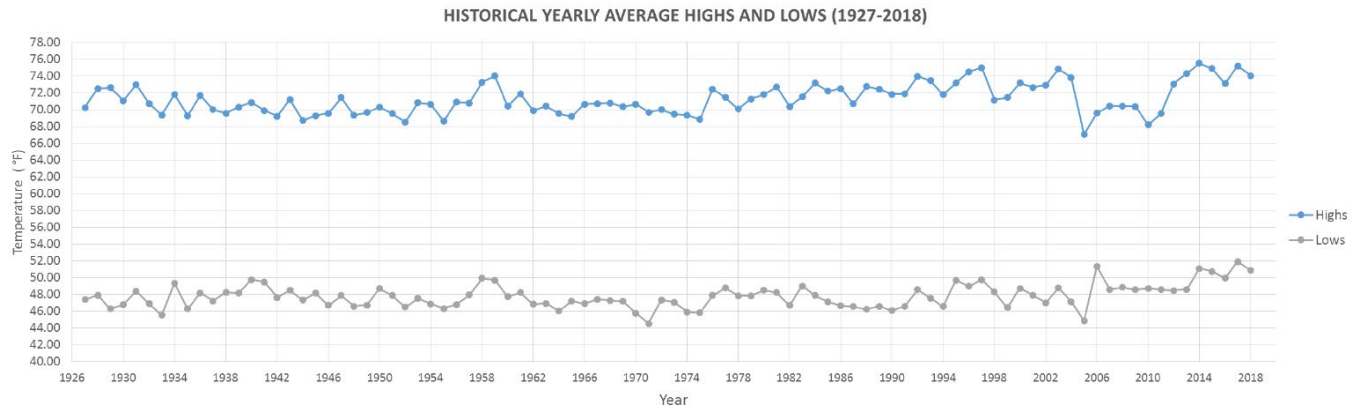


Sources: Resilient SLO Community Priorities Survey

Figure 2-2 City Resident’s Flooding Concern and Impact

2.3.3 Average Temperatures, Extreme Heat, and Drought

The City is characterized by a Mediterranean climate. While the City is generally considered to have a mild climate, weather patterns and events have historically observed both unseasonably warm periods and cold spells. According to Cal-Adapt, during the historic period (1961–1990), the annual average maximum temperature in the City was 71.1°F and the annual average minimum temperature was 43.7°F (CEC 2019a). Although the City has not historically experienced many extreme heat conditions, the City could be experience increased sensitivity to extreme temperatures because residents are not acclimatized to or prepared for extreme heat conditions. Extreme heat events are described in this section in terms of their intensity (i.e., average maximum temperature), frequency (i.e., how often they occur), time of year in which they occur, and duration (total number of consecutive extreme heat days). Figure 2-3 includes the average annual maximum and minimum temperatures for the City from 1926 through 2018.



Sources: Cal Poly 2020

Figure 2-3 City Average Annual Temperature from 1928 to 2018 (Cal Poly Weather Station)

EXTREME HEAT DAYS AND WARM NIGHTS

Cal-Adapt defines an extreme heat day as a day in a year when the daily maximum temperature exceeds the 98th historical percentile of daily maximum/minimum temperatures based on observed historical data from 1961–1990 between April and October. Based on the parameters set in Cal-Adapt, an extreme heat day for the City is defined as a day with a maximum temperature of 89.6°F or above. An average of 4 extreme heat days per year occurred in the City during the historic period (1961–1990). Heat days have historically occurred between April and late October (CEC 2019b).

Cal-Adapt defines a warm night as a night when the daily minimum temperature is above the extreme heat threshold of 57.1°F, which is the 98th historical percentile of daily minimum temperatures in the historic period (1961–1990) between April and October. In the historic period (1961–1990), an average of four warm nights per year occurred in the City (CEC 2019b). Notably, in the summer of 2020, the City experienced several prolonged extreme heat periods. In August 2020, the daily maximum temperature, recorded at San Luis Obispo Airport, was above 90°F for seven consecutive days between August 14 and August 20, 2020, breaking several maximum daily temperature records during this period (NOAA 2020).

HEAT WAVE EVENTS

Cal-Adapt defines a heat wave as four or more consecutive extreme heat days. During the historic period (1961–1990), the maximum number of consecutive extreme heat days in the City was 2.6 days, which does not qualify as a heat wave event according to the Cal-Adapt definition. These partial heat wave events (2.6 days) have been infrequent in the City, with an average of 0.2 event per year during the historic period (1961–1990). Because prolonged heat events have been rare in the City, both the City's 2006 LHMP and the more recent Annex G of the County's HMP do not discuss or evaluate extreme heat events in depth. However, maximum daily temperature records continue to be exceeded with several heat waves events occurring in the City in recent years. Because extreme heat events have not been an issue historically for the City, this may make the City particularly vulnerable and unprepared when these events do occur.

URBAN HEAT ISLAND

Although the City's Mediterranean climate includes high temperatures during summer and fall months, the City's urban land use patterns can intensify periods of extreme heat through the "urban heat island" (UHI) effect. The UHI effect is generally understood as the phenomenon of urban areas being significantly warmer than surrounding rural areas because of human activity and land use patterns in the built environment. Several factors contribute to the effect, with the primary cause being changes in land surfaces (EPA 2008). The albedo of a surface is the measure of

the ability to reflect or absorb solar radiation, with darker surfaces having a lower albedo and absorbing more solar radiation. As urban areas develop over time, resulting in the development of more land surfaces with low albedos (e.g., asphalt pavement, dark building surfaces), more solar radiation is absorbed in these materials causing increased ambient temperatures and warmer nighttime temperatures. Another factor contributing to the UHI effect is the loss of evapotranspiration in urban areas. Evapotranspiration, the movement of water to the air from sources such as the soil, plants, and bodies of water, reduces ambient air temperatures (EPA 2008). As cities grow and often reduce the extent of available vegetation that contributes to evapotranspiration, UHI effects are exacerbated. Additionally, waste heat from human activities involving machinery (e.g., vehicle traffic, using air conditioning, industrial activity) can also contribute to the UHI effect, with excess heat absorbed by surrounding surfaces (Sailor 2011; Zhu et al. 2017).

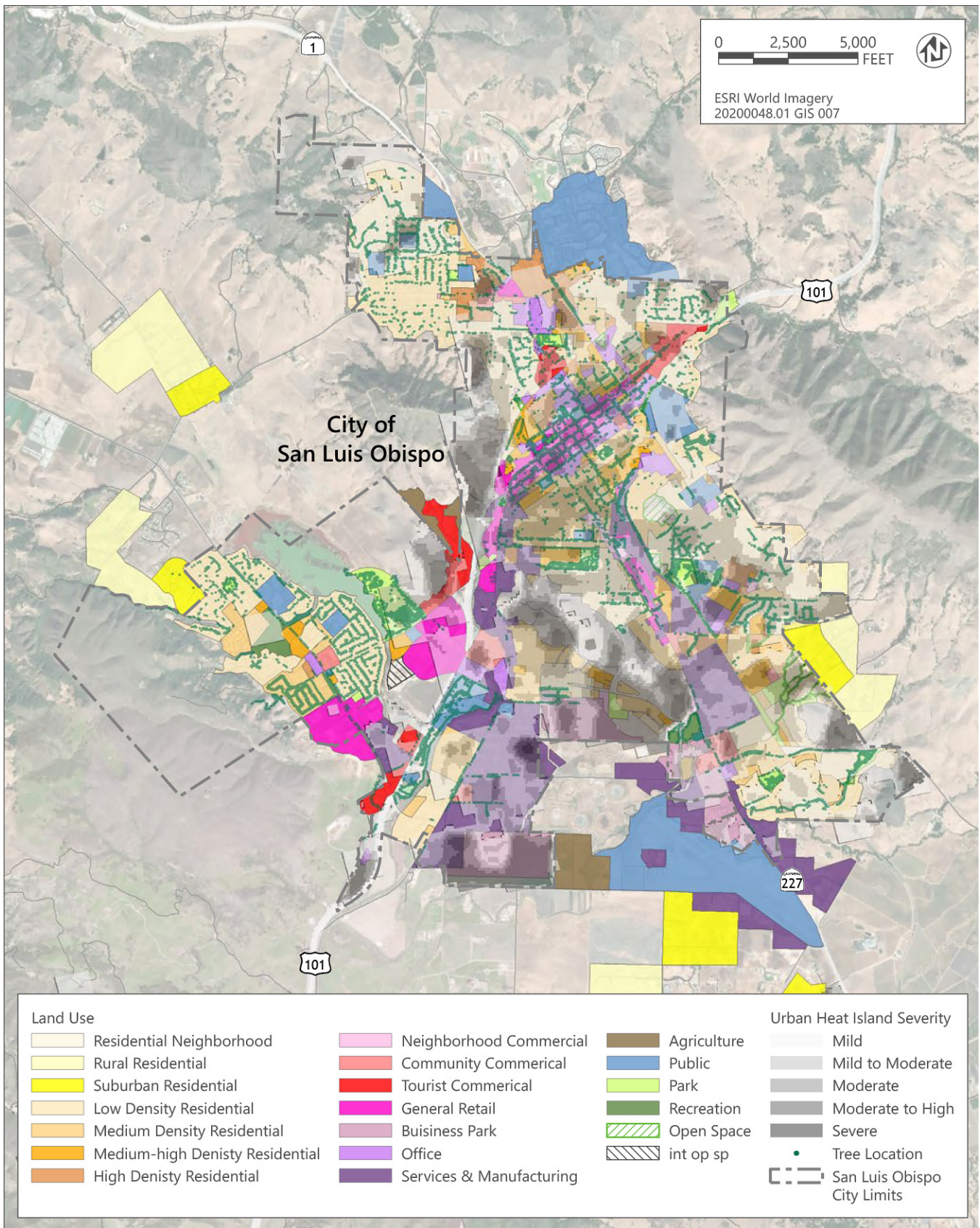
Several factors contribute to the UHI effect, including land use patterns; the presence of large, paved areas (e.g., roads and parking lots); traffic from high-volume roadways (Zhu et al. 2017), impervious surfaces (e.g., roofs); and the presence of vegetation and trees, which contribute to evapotranspiration. All these factors affect surface temperatures in urban areas. To show how the UHI effect is affecting various parts of the City, Figure 2-4 identifies land uses in the City, street trees owned and maintained by the City data from The Trust for Public Land, which has developed maps to identify hot spots in cities with above-average temperatures compared to the City as a whole.

LONG-TERM DROUGHT

Long-term drought can have significant environmental, agricultural, health, economic, and social consequences. San Luis Obispo County, along with larger areas of California, experiences periods of long-term drought that stress the ecosystem and water supplies; and subsequently, impact agriculture, public health, and the economy. Notable multi-year droughts that have affected the County and the City include:

- ▶ **1929 – 1934** – This statewide drought established the criteria commonly used in designing storage capacity and yield for large Northern California reservoirs; and hence, is one of the first major historic droughts noted in California.
- ▶ **1975-1977** — From November 1975 through November 1977, California experienced one of its most severe droughts. In 1976 and 1977, the winters brought only one-half and one-third of normal precipitation, respectively.
- ▶ **1987-1992** — San Luis Obispo County suffered adverse effects resulting from this statewide drought, when low precipitation and runoff levels greatly affected the Central Coast, adversely affecting about 30 percent of the state's population, much of the dry-farmed agriculture, and over 40 percent of the irrigated agriculture.
- ▶ **2007 – 2009** – California proclaimed a statewide drought in 2009. The greatest impacts of this multi-year drought were suffered on the western side of the San Joaquin Valley, on agricultural communities where drought effects were coupled with the economic recession. Emergency response actions were necessary with regard to social services.
- ▶ **2012 – 2017** – Drought produced severe impacts to water wells throughout the San Luis Obispo planning area, with a high number of wells running dry. Water allotments were drastically reduced in many towns and to water agencies, with extremely high costs for procuring water. In addition, job loss occurred with many families requiring food supply and water supply assistance to homeowners experiencing dry wells. For the County of San Luis Obispo, there were 13 disaster declarations from 2012–2017, though total associated financial losses across the various economic sectors is not available for all these recent drought-related declarations.

The City relies on regional water supplies, the four primary sources including Whale Rock Reservoir, Salinas Reservoir, Nacimiento Reservoir, and recycled water (City of San Luis Obispo 2019a). As discussed in Section 2.1.3, the UWMP, which evaluates the City's current and projected water supplies through the year 2035, includes strategies to reduce water demand and prepare for long-term drought scenarios. Water demand modeling estimates that these sources provide a 7.5-year combined water supply, assuming an extended worst-case historical drought (San Luis Obispo County 2019a).

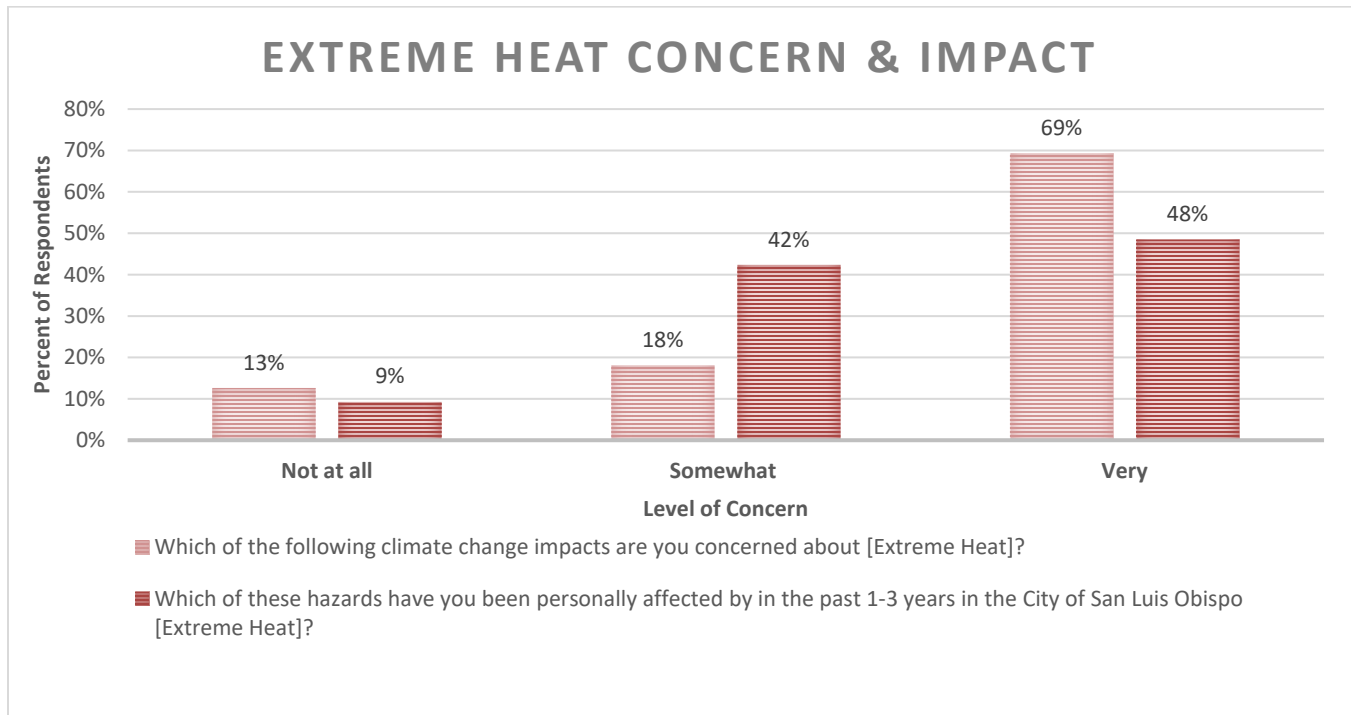


Source: Data received and downloaded from City of San Luis Obispo and the Trust for Public Land.

Figure 2-4 Urban Heat Island Effect and Tree Cover in the City

COMMUNITY EXTREME HEAT CONCERNS

As part of the community priority survey, when participants were asked to report on their level of concern for extreme heat, as shown in Figure 2-5, 87 percent of respondents indicated that they were “Somewhat” or “Very” concerned about the issue. Ninety percent of individuals indicated they had been “Somewhat” or “Very” impacted by extreme heat in the past 1-3 years. Additionally, individuals with a household income of less than \$50,000 and individuals between the ages of 18 and 24 had the highest level of concern for extreme heat. Individuals who note their housing situation as “Renter” or “Other” indicate the highest level of concern for extreme heat (i.e., 79 percent versus 58 percent for homeowners).



Sources: Resilient SLO Community Priorities Survey

Figure 2-5 City Resident’s Extreme Heat Concern and Impact

2.3.4 Wildfire

A wildfire is defined as an uncontrolled fire spreading through vegetative fuels that poses a threat to life and/or property (San Luis Obispo County 2019b). Wildfires can be ignited by natural events, such as lightning strikes, or can be caused by damaged infrastructure (e.g., downed power lines) or human activities (e.g., campfires, arson). Wildfires can move quickly, casting embers into downwind areas, and spread to developed areas, putting human life and properties at risk.

Three factors that contribute significantly to wildfire behavior are topography, fuel, and weather:

- ▶ **Topography**—An area’s terrain and slope affect its susceptibility to wildfire spread. Both fire intensity and the rate of spread increase as slope increases because heat from a fire tends to rise through convection. For this reason, wildfires tend to spread more slowly downhill. The arrangement of vegetation on a hillside can also contribute to increased or decreased fire activity on slopes.
- ▶ **Fuel**—The type, condition, and volume of fuel material are key factors that influence wildfire behavior. Fuel sources are diverse and can include dead vegetative matter, live trees, brush, and cured grasses. Buildings and other structures, such as homes, can also be sources of fuel. Certain types of plants are more susceptible to burning or will burn with greater intensity, and dead, dry plant matter tends to burn more easily than living plant

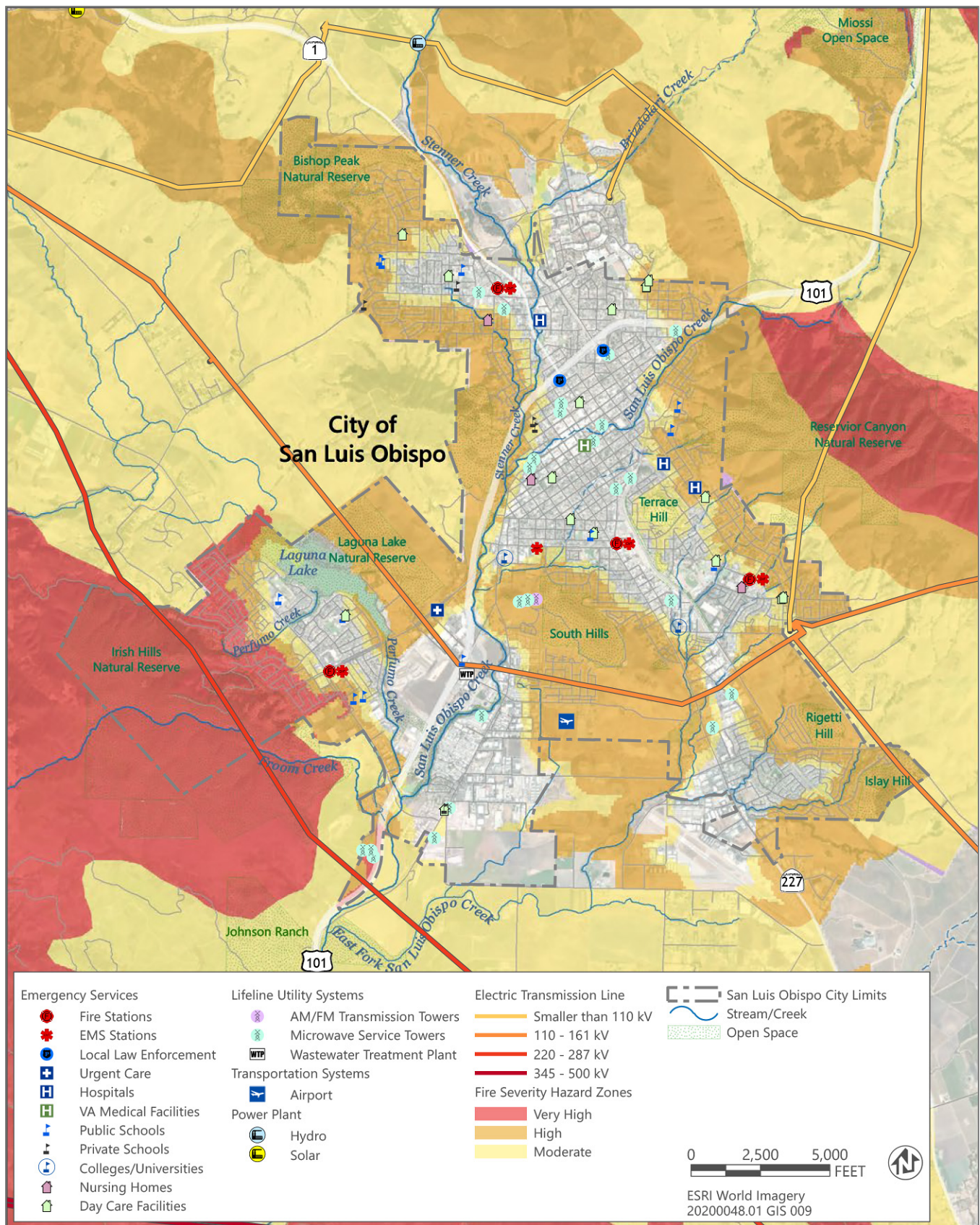
matter. Thus, fire risk is increased significantly during periods of prolonged drought. The density of vegetation increases the amount of combustible material available, also called the fuel load.

- ▶ **Weather**—Factors such as temperature, humidity, wind, and the occurrence of lightning affect the potential for wildfire and its spread. High temperatures and low humidity can dry out wildfire fuels, creating a situation in which fuel will ignite more readily and burn more intensely. Thus, wildfire risk increases during periods of drought. Wind is one of the most significant weather factors in the spread of wildfires. Higher wind speeds lead to faster wildfire spread and, oftentimes, greater fire intensity.

Environmental and climatic conditions in and around the City influence the frequency and magnitude of wildfires. The City often experiences high-wind events, such as the Santa Lucia winds, which originate inland and flow westward during the late summer and early fall, counter to the prevailing westerly winds that occur throughout much of the year. Santa Lucia winds contain little humidity, and summers in the City are hot and dry, with precipitation primarily occurring in the winter months. Thus, the combination of the relatively hot, dry Santa Lucia winds occurring at a time when vegetation in the County and the City is particularly dry following the summer months can contribute to the ignition and spread of large wildfires. Periods of low relative humidity, when dead trees and vegetation cannot absorb moisture from the air, can also increase the risk of wildfires (City of San Luis Obispo 2011).

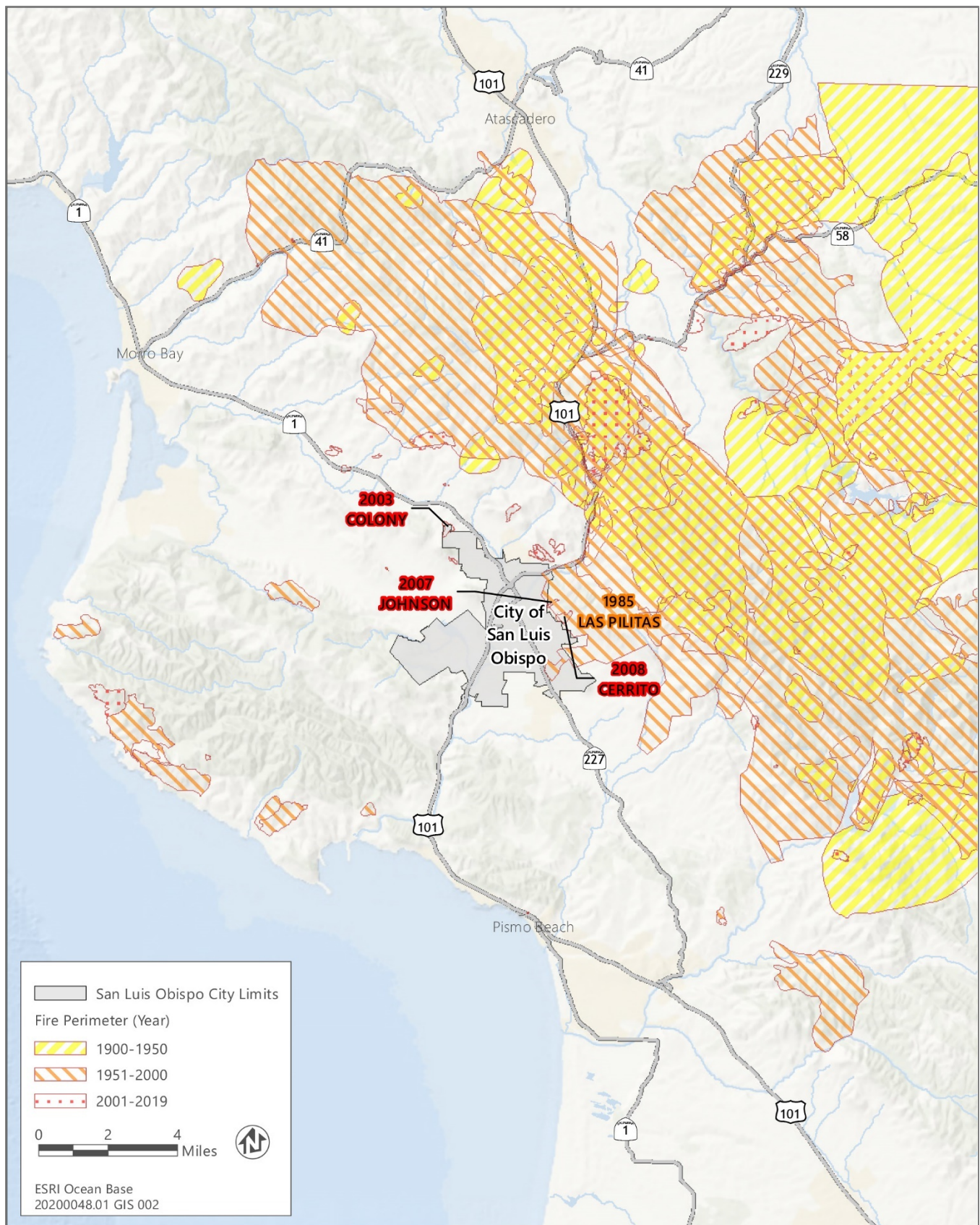
The risk of wildfires and subsequent impacts to property and life is greatest at the wildland-urban interface (WUI), which is where urban development borders wildland fuels. Wildfire risk is compounded in areas of the WUI that are also located in or near High or Very High Fire Hazard Severity Zones. Figure 2-6 includes CAL FIRE designated Fire Hazard Severity Zones in and surrounding the City. Portions of southwestern and northeastern parts of the City are located in or near a Very High Fire Hazard Severity Zones, and many of these portions of the City overlap with the WUI. Locations identified by CAL FIRE as Hazard Severity Zones for the City and County are identified in Appendix A. Beyond these areas of the City, the risk of urban fires decreases, with most of the areas surrounding the City located in a Moderate Fire Hazard Severity Zone.

Figure 2-7 shows the locations of fires that have occurred within 10 miles of the City between 1900 and 2020. Four fires (labelled in Figure 2-7) have occurred within City boundaries. Between 1900 and 2018, 490 wildfires have been recorded in the County (San Luis Obispo County 2019a). Notable fires that have occurred in the County include the Weferling fire (1960), the Las Pilitas fire (1985), the Chispa fire (1989), the Highway 41 fire (1994), the Highway 58 fire (1996), the Logan fire (1997), and the Chimney fire (2016). In total, these fires burned approximately 400,000 acres, destroyed numerous structures, and cost millions of dollars to suppress (City of San Luis Obispo 2019b). The Las Pilitas fire burned 75,000 acres and burned within City limits, damaging a number of structures (City of San Luis Obispo 2011). The 1994 Highway 41 fire burned more than 50,000 acres close to the City's northern boundary and destroyed 42 homes, 61 other structures, and 91 vehicles (San Luis Obispo County 2019a).



Source: San Luis Obispo County 2019a

Figure 2-6 Wildfire Hazard Severity Zones In and Surrounding the City of San Luis Obispo with Critical Facilities



Sources: Data downloaded from CalFire in 2020

Figure 2-7 Wildfire Perimeters for Wildfires within 10 Miles of the City of San Luis Obispo (1900–2020)

WILDFIRE MANAGEMENT

The City's Fire Department is the main agency responsible for wildfire response, management, and mitigation in the City, with many fires being addressed through mutual aid by both the City's Fire Department and CAL FIRE. Several agencies, including the County, provide support to incorporated areas, including the City, during wildfire events. Supporting agencies, such as CAL FIRE, are also available to mobilize during fire response if needed. In addition to having the authority to declare local emergencies, the County can provide support for evacuations, shelter, and other forms of assistance for municipalities, including the City (San Luis Obispo County 2016). The City can also declare a disaster declaration through the City's Disaster Council, absent the County. Because fire risk is highest for regions of the City within the WUI, the City has produced detailed maps of these regions, indicating evacuation routes and other critical information for responders. Locations identified by CAL FIRE as Hazard Severity Zones for the City and County are identified in Appendix A. The City's Community Wildfire Protection Plan serves as the primary document for assessing wildfire risk in different areas in the City and helping to implement a series of policies and strategies to reduce this risk. These policies, along with corresponding strategies, include:

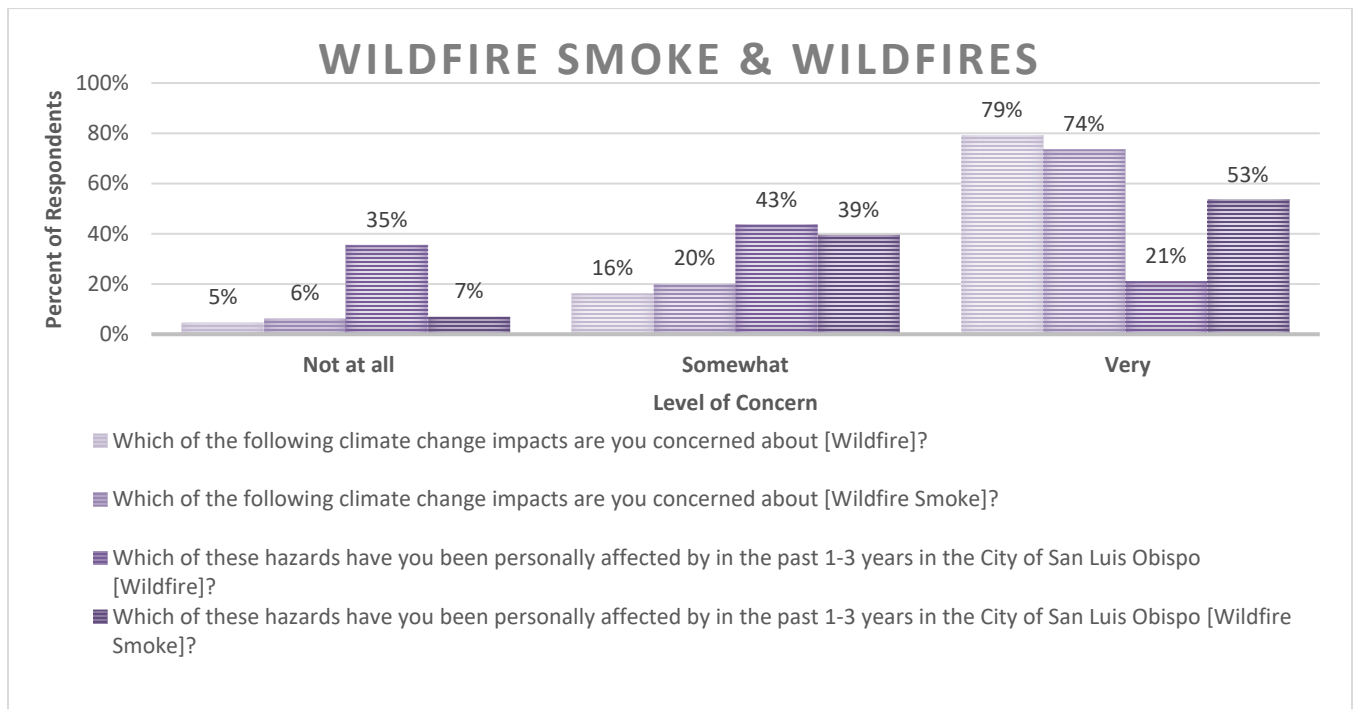
- ▶ **Education** - The goal of the Education policies and strategies are to prepare response organizations, communities, the public, and policy makers regarding appropriate community actions and interactions to reduce the unwanted impacts of fires in the WUI.
- ▶ **Fuel** - The goal of the fuel policies and strategies are to mitigate the unwanted impacts of wildfires on communities through proper vegetation management techniques that reduce hazardous fuels and the resulting wildfire intensity.
- ▶ **Planning** - The goal of the planning policies and strategies are to mitigate the unwanted impacts of wildfires on communities through community planning (including new resilient community design, retrofitting existing communities, and community recovery from the impact of fire), response planning, evacuation planning, and preparedness planning for responders, communities, and individuals and animals and livestock.
- ▶ **Response** - The goal of the response policies and strategies are to mitigate the unwanted impacts of wildfires on life, property and resources by having an efficient and effective response that includes properly trained personnel, appropriate equipment, and a community prepared to take appropriate action or evacuation.
- ▶ **Ignition Resistance** - The goal of the ignition resistance policies and strategies are to eliminate or mitigate structural ignitions from radiant heat, flame contact, or embers from WUI fires.

WILDFIRE SMOKE

While the City is at risk from the impacts of wildfires, the City and its residents are also susceptible to impacts of smoke from wildfires in the coastal mountain ranges of central California and the Los Padres National Forest to the east of the City. Wildfire smoke in the surrounding region and, due to wind patterns, wildfires along the central coast in general, can greatly reduce air quality in the City and cause public health impacts as well as impacts to tourism and normal community functions. Community public health factors that can increase the impacts of wildfire smoke include the prevalence of asthma in children and adults; chronic obstructive pulmonary disease; hypertension; diabetes; obesity; percent of population 65 years of age and older; and indicators of socioeconomic status, including poverty, income, and unemployment. Exposure to wildfire smoke, particularly exposure to vulnerable populations, can result in worsening of respiratory symptoms, increased rates of cardiorespiratory emergency visits, hospitalizations, and even death (Rappold et al. 2017). In the summer of 2020, wildfire smoke alerts were issued for San Luis Obispo County due to poor air quality caused by the Dolan Fire near Big Sur (The Tribune 2020a). Wildfire smoke can also have impacts on the labor market and the economy in general, with air quality affecting the ability of outdoor workers to perform their work and impact industries that operate in the open air (e.g., wineries, recreation activities, sporting events) (Borgschulte et al. 2019).

COMMUNITY WILDFIRE AND WILDFIRE SMOKE CONCERNS

As part of the community priorities survey, when asked about their concern for wildfires and wildfire smoke, as shown in Figure 2-8, 94 percent of participants indicated “Somewhat” or “Very”. When asked about whether they have been personally affected by either event, 64 percent of respondents indicated “Somewhat” or “Very” for wildfires and 92 percent of respondents indicated “Somewhat” or “Very” for wildfire smoke. Additionally, wildfire smoke was of paramount concern for individuals within the lowest income group (i.e., 84 percent). Renters and individuals between the ages of 18 and 24 expressed the highest level of concern for wildfire and wildfire smoke. Individuals who identify as White or Caucasian express a slightly higher level of concern both wildfire and wildfire smoke than individuals who identify as all other Races/Ethnicities.



Sources: Resilient SLO Community Priorities Survey

Figure 2-8 City Resident’s Wildfire and Wildfire Smoke Concern and Impact

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