spatial footprint on a map of people and assets. Notably, Glenn County's hazards, including dam failure, flood, wildfire, and geologic hazards, such as earthquakes, expansive soil, subsidence, and levee failure, have known geographic extents. The spatial information on these hazards is crucial in determining the areas of exposure and vulnerability of the assets.

To conduct a vulnerability analysis, access to data from several sources is required. This study used asset data from the county and cities to provide a snapshot of the impacts of the natural hazards on the assets. The term "asset data" refers to critical infrastructure in the county and cities, such as utilities, owned facilities, bridges, schools, and other community facilities that are necessary for residents (see Table 21). The MJHMP Project Team compiled a list of critical facilities various of sources, including datasets owned and maintained by the county and cities, state and federal governments, and private industry. The critical facilities were described in terms of the basic critical functions they serve for the community. They were also categorized according to FEMA's community lifelines so that results could be filtered accordingly.

Table 21: Critical Facilities by Community Lifeline and Jurisdiction

Lifeline	County	Orland	Willows	Total
Communications	3	0	0	3
Energy	3	0	0	3
Food, Hydration, Shelter	1	2	0	3
Hazardous Materials	2	1	1	4
Health and Medical	3	4	4	11
Safety and Security	31	24	19	74
Transportation	4	4	2	10
Water Systems	29	6	17	52
Total	**76**	**41**	**43**	**160**

Hazus 6.0 was used to estimate potential losses for four hazard scenarios: 100-year flood, 500-year flood, an M5.8 Probabilistic Earthquake, and an M6.8 Great Valley Fault scenario earthquake. The models estimate the amount of damage that could be expected for different building occupancies, critical facilities, transportation systems, and utilities from these events. Table 22 shows the total value of exposed buildings in Orland, Willows and Glenn County, grouped by the building occupancy type. These values can be compared with the results in the flood and earthquake hazard profiles to understand the impact of the projected losses.

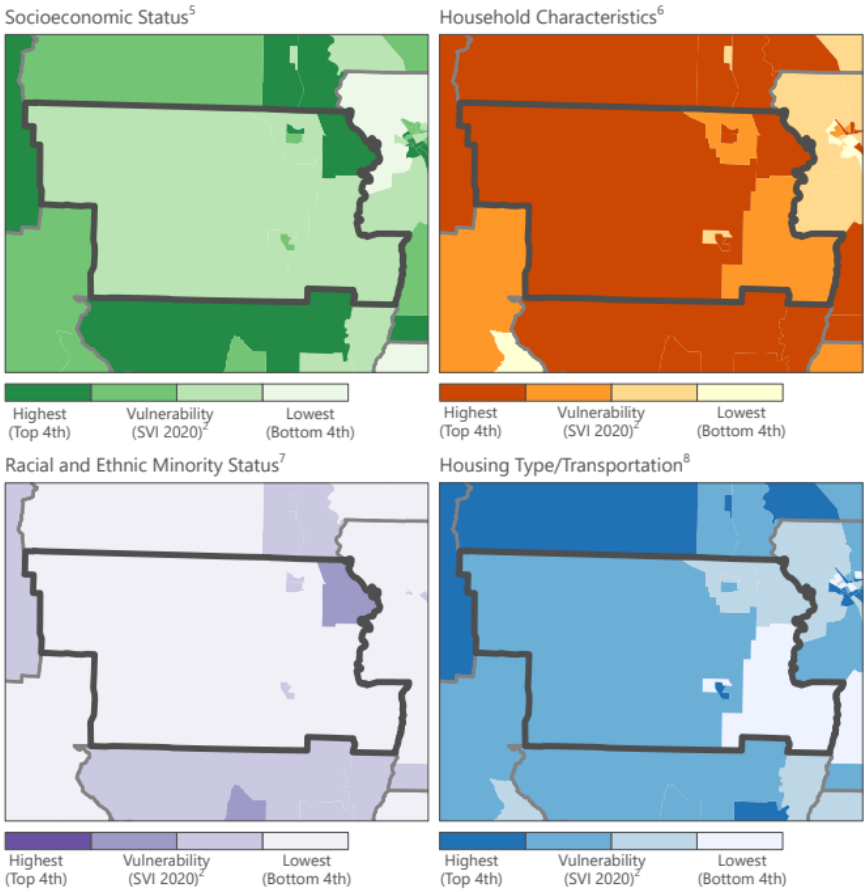
Table 22: Values of Exposed Buildings and Their Contents, by Occupancy

	Residential	Commercial	Industrial	Agriculture	Religious	Government	Education	Total Exposure
Orland	$974,377,000	$898,093,000	$173,811,000	$7,798,000	$70,322,000	$48,855,000	$184,694,000	$2,357,950,000
Willow	$839,310,000	$759,713,000	$86,139,000	$16,576,000	$86,074,000	$167,937,000	$183,972,000	$2,139,721,000
County	$2,371,513,000	$923,552,000	$1,506,164,000	$2,330,638,000	$98,324,000	$137,857,000	$159,932,000	$7,527,980,000
Total	$4,185,200,000	$2,581,358,000	$1,766,114,000	$2,355,012,000	$254,720,000	$354,649,000	$528,598,000	$12,025,651,000

Vulnerable Populations

Socioeconomic and demographic characteristics affect how people are impacted by disasters and their ability to access the resources needed to recover. These factors can include age (both children and elderly), gender, income, disabilities, housing conditions, English-speaking proficiency, racial and ethnic background, and access to transportation. People who exhibit one or more of these vulnerability characteristics often experience more severe effects from a disaster. To better understand the impacts of hazards on different demographic groups in Glenn County, a variety of tools and data were used.

A convenient way to get an overall understanding of vulnerability is to use an index, which summarizes a series of variables into a simplified value. The Social Vulnerability Index (SVI) summarizes 16 variables in four themes: Socioeconomic Status, Household Characteristics, Racial and Ethnic Minority Status, and Housing Type/Transportation. These data can be displayed in tabular form or by geographic distribution in a map, as shown in Figure 16. The northwest corner of the county near Hamilton showed higher vulnerability in socioeconomic, household, and racial/ethnic minority status. Orland and Willows showed moderately high to high vulnerability in all four themes. Unincorporated areas in the western area of the county showed higher vulnerability in household characteristics and housing type/transportation. These trends are considered when discussing possible impacts on the population in each hazard profile.



Source: CDC/ATSDR Social Vulnerability Index, 2020.
https://svi.cdc.gov/Documents/CountyMaps/2020/California/California2020_Glenn.pdf

Figure 16: Glenn County Social Vulnerability Themes

In addition to the SVI, a series of demographic reports were developed using the Environmental Systems Research Institute, Inc. (Esri) Business Analyst Tool, including At-Risk Populations (Figure 17). A series of maps showing individual vulnerability characteristics were generated using 2020 Census and American Community Survey (ACS) demographic variables, published in the Esri Demographics gallery.[20] These include characteristics such as age, language, disability, and income. The results of some of these variables are shown in Figure 18 through Figure 21.

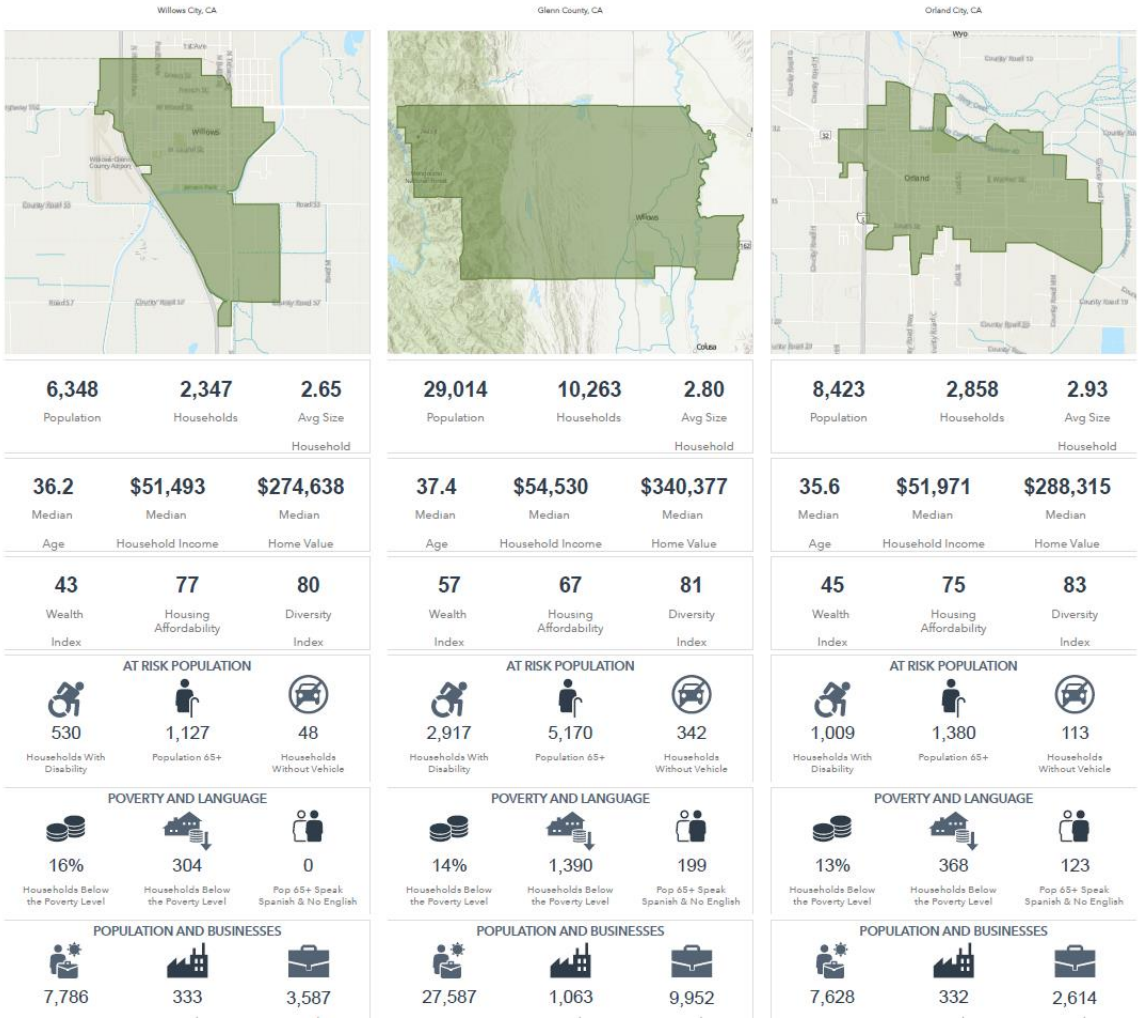


Figure 17: Comparison of At-Risk Populations in Willows, Glenn County, and Orland

The Climate and Economic Justice Screening Tool (CEJST) is a tool from the Council on Environmental Quality to identify communities that are experiencing burdens in one or more of eight categories: climate change, energy, health, housing, legacy pollution, transportation, water and wastewater, and workforce development. The tool was originally designed to identify communities that could benefit from investments in climate, clean energy, and other resources as part of the Justice40 initiative. However, it also serves as a reference for communities which are overburdened and underserved and which might experience

[20] Esri Demographics. https://www.arcgis.com/home/search.html?restrict=false&sortField=relevance&sortOrder=desc&searchTerm=owner%3A%22esri_demographics%22#content

disadvantages in relation to natural hazards. The climate change threshold includes several indicators related to natural hazards, such as flooding, wildfire, and agricultural losses.

CEJST identified three census tracts in Glenn County as disadvantaged. These areas are considered disadvantaged because they meet one or more burden threshold and the associated socioeconomic threshold. Table 23 identifies the burdens met for each of these communities.

Table 23: CEJST Threshold for Disadvantage Communities

Orland	Willows	Hamilton
Agricultural loss rate	Agricultural loss rate	Agricultural loss rate
Projected flood risk	Projected flood risk	Projected flood risk
PM2.5 in the air	PM2.5 in the air	PM2.5 in the air
Wildfire risk		
	Wastewater discharge	
		Lack of green space
		Linguistic Isolation
High school education	High school education	High school education
Low income	Low income	Low income

Agricultural loss: Economic loss in agricultural value from natural hazards each year.

Projected flood risk: Risk to properties from projected floods in the next 30 years.

Projected wildfire risk: Risk to properties from wildfire from fire fuels, weather, humans, and fire movement in the next 30 years.

PM2.5 in the air: Inhalable particles, 2.5 micrometers or smaller.

Lack of green space: The amount of land, not including crop land, covered with artificial materials, such as concrete and pavement.

Wastewater discharge: Modeled toxic concentrations at stream segments within 500 meters, divided by distance in kilometers.

Linguistic isolation: The share of households where no one over age 14 speaks English very well.

High school education: Percent of people aged 25 years or older without a high school diploma.

Low income: People in households where income is less than or equal to twice the federal poverty level.

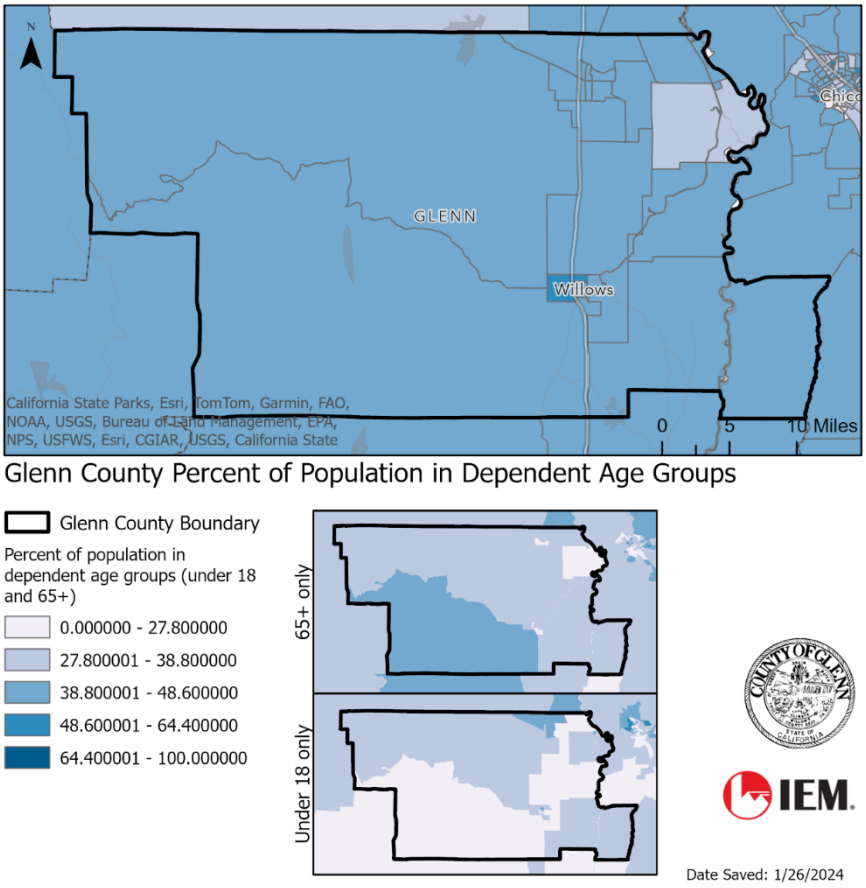


Figure 18: Dependent Age Vulnerability for Glenn County

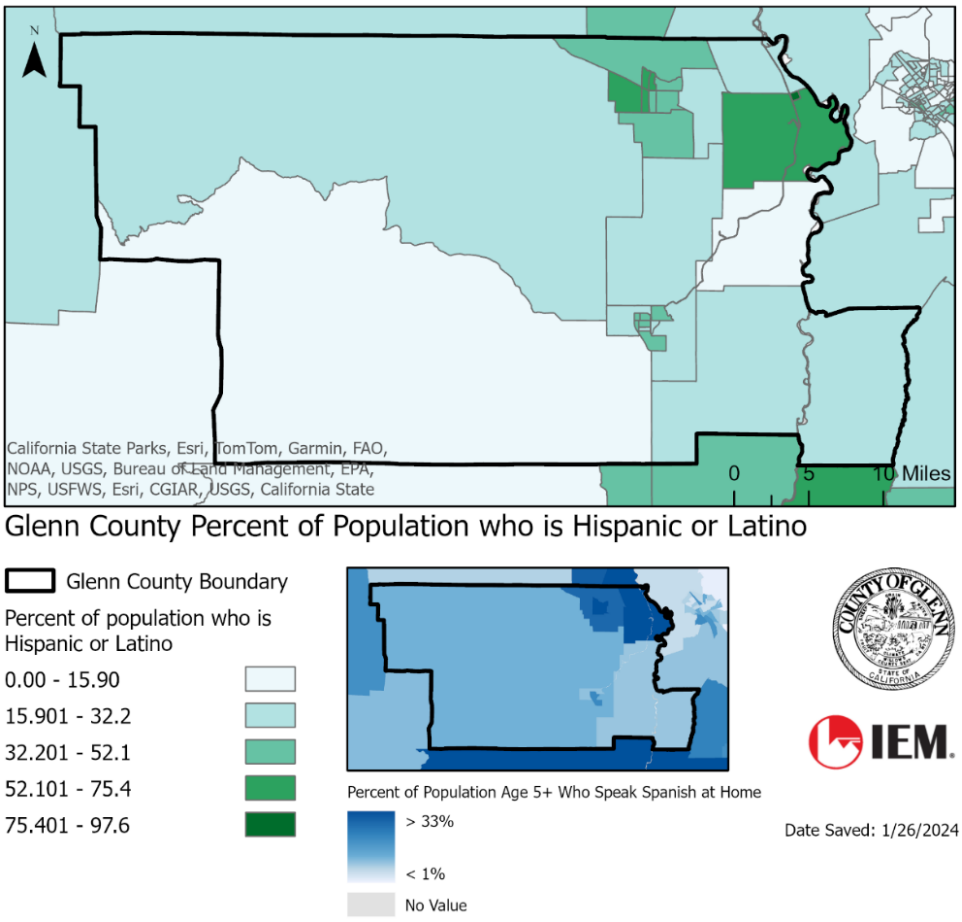


Figure 19: Hispanic or Latino Population and Spanish Speaking in Glenn County

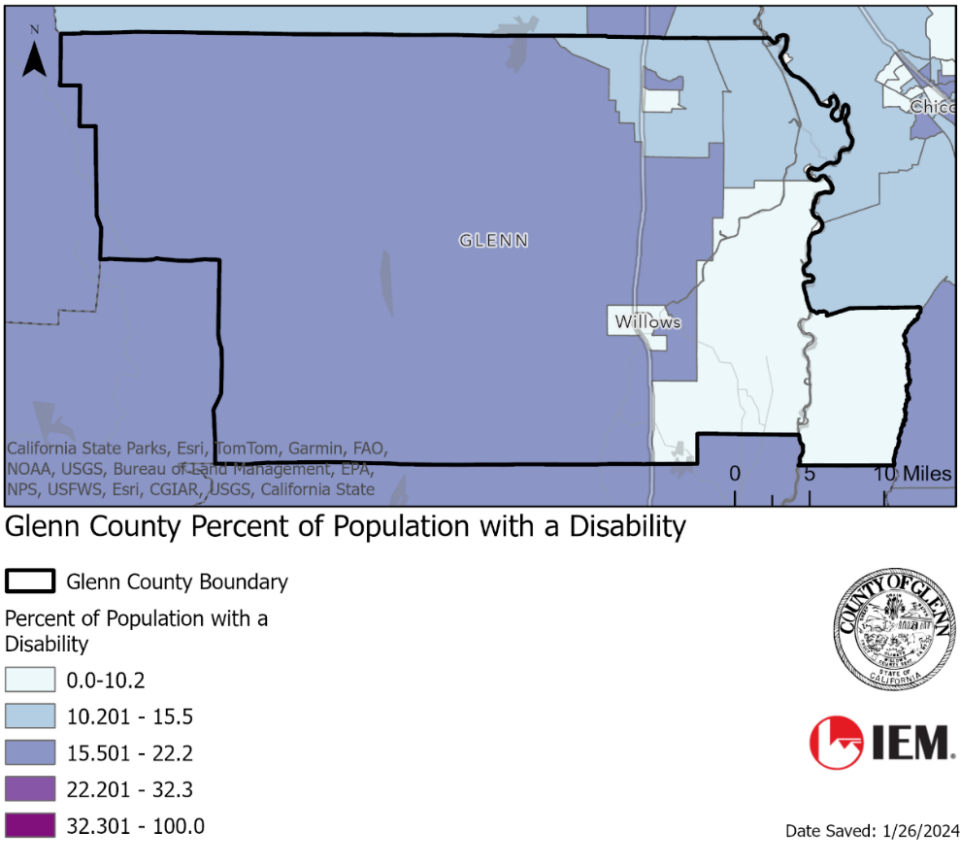


Figure 20: Percentage of Glenn County Population with a Disability

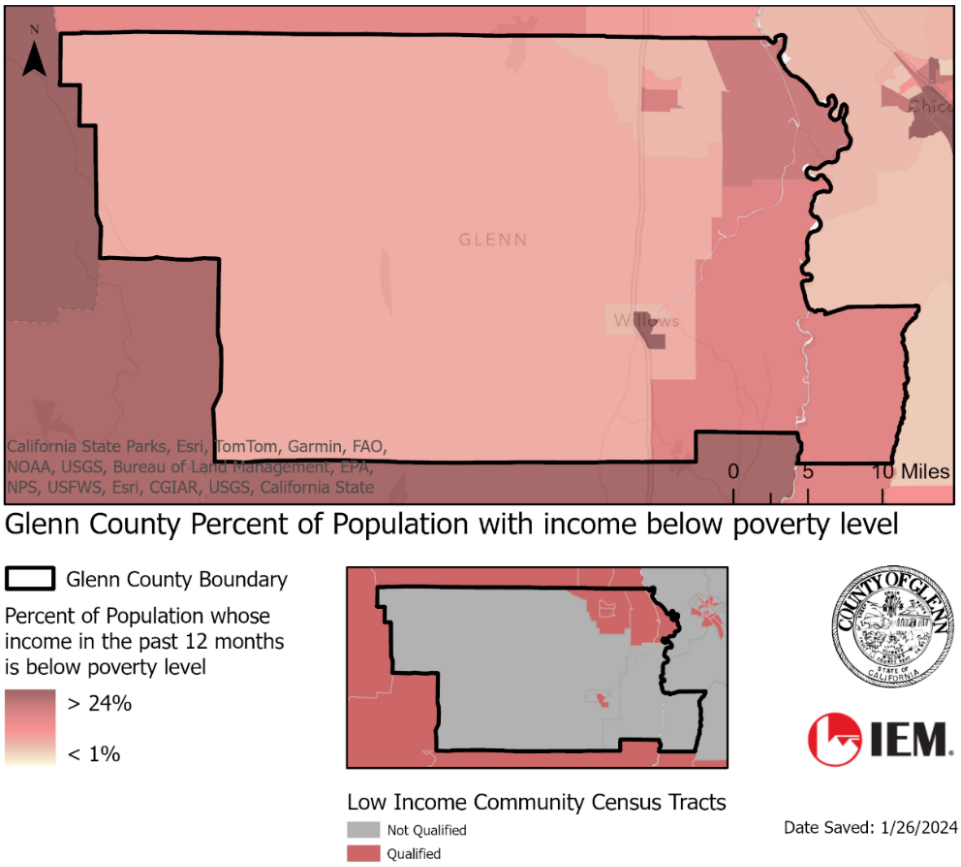


Figure 21: Glenn County Population below the Poverty Level

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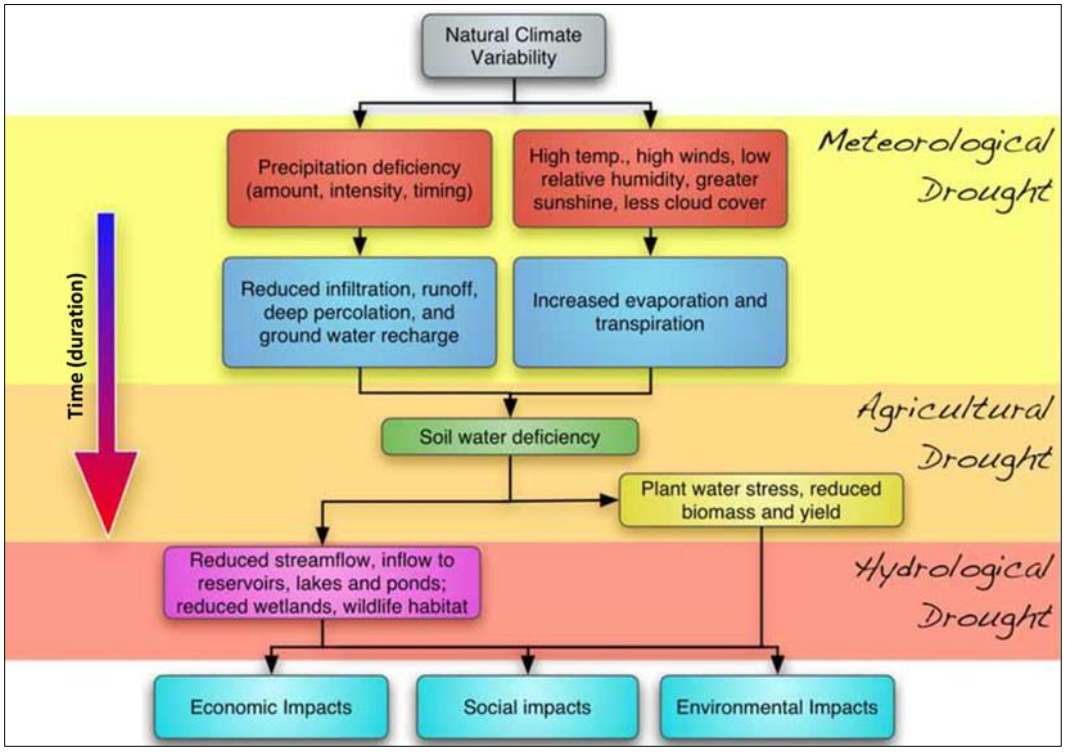
Section 3.1 Drought

Drought is an intrinsic cyclic feature of the climate that prevails across most geographical regions, albeit with varying degrees of severity and characteristics. The magnitude of its impact is contingent on a myriad of factors, such as duration, intensity, geographic extent, and demands on the regional water supply by humans, livestock, and vegetation. Climatic factors, such as prolonged high winds and low relative humidity, can exacerbate the severity of drought.

Drought arises from a lack of precipitation that persists for an extended period, typically one or more seasons, and can culminate in a water shortage for specific activities, groups, and environmental sectors. Drought is a multifaceted natural hazard that is commonly described through four distinct definitions and represented in Figure 22.



Source: Semantic Scholar, “Methodology for development of drought severity-duration-frequency (SDF) Curves.” https://www.semanticscholar.org/paper/Methodology-for-development-of-drought-(SDF)-Curves-Rahmat/dfd51bf8969149b75ee6f15fcd39380f79bdd8fd

Figure 22: Types of Droughts and Their Development

- **Agricultural Drought:** A naturally occurring phenomenon that arises when the moisture levels of the soil fall below the water requirements of plant life and dehydrate crops. It is a significant concern for farmers and businesses, as it can have far-reaching consequences for agricultural yields, food security, and overall economic stability.
- **Hydrological Drought**: This is related to the impact of precipitation shortfalls on stream flows and water levels in reservoirs, lakes, and groundwater. This phenomenon is characterized by a significant shortage of rainfall, leading to a reduction in the availability of water resources. The effects include a decrease in the quantity and quality of available water, which can have serious implications for various sectors, including agriculture, forestry, and public health.

- **Meteorological Drought**: A weather phenomenon characterized by the degree of dryness. It is the departure from the average or normal precipitation based on monthly, seasonal, or annual time frames. It is a significant concern for businesses and academic institutions, as it can severely impact agriculture, water resources, and the environment.
- **Socioeconomic Drought:** An economic phenomenon whereby the supply and demand of economic goods or services become imbalanced because of meteorological, hydrological, and agricultural droughts. This type of drought is characterized by a weather-related shortfall in the water supply, leading to a situation where the demand for water exceeds its supply. This is often called a water management drought, as it requires effective management practices to ensure the proper allocation and distribution of water resources. The implications of socioeconomic drought can be far-reaching, impacting various sectors of the economy, including agriculture, industry, and urban water supply.

Although climate is a primary contributor to hydrological drought, other factors, such as changes in land use (e.g., deforestation), land degradation, and dam construction, all affect the basin's hydrological characteristics. Since hydrologic systems interconnect regions, the impact of meteorological drought may extend well beyond the borders of precipitation-deficient areas. Similarly, changes in land use upstream may alter hydrologic characteristics, such as infiltration and runoff rates, resulting in a more variable streamflow and a higher incidence of hydrologic drought downstream. Land use change is one of the ways in which human actions alter the frequency of water shortages, even when no change in the frequency of meteorological drought has been observed.

Because of its multi-dimensional nature, drought represents a significant challenge in terms of defining it and conducting comprehensive risk assessments. Drought differs from other natural hazards in three fundamental ways. First, the onset and conclusion of a drought are difficult to determine because of the event's slow accumulation and lingering effects after its apparent end. Second, the lack of an exact and universally accepted definition adds to the confusion about its existence and severity. Third, in contrast to other natural hazards, the impact of drought is less obvious and may be spread over a larger geographic area. These attributes have made it difficult for many governments to prepare and implement drought contingency or mitigation plans.

Drought should not be perceived merely as a physical or natural phenomenon. Rather, its impact on society comes from the interaction between natural climatic variability, which manifests as less precipitation than anticipated, and a greater demand for water. Human activities further exacerbate the impact of drought. Recent droughts in both developing and developed countries, with their economic and environmental repercussions and personal hardships, have underscored the vulnerability of all societies to this "natural" hazard. Droughts can cause a lack of water for household and industrial consumption, hydroelectric power, recreation, and navigation. Water quality also may deteriorate, and the number and severity of wildfires may rise. Severe droughts may result in the loss of agricultural crops and forest products, undernourished wildlife and livestock, lower land values, and higher unemployment.

Regulatory Environment

Several regulatory requirements and documents have been developed in Glenn County to address drought planning. These include the 2012 Groundwater Coordinated Resource Management Plan, the 2006 Northern Sacramento Valley Four County Regional Water Management Group, the 2015 Glenn County Water Advisory Committee, the 2023 Glenn County General Plan Update, a Drought Taskforce established by the Glenn County Board of Supervisors in 2021, and the 2015 Glenn County Emergency Operations Plan.

These documents and requirements are of great importance to Glenn County's ability to prepare for and respond to drought conditions. They provide a framework for managing and conserving water resources, and they help ensure that emergency plans are in place to protect residents and businesses during times of drought. Therefore, it is essential that these regulatory requirements and documents are regularly

reviewed and updated to reflect changes in the local landscape and to ensure that they remain effective in promoting drought resilience and preparedness.

2012 Glenn County Groundwater Coordinated Resource Management Plan Update

The drought issue in Glenn County has been addressed by implementing the 2012 Groundwater Coordinated Resource Management Plan. The Board of Supervisors has acknowledged that safeguarding groundwater resources for use in the county is necessary to ensure its residents' health, welfare, and safety. Furthermore, the Board has emphasized the critical role of maintaining a safe yield of groundwater in supporting the county's economy. As such, it is imperative to ensure the continued availability of groundwater while strictly adhering to the principles of safe yield, which prohibit extracting groundwater beyond its capacity, degrading groundwater quality, and land subsidence.

Inadequate management and monitoring of groundwater resources may have adverse impacts. These negative effects include resource depletion, contamination, and water quality degradation. To ensure the sustainable use of groundwater resources, it is imperative to establish and maintain a robust monitoring system that tracks the quality and quantity of the resources over time. By doing so, stakeholders can identify potential issues early and take corrective measures to mitigate any negative impacts on the resource, such as the following:

1. Lowering groundwater levels leads to increased energy consumption, the cost of deepening existing wells, and the prospect that new wells will have to be deeper and more costly than would otherwise be required.
2. Damage to public roads, bridges, canals, and other structures caused by land subsidence can create substantial costs to the public treasury.
3. Drying up of surface and subsurface flows leads to the potential loss of critical riparian and wetland habitats.
4. Degradation of groundwater quality leads to increased salinity or higher concentrations of contaminants.
5. The water needs of county residents, the vibrancy of the agricultural economy, and the rural lifestyle are challenged.

The purpose and intent of this management plan is to establish an effective policy on groundwater and coordinated resource management. The goal is to ensure that the county's overall health, welfare, safety, economy, and environment are not negatively impacted. To accomplish this objective, the plan aims to establish strategies to promote efficient resource management while minimizing the potential environmental impacts of such activities. Furthermore, this plan seeks to provide clear guidelines for managing groundwater as a valuable resource, recognizing the importance of conserving it for future generations.

Through this approach, the county can maintain a sustainable balance between using its natural resources and preserving its ecological health. Implementing this plan will require the cooperation and coordination of all stakeholders, including government officials, industry representatives, and the public.[21]

[21] County of Glenn, "Title 20 Water."
https://www.countyofglenn.net/sites/default/files/resources/County_Code_Directory/Title%2020.pdf

City of Orland Municipal Code 17.85.040

Chapter 17.85, Section 4 of the Municipal Code of Orland stipulates that all newly introduced vegetation must consist of native, drought-tolerant species that are compatible with the predominant natural setting of the project area. This indicates that the region has recognized the drought affecting the southwestern portion of the United States and has begun to implement measures to cope effectively by requiring drought-tolerant vegetation to be planted in areas of new vegetation.

2009 Northern Sacramento Valley Four County Regional Water Management Group

The counties of Butte, Colusa, Glenn, and Tehama have a long-standing collaboration on resource management issues. This partnership was made official through the Four County Memorandum of Understanding (Four County MOU) in early 2006. The group is now known as the Four County Group. Over time, three addendums were added to the MOU, which clearly outlined the working relationship between these four counties and added Sutter County to the group in 2009.[22] This document was created in response to the California Department of Water Resources Regional Acceptance Process (RAP), as described in the guidelines published in December 2008, to define the way that neighboring and/or overlapping integrated regional water management plans (IRWMPs) will work together in the management of water and other natural resources in the State of California.

Since its inception, the Four County Group has been actively meeting with other IRWMP groups in the Sacramento River Hydrologic Area to coordinate their efforts to ensure optimal resource management in the larger region. The Four County Group is a continuously evolving planning effort that is constantly changing and adapting to new situations. While the Butte County plan serves as a foundational document, it also represents the starting point for a more extensive and inclusive regional approach to resource planning. This approach aims to satisfy the needs and desires of all five counties and other interested groups and organizations in the planning region. As the process has evolved, additional partnerships have formed, with some IRWMPs undergoing changes and consolidations, much like the expansion of the Four County Group.

2015 Glenn County Water Advisory Committee

The Glenn County Water Advisory Committee was established in response to pressing drought issues in the region. The committee is responsible for ensuring an adequate, affordable, and sustainable supply of good-quality water to cater to the needs of the agricultural, industrial, recreational, environmental, residential, and municipal users in the county, both now and in the future. The committee's mandate is to ensure that all stakeholders have access to a reliable water supply that meets the highest standards of quality and affordability, thereby promoting the sustainable development of the region.

Sustainable Groundwater Management Act (SGMA)

The Sustainable Groundwater Management Act (SGMA) requires local Groundwater Sustainability Agencies (GSAs) in high- and medium-priority basins to develop and implement Groundwater

[22] County of Glenn, "Northern Sacramento Valley Four County Group Integrated Regional Water Management Regional Acceptance Process 2009 Application."
https://www.countyofglenn.net/sites/default/files/Water_Advisory_Committee/FourCountyRAP042609_000.pdf

Sustainability Plans (GSPs).[23] These plans provide a roadmap for how groundwater basins will reach long-term sustainability. Glenn County includes three subbasin GSAs: Butte, Colusa, and Corning. These agencies have authority to manage groundwater to avoid chronic lowering of groundwater levels, reduction of groundwater storage, seawater intrusion, degraded water quality, land subsidence, and depletions of interconnected surface water.[24]

2023 Glenn County General Plan

The 2023 Glenn County General Plan addresses drought in policies COS 6-5, COS-3d, and LU 4-7c as part of the discussion of the Groundwater Sustainability Plan.[25] The GSP also states that local priorities should be established for water use and placed in the general plan. Staff should be assigned to monitor drought-related actions at the state and federal levels.

Location/Geographic Extent

Drought can adversely affect the entire state of California and can occur in any region of the country, regardless of location or time. The water supply in Glenn County is particularly susceptible to the adverse effects of drought. The scarcity of precipitation in the Sierra Nevada, coupled with the depletion of groundwater levels, can significantly impact the water supply in the county. This is primarily based on the county's dependence on the Upper Sacramento River and Coast Range watersheds for its water supply. Drought has no defined geographic boundaries. All of Glenn County, including the cities of Orland and Willows, is subject to drought.

Magnitude/Extent

There is no commonly accepted return period or non-exceedance probability for defining the risk of drought (such as the 100-year or one percent annual chance of flood). The magnitude of drought is typically measured based on the time of its occurrence and the severity of the hydrologic deficit. However, several resources are available to evaluate drought status and forecast expected conditions.

The National Integrated Drought Information System (NIDIS) Act of 2006 (Public Law 109-430) ensures an interagency approach to drought monitoring, forecasting, and early warning. The U.S. Drought Portal is a web-based platform that provides access to several drought-related resources, including the U.S. Drought Monitor (USDM), Figure 23, and the U.S. Seasonal Drought Outlook (USSDO), as shown in Figure 24. These resources can help in evaluating drought conditions and making informed decisions to mitigate its impact.

As shown by the red oval in Figure 23, Glenn County was not experiencing drought conditions at when this report was being drafted. However, historic records available in the USDM show that extreme and exceptional droughts have occurred in Glenn County in the past 10 years. This is discussed further in the section on Past Occurrences.

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[23] California Department of Water Resources Groundwater Sustainability Plans. https://water.ca.gov/Programs/Groundwater-Management/SGMA-Groundwater-Management/Groundwater-Sustainability-Plans
[24] County of Glenn Water Resources, Sustainable Groundwater Management Act. https://www.countyofglenn.net/dept/planning-community-development-services/water-resources/sustainable-groundwater-management-4
[25] https://static1.squarespace.com/static/5c8a73469b7d1510bee16785/t/6501ddc090fa5b221162db04/1694621148151/GlennCounty_General+Plan+Adopted+7-18-23.pdf

Map released: Thurs. November 2, 2023
Data valid: October 31, 2023 at 8 a.m. EDT

Intensity
None
D0 (Abnormally Dry)
D1 (Moderate Drought)
D2 (Severe Drought)
D3 (Extreme Drought)
D4 (Exceptional Drought)
No Data

Authors
United States and Puerto Rico Author(s):
Brian Fuchs, National Drought Mitigation Center
Pacific Islands and Virgin Islands Author(s):
Brad Rippey, U.S. Department of Agriculture

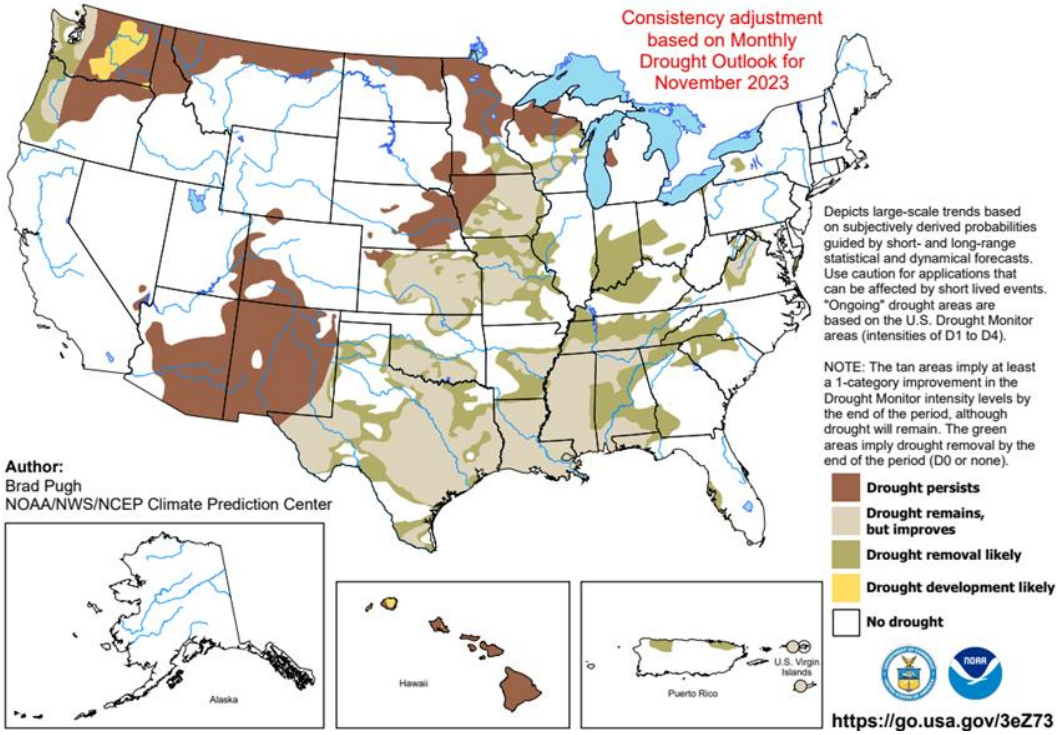
Week	Date	None	D0	D1	D2	D3	D4	DSCI
Current	2023-10-31	94.34	5.66	0.00	0.00	0.00	0.00	6
Last Week to Current	2023-10-24	94.32	5.68	0.00	0.00	0.00	0.00	6
3 Months Ago to Current	2023-08-01	74.43	19.05	6.52	0.00	0.00	0.00	32
Start of Calendar Year to Current	2022-12-27	0.00	2.06	17.38	45.06	28.33	7.16	321
Start of Water Year to Current	2023-09-26	94.01	5.93	0.07	0.00	0.00	0.00	6
One Year Ago to Current	2022-11-01	0.00	0.23	7.94	48.76	26.50	16.57	351

Source: U.S. Drought Monitor, “California.”
https://droughtmonitor.unl.edu/CurrentMap/StateDroughtMonitor.aspx?CA

Figure 23: Drought in the State of California, November 2, 2023

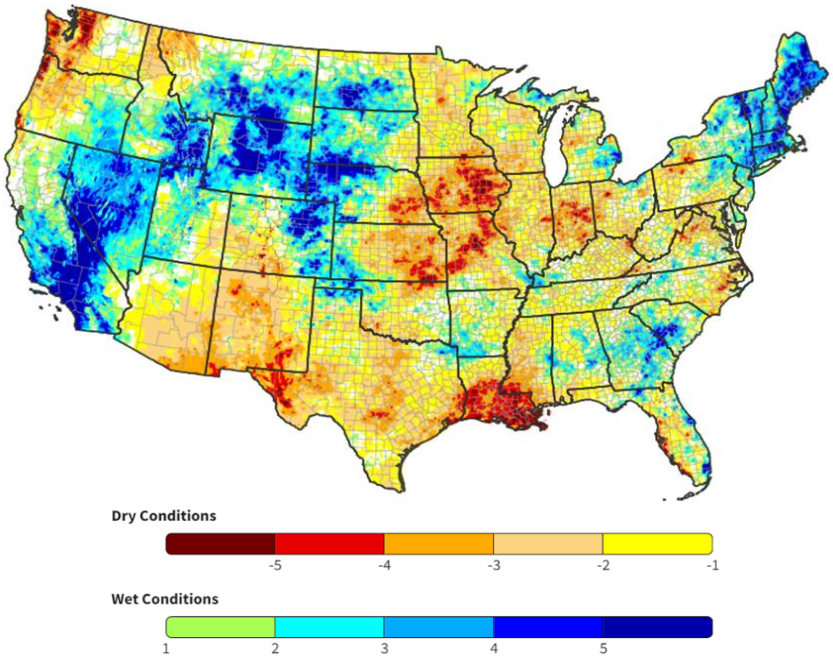
The US Seasonal Drought Outlook (USSDO) in Figure 24 projects potential drought conditions for the next three months. Currently, California is not experiencing drought.

Several indices measure how much precipitation for a given period deviates from historically established norms. The primary indicator for the USDM and USSDO for the western United States is the Palmer Drought Severity Index (PDSI, see Figure 25). The PDSI is widely used by the U.S. Department of Agriculture (USDA) to determine when to grant emergency drought assistance to affected areas. This new experimental implementation of the PDSI is updated every five days using the high-resolution gridMET gridded research dataset and data from the USDA State Soil Geographic Database (STATSGO). The PDSI is a standardized index based on a simplified soil water balance and estimates relative soil moisture conditions. The magnitude of the PDSI indicates the severity of the departure from normal conditions. A PDSI value >4 represents very wet conditions, while a PDSI <-4 represents an extreme drought.



Source: U.S. Drought Monitor, "California."
https://droughtmonitor.unl.edu/CurrentMap/StateDroughtMonitor.aspx?CA

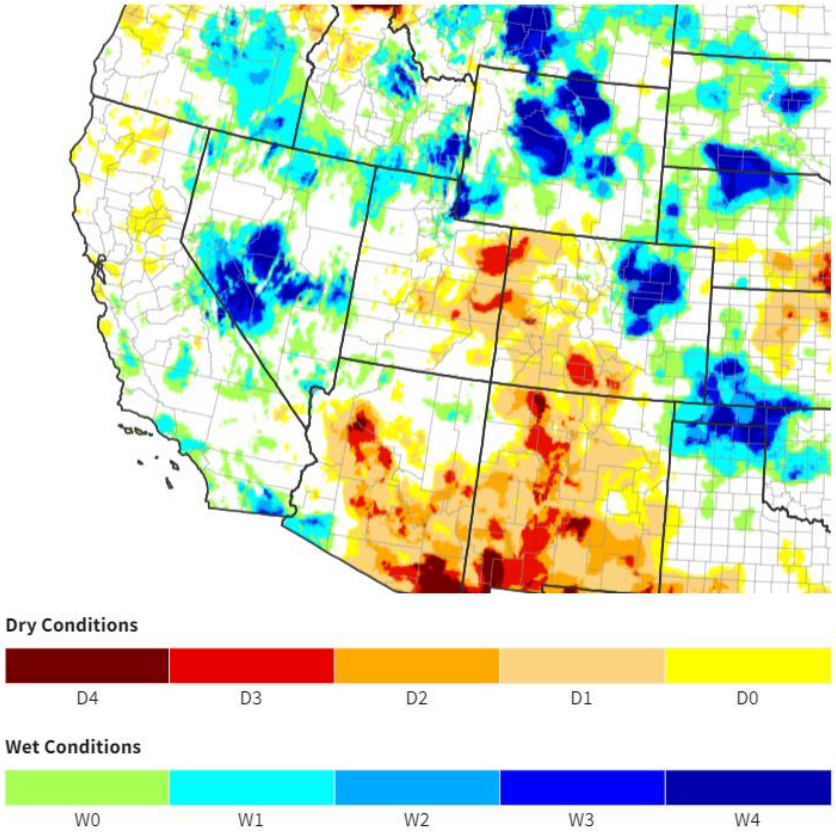
Figure 24: Drought Tendency in the United States, November 01, 2023–January 31, 2024



Source: National Integrated Drought Information System, "U.S. Gridded Palmer Drought Severity Index (PDSI) from gridMET." https://www.drought.gov/data-maps-tools/us-gridded-palmer-drought-severity-index-pdsi-gridmet#:~:text=The%20PDSI%20is%20a%20standardized,4%20represents%20an%20extreme %20drought

Figure 25: Drought Severity in the United States

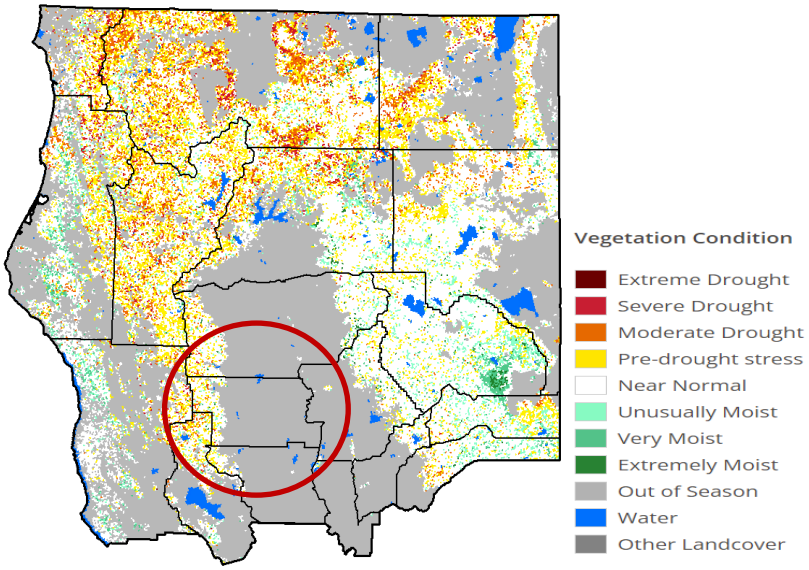
For western states with mountainous terrain and complex regional microclimates, it is also useful to supplement PDSI values with other indices, such as the Surface Water Supply Index and the Standardized Precipitation Index (SPI). The Surface Water Supply Index takes snowpack and other unique conditions into account. The National Drought Mitigation Center (NDMC) uses the SPI to identify emerging drought months sooner than the PDSI does. It is computed on various time scales to monitor moisture supply conditions. The SPI is the number of standard deviations in the precipitation value that deviate from the long-term mean. As shown in Figure 26, the SPI through January 2024 for Glenn County is currently neither drier nor wetter than normal.



Source: https://www.drought.gov/data-maps-tools/us-gridded-standardized-precipitation-index-spi-nclimgrid-daily

Figure 26: 12-Month Standard Precipitation

The Vegetation Drought Response Index (VegDRI) is a weekly indicator of vegetation stress across the contiguous United States. It provides fine-resolution (1 km^2) data based on remote sensing information, which considers climate and biophysical data to determine the underlying cause of vegetation stress. The NDMC, the U.S. Geological Survey's National Center for Earth Resources Observation and Science, and the High Plains Regional Climate Center have collaborated to develop the VegDRI map and associated products. Figure 27 presents the VegDRI results for California Region 1 on November 5, 2023, with Glenn County circled in red.



Source: https://vegdri.unl.edu/Home/VegDRIQuad.aspx?CA,1

Figure 27: Vegetation Drought Response Index Region 1, November 05, 2023

Past Occurrences

Glenn County has experienced 13 instances of drought since 1977, one of which was declared a federal disaster. Figure 28 is a graph from the Drought Monitor Index of several periods of drought since 2000. Although record-breaking storms in 2022 and early 2023 brought substantial rain and snow to California, the area has yet to fully recover because of heat waves, evaporation, and lack of available water. Moreover, atmospheric thirst, a phenomenon in which warm air holds more moisture, further contributes to drought, as it absorbs water from lakes, plants, and soil, exacerbating the depletion of water supplies. The lack of replenishment in water sources from the previous drought has impeded the full recovery of parched land. Despite this, drought conditions have eased across most of the state.

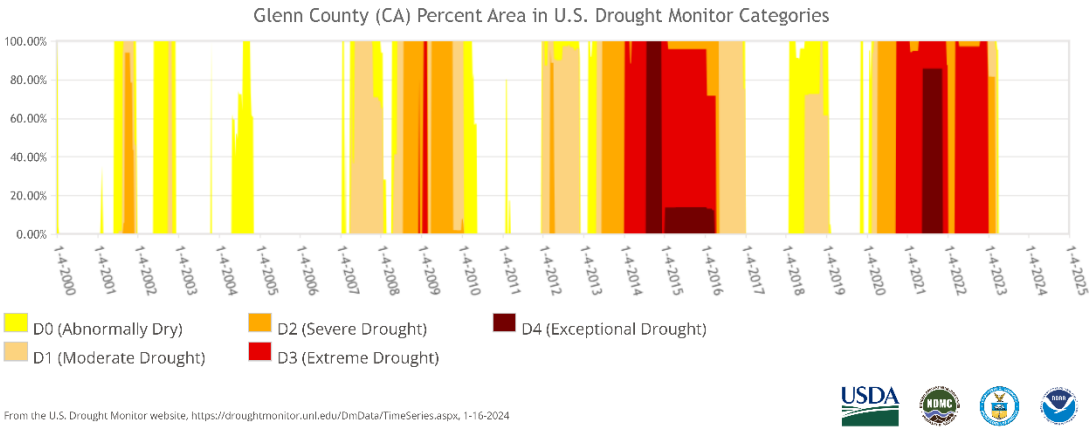


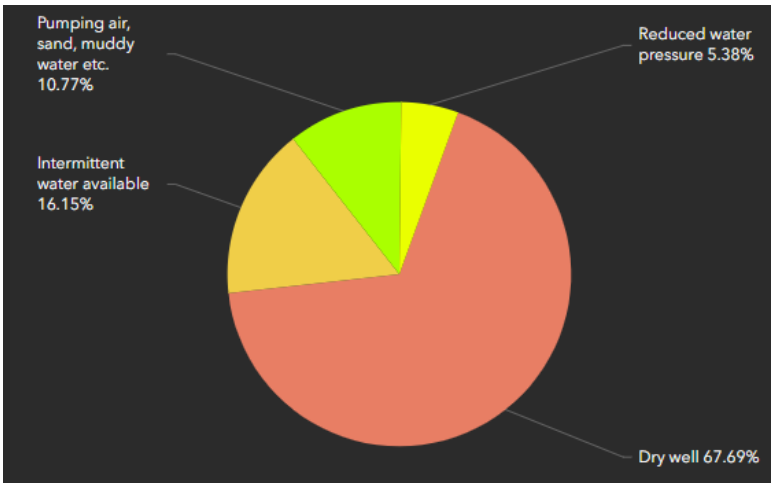
Figure 28: Drought Monitor Time Series Chart for Glenn County

A major drought affected California from 2012 to 2016, when there was extremely low precipitation, below-average snowpack, and record low PDSI values. In sharp contrast, the Sacramento Valley experienced its wettest year on record in 2016–2017, with an above-average number of atmospheric rivers.

In early 2021, Glenn County and the entire state of California entered a drought period. Because of critically low rainfall and water storage supplies, Glenn County proclaimed a local drought emergency. Most water shortages were reported in Tehama and Glenn Counties. In July 2021, 58 well water shortages in Glenn County were reported. In July, state officials analyzed 175 wells in Glenn County and found that about 84% had reached historically low levels. Of these wells, 31% had reached their lowest levels recorded for that month, while 53% were in the lowest 10th percentile compared to historic levels.

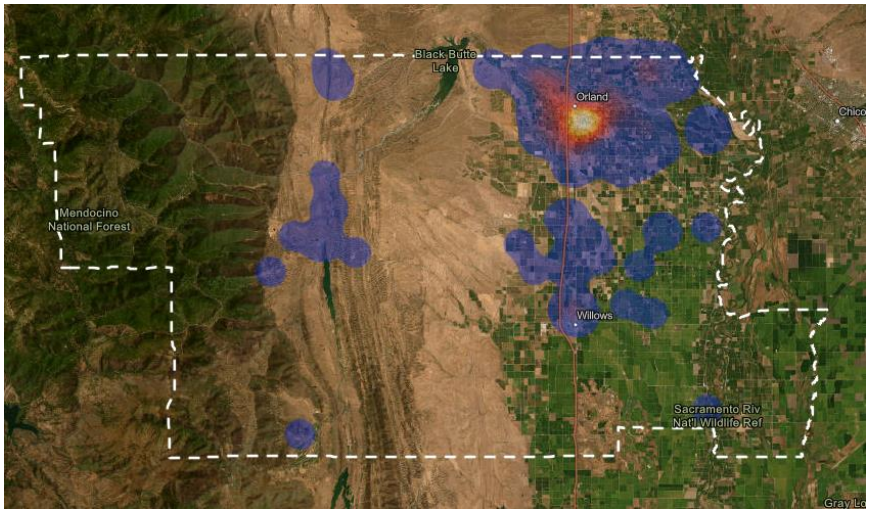
An additional 178 wells were not included in the analysis because no historical or recent measurements were available.[26] Glenn County also implemented a survey for residents to report dry wells and is tracking well conditions with a dashboard, including results, as shown in Figure 29. Figure 30 shows where dry wells were reported, with the greatest number occurring near Orland.

[26] Cal Matters, “California enacted a groundwater law 7 years ago. But wells are still drying up-and the threat is spreading.” https://calmatters.org/environment/2021/08/california-groundwater-dry/



Source: Planning and Community Development Services, "Well Incident Data Summary." https://storymaps.arcgis.com/stories/d24176a9a1974ffd8b6e4e51deff8540?fbclid=IwAR1Gg7QIbFSF6fVmY4URVmSAdFFDnCqHi4BfshszxgqB2FMVq7TbUtDKuo8

Figure 29: Ground Water Supply Issues in Glenn County, 2022–2023



Source: Planning and Community Development Services, "Well Incident Data Summary." https://storymaps.arcgis.com/stories/d24176a9a1974ffd8b6e4e51deff8540?fbclid=IwAR1Gg7QIbFSF6fVmY4URVmSAdFFDnCqHi4BfshszxgqB2FMVq7TbUtDKuo8

Figure 30: Dry Wells in Glenn County, 2021–2022

The California Division of Water Resources maintains multiple tools for tracking groundwater trends over time. Groundwater basins act as buffers between wet and dry periods by providing additional supply during dry years. Eighty-five percent of Californians rely on groundwater for some portion of their water supply. Groundwater levels serve as a proxy for groundwater storage and provide valuable information on seasonal fluctuations, long-term changes, and trends in groundwater storage. These data show that water levels respond differently to precipitation at the regional and local levels. The supply depends on a complex interaction of water recharge and management, precipitation, the use of surface and recycled

water, and groundwater pumping.[27] Figure 31 shows that numerous wells in Glenn County have had declining groundwater levels over the past 20 years and Figure 32 shows current groundwater conditions.

The drought that started in the summer of 2020 and lasted until spring 2021 was caused by a lack of rain over four consecutive seasons. The driest summer on record occurred in 2020, with extremely dry conditions in August. From winter 2020 to spring 2021, drought conditions worsened because of the development of La Niña in the tropical Pacific Ocean. Over decades, variability in the Pacific Ocean also contributed to the drought in the southern region by making the cool season drier over the last twenty years. Moreover, there is evidence that human-driven climate change is causing the southern region to become drier in the spring. In conclusion, the drought was caused by a combination of internal atmospheric variability, interannual climate variability, natural decadal variability, and human-driven climate change.[28]

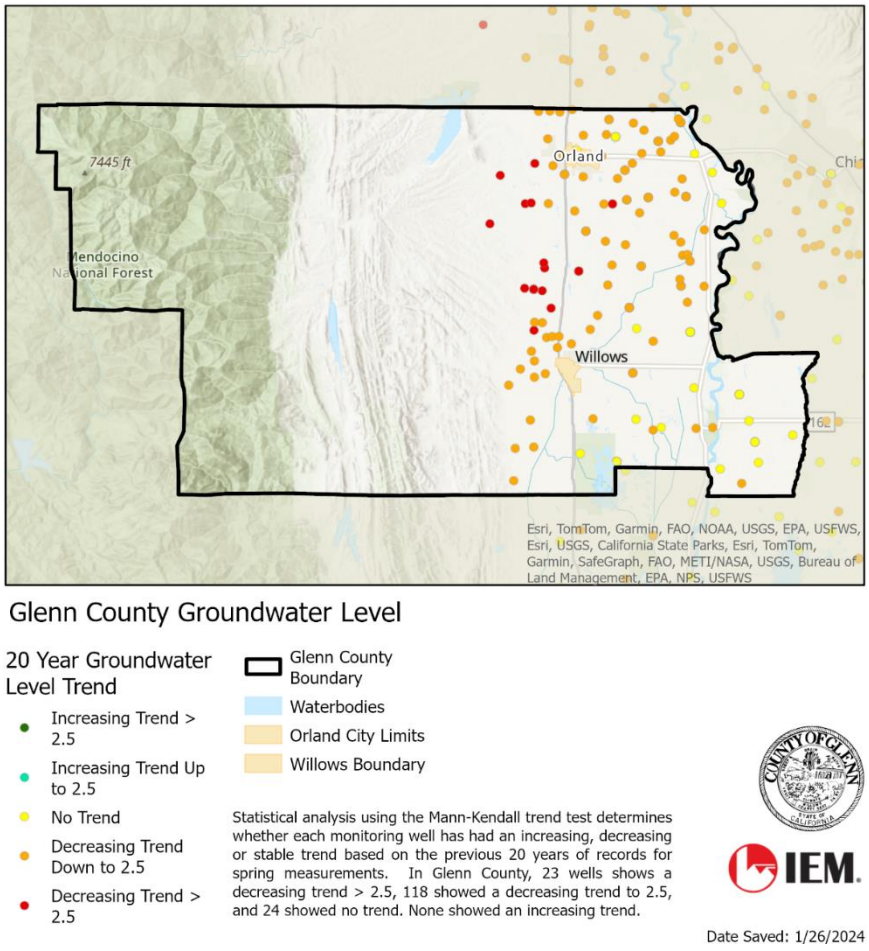


Figure 31: 20-Year Trends in Groundwater Levels in Glenn County

[27] California Department of Water Resources. "California Groundwater Conditions Update," 2021. https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Data-and-Tools/Files/Maps/Groundwater-Level-Change/DOTMAP_Reports/Spring-2021-Groundwater-DOTMAP-Report.pdf

[28] NOAA, "What Caused the Summer 2020 to Spring 2021 Drought in Southwestern North America?" https://cpo.noaa.gov/what-caused-the-summer-2020-to-spring-2021-drought-in-southwestern-north-america/

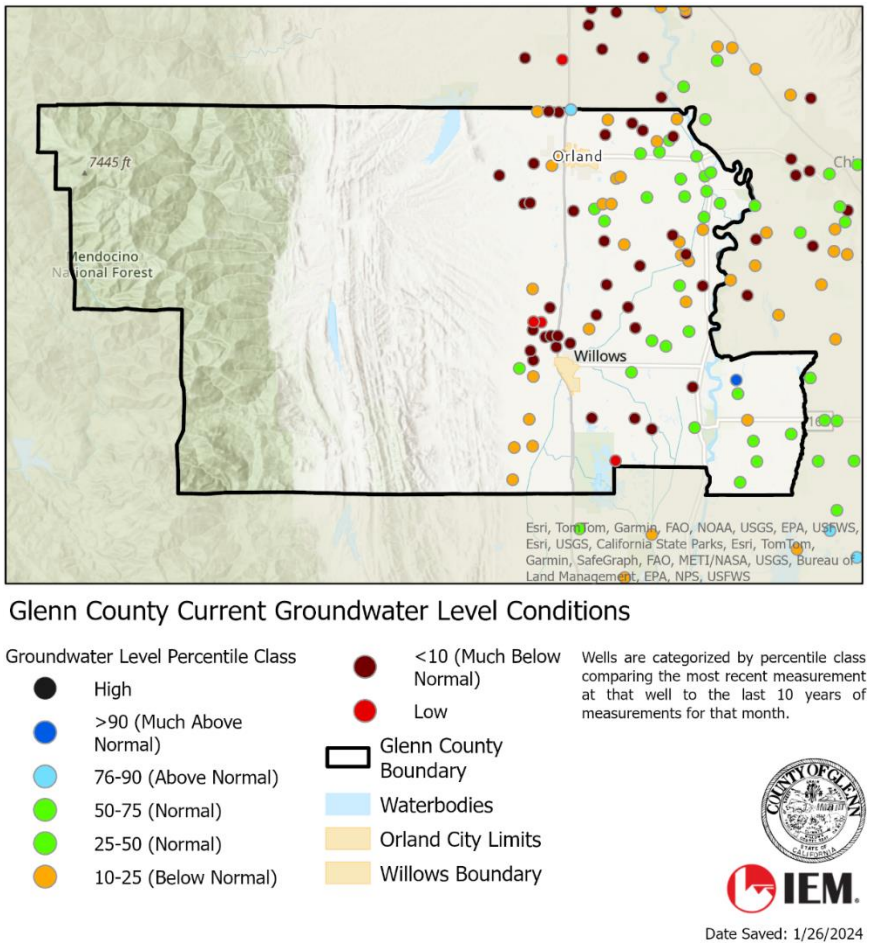


Figure 32: Glenn County Groundwater Conditions, January 2024

Table 24 lists the agencies that have declared droughts in Glenn County.

Table 24: Executive Orders for Drought in Glenn County

Agency	Executive Order Date	Executive Order #
FEMA[3]	January 20, 1977	EM-3023
State of California[1]	May 26, 1990	D-85-90
State of California[1]	February 01, 1991	W-3-91
State of California[1]	June 4, 2008	S-06-08
State of California[1]	June19, 2009	S-11-09
Board of Supervisors, Glenn County California[2]	June 01, 2021	2021-032
State of California[1]	July 08, 2021	N-10-21
U.S. Department of Agriculture[2]	October 1, 2021	USDA S5146
State of California[1]	March 28, 2022	N-7-22

Agency	Executive Order Date	Executive Order #
U.S. Small Business Administration[2]	December 08, 2022	17389
State of California[1]	February 13, 2023	N-3-23
State of California[1]	March 10, 2023	N-4-23
State of California[1]	March 24, 2023	N-5-23

Sources:

[1] California State Library, "Executive Orders and Proclamations." https://www.library.ca.gov/government-publications/executive-orders/?SelectedType=2&TranscriptFilter=DROUGHT&pageNo=3

[2] State Water Resource Control Board, "Drought Orders, Proclamations, Notices, and Letters." https://www.waterboards.ca.gov/drought/drought_orders_proclamations.html

[3]FEMA, "Disaster Declarations for States and Counties." https://www.fema.gov/data-visualization/disaster-declarations-states-and-counties

Frequency/Probability of Future Occurrences

The USDM provides short-term predictability for future droughts, but long-term drought forecasting is a complex challenge, given the intricacies of the Earth's climate. The severity of droughts and the number of dry years are anticipated to rise, even if precipitation remains stable or increases. Warming air temperatures are expected to cause moisture loss from soils, creating drier seasonal conditions despite increases in precipitation.[29]

The snowpack in California's mountains is a crucial source of surface and groundwater for the state. However, the snowpack is expected to decline by more than a third by 2050 and by more than half by 2100 because of rising temperatures. Climate change is having a significant impact on water availability. When winters are warmer, less snow falls in regions such as the Sierra Nevada of California. The reduced snowpack can cause problems for water management systems that rely on spring snowmelt. Moreover, snow has a reflective surface, so a decrease in snow cover increases surface temperatures, which can exacerbate drought.

Several climate models predict that a warming climate will increase precipitation variability, leading to more frequent periods of extreme precipitation and drought. This means that there will be a greater need for expanded water storage to prepare for drought years. However, there will also be an increased risk of flooding and dam failure during times of extreme precipitation.[30] These changes will occur even if annual precipitation levels remain constant.

The National Risk Index (NRI) lists 1,337 drought event-days that have occurred in Glenn County. Based on the number of event-days per year over the period of record (21.8 years).[31] This equates to an annualized frequency of 60.77. Thirteen events since 1977 were severe enough to result in Executive Orders or disaster declarations, an annualized frequency of 27%. This figure was considered to be a more accurate indicator of the future probability of Drought for the planning area.

[29] California Climate Adaption Strategy, "Summary of Projected Climate Change Impacts on California." https://climateresilience.ca.gov/overview/impacts.html#:~:text=However%2C%20there%20is%20high%20confidence,extreme%20precipitation%20events%20may%20occur

[30] Center for Climate and Energy Solutions. "Drought and Climate Change." https://www.c2es.org/content/drought-and-climate-change/#:~:text=How%20climate%20change%20contributes%20to,would%20be%20in%20cooler%20conditions.

[31]National Risk Index, "Drought." https://hazards.fema.gov/nri/drought

Changes in Development

California's Fourth Climate Change Assessment for the Sacramento Valley Region addresses anticipated changes in future conditions related to drought. The report describes anticipated changes to climate patterns, including more intense droughts and floods combined with less predictability. Dry years are expected to become even drier, and wet years will become even wetter. More extreme droughts place greater water demands for crop and landscaping uses.

Agriculture is a critical component of the Glenn County economy. Since the last plan, Glenn County farms have had to adapt to drought and water shortages even further. For example, in 2022, rice growers planted only half as much grain as was normal.[32] This led to lower annual growth and fewer employment opportunities than expected. However, by the end of 2023, because of storm events and snow melt, the county no longer experienced the drought, and farm employment has generally been restored. Nevertheless, it can be assumed that the county's vulnerability to this hazard has not changed.

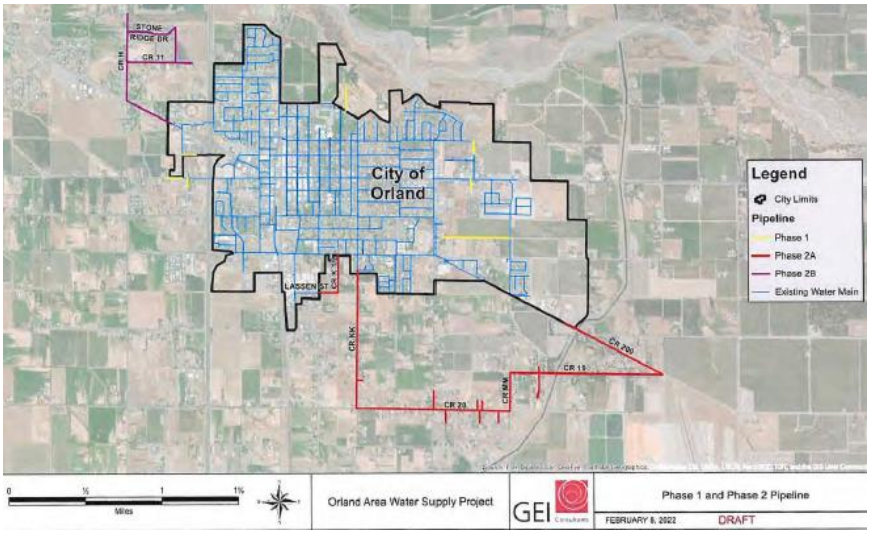
City of Orland

Orland's vulnerability to drought has been balanced since the last plan update because of changes in development. As emphasized in the city's general plan, the agricultural land surrounding the city is a significant natural resource, and development should be directed away from it. Little area remains in the city to develop. Smart growth principles are promoted to help reduce urban sprawl. This means preventing the loss of green space and agricultural land and building livable communities in the already built environment. These principles focus on infill development, more concentrated development, and more redevelopment.

Although Orland is not experiencing drought conditions, it has had extended periods of drought, resulting in residential wells in the area drying up. To prevent future water shortages, and with a careful evaluation of the location of all dry wells that were reported to Glenn County in November and December 2021, the Orland Area Water Supply Project is implementing a pipeline extension from the city's water system to residential properties outside city limits (Figure 33). This will provide owners of dry and at-risk wells with a reliable supply of municipal water. This project also includes increasing the capacity of Orland's municipal water system with a new well, storage tank, and booster pump. This project will help reduce the city's vulnerability to drought.

Besides extending municipal water service to well users in the city and into the county, the final phase of the project includes replacing an 80,000-gallon water storage tank with a 1-million gallon tank, which will not only store water for residences and businesses but will significantly increase the city's firefighting capacity.[33]

[32] Caltrans, "Glenn County Economic Forecast" https://dot.ca.gov/-/media/dot-media/programs/transportation-planning/documents/data-analytics-services/transportation-economics/socioeconomic-forecasts/2023/2023-pdf/glenn-2023-a11y.pdf
[33] "Orland Begins First Phase …" https://www.mynspr.org/news/2023-10-04/orland-begins-first-phase-of-bringing-residents-with-dry-wells-relief



Source: Orland Area Water Supply Project https://www.cityoforland.com/wp-content/uploads/2022/02/ Orland-Area-Water-Project-Press-Release.pdf

Figure 33: Orland Area Water Supply Project, Phases 1 & 2

City of Willows

No significant changes in development have occurred which would influence Willow's vulnerability to this hazard. Willows is a slow-growing community with modest development. Cal Water Willows District reported that new services to the area have increased at only 0.3% per year.[34] New residential structures comprise most of this increase. The district has been able to meet the needs of its service area despite recent droughts, and it anticipates having a sufficient supply under normal, single dry, and multiple dry year conditions.

Vulnerability Assessment

The National Risk Index ranks drought risk in Glenn County as very high. The Climate Mapping for Resilience and Adaptation (CMRA) Tool projects climate trends for the early, mid-, and late centuries for different emissions levels.[35] Drought projections for Glenn County show an expected increase in the number of days per year with no precipitation, and the maximum number of consecutive dry days.

Droughts can occur anywhere in the county and may affect the entire county or a portion at a time. The entire population of 28,399 is potentially vulnerable to the effects of drought. Water is a critical resource for everyday use in drinking, cleaning, cooking, farming, manufacturing, and habitat.

Drought is not expected to have direct health consequences for individuals, but it might have indirect effects. Particularly during persistent drought, conditions can cause mental and physical stress on people, reduce the number of farm-labor days, and deteriorate air and water quality. Prolonged drought may require restrictions in water use. Economic losses from drought may affect the livelihoods of residents employed in the agricultural sector. Alternating extremely wet and dry years can promote the spread of vector-borne diseases, such as West Nile Virus and Valley Fever, particularly in agricultural areas.

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[34] Willows District, "2020 Urban Water Management Plan" https://www.calwater.com/docs/uwmp2020/WIL_2020_UWMP_FINAL.pdf
[35] Climate Mapping for Resilience & Adaptation Assessment Tool. https://livingatlas.arcgis.com/assessment-tool/home/

While its impacts on the built environment are not as dramatic as those from other hazards, drought can have significant effects on buildings and infrastructure. In areas with expansive soils, reduced soil moisture during droughts can damage the foundations of buildings if it results in soil compaction. Municipal water supply and distribution systems, wastewater systems, wells, and parks and recreational facilities could be affected by restrictions or reductions in water supply during a drought.

Urban areas tend to fare better during droughts than rural less populated areas. By encouraging or invoking water conservation measures during droughts, public municipal water systems can reduce residential and industrial demand for water. Rural areas depend much more on water for irrigation for agricultural production. Landowners in rural or less-populated areas are reliant on individual, privately owned wells as a drinking water sources.

Low water levels resulting from drought have a significant impact on ecosystems. Drought can reduce rangeland forage production and wildlife habitats. When water levels are low in lakes, rivers, and other water bodies, their ability to flush out contaminants diminishes, causing increases in waterborne pollutants. Reduced plant growth, local species reduction or extinction, and landscape-level transitions, such as forest conversion to non-forested vegetation, which may in turn reduce water retention in soils, may occur. In addition, freshwater ecosystems may change flow regimes, increase water temperature, and deteriorate water quality, which may result in fish kills, reduced opportunities for recreation, and decreased hydropower production.

The Sacramento River National Wildlife Refuge is a natural resource that provides a wide variety of habitats for birds, fish, and other wildlife. Drought may further limit sensitive habitats in this area. The refuge works with partners to manage and restore wetlands, uplands, and riparian areas, and it promotes high-quality habitats. Water management is critical to providing the proper habitat to specific species at different times of the year.

Drought can occur in conjunction with extreme heat, which is also a hazard of concern in Glenn County. Extreme heat increases evaporation, leading to reduced water availability in soils and surface water. Drought can cause extreme heat because of a lack of water in the atmosphere, soils, and rivers, where decreased water availability in the system reduces the amount of evaporation happening at the surface, quickly increasing temperatures. Extreme heat can also increase the demand for water, leading to reduced water supplies. These hazards occurring together can compound human health impacts and negative impacts on ecosystems.

Drought can also increase the risk of wildfires. Decreased soil moisture during a drought stresses vegetation and increases plant mortality, which provides fuel for wildfires. When combined with extreme heat, more extreme wildfires are possible.

Jurisdiction-Specific Vulnerabilities

Glenn County

The National Risk Index score for drought in Glenn County is very high, in the 99th percentile. Agriculture and related practices are the predominant land use in Glenn County. They depend on a reliable water supply and, therefore, are very vulnerable to drought. Annual agricultural/crop losses from drought in Glenn County are estimated at almost $58 million per year.

Drought may reduce groundwater in response to increased water demands. As noted in the Sacramento Valley Region Climate Change Assessment, agricultural efforts to mitigate the risks of climate-related drought could include investing in precision agriculture and water sensors and planting drought-tolerant crop varieties. Water conservation, improving water-use efficiency, water storage solutions, and increased stormwater capture also can have a significant impact on drought resilience.

Homes in the county also tend to be older; many were built before 1990. This means they are less likely to be fitted with federally compliant plumbing fixtures.

The Glenn Groundwater Authority, formed by 10 agencies including Glenn County, the City of Orland, the City of Willows, and 7 water and irrigation districts, encourages water conservation. The Glenn County Drought Taskforce is an ad-hoc committee that identifies available resources that may assist residents and businesses impacted by drought and promotes public awareness of water-saving activities.

City of Orland

Drought is a regional hazard with no defined boundaries; thus, drought conditions in Orland are on par with the rest of the county. Less land is used for agriculture in the cities. However, employment in the farming industry could still be reduced, impacting local jurisdictions. Significant drought events have affected California (and the rest of the United States) throughout history. Orland obtains a large portion of its water from deep wells, which are in Orland and surrounding areas in Glenn County. New wells are often drilled in the region during intense drought. The City of Orland Public Works department maintains the city water system from well production.

As shown in Figure 30, Orland and its immediate surroundings have numerous dry wells. As discussed earlier, Orland is undertaking a Municipal Water Extension Project to connect the owners of dry wells outside the city limits to the municipal water system. However, some owners outside of the city cannot be connected at this time because their properties are too far from the project and funding limitations make these connections cost prohibitive.

City of Willows

Willows will likely experience drought at the same or lower frequency then the rest of the county. However, as a municipality with less agricultural land and without the same dependency on private wells as the county, Willows is not as vulnerable to this hazard. Cal Water, which serves Willows residents, implemented Stage 2 of its Water Shortage Contingency Plan on May 23, 2022. It limited outdoor watering to two days per week between 6 p.m. and 8 a.m. Similar shortages in the future are likely, which could require additional restrictions. Cal Water has taken steps to mitigate drought in Willows, including replacing, repairing, and upgrading infrastructure to minimize water loss; identifying, and correcting system leaks; and developing rebate programs. The Climate Change Risk Assessment and Adaptation Framework includes mitigation strategies based on the vulnerability and risk of climate change to water resources. Cal Water has also educated local residents about water-saving strategies using the “Imagine a Day Without Water” campaign.[36]

Worsening drought conditions require continued conservation, public education, and infrastructure investment to reduce the impact of drought.

[36] Glenn County Transcript. “Cal Water continues water conservation efforts in Willows,” 2021. https://www.appeal-democrat.com/glenn_county_transcript/cal-water-continues-water-conservation-efforts-in-willows/article_4600aeac-369e-11ec-8cd1-af91a53b4e88.html

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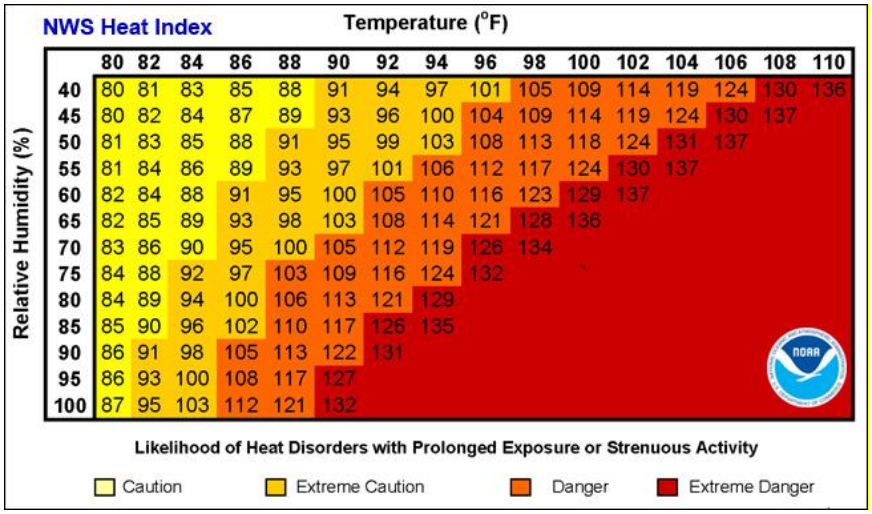
Section 3.2 Extreme Heat

Extreme heat occurs when conditions are substantially hotter and/or more humid than average for a location at that time of year. According to the Federal Emergency Management Agency (FEMA), extreme heat is characterized by temperatures exceeding 90 ° Fahrenheit combined with humidity—which substantially increases the heat index—for two to three consecutive days for most of the United States.[37] In California, particularly in drier areas like the Central Valley—San Joaquin Valley and Sacramento Valley, which includes Glenn County—extreme heat is defined as three successive days over 100°F .

Heat is the primary cause of weather-related fatalities in the United States, and it can significantly impact the human body. Individuals at higher risk of heat-related illnesses include infants and young children, pregnant women, and individuals with chronic medical conditions. The relationship between humidity and heat can influence the severity of extreme heat events. Prolonged exposure to excessive heat can have negative consequences for agrarian systems, including crop damage, livestock harm, and increased risk of wildfires. Furthermore, extended periods of extreme heat can lead to power outages, as the heavy demand for air conditioning taxes the power grid.

The heat index, also called the apparent temperature, measures how hot it feels to the human body when relative humidity is combined with air temperature. This index is particularly important in hot and humid climates, as high humidity levels can make the air feel much hotter than it is. In such conditions, the human body may not be able to cool itself efficiently through sweating, leading to a range of heat-related illnesses, such as heat cramps, heat exhaustion, and heat stroke. Therefore, monitoring the heat index is crucial for ensuring the safety and well-being of individuals exposed to high temperatures and humidity levels, such as outdoor workers, athletes, and the elderly. Figure 34 presents the likelihood of heat disorders based on the heat index, and Figure 35 describes the effect on the body of different temperatures.



Source: National Weather Service, “What is the Heat Index?” https://www.weather.gov/ama/heatindex

Figure 34: Heat Index in Shady Locations

[37] FEMA, “Extreme Heat.” https://community.fema.gov/ProtectiveActions/s/article/Extreme-Heat#:~:text=In%20most%20of%20the%20United,on%20the%20hazard’s%20Information%20Sheet

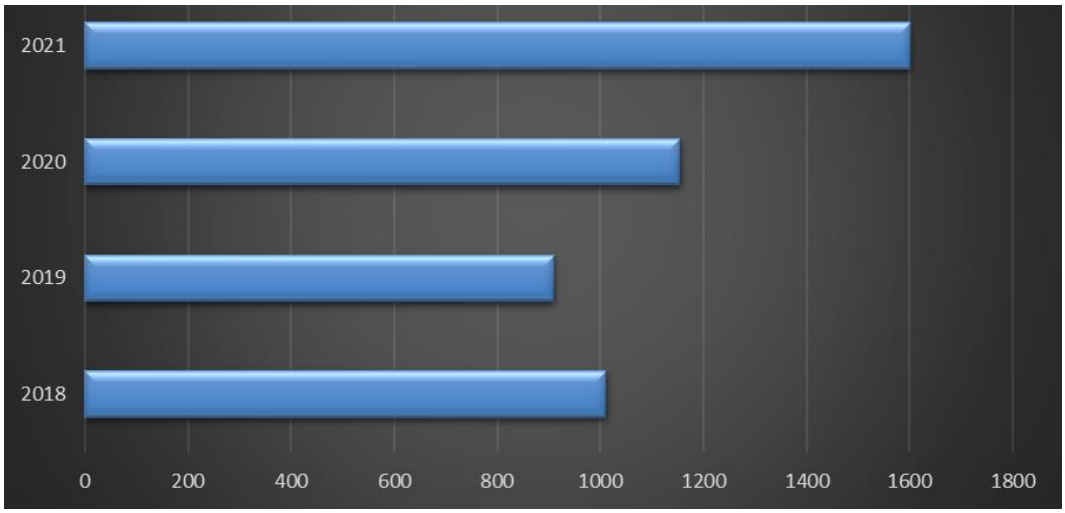
Classification	Heat Index	Effect on the body
Caution	80°F - 90°F	Fatigue possible with prolonged exposure and/or physical activity
Extreme Caution	90°F - 103°F	Heat stroke, heat cramps, or heat exhaustion possible with prolonged exposure and/or physical activity
Danger	103°F - 124°F	Heat cramps or heat exhaustion likely, and heat stroke possible with prolonged exposure and/or physical activity
Extreme Danger	125°F or higher	Heat stroke highly likely

Source: National Weather Service, "What is the Heat Index?" https://www.weather.gov/ama/heatindex

Figure 35: Heat Classification

The phenomenon of extreme heat has worsened over the last few decades, with increasing frequency, length, and intensity linked to climate change. The summer of 2023 was particularly severe, with escalating incidents of extreme heat and air quality events around the globe and across the United States. For instance, June 2023 was the hottest June ever documented globally, and over 60 million individuals in the U.S. affected by air pollution caused by smoke from Canadian wildfires, which were driven by heat related to climate change. Then, in August, prolonged dry conditions and high winds in Hawai'i led to wildfires that caused massive destruction on the island of Maui and other areas, leading to the most significant loss of life because of wildfires in contemporary U.S. history.

According to the Community Resilience Estimates (CRE) for Heat tool, a quarter of individuals in the U.S. are socially vulnerable if exposed to extreme heat, considering factors such as transportation exposure, housing quality, and financial hardship. Heatwaves are responsible for more deaths than any other weather event, and fatality rates have risen each year since 2018, except in 2019, when there was a slight reduction. A total of 4,681 heat-related deaths were reported between 2018 and 2021 (see Figure 36). Nevertheless, studies suggest that this figure is a significant underestimation, and other evidence suggests that extreme heat is associated with higher mortality rates from all causes.[38]



Source: KFF, "Continued Rises in Extreme Heat and Implications for Health Disparities." https://www.kff.org/racial-equity-and-health-policy/issue-brief/continued-rises-in-extreme-heat-and-implications-for-health-disparities/

Figure 36: Heat-Related Deaths in California, 2018–2021

[38] KFF, "Continued rises in Extreme Heat and implications for Health Disparities." https://www.kff.org/racial-equity-and-health-policy/issue-brief/continued-rises-in-extreme-heat-and-implications-for-health-disparities/

Between August 31 and September 9, 2022, California experienced an unprecedented heat wave that broke temperature records in around 1,500 locations. Much of the state was also under excessive heat warnings during this period. The following statistics analyze the increase in deaths, or excess mortality, in California during the heat wave, based on death certificates from California vital statistics.

During the 10-day heat wave, there were 8,324 deaths in California. This number is higher than the 7,929 deaths that occurred during the same timeframe in the summer of 2022 (as shown in Table 25). In other words, there were 395 excess deaths during the heat wave, which represents a 5.0 percent increase in deaths compared to what would be expected; if we include the additional three days, the estimated number of excess deaths rises to 441, an increase of 4.0 percent.

Table 25: Excessive Deaths in California, August 31–September 9, 2022

Time Frame	10-Day Heat Wave	+3 Days
Expected Number of Deaths (based on the reference period in Summer 2022)	7,929	10,296
Number of Deaths, 2023	8,324	10,737
Excess Deaths	395	441
Rate Ratio	1.05	1.04

Source: California Department of Public Health, "Excess Mortality During the September 2022 Heat Wave in California." https://www.cdph.ca.gov/Programs/OHE/CDPH%20Document%20Library/Climate-Health-Equity/CDPH-2022-Heat-Wave-Excess-Mortality-Report.pdf

Deaths in excess were noted across all disease categories, with heat-related illnesses and external causes exhibiting statistically significant trends (as shown in Table 26). The highest rate ratio was observed in cases where heat-related illness was directly listed as the underlying cause of death, with a rate ratio of 5.00.

Table 26: Excess Deaths in California, August 31–September 9, 2022, with Underlying Cause of Death

ICD-10#	Deaths During Heatwave	Expected Number of Deaths	Excess Deaths	Rate Ratio
Heat Illness	20	4	16	5.00
Cardiovascular Deaths	2,310	2,210	100	1.05
Respiratory Deaths	545	521	24	1.05
Endocrine Deaths	451	438	13	1.03
Genitourinary/Renal Deaths	194	175	19	1.11
Digestive	351	332	19	1.06
Musculoskeletal	37	32	5	1.15
External Causes	817	724	93	1.13
Mental/Behavioral	242	232	10	1.04

Source: California Department of Public Health, "Excess Mortality During the September 2022 Heat Wave in California." https://www.cdph.ca.gov/Programs/OHE/CDPH%20Document%20Library/Climate-Health-Equity/CDPH-2022-Heat-Wave-Excess-Mortality-Report.pdf

An analysis grouped counties into climate regions based on where the deaths occurred. These regions comprise specific counties, as listed in Table 27. They were adapted from the U.S. Climate Divisions for California, shown in Figure 37.

Table 27: Regions Analyzed during the California Heatwave, August 31–September 9, 2022

Central Coast	Central Valley	North Central	North Coast	South Coast	Southeast Desert/Inland Empire
Alameda	Amador	Alpine	Del Norte	Los Angeles	Imperial
Contra Costa	Calaveras	Butte	Humboldt	Orange	Inyo
Monterey	Fresno	Colusa	Lake	San Diego	Riverside
San Benito	Kern	El Dorado	Marin	Santa Barbara	San Bernardino
San Francisco	Kings	Glenn	Mendocino	Ventura	
San Luis Obispo	Madera	Lassen	Napa		
San Mateo	Mariposa	Modoc	Solano		
Santa Clara	Merced	Mono	Sonoma		
Santa Cruz	Placer	Nevada	Trinity		
	Sacramento	Plumas			
	San Joaquin	Shasta			
	Stanislaus	Sierra			
	Tulare	Siskiyou			
	Tuolumne	Sutter			
		Tehama			
		Yolo			
		Yuba			

Source: California Department of Public Health, “Excess Mortality During the September 2022 Heat Wave in California.” https://www.cdph.ca.gov/Programs/OHE/CDPH%20Document%20Library/Climate-Health-Equity/CDPH-2022-Heat-Wave-Excess-Mortality-Report.pdf

Figure 37: U.S. Climate Divisions for California

Deaths from extreme heat increased in all regions except the North Coast. However, only the South Coast Region showed a statistically significant increase in deaths during the heatwave. The North Central Region, including Glenn County, had minimal excess deaths during this period (see Table 28).

Table 28: California Heatwave Deaths by Region, August 31–September 9, 2022

Region	Deaths During Heatwave	Expected Number of Deaths	Excess Deaths	Rate Ratio
Central Coast	1,354	1,315	39	1.03
Central Valley	1,445	1,425	20	1.01
Desert/Inland Empire	1,042	1,006	36	1.04
North Central*	331	327	4	1.01
North Coast	372	390	-18	0.95
South Coast	3,779	3,462	317	1.09

*Glenn County Region. Source: California Department of Public Health, "Excess Mortality During the September 2022 Heat Wave in California." https://www.cdph.ca.gov/Programs/OHE/CDPH%20Document%20Library/Climate-Health-Equity/CDPH-2022-Heat-Wave-Excess-Mortality-Report.pdf

Regulatory Environment

California Heat Study: Advisory Committee (AB 1643)

Governor Gavin Newsom signed AB 1643 (Robert Rivas, Chapter 263, Statutes of 2022) into law on September 9, 2022. It established an advisory committee to study and evaluate the effects of heat on California's workers, businesses, and the economy by July 1, 2023. The committee developed a study that addresses topics related to data collection, economic losses, injuries and illnesses, and methods of minimizing the impact of heat on workers. The committee comprised representatives from various state agencies, labor and business entities, and academia, including the Division of Occupational Safety and Health (Cal/OSHA), which was responsible for convening the advisory committee.

The Labor Workforce Development Agency will convene an advisory committee to recommend a study's scope and issue its findings to the Legislature by January 1, 2026.

The advisory committee's objectives were to recommend a study that addressed the following:

- How to improve data collection on worker injuries, illnesses, and deaths and losses to businesses and the economy from heat-related issues to capture these cases more accurately.
- Time away from work and lost wages because of heat.
- The frequency of different types of occupational injuries and illnesses at different temperatures and humidity levels, including those not directly related to heat exposure.
- Instances of underreporting of heat illnesses and injuries covered by workers' compensation, especially among low-income employees, including underreporting of occupational heat exposure with long-term effects on workers after their shifts.
- Evidence-based ways to minimize the impact of heat on workers.[39]

State of California Department of Industrial Relations

Cal/OSHA's Heat Illness Prevention (HIP) Regulation applies to all outdoor places of employment in agriculture, construction, and landscaping. The HIP Network is a voluntary partnership between public and private entities that aims to increase employers' and employees' awareness of the dangers of heat illness and the importance of preventive measures to avoid fatalities and serious illnesses in California workplaces.

The HIP Network collaborates closely with Cal/OSHA to provide crucial information to employers and employees, thus helping to prevent heat illness in workplaces all over California.[40]

Location/Geographic Extent

Data show that heat waves have been increasing in every state since the 1970s. Even Maine, Montana, and Wyoming, which are known for their lower temperatures, have experienced a rise in extreme heat

[39] Department of Industrial Relations, "AB 1643-California Heat Study: Advisory Committee." https://www.dir.ca.gov/dosh/doshreg/Heat-Advisory-Committee/#:~:text=On%20September%209%2C%202022%2C%20Governor,or%20before%20July%201%2C%202023.
[40] Department of Industrial Relations, "Heat Illness Prevention." https://www.dir.ca.gov/dosh/heatillnessinfo.html

days per year. From 9 in the 1980s, it has gone up to 13 in the 2010s across all counties in each state. Montana and Wyoming have recorded their hottest years on record in the last decade.[41]

Very hot days have temperatures over 90°F , and Glenn County experiences an average of 85.1 such days each year, making it hotter than most places in California.[42] There may be slight variations in temperature and humidity in different areas of the county because of differences in terrain. Nonetheless, the danger of extreme heat has no geographical limits and could impact the entire planning area.

Urban areas, characterized by expanses of concrete and asphalt, tend to have higher temperatures than surrounding rural areas. This phenomenon is known as the urban heat island effect. Cities with dense populations, extensive infrastructure, and minimal green spaces trap heat, exacerbating the effects of extreme heat events. Metropolitan areas such as Los Angeles, New York, and Phoenix experience elevated temperatures because of the concentration of buildings, vehicles, and industrial activities. Therefore, urban planning and incorporating green spaces have become crucial strategies for mitigating the urban heat effect.

Magnitude/Extent

Extreme heat (temperatures over 100°F) has become more common in California since 1950. The number and intensity of extreme heat events have significantly risen in most locations studied. Heat waves, two or more consecutive heat events, vary yearly but have become more frequent in the last decade. One way to measure the extent of heat-related impacts is through the NWS HeatRisk Prototype (see Figure 38). This color-coded risk forecast by the National Weather Service helps identify risk over a 24-hour period.

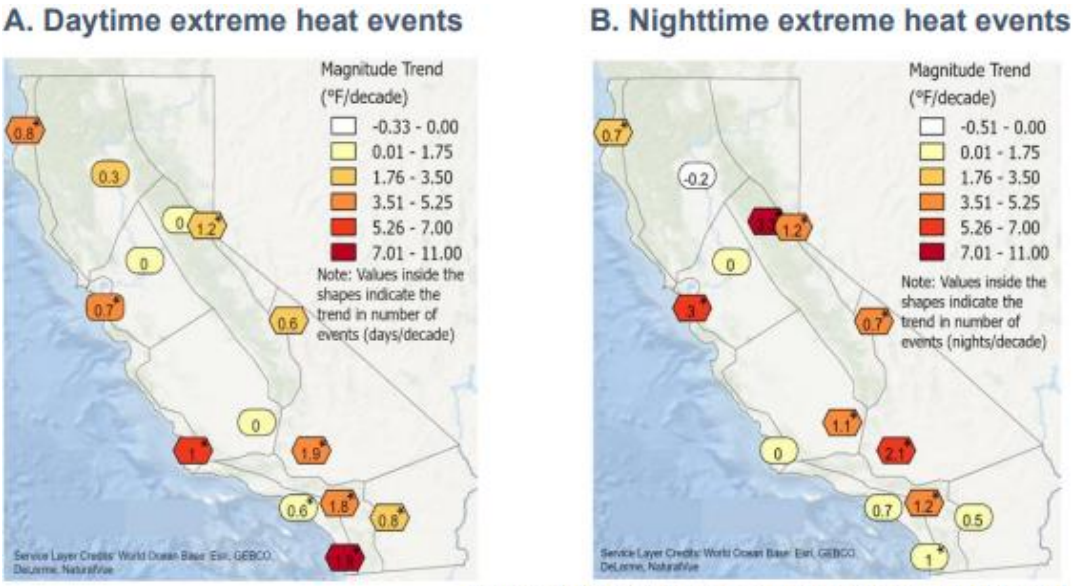
Since 1950, the frequency and magnitude of nighttime extreme heat events have increased more than daytime heat events. The maps in Figure 39 display trends in the magnitudes and frequencies of daytime and nighttime extreme heat events at selected locations between April and October. These events occur when the temperature exceeds a location-specific historical temperature threshold, set at the 95th percentile of daily maximum for daytime extreme events and daily minimum temperatures for nighttime events between 1960 and 1990. The frequency and magnitude of the rates of change are presented using hexagons and ovals, with asterisks indicating statistically significant trends. The maps' outlines show the boundaries of the 11 climate regions defined by the Western Regional Climate Center.

[41] USA Facts: https://usafacts.org/articles/how-frequent-are-heat-waves-in-the-us/
[42] Best Places, "Climate in Glenn County, CA." https://www.bestplaces.net/climate/county/california/glenn

Category	Risk of Heat-Related Impacts
Green 0	Little to no risk from expected heat.
Yellow 1	Minor - This level of heat affects primarily those individuals extremely sensitive to heat, especially when outdoors without effective cooling and/or adequate hydration.
Orange 2	Moderate - This level of heat affects most individuals sensitive to heat, especially those without effective cooling and/or adequate hydration. Impacts possible in some health systems and in heat-sensitive industries.
Red 3	Major - This level of heat affects anyone without effective cooling and/or adequate hydration. Impacts likely in some health systems, heat-sensitive industries and infrastructure.
Magenta 4	Extreme - This level of rare and/or long-duration extreme heat with little to no overnight relief affects anyone without effective cooling and/or adequate hydration. Impacts likely in most health systems, heat-sensitive industries and infrastructure.

Source: NOAA, “NWS HeatRisk Prototype” https://www.wrh.noaa.gov/wrh/heatrisk/

Figure 38: NWS HeatRisk Prototype



Source: Cal-Adapt, 2018, Dunn 2019, and RCC-ACIS, 2021

An extreme heat event occurs between April and October when the temperature is at or above a location-specific historical temperature threshold, set at the 95th percentile of daily maximum for daytime extreme events (Figure 1A), or of daily minimum temperatures for nighttime events (Figure 1B), during the 1960-1990 reference period.

The rate of change (per decade) in ***frequency,*** *the total number of extreme heat events each year, is the value in each shape (hexagon or oval); an asterisk indicates a statistically significant trend ($p \leq 0.05$). The rate of change (per decade) in* ***magnitude****, the annual sum of daily exceedances above the historical temperature threshold, in degrees Fahrenheit (°F), is presented using the fill colors (see legend); a hexagon denotes a trend that is statistically significant ($p \leq 0.05$), while an oval is not significant. The outlines on the map show the boundaries of the eleven climate regions, as defined by the Western Regional Climate Center.*

Source: Office of Environmental Health Hazard Assessment, "Indicators of Climate Change in California (2022)." https://oehha.ca.gov/media/epic/downloads/02extremeheat.pdf

Figure 39: Magnitude and Frequency of Extreme Heat Events, 1950–2021

Past Occurrences

In California's Sacramento Valley, unlike the national average, extreme heat is characterized as high heat and humidity, with temperatures 100°F for two to three consecutive days. These temperatures can harm human health, the environment, and ecosystems. Thirty years ago, there were 11 days in which temperatures exceeded 100°F in Glenn County, while this year, there have been such 22 days. It is anticipated that in 30 years, there will be an estimated 37 days of extreme heat days in Glenn County each year.[43]

Eight heat or excessive heat events have been recorded in the Storm Events Database for regions including Glenn County. On July 1–2, 2023, record-breaking temperatures and major heat risk were recorded for the Central Sacramento Valley. Daytime highs across this zone were in the 100 to 110-

[43] Risk Factor, "Does Glenn County Have Heat Risk?" https://riskfactor.com/county/glenn-county-ca/6021_fsid/heat

degree range, and overnight lows were in the mid-70s to low 80s. Similar conditions occurred in the region on July 15–16, 2023, July 21–22, 2023, and August 8–17, 2023.[44]

"Cooling Zones" in public buildings have been implemented throughout the county.[45] Cool zone facilities include libraries, community centers, and senior centers. Over the last few years, they have been employed regularly to keep people cool, despite the heat and summer power outages. A Public Safety Power Shutoff (PSPS), often a result of severe weather and to prevent wildfire, is one of the biggest reasons for establishing cooling zones. Extreme heat is no surprise in Glenn County. However, these PSPSs present a real concern, as residents can no longer cool themselves at home. Schools are also at risk from the impacts of PSPSs, including delayed start times and missed days. So far, there has been an estimated one death from heat in the last 13 years. However, it can be assumed that other injuries and illnesses are related to extreme heat events.

Frequency/Probability of Future Occurrences

The National Risk Index has recorded 49 heat wave events for Glenn County over 16 years (2005-2021), which is an annualized frequency of 3 events per year. The planning area will likely continue to experience Extreme Heat on an annual basis in the future. California faces many environmental issues, such as droughts, wildfires, and extreme weather conditions, and the situation is predicted to get worse as climate change increases. Greenhouse gases, released primarily from human activities like transportation and industrial processes, trap heat radiating from the Earth's surface and enhance the atmospheric greenhouse effect. This leads to a further rise in global temperatures. As a result, the average summer temperatures in California have already increased by about 3°F (1.8 ° Celsius) since 1896, with more than half of this increase occurring since the early 1970s. The probability of future occurrences of Extreme Heat will likely be influenced by the changing climate.

Annual temperature increases in most parts of California have already exceeded 1°F, and some areas have experienced increases over 2°F . By mid-century, the daily maximum average temperature, which indicates extreme temperature changes, is projected to rise by 4.4°F –5.8°F . By the end of the century, it may rise by 5.6°F –8.8°F . Heat-Health Events (HHEs), which are better predictors of risk to populations vulnerable to heat, are expected to worsen significantly across the state. By mid-century, the Central Valley is expected to experience HHEs that last for two more weeks each year on average, while the Northern Sierra region could experience HHEs 4 to 10 times more often than usual.

If we continue to emit greenhouse gases at the current rate, the temperature is expected to rise even more in the coming years. By 2040, the State of California is likely to experience a further increase in temperature of more than 2°F , more than 4°F by 2070, and more than 6°F by 2100. This warming will be most noticeable during short periods of extreme heat, such as days exceeding 106.6°F .

If current emissions continue, by 2099, Glenn County will likely experience a +3.5°F increase in temperature for low-emissions scenarios and a + 6.2°F increase for high-emissions scenarios.[46] The Northern Central Valley Region, in which Glenn County is situated, is expected to see temperatures increase from 1990 to 2100, as shown in Table 29.

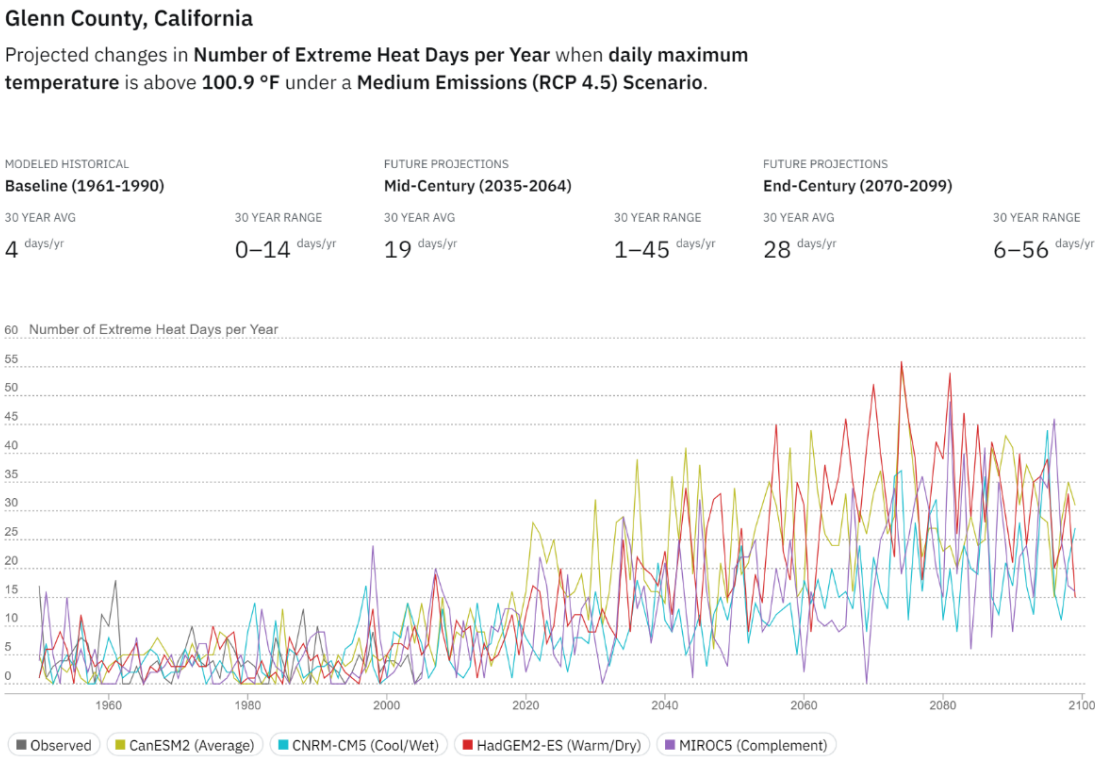
[44] NOAA NCEI Storm Events Database. www.ncdc.noaa.gov/stormevents
[45] Glenn County Office of Emergency Services. https://www.countyofglenn.net/dept/sheriff/office-emergency-services/summer-heat-and-power-outages
[46] California Department of Public Health, "Climate Change and Health Profile Report Glenn County." https://www.cdph.ca.gov/Programs/OHE/CDPH%20Document%20Library/CHPRs/CHPR021Glenn_County2-23-17.pdf

Table 29: Climate Projections for Glenn County

Change	Ranges
Temperature Change between 1990 and 2100	By 2050, high carbon emissions will raise average temperatures in January by 4°F to 6°F and in July by 6°F to 7°F . By 2100, these increases could reach 8°F to 12°F and 12°F to 15°F , respectively.
Heat Wave	A heat wave is a period of prolonged, abnormally hot weather, typically, lasting two or more days. In the eastern mountainous regions, the temperature range is 102°F to 105°F . By 2050, two to three more heat waves are expected to occur per year, and by 2100, they could increase to five to eight more heat waves per year.

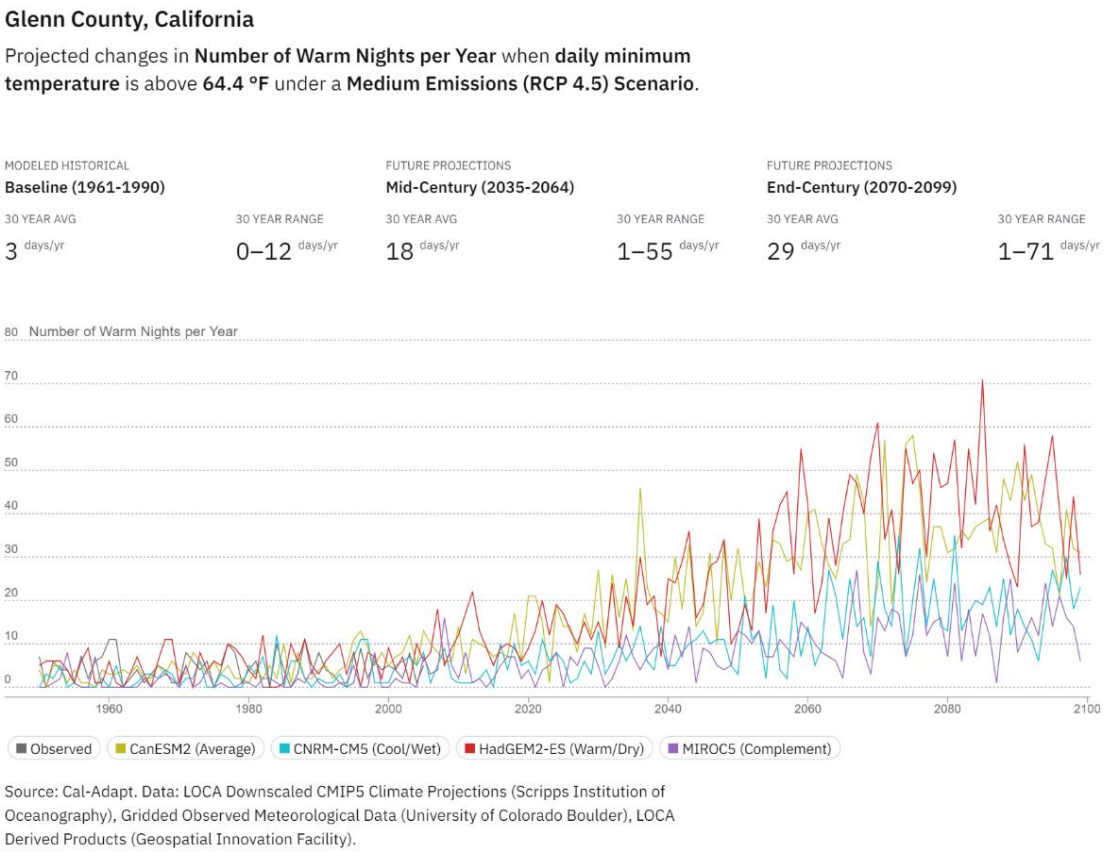
Source: California Department of Public Health, "Climate Change and Health Profile Report Glenn County." https://www.cdph.ca.gov/Programs/OHE/CDPH%20Document%20Library/CHPRs/CHPR021Glenn_County2-23-17.pdf

Cal-Adapt provides tools to compare multiple climate projections, or estimates of future climate. These models can give insight into what to expect from the climate, based on the changing atmospheric concentration of greenhouse gases. Figure 40 includes a time series of project numbers of extreme heat days for Glenn County from individual downscaled global climate models (GCMs). The historical data are represented by a gray line from 1950 to 2006. This model indicates that Glenn County may have an average of 19 extreme heat days per year by mid-century. Figure 41 is a similar visualization. It represents a time series of the numbers of warm nights, and it also projects significant increases over time.



Source: Cal-Adapt, Extreme Heat Days. https://cal-adapt.org/tools/extreme-heat/

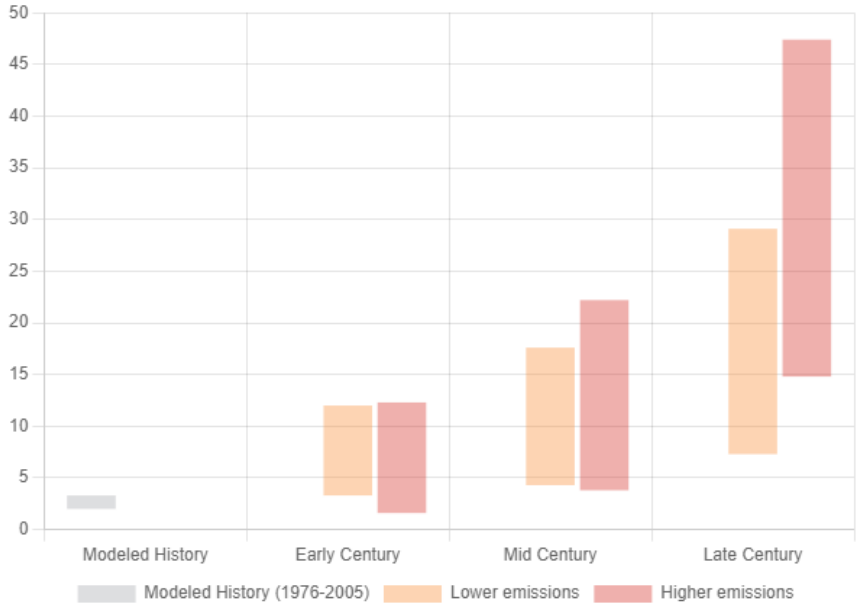
Figure 40: Cal-Adapt Extreme Heat Days per Year for Glenn County, California



Source: Cal-Adapt, Extreme Heat Days. https://cal-adapt.org/tools/extreme-heat/

Figure 41: Cal-Adapt Number of Warm Nights for Glenn County

The Climate Mapping for Resilience & Adaptation (CMRA) Tool is another model that projects climate conditions for the early, mid-, and late century, based on lower and higher emissions scenarios. CMRA anticipates increases for all time periods in both lower and higher emissions scenarios for annual days with a maximum temperature over 100°F and 105°F (see Figure 42). It also projects increases in the highest maximum temperature, the highest temperature averaged over 5 days, and the number of cooling degree-days which measure the demand for energy to cool homes and businesses.



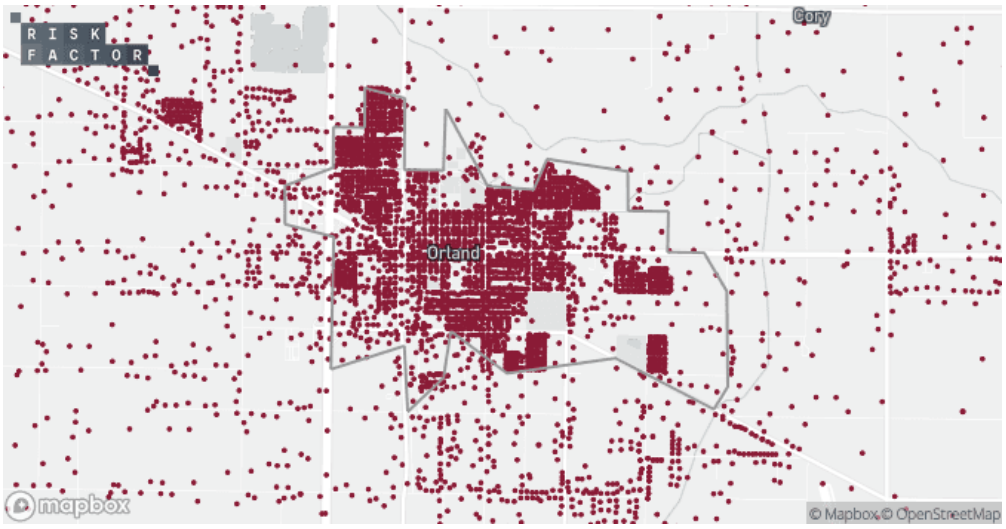
Source: Climate Mapping & Resilience Tool: Extreme Heat.
https://livingatlas.arcgis.com/assessment-tool/explore/details

Figure 42: CMRA Annual Days with Maximum Temperature > 105°F in Glenn County

City of Orland

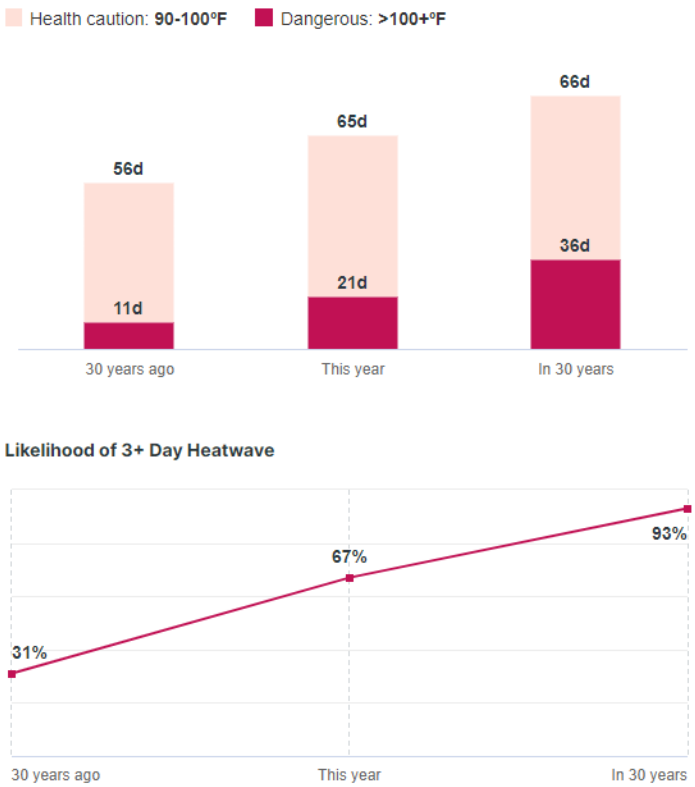
Annual average temperatures in Orland are projected to increase steadily. Orland's average annual maximum temperature, based on data from 1961 to 1990, was 74.9°F (Cal-Adapt, 2017). Under a medium emissions scenario (RCP 4.5), Orland's average annual maximum temperature will rise from the historical average baseline of 74.9°F to 78.8°F by 2064 and to 79.9°F by 2099 (Cal-Adapt, 2017). Under a high emissions scenario (RCP 8.5), Orland's average annual maximum temperature will rise from 74.9°F to 79.6°F by 2064 and to 83.1°F by 2099 (Cal-Adapt, 2017). Increased average temperatures are expected to lead to secondary climate change impacts, including increases in the frequency, intensity, and duration of extreme heat days and multi-day heat waves in California. Cal-Adapt defines the extreme heat day threshold for Orland as 105°F . Orland has a historical average of four extreme heat days per year. Under a medium emissions scenario (RCP 4.5), Orland is expected to experience 16 extreme heat days annually by 2064 and 23 a year by 2099 (Cal-Adapt, 2017). Under a high-emissions scenario (RCP 8.5), Cal-Adapt predicts that Orland will experience 22 extreme heat days annually by 2064 and 46 such days per year by 2099 (Cal-Adapt, 2017).

Figure 43 shows the heat factors for Orland, and Figure 44 shows the change over the last 30 years and projections for the next 30 years.



Source: Risk Factor. Does Orland Have Heat Risk? https://riskfactor.com/city/orland-ca/654274_fsid/heat

Figure 43: Heat Factors in and Near the City of Orland

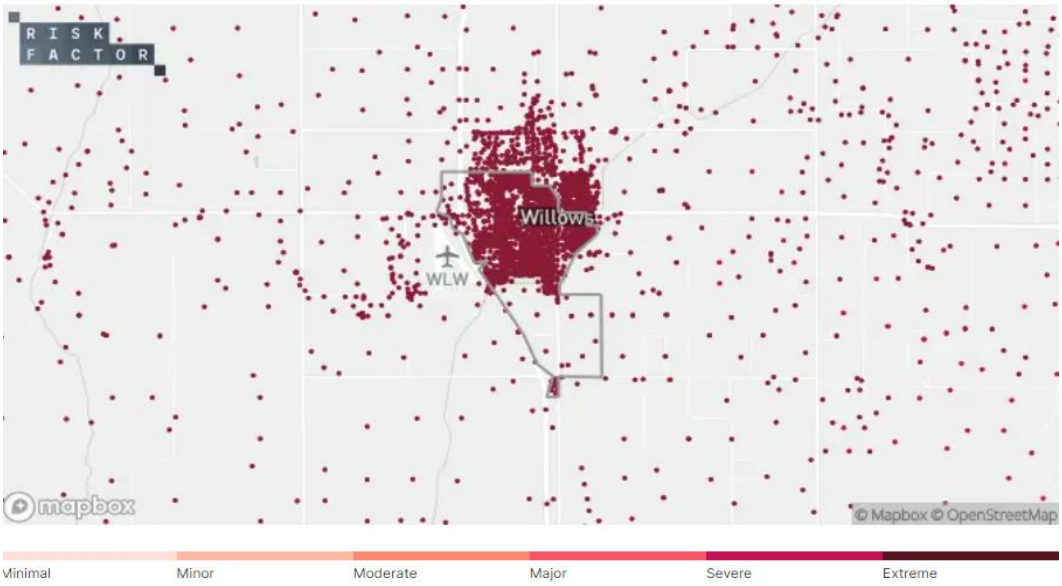


Source: Risk Factor. Does Orland Have Heat Risk? https://riskfactor.com/city/orland-ca/654274_fsid/heat

Figure 44: Heat Projections for the City of Orland

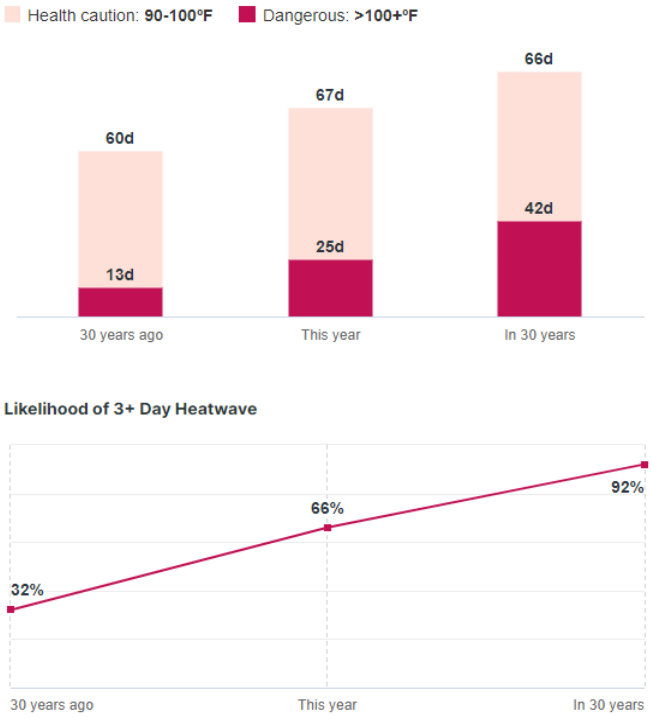
City of Willows

Because of increasing “feel-like” temperatures, 100% of the homes in Willows have severe heat factors (see Figure 45). As temperatures continue to rise, the probability of dangerously hot days and heatwaves with temperatures above 100°F pose a serious health threat to everyone. Willows is projected to have 7 hot days with a “feels like” temperature of 106°F this year, and with climate change, it is expected to have 16 such hot days per year 30 years from now (see Figure 44).



Source: Risk Factor, Does Willows Have Heat Risk? https://riskfactor.com/city/willows-ca/685684_fsid/heat

Figure 45: Heat Factors in and Near the City of Willows



Source: Risk Factor, Does Willows Have Heat Risk?
https://riskfactor.com/city/willows-ca/685684_fsid/heat

Figure 46: Heat Projections for the City of Willows

Changes in Development

California's Fourth Climate Change Assessment, Sacramento Valley Region, indicates an increased risk of extreme heat events resulting from climate change. Climate change has increased both average temperatures and the frequency and intensity of extreme heat events. Local increases that affect neighborhoods and ecosystems are far more variable and often of greater magnitude than global temperature increases. Warming may be greater inland than in coastal regions. Heat waves are expected to have both higher daytime and nighttime temperatures with longer durations and geographic extents.[47]

This may result in more heat-related illnesses; an increase in disease-causing pathogens, such as West Nile Virus, Valley Fever, and algal blooms; and exposure to ozone and other air pollution. All three participating jurisdictions are likely to be more vulnerable to extreme heat. While broader changes to the climate may increase extreme heat, there has not been significant changes in development since the last plan update which would impact Glenn County's vulnerability to extreme heat .

Vulnerability Assessment

Because extreme heat does not have a defined geographic extent, spatial analysis to identify assets at risk are not practical. A qualitative assessment of potential impacts on the planning area is as follows.

[47] California's Fourth Climate Change Assessment: Sacramento Valley Region. 2018. https://www.energy.ca.gov/sites/default/files/2019-11/Reg_Report-SUM-CCCA4-2018-002_SacramentoValley_ADA.pdf

Extreme heat can be harmful to human health, particularly to the elderly and those with chronic conditions, such as respiratory or cardiovascular diseases. Heat-related illnesses arise when the body is unable to regulate temperature. Illnesses can range from mild dehydration to hospitalization or death from heat stroke. Outdoor workers, older persons, infants and children, pregnant women, and individuals with low incomes are among those most vulnerable to prolonged heat. Older adults are less able to regulate body temperature and are more likely to have underlying medical conditions. Outdoor workers may lack a location to get relief from high temperatures. Avoiding work in the heat of the day may reduce heat-related illnesses but can lead to overall loss of productivity.

Lower-income households may not have access to air conditioning or other means of maintaining comfortable indoor temperatures. Cooling centers or other facilities that provide air-conditioned spaces for residents who lack cooling at home improve comfort and reduce mortality during extreme heat events.

Those suffering from heat-related illnesses might not recognize the symptoms and seek proper treatment. While the preceding health risks are significant, it is important to note that heat-associated deaths and illnesses can be reduced through the prevention and management of individual and community exposure.

All of the critical facilities in Glenn County, the City of Orland, and the City of Willows are in a geographic area exposed to extreme heat. However, extreme heat does not typically cause direct damage to critical facilities or other structures. Prolonged extreme heat may put extra strain on power resources for cooling systems. This may strain their ability to provide adequate cooling, and it increases the potential for power outages. In some parts of the country, extreme heat has contributed to cracking and buckling of pavement on roadways, which can result in road closures for emergency repairs, but there have been no reports of this in Glenn County.

Urban heat island conditions can retain high temperatures at night. Although Glenn County is predominantly rural, community efforts to reduce heat island effects could contribute to the protection of public health. Adaptation measures, such as planting trees, developing reflective surfaces on roofs, and greenspaces, may reduce risks of extreme heat.

Prolonged high temperatures can impact crop yields. Specific measures of potential impacts on agriculture in Glenn County were not identified.

Extreme heat can contribute to an increased risk of wildfire. Prolonged heat draws moisture out of the ground and dries out vegetation and other wildfire fuels. Warmer and dryer conditions can contribute to more extreme fire behavior and a longer and more active fire season.

Jurisdiction-Specific Vulnerabilities

Glenn County

Residents in the unincorporated areas of the county are less densely concentrated, and many are located farther away from public facilities where they could seek relief from the heat. Some populations may be more sensitive, or negatively affected to a greater degree by extreme heat.

Land use in the county is primarily related to agriculture, forestry, and recreation. These sectors are more likely to employ workers who are exposed to extreme heat in outdoor work. Prolonged heat may directly impact the health of crops and livestock and could reduce crop yields.

Extreme heat can occur simultaneously with drought. Drought can make a hot day feel hotter, and a heat wave can make dry conditions even drier. Both conditions also worsen the risk of wildfires. Much of the county is at high risk of all three hazards.

The Cities of Willows and Orland

Compared to more rural or less-populated areas, a number of variables can worsen the effects of heat in specific areas, particularly more urban settings, creating what are known as heat islands. Daytime maximum temperatures in a heat island can differ by as much as 7°F from the area surrounding it. Second, they can retain heat through the night, which can increase the cost of cooling for homes and businesses. Some of the most notable causes of the heat island effect include man-made construction materials, such a concrete and asphalt, which capture and radiate heat long after sunset. Layouts that might trap heat but prevent airflow also can contribute to higher temperatures. On the other hand, proximity to open vegetation and bodies of water has the opposite effect. It helps to lower surrounding temperatures. Finally, the use of motor vehicles and industrial machinery contributes to rising temperatures. Both Willows and Orland have characteristics that contribute to the “heat island effect.”

Because both cities have higher-than-average populations below the poverty line, those who are socioeconomically disadvantaged will experience even greater budget problems to meet the increased cost of cooling because of higher temperatures sustained over longer times.

These communities also have higher percentages of people in the at-risk age categories of under 18 and over 65. These individuals may be more dependent on others for their care. Very young people may be less able to regulate their body temperatures. Older individuals are more likely to have underlying health conditions that make them more susceptible to heat-related illnesses.

In sync with a higher demand for electricity for air-conditioning is a greater strain on the electrical grid, which can lead to significant outages when overburdened.

Section 3.3 Flood

Flood refers to a general and temporary condition of partial or complete inundation of normally dry land. Flood reduction, prevention, and mitigation are major challenges for Glenn County residents and floodplain managers. Many areas of the county are vulnerable to flooding, especially property near drainage channels and along the county's creeks and the Sacramento River. This is because of heavy seasonal rainfall, flat terrain, and an intricate network of canal and levee systems. Glenn County has three types of flooding: pluvial, riverine, and dam failure. Most of the county's flood-prone properties are subject to inundation because of heavy rainfall and the overflowing of streams and drainage canals.

Pluvial flooding is localized flooding that occurs during heavy seasonal rainfall, independent of an overflowing water body. This occurs when ground becomes saturated and rainfall runoff volumes exceed the design capacity of drainage or stormwater facilities, flood control structures are not sufficient, or maintenance in drainage areas causes pinch points in flood control structures.

Riverine or fluvial flooding occurs when streams or rivers exceed their carrying capacity because of heavy seasonal rainfall, which typically occurs from December through February. Flood risk is intensified along the Sacramento River where the largest volumes of water flow. Both fluvial and riverine flooding can cause significant damage to structures, transportation systems, and other critical community assets.

Flooding can also occur when dams fail or levees are breached. Dams fail when the constructed barrier can no longer contain water as intended, leading to the sudden flooding of a large area. Levees are embankments built to prevent rivers, and streams from overflowing. Flood risk is increased by levee breaches or dam failures caused by severe storms, accumulation of melted snow, debris jams, landslides, volcanic eruptions, or fires. Earthquake activity also can damage dams and lead to their failure.

Dams are classified in three ways:

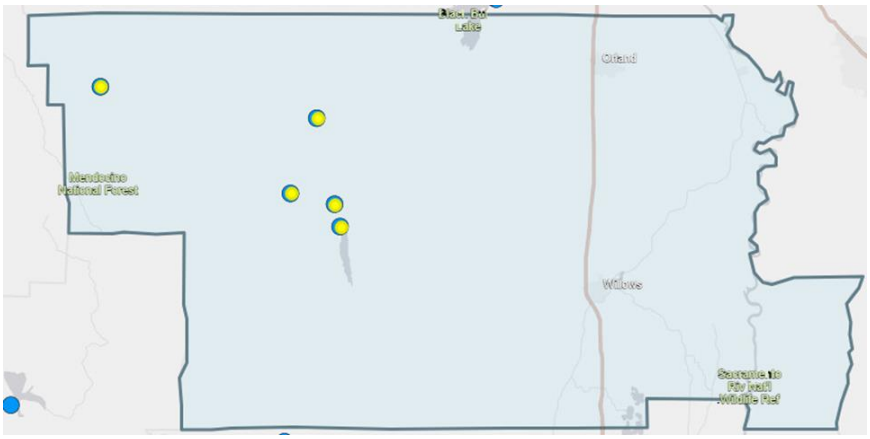
- High Hazard – Dam failure would probably cause loss of life and major damage to property.
- Significant Hazard – Dam failure could cause some loss of life and property damage.
- Low Hazard – Dam failure is unlikely to cause loss of life or damage to property.

Table 30 lists dams in Glenn County, and Figure 47 shows dam locations.

Table 30: Glenn County Dams

Name	Hazard Classification	Condition	Emergency Action Plan	Owner	Last Inspection
E.A. Wright	Significant	Satisfactory	No	Private Entity	02/22/2022
Hamilton	Low	Satisfactory	Not Required	Private Entity	01/24/2022
Sanhedrin Ranch	Low	Satisfactory	Not Required	Private Entity	02/22/2022
Stony Gorge	High	Not Available	Yes	Reclamation	06/11/2020
Upper Plaskett	Low	Not Rated	Not Required	U.S. Forest Service	06/09/2014

Source: https://www.usbr.gov/projects/index.php?id=373



Source: National Inventory of Dams, "Glenn, California." https://nid.sec.usace.army.mil/#/dams/search/sy=@countyState:Glenn,%20California&viewType=map&resultsType=dams&advanced=false&hideList=false&eventSystem=false

Figure 47: Glenn County Dams in Perspective

In addition, there are four dams outside of Glenn County that could affect both waterways and properties in the county:[48]

- Black Butte Dam
- East Park Dam
- Oroville Dam
- Shasta Dam

On February 7, 2017, the Oroville Dam service spillway ran at a flow rate of approximately 52,500 cubic feet per second (cfs). Suddenly, a section of the concrete slab about halfway down the chute failed, rapidly eroding the foundation and adjacent ground. The erosion caused progressive failure and removal of the chute slab in both the upstream and downstream directions. To prevent further damage to the chute while managing the water level of the reservoir, adjustments were made to the chute flow. However, major storms in the large watershed caused the reservoir to rise until the crest of the emergency spillway was overtopped for the first time in its history, four days after the chute damage was first observed. Although the maximum flow at the emergency spillway reached only about 12,500 cfs (less than 4% of its design capacity), the hillside eroded and rapid headcutting occurred because of the overflow. (Headcutting is rapid erosion where the depth of a stream or channel changes, often at the beginning—the head—of the waterway.) This posed the risk that the small barrier (known as a weir) at the crest of the emergency spillway could be undermined and fail because it is overturned or moved, leading to downstream flooding from the uncontrolled release of the reservoir.

Because of this risk, the gates for the service spillway were opened to increase the chute flow, lower the reservoir level, and facilitate the evacuation of approximately 188,000 people. Because of the very large size of the dam and spillways and the number of people at risk, this was one of the most serious dam safety incidents in United States history, and the estimated cost for repairs and recovery was about $1.1 billion.[49]

[48] County of Glenn, "Did you know that there are multiple dams in Glenn County?" https://www.countyofglenn.net/dept/sheriff/office-emergency-services/preparedness
[49] Association of State Dam Safety Officials, "Case Study: Oroville Dam (California, 2017)." https://damfailures.org/case-study/oroville-dam-california-2017/

Before this incident, there was no requirement for a dam under state jurisdiction to have an Emergency Action Plan. Under Senate Bill 92, based on their hazard classifications, all state dams must submit such plans to the California Governor's Office of Emergency Services (OES) for review and approval.[50]

To assist Butte County, Glenn County activated the Oroville Dam spillway incident. Law enforcement was prepared to provide mutual aid for evacuations, closures, and patrols. Shelter operations were ready in Glenn County for evacuated Butte County residents. Healthcare facilities in Glenn County were ready to address a medical surge or to treat anyone displaced from facilities in Butte County. This response cost Glenn County approximately $100,000.

Regulatory Environment

The regulatory landscape for flood control is often characterized by its complexity, multi-level governance structures, disparate regulations that apply to flood control structures and water bodies, and local participation in state and federal programs. This section examines the regulatory frameworks employed by Glenn County and the Cities of Orland and Willows to govern floodplain development. It also provides insights into the latest requirements from the State of California and the National Flood Insurance Program *(*NFIP).

Local Building Codes

Glenn County and the Cities of Orland and Willows have implemented a comprehensive set of building codes and construction best management practices aimed at reducing the flood risk of newly constructed buildings. As the designated floodplain administrator for the county, the Building Official is vested with the authority to administer, implement, and enforce the Glenn County Flood Plain Management Zone Code by granting development permits only if they comply with the provisions of the code.

Local Floodplain Delineation

Upon application for a building permit in Glenn County, the Building Inspection Division undertakes a thorough review of the submitted application and accompanying plans to assess the site of the proposed structure for its proximity to a Special Flood Hazard Area (SFHA) as designated by the Federal Emergency Management Agency (FEMA) on regulatory Flood Insurance Rate Maps (FIRMs). It is noteworthy that FEMA's flood hazard areas are subject to periodic updates to reflect changes in the risk of flooding. Therefore, it is imperative to stay up to date with the regulatory maps to ensure compliance. More detailed information on FEMA flood hazard areas can be found in the section on Location/Geographic Extent.

In the context of new construction and significant improvements, fully enclosed areas below the lowest floor, which are susceptible to flooding, must be designed in a manner that enables the automatic balancing of hydrostatic flood forces on exterior walls. This can be achieved by allowing for the entry and exit of floodwater. It is imperative to note that these measures are necessary to ensure the safety and structural integrity of the building and to mitigate the risks and damage associated with flooding. Therefore, it is recommended that professionals in the construction industry adhere strictly to these guidelines and regulations to ensure compliance with the required standards and to minimize the risk of damage or loss.

[50] YouTube, "Cal OES's Hazard Mitigation Chief Jose Lara Remembers Oroville Spillway Incident for 5th Anniversary." https://www.youtube.com/watch?v=65o2uiUGRyM&t=205s

On November 8, 2022, Willows adopted its Floodplain Management Plan. New construction, including manufactured homes, must be anchored to prevent movement or collapse because of floods. It must use flood-resistant materials and utility equipment and have proper drainage paths. The lowest floor of residential structures must be elevated to or above the base flood elevation. The elevation of the lowest floor must be verified by a civil engineer or land surveyor and confirmed by the building inspector.

New nonresidential construction or significant improvements to existing structures must be elevated or floodproofed below the recommended elevation and have structural components that can resist hydrostatic and hydrodynamic loads and buoyancy effects. Flood openings must be designed to equalize hydrostatic flood forces and allow for the entry and exit of floodwater. Garages and low-cost accessory structures must be adequately anchored, constructed with flood-resistant materials, and designed to allow for the automatic entry of floodwaters.[51]

National Flood Insurance Program

The NFIP is a federal initiative that offers flood insurance to homeowners, renters, and business proprietors in communities that participate in the program. As part of their participation in the NFIP, Glenn County and the Cities of Orland and Willows are committed to protecting homes with policies currently in force. As is customary in most communities, FEMA has undertaken a detailed flood insurance study for selected areas in Glenn County. Such studies include water surface elevations for various flood magnitudes, such as the 1 percent annual chance of flood (the 100-year flood) and the 0.2 percent annual chance of flood (the 500-year flood). FIRMs display the base flood elevations and the limits of the 100- and 500-year floodplains. The Location/Geographic Extent section provides additional information.

Glenn County joined the NFIP on September 3, 1980, and it is committed to regulating development in the floodplain areas that fall under FEMA's purview in accordance with the criteria of the NFIP. Before issuing permits for development in floodplain areas, the county requires that two fundamental criteria be met to ensure compliance with the NFIP's guidelines. These requirements promote the safety and well-being of the county's residents:

- All new buildings and development undergoing substantial improvements must, at a minimum, be elevated to protect against damage from 100-year floods.
- New floodplain development must not aggravate existing flood problems or increase damage to other properties.

Structures that were authorized or erected in Glenn County before the NFIP requirements were implemented are commonly referred to as "pre-FIRM" structures. (The regulatory requirements were later integrated into the county's ordinances.) For unincorporated regions of Glenn County, pre-FIRM structures are those that were authorized or constructed before September 3, 1980. The FIRMs for Glenn County, Orland, and Willows are current as of August 5, 2010.

Both Orland and Willows are active participants in the NFIP. Willows joined the program on June 4, 1980, and Orland joined on September 16, 2011. To comply with the NFIP, Orland adopted Ordinance No. 2011-03 on September 6, 2011. This ordinance effectively adopted the flood insurance study and flood insurance rate maps for Glenn County. Furthermore, the City of Orland Municipal Code, Chapter 17.68, established a floodway conservation zone to protect life and property in floodways. This zone is applied to lands near streams and drainage channels that are periodically inundated or will be inundated by a design flood. The specific design flood for each floodway zone is defined on the zone map. The regulations set forth in this chapter aim to provide for the reasonably unrestricted passage of a design flood and offer reasonable measures for protecting life and property in floodway areas.

[51] Code Publishing, "Chapter 15.65 Floodplain Management." https://www.codepublishing.com/CA/Willows/html/Willows15/Willows1565.html

Chapter 15.65 of the Willows Municipal Code outlines the city's Floodplain Management Ordinance. It includes regulations to do the following:

1. Restrict or prohibit uses which are dangerous to health, safety, and property because of water or erosion hazards or which result in damaging increases in erosion or flood heights or velocities;
2. Require that uses vulnerable to floods, including facilities which serve such uses, be protected against flood damage at the time of initial construction;
3. Control the alteration of natural floodplains, stream channels, and natural protective barriers, which help accommodate or channel floodwaters;
4. Control filling, grading, dredging, and other developments that may increase flood damage; and
5. Prevent or regulate the construction of flood barriers that will unnaturally divert floodwaters or which may increase flood hazards in other areas.

Central Valley Flood Protection Plan

State bond legislation spearheaded by the California Department of Water Resources (DWR) to provide protection to people and property in areas especially prone to flooding was enacted in 2007. The legislative requirements give Glenn County planning responsibilities for local floodplain management (general plans, zoning ordinances, development agreements, tentative maps, and other actions).

This legislation imposed certain statewide requirements, while other provisions are complementary and extend to lands in the Sacramento–San Joaquin Valley. Additional legislation applies to lands in the Sacramento–San Joaquin Drainage District, which encompasses Glenn County.

The Central Valley Flood Protection Plan (CVFPP) is a strategic blueprint that California has designed to manage flood risk in the Central Valley. The DWR prepared this plan in accordance with the Central Valley Flood Protection Act of 2008 (Act), and the Central Valley Flood Protection Board adopted it in June 2012. The CVFPP must be updated every five years and the most recent update was adopted on 12/16/2022.[52] The plan has the following aims:

- Prioritize the investment in flood management by the state over a 30-year planning horizon.
- Promote multi-benefit projects.
- Integrate and enhance ecosystem functions associated with flood-risk-reduction projects.

Despite considerable improvements in flood management in the Central Valley since the 2007 legislation and passage of the Act in 2008, this vast region still faces significant flood risk, particularly under the urgent threat of climate change. Investments worth about $4.1 billion were made between 2007 and 2021 to reduce flood risks, improve operation and maintenance, and enhance ecosystems in the Central Valley. However, flood risk in the region continues to grow because of increased extreme weather events caused by climate change. This risk highlights the significance of the CVFPP and its recommended actions. The pace and scale of implementation must increase to meet the challenges of flood management that arise from accelerating climate change. These risks include the following:

- Communities in the Central Valley are threatened by the current and future effects of climate change on hydrology, such as extreme precipitation events and loss of snowpack. Extreme events, such as floods and droughts, are expected to increase in frequency and intensity.

[52] The State of California Central Valley Flood Protection Board, "Central Valley Flood Protection Plan." https://cvfpb.ca.gov/cvfpp/

- Flood risks for over 1.3 million Central Valley residents remain high and are set to increase with projected growth. Without the recommended flood system investments, estimates show that over a 50-year period (2022–2072), the annual lives lost more than doubles in the Sacramento River Basin and quadruples in the San Joaquin River Basin.
- More than $223 billion of structures and their contents are at risk, according to 2021 data.
- Agriculture-based communities and the $17 billion agricultural economy could be significantly affected, and flood events during the growing season could disrupt national and international food supplies.
- Socially vulnerable populations bear a disproportionate share of the adverse effects of flooding, yet recovery spending underserves the populations that need it the most.
- Despite significant recent investments in repair, rehabilitation, and replacement, a backlog of deferred maintenance continues to increase, creating the need for new and more expensive capital improvements.
- Although projects have been implemented to improve environmental conditions at specific locations, the configuration and management of the flood system and other factors, such as infrastructure and land uses adjacent to rivers, continue to obstruct natural processes, fragment riverine habitats, and contribute to the decline of native species.[53]

The Mid & Upper Sacramento River Regional Flood Management (MUSR RFM) Plan is a locally driven assessment of regional flood management issues. This follow-up to the 2012 CVFPP informed the 2017 update of the CVFPP. It outlined the long-term vision for flood management in the region, described current flood management conditions, identified opportunities for improving flood management, and prioritized project needs. The flood protection system includes reservoirs with active flood control space, hundreds of miles of levees, multiple weirs, an outfall structure, diversion channels, massive bypasses, and drainage facilities, which pump interior runoff and seepage from levee-protected areas back into flood control channels. These structural elements work together to contain high flows in the main river channel and, when necessary, divert water from the main river channel into the bypass system.[54] However, this plan lacks strong governance to implement the needed risk-reduction projects.

Government Code 65302

Under this code, cities and counties are authorized to incorporate local hazard mitigation plans into the safety elements of their general plans. While the code does not mandate the adoption of such plans, it allows for their implementation, providing local governments with the flexibility to undertake measures that address potential hazards in their communities. Compliance with the Federal Disaster Mitigation Act of 2000 further underscores the importance of such plans, as it helps mitigate the effects of natural disasters and other events that may pose significant risks to public safety and welfare.

The Glenn County 2023 updated Safety Element addresses flood to ensure that construction and new development projects do not have any adverse impacts on existing properties and flood control and drainage structures. New structures must be located outside the 100-year floodplain, unless otherwise mitigated. All new development in a special flood hazard area must be built according to FEMA standards. The plan also encouraged and accommodated multipurpose flood control projects that incorporate recreation, resource conservation, preservation of natural riparian habitats, and the scenic

[53] The State of California Central Valley Flood Protection Board, “Central Valley Flood Protection Plan Update 2022 Highlights.” https://cvfpb.ca.gov/wp-content/uploads/2023/01/a0000-CVFPP_U22_layout_Highlights_vFINAL_online.pdf.
[54] Mid & Upper Sacramento River Regional Flood Management Plan, 2014. https://musacrfmp.com/wp-content/uploads/2014/11/MUSR_RFMP_Executive_Summary_111014.pdf

values of drainages, creeks, and detention ponds. Where appropriate and feasible, water detention facilities should be used as groundwater recharge facilities. The General Plan also prioritized flood control measures that respect natural drainage features, vegetation, and natural waterways while providing adequate flood control and protection. Any development activity that requires a grading permit must be designed and built to drain properly to minimize drainage issues, erosion, and sedimentation. Finally, these new policies must ensure that new development and infrastructure improvements do not contribute to potential flooding.[55]

Government Code 8685.9

Pursuant to Government Code 8685.9, the state's allocation of financial resources for eligible projects under the California Disaster Assistance Act is restricted to 75% of state-eligible costs. This limit can be exceeded only if the local agency is in a city and/or county that has incorporated a local hazard mitigation plan in accordance with the Federal Disaster Mitigation Action (DMA) 2000 as part of the safety element of its general plan. If the local jurisdiction/agency has adopted a local hazard mitigation plan, the Legislature may consider providing a state share of local costs that exceed 75% of state-eligible costs.

Location/Geographic Extent

Two major watershed basins of the Sacramento River Watershed extend across Glenn County: Glenn–Colusa and Shasta–Tehama. They pose significant flood risks from natural and human-made factors in their respective floodways. Most of the flood risk in Glenn County is specifically subject to inundation from heavy rainfall and the overflowing of streams and drainage canals. In the unincorporated portions of the county, most flood risk is near the drainage canals used to collect local runoff and areas close to regional watershed floodways, such as the Sacramento River. Areas adjacent to Hambright Creek and Stony Creek near Orland also are at risk of flooding. Willows could be impacted by flooding along Walker Creek, Wilson Creek, and South Fork Willow Creek.

Various regulatory agencies employ Special Flood Hazard Areas (SFHAs) to evaluate vulnerability and risk in flood-prone communities. An SFHA is determined by the extent of flooding associated with a one-percent annual probability of occurrence (the base flood or 100-year flood). Flood hazard maps (Figure 48 through Figure 50) illustrate the 100-year and 500-year floodplains, which represent estimated inundation areas based on floods with one percent (100-year) and 0.2 percent (500-year) chances of occurring during a given year. Experience has shown that FEMA maps of rural areas of the county are not always accurate. FEMA flood insurance data do not always indicate flood losses, as not every property that floods has flood insurance.

The FEMA FIRM for Glenn County has identified over 140,000 acres of flood hazard areas. Figure 48 shows these areas, and Table 31 lists the amounts of land in 100-year and 500-year flood hazard areas. This information makes it possible to identify the location and extent of flooding in areas across Glenn County. These findings are particularly useful in assessing vulnerability and risk in flood-prone communities.

[55] Static 1, "Glenn County General Plan Update." https://static1.squarespace.com/static/5c8a73469b7d1510bee16785/t/6501ddc090fa5b221162db04/1694621148151/GlennCounty_General+Plan+Adopted+7-18-23.pdf

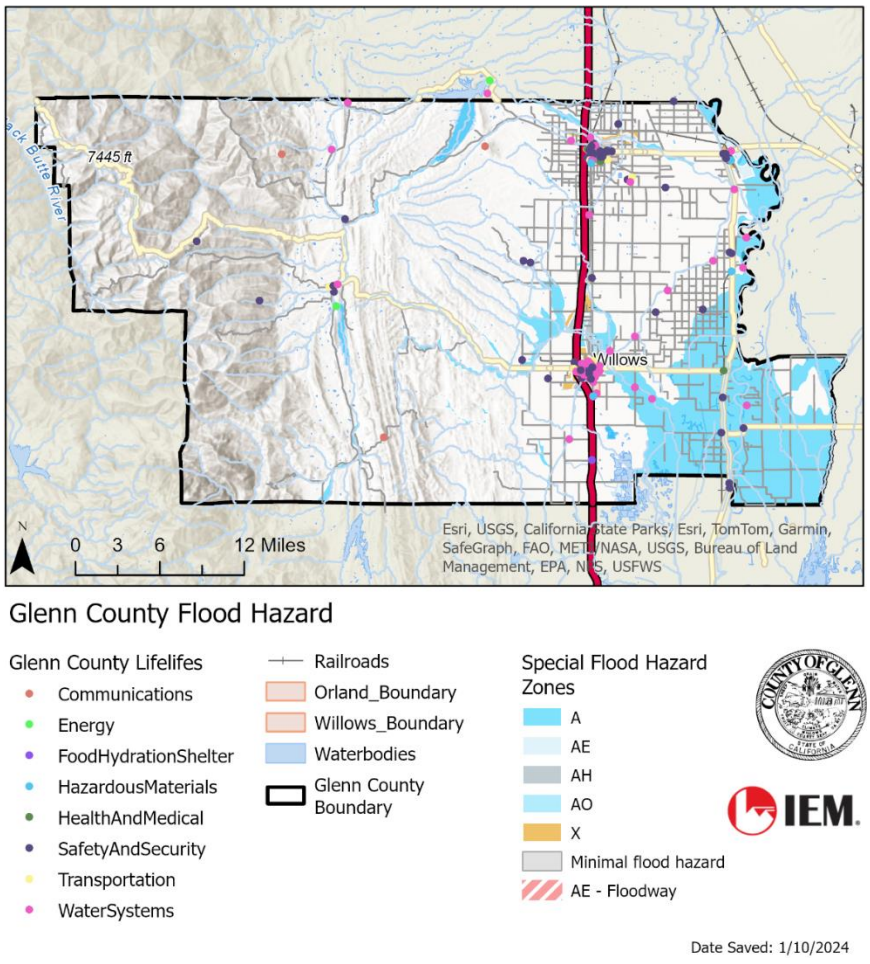


Figure 48: Glenn County Community Lifelines in Flood Hazard Zones

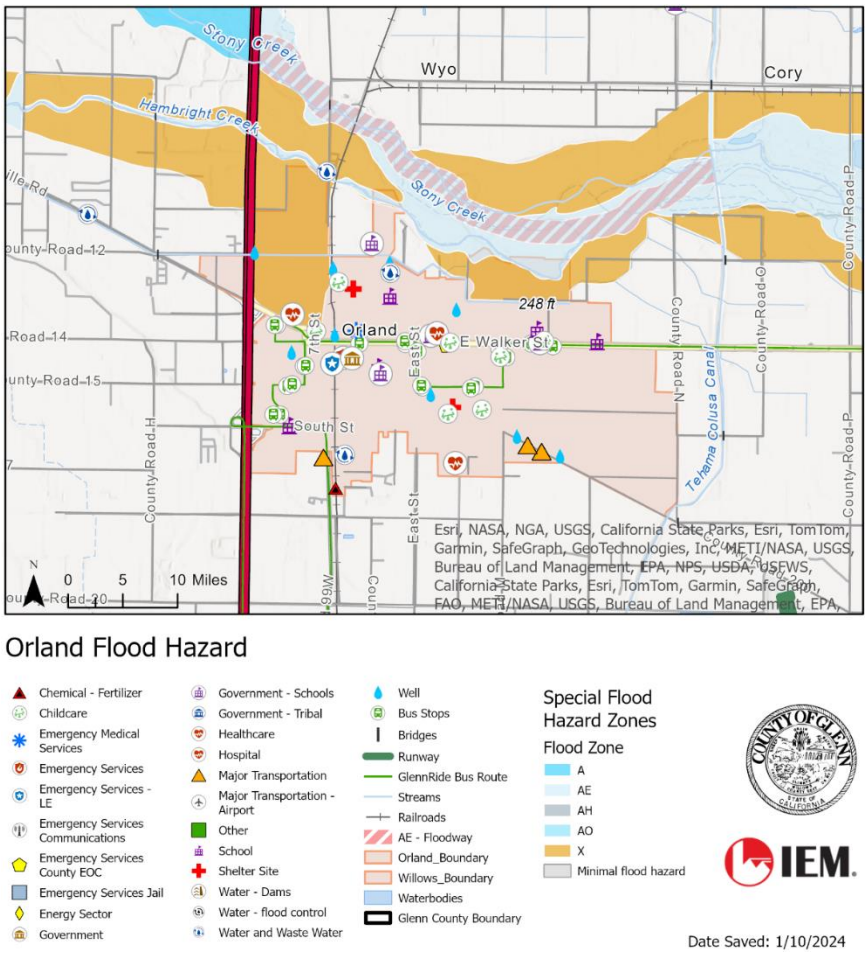


Figure 49: Critical Facilities in Flood Hazard Zones in Orland

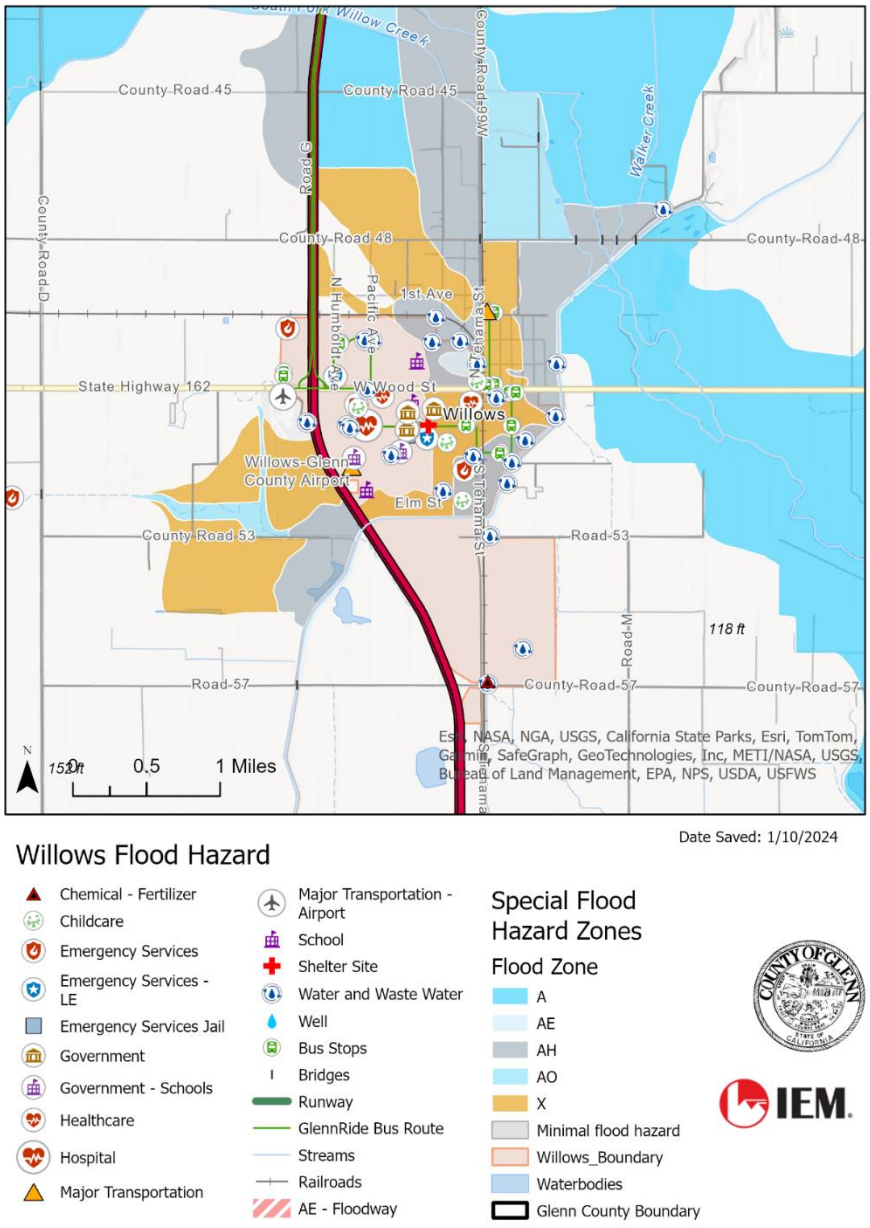


Figure 50: Critical Facilities in Flood Hazard Zones in Willows

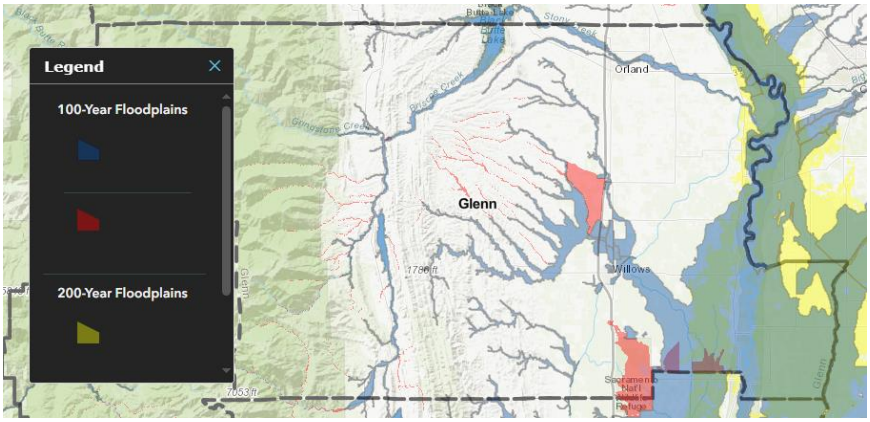
Table 31: Area in Glenn County Inundated by 100- & 500-Year Floods

Hazard	Square Miles	Acres
100-Year Flood	211.6	135,411
500-Year Flood	7.5	4,801.7
Total	**219.10**	**140,212.7**

Source: FEMA, "FEMA Flood Map Service Center: Welcome." https://msc.fema.gov/portal/home

State Flood Awareness Zones

DWR created State Flood Awareness Zones after analyzing floodways and future projections for population growth and development in California. The goal was to conduct floodplain studies in areas where future growth and development might be expected. These efforts were concentrated in areas currently shown on FEMA's Digital FIRMs (DFIRMs) as Zone X, which has no apparent flood risk. DWR made significant efforts to conduct basic flood studies in Zone X in each county in California to identify overlooked flood-prone areas before any development starts. The concept and final mapping products are meant to be used by local governments to control development and protect floodplains in identified awareness zones (see Figure 51). FEMA's Special Flood Hazard Areas (SFHAs) and State Flood Awareness Zones together provide a comprehensive understanding of flood risk in California.



Source: Best Available Map, Glenn County California
https://gis.bam.water.ca.gov/bam/

Figure 51: State Flood Awareness Zones

Localized Flooding

Besides FEMA special planning and hazard areas and State Flood Awareness Zone, the Steering Committee of the Multi-Jurisdictional Hazard Mitigation Plan identified areas that flooded because of heavy rains and inadequate stormwater infrastructure. Several of these were identified by responses to the public outreach survey, including the following:

- SR 162 east of Willows
- Hwy 99 between Orland and Willows (between Road 48 and 45) has experienced frequent flooding, leading to road closures,
- Dips on Broadway and 2nd Street in Hamilton City
- Los Robles and 1st Avenue in Hamilton City
- Hambright Creek bank failures have led to home damages nearby. The creek needs ongoing maintenance to clear vegetation and strengthen banks.
- The "S" turn on Road 39
- Flooding of Wood Street near Walmart in Willows which limits access between Willows and Elk Creek
- Modoc Street in Orland
- County Road 200 (Newville Rd) outside of Orland

- The trailer park south of Hwy 162 west of Willows
- Erosion of Stony Creek and possible flooding near Stoney Creek Dr. and Woodhaven Court
- Insufficient drainage near County Rd 28 near the TC canal
- Hwy 306 past Newville needs repairs and flood prevention
- Concern for bridges near Ord Bend and Grindstone Rancheria

Repetitive Loss Properties

Glenn County, Orland, and Willows are required to assemble a flood management plan that addresses claims for repetitive loss (RL) and severe repetitive loss (SRL), as prescribed by the NFIP. It is important to understand the difference between a repetitive loss property and a repetitive loss area, as both are important for analysis.

FEMA has designated a specific category of insured properties as RL properties. Such properties have filed two or more claims of over $1,000 each in a rolling 10-year period since 1978. The term “rolling 10-year period” means that claims can be made less than 10 years apart, but they must be at least 10 days apart. Properties may be classified as SRL properties when they have involved four or more claims of at least $5,000 each or at least two claims that cumulatively exceed the reported value of the building. It is important to note that properties that experience repeated flooding may or may not appear on Glenn County’s RL property list for reasons, such as the following:

- Not everyone is required to carry flood insurance. Structures in Glenn County that carry federally backed mortgages in an SFHA must carry flood insurance.
- Owners who have completed the terms of the mortgage or who have purchased their property outright may choose not to carry flood insurance and bear the costs of recovery on their own.
- The owner of a flooded property that does carry flood insurance may choose not to file a claim.
- Even insured properties flooded regularly with filed claims might not meet the $1,000 minimum threshold to be recognized as RL properties.
- The owner adopted mitigation measures that reduce the impact of flooding on the structure, removing it from the RL threat and the RL list (in accordance with FEMA’s mitigation reporting requirements).

The properties that appear on FEMA’s RL inventory have flood insurance and received two or more claims. Such properties reflect the repetitive flooding problem that the entire community faces, and they can be used to identify areas of mitigation interest. To maintain the NFIP as a viable program, efforts are made to reduce flood risk in the community and to develop mitigation measures to lower insurance payouts. Extensive NFIP databases track claims for every participating community, including Glenn County, Orland, and Willows. DWR, which is responsible for floodplain management for the state, coordinates with FEMA to obtain the RL and SRL numbers, although a discrepancy between the numbers used by FEMA and the state has been noted. However, for the purposes of this plan, the following numbers have been pulled from PIVOT and are likely to be correct:

- Unincorporated area in Glenn County has 13 RL properties and 1 SRL property. The last plan update reported only 11 RL properties, indicating an increase in RL/SRL properties. All the properties are residential and have not yet been mitigated. Three are outside the high-risk flood zone on the current FIRMs, and only one is a post-FIRM structure. In total, they received $523,778 for building payments and $171,121 for contents.
- Willows has nine RL properties—single-family homes that have not yet been properly protected. Of these properties, only two were insured. This has cost NFIP $238,205 in building payments

and $13,753 in content claims. Since the last plan update, the NFIP has paid an additional $63,003 for these properties.

- Orland does not have any RL or SRL properties.

It is not necessary for a property to have an active flood insurance policy to be considered an RL or SRL property. Homes in certain communities that do not have flood insurance are still on the RL list. The RL designation stays with a property from owner to owner, even if there is no insurance policy in place or after the property has been mitigated. If a property has an insurance policy and makes claims that meet the RL criteria, it is added to the RL list. Furthermore, even if the policy on a property has expired or has been terminated, the property remains on Glenn County's RL list.

The Privacy Act of 1974 (5 U.S.C. 522a) restricts the disclosure of certain types of data to the public. Flood insurance policies and claims data are among the types of information that are restricted. FEMA is authorized to release such data to state and local governments only if they are used for floodplain management, mitigation, or research purposes. Therefore, this plan does not contain information on RL properties or claims data for individual properties. Only generalized locations of the county's RL properties are included.

Magnitude/Extent

Floods are described in terms of the area affected, the depth of floodwaters, and the probability of occurrence. Flood studies often use historical records, such as streamflow gauges, to determine the probability of occurrence of floods of different magnitudes. This probability is expressed in percentages as the chance of a flood of a specific extent occurring in a given year. Probability of flooding is measured as the average recurrence interval of a flood of a given size and place. It is defined as the percent chance that a flood of a certain magnitude or greater will occur at a particular location in a given year.[56]

The annual probabilities calculated for flood hazards fall into the following categories:

- A 10-year flood has a 10% chance of occurring in a given year.
- A 50-year flood has a 2% chance of occurring in a given year.
- A 100-year flood has a 1% chance of occurring in a given year. This category is used as the standard for floodplain management in the United States and is referred to as a base flood.
- A 500-year flood has a 0.2% chance of occurring in a given year.

The Glenn–Colusa and Shasta–Tehama watersheds pose inherent flood risks to the region owing to their natural and human-made features. Specifically, much of the flood risk in Glenn County comes from heavy rainfall that leads to the overtopping of streams and drainage canals. In the unincorporated areas of the county, flooding is most likely from drainage canals that collect regional runoff and in areas near regional watershed floodways, including the Sacramento River. According to the hazard priority ranking exercise, there is a significant flood risk in the unincorporated areas and in Orland and Willows.

Almost a fourth of the county could be subject to flooding if the Black Butte Dam failed. The risk lies primarily along the eastern area of the county, roughly parallel to the Sacramento River and extending almost to Interstate-5 (see Figure 52).

[56] The 100-Year Flood. USGS, 29018. https://www.usgs.gov/special-topics/water-science-school/science/100-year-flood

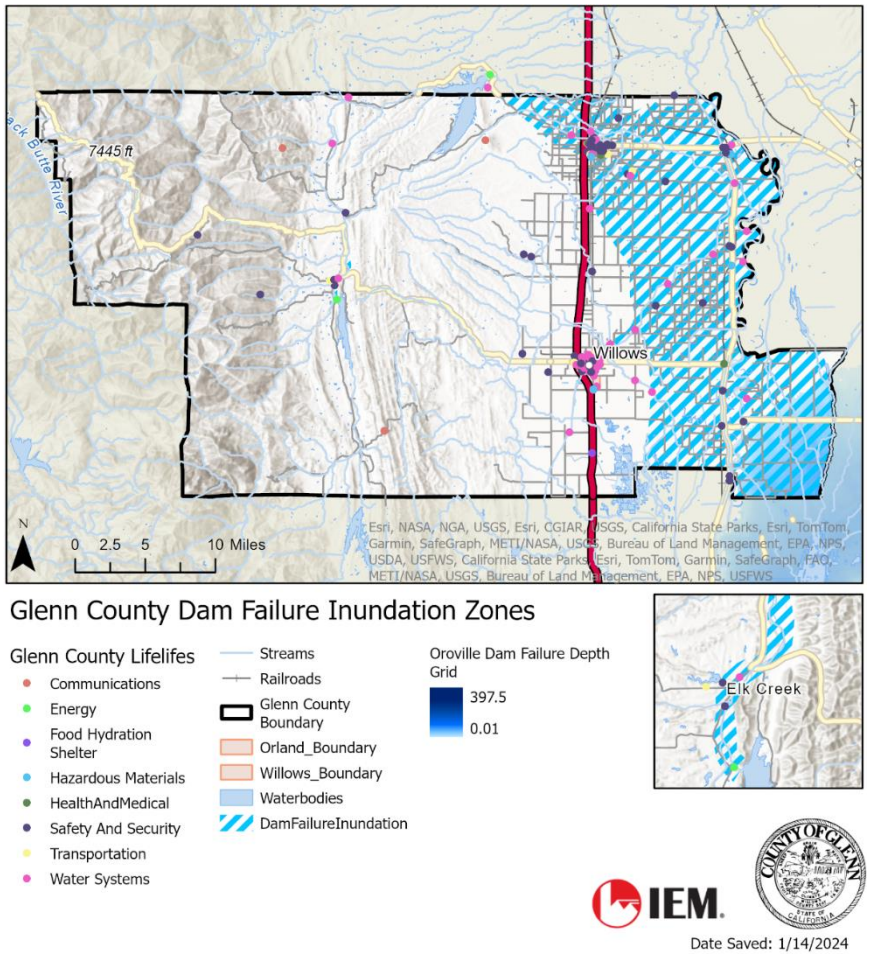


Figure 52: Community Lifelines in Glenn County with the Extent of Dam Failure

Flood Warning and Notification

The damage from flooding can be mitigated through longer warning times and proper notifications before floodwaters arrive. Read Sturgess and Associates (2000) found that communities that are warned at least 12 hours in advance have been prepared enough to reduce flood damage by approximately 40% compared to unprepared communities. Advancements in flood warning and notification systems have led to seasonal notifications for flooding, which has helped enhance the awareness of at-risk citizens. When communicated effectively, advance notifications can reach target audiences on a large scale. The following sections elaborate on Glenn County's and the State of California's flood warning and flood notification systems.

Warning times for dam failures can vary based on the conditions leading to the failure. When a dam is approaching capacity and risks overtopping or shows other signs of deterioration, officials may closely monitor conditions and warn those downstream to take protective action. However, in the case of a sudden unexpected failure, warning times may be very limited for those in the inundation areas, particularly those closest to the breach.

DWR Awareness Zone Notification

DWR's Levee Flood Protection Zones (LFPZs) include levees that are both accredited and disaccredited under NFIP. DWR LFPZ maps are used to determine which property owners will receive notices. The

LFPZs include portions of Butte, Colusa, Fresno, Glenn, Lake, Madera, Merced, Placer, Plumas, Sacramento, San Joaquin, Solano, Stanislaus, Sutter, Tehama, Yolo, and Yuba Counties.

The intent of the Awareness Floodplain Mapping project was to identify by 2015 the flood hazard areas that are not mapped under NFIP and to give communities and residents another tool for understanding potential flood hazards not on regulated floodplains. Awareness Floodplain Maps identify the 100-year flood hazard areas using approximate assessment procedures. These floodplains are shown simply as flood-prone areas without specific depths or other flood hazard data. Additional maps will be added as they become available. In 2017, the California Legislature passed a law mandating inundation maps and emergency action plans for all dams under state jurisdiction, except low-hazard dams.

DWR has launched the Flood Risk Notification Program to reduce the physical and financial impacts of flooding. Under state law adopted in 2007 (Water Code Section 9121), a flood risk notice must be sent each year to owners of properties located behind a state–federal levee and in an LFPZ. Nearly 275,000 Central Valley property owners in 17 counties received a “Flood Risk Notice” to raise flood risk awareness and encourage preventative actions to reduce flood damage and minimize losses.

Property owners may enter their addresses at the program’s interactive website at www.water.ca.gov/myfloodrisk to get more-detailed information about their flood risk, including the sources of flooding and potential flood depths for their properties. This website includes frequently asked questions that may help inform affected property owners.

Past Occurrences

Many areas in the county have a prolonged history of seasonal flooding, frequently causing significant damage. Floodwaters are frequent in communities in and near the lowlands of creeks and rivers. Typically, wintertime storm floodwaters are contained within predetermined limits by levees, dykes, and open lowlands, so they cause little or no damage. Dams such as Black Butte, Shasta, and Stony Gorge also help control floodwaters. However, on rare occasions, the combination of frequent storms, prolonged heavy rain, and melting snow causes floodwaters to surpass normal high-water boundaries, leading to significant damage.

State Emergency Disaster Proclamations, prompted by flood damage from severe storms and heavy rains, have been issued eight times from 1964 to March 2023. For Glenn County, eight Federal Flood Disaster Declarations have been specifically identified and documented (see Table 32). The MUSR RFMP also notes that major floods occurred on the Sacramento River in 1982–1983, 1986, 1995, 1997, and 2006. A major dam failure has not occurred in Glenn County, but one in the region would have a significant impact on the county. Additional details about some flooding events follow the table.

Table 32: FEMA Flood Declarations

Event	Declaration Date	Disaster Number
Severe Winter Storms, Flooding, Landslides, and Mudslides	March 10,2023	3592
Severe Winter Storms, Flooding, Landslides, and Mudslides	January 14, 2023	4683
Severe Winter Storms, Flooding, Landslides, and Mudslides	January 9, 2023	3591
Severe Winter Storms, Flooding, Landslides, and Mudslides	April 1, 2017	4308
Severe Storms and Flooding	February 21, 1986	758
Severe Storms and Flooding	January 25, 1974	412

Event	Declaration Date	Disaster Number
Severe Storms and Flooding	February 16, 1970	283
Heavy Rains and Flooding	December 24, 1964	183

Source: FEMA, "Disaster Declarations for States and Counties." https://www.fema.gov/data-visualization/disaster-declarations-states-and-counties

March 2023: Approximately $400,000 was spent on county public works-related response and recovery efforts because of significant damage to infrastructure. The response included closing approximately 30 roadways to ensure public safety, rescuing stranded motorists in flooded roadways, erecting a temporary structure of sandbags and muscle wall to contain a breach of Hambright Creek, and damage to six roads.

January 2023: The winter storms and flood of January 6–20, 2023, caused significant damage to infrastructure, which cost approximately $5.5 million for county public works-related response and recovery efforts. These included closing approximately 40 roadways to ensure public safety, rescuing stranded motorists in flooded roadways, closing the County Road 306 bridge over Salt Creek for nearly 9 months, and addressing the failure of a bank of Hambright Creek, debris flows in the August Complex Burn Scar (Forest Highway (FH) 7 and CR 309), and damage to 30 roads, including the collapse of CR 309.

September 2022: Severe storms impacted Northern California on September 18–22, 2022, bringing excessive rainfall, flash flooding, debris flows, and rock and mud slides. They had a significant impact on the area of the August Complex burn scar on the west side of the county, damaged county infrastructure and road systems, estimated at $1 million, and caused significant debris flows on CR 309 and FH7, which eroded the roadways and clogged more than 90 culverts.

October 2021: An atmospheric river impacted northern California on October 22-25, 2021, bringing high winds, excessive rainfall, flash flooding, debris flows, and rock and mud slides. The storms damaged county infrastructure, including CRs 309, 313, 303, and the Glenn County Landfill, at a cost of $300,000.

2019: Response included closing more than 40 roadways to ensure public safety, taking emergency protective actions to protect the J-Levee system on the Sacramento River in Hamilton City, rescuing stranded motorists in flooded roadways and in remote snowed-in areas of the mountains. The damages cost approximately $300,000.

2017: The response to a winter storm and floods February 1–23, 2017, included closing approximately 40 roadways to ensure public safety, taking emergency protective actions to protect the J-Levee system on the Sacramento River in Hamilton City, and rescuing stranded motorists in flooded roadways. Glenn County Public Works experienced issues with the VHF radio system because of a power outage. The generator did not have enough water and could not auto-start, causing a loss of power to the repeater. The damages were approximately $300,000.

Frequency/Probability of Future Occurrences

According to the National Risk Index, the annualized frequency of riverine flooding is 0.5 events per year, based on 13 events over 24 years. The 100-year flood recurrence interval has traditionally been used as a reference level for flood probability. There is a high probability of flooding occurring in Glenn County. Based on meteorological patterns and the effects of climate change, it is anticipated that the county will face flooding annually, with a higher probability of inundation events in its unincorporated areas, and that the likelihood of flooding is expected to increase.

Climate change is altering other aspects of the occurrence of extreme events. These changing patterns of hazards increase the likelihood of unexpected weather that will overwhelm capacity and create cascading impacts. Climate change is also increasing the frequency of many sudden-onset hazards. Warmer air holds more moisture, which increases the likelihood of extreme rainfall and leads to flooding and other consequences. The number of floods and other hydrological events has quadrupled since 1980, while climatological events, such as extreme temperatures, droughts, and forest fires, have more than doubled since 1980. As the frequency of these hazards increases, it is more likely that hazards will strike simultaneously or in closer succession, compounding and cascading the impacts from such events.

Based on the 8 FEMA declared flood events in Glenn County, and at least 3 others described in the narrative, flooding has an annualized frequency of 0.183 or an average of almost 1 every 5 years. This indicated that probability of future events is likely.

Changes in Development

The California Fourth Climate Assessment: Sacramento Valley Region addresses several changing conditions that may affect flood hazards. More-frequent severe storms and floods are expected. This could place increased stress on levee systems and increase the need to expand flood bypasses, levees, and flood storage, such as reservoirs. The report identified a risk of disruptions to the housing market in response to unmitigated flooding and concomitant economic impacts that disproportionately affect particular sociodemographic groups. It is also anticipated that future wet seasons will produce more rain than snow because of higher temperatures. This may shift the timing of streamflow into the Sacramento Valley from spring to winter. This could also contribute to higher surface runoff and less groundwater recharge, which may require additional stormwater or reservoir capture. No significant changes since the last plan update to the population or land use which would impact Glenn County, the City of Orland, or the City of Willow's vulnerability to this hazard.

Vulnerability Assessment

The vulnerabilities and impacts of flooding can vary widely, depending on the size, extent, and magnitude of the event. A general description of flood impacts follows, and specific impacts on the population, structures, critical facilities and infrastructure, economy, and environment in Glenn County are elaborated later in this section.

Injury or death can occur if people are caught in floodwaters, and floodwaters can create other public health concerns by spreading infectious diseases and exposure to chemicals and hazardous materials, including pollutants that can be stored in sediment. Flooding can cause extensive damage to structures depending on its depth and velocity, the construction types of buildings, and other factors. Increased development can accelerate the risk of flooding in urban areas. Impervious surfaces, such as concrete and asphalt, shed water at a faster rate than undeveloped areas. Storm drains may back up because of excessive volume or blockages by debris.

Water and wastewater systems can become contaminated by floodwaters, and flooding can damage electrical and communication systems, disrupting important services to affected areas. Transportation routes, including roads, railways, bridges, and other systems, are at risk of inundation, pavement deterioration, and scour damage, requiring costly and sometimes time-consuming repairs.

Floodwaters can become contaminated with chemicals, wastewater, and other hazardous materials that can pollute the natural environment. Stream bank erosion, channel migration, and landslides impact the natural environment. Although some aspects of ecosystems can benefit from the spread of organic material and nutrients and the replenishment of sediment and water, a large-scale flood can injure or kill plants and animals and drastically change habitats.

Dam Failure

A total of 72 critical facilities are in potential dam inundation zones in Glenn County, as shown in 34. Figure 52 shows the locations of these facilities grouped by community lifelines. Many of these facilities are in or near Orland. Depth grids were not available for the Black Butte and Stony Gorge dams, and Hazus was not used to estimate potential losses. However, GIS overlay analysis determined which facilities and other community assets were in possible inundation zones and the exposure values of the general building stock in those areas. Residences make up most of the building exposure values, followed by agriculture and commercial structures. Total building exposure values in dam inundation boundaries are $6.8 billion. An earthquake centered close to a dam may cause the dam to fail.

The inundation boundary of Oroville Dam in neighboring Butte County covers a portion of the southeast corner of Glenn County. No critical facilities are in the potential inundation area from Oroville Dam, but State Highway 162, and County Roads Y, Z, ZZ, 67, and 69 could experience flooding from a failure of the Oroville dam.

Figure 53 and Figure 54 show the critical facilities and potential dam inundation areas in Orland and Willows, respectively.

Table 33: Exposure of Buildings and Their Contents to Dam Failure

	Residential	Commercial	Industrial	Agriculture	Religious	Government	Education	Total Exposure
Orland	$974,377,000	$898,093,000	$173,811,000	$7,798,000	$70,322,000	$48,855,000	$184,694,000	$2,357,950,000
Willows	0	0	0	0	0	0	0	0
County	$1,727,258,000	$570,862,000	$342,915,000	$1,525,800,000	$66,148,000	$71,602,000	$139,092,000	$4,443,677,000
Total	$2,701,635,000	$1,468,955,000	$516,726,000	$1,533,598,000	$136,470,000	$120,457,000	$323,786,000	$6,801,627,000

Table 34: Community Lifelines within Dam Failure Inundation Boundaries

Lifeline	County	Orland	Willows	Total
Communications	0	0	0	0
Energy	1	0	0	1
Food, Hydration, Shelter	0	2	0	2
Hazardous Materials	2	1	0	3
Health and Medical	1	4	0	5
Safety and Security	14	24	1	39
Transportation	0	4	0	4
Water Systems	7	6	5	18
Total	**25**	**41**	**6**	**72**

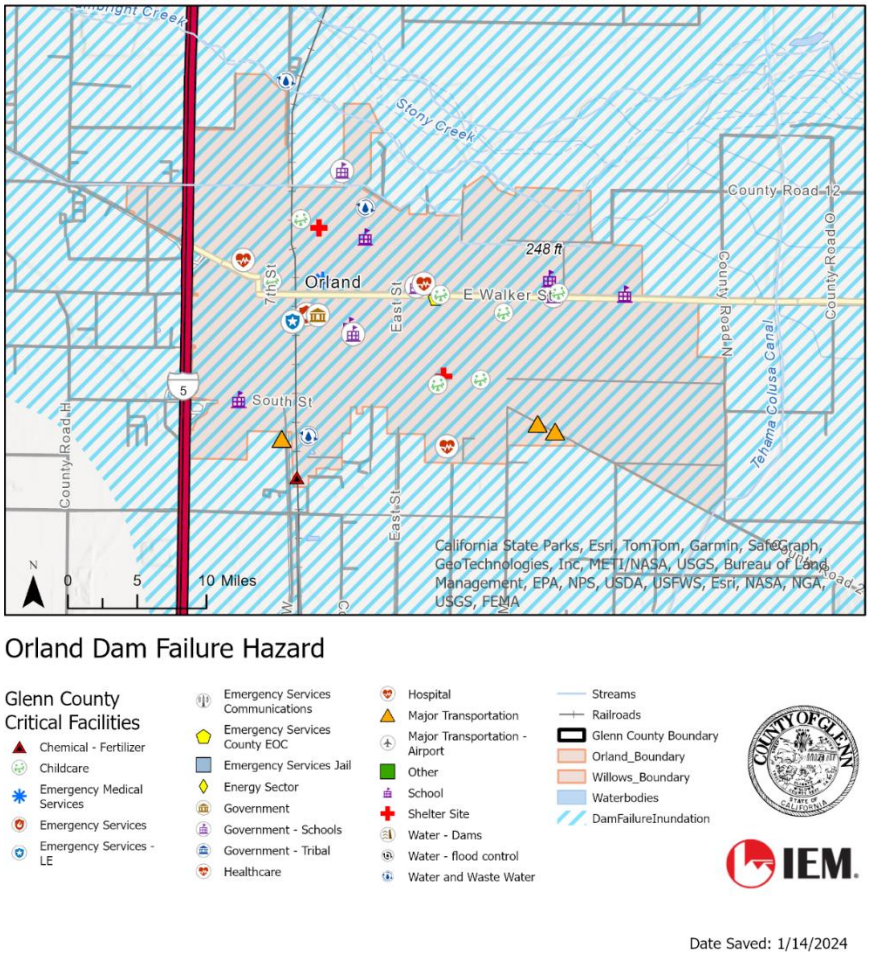


Figure 53: Critical Facilities and Potential Dam Inundation in Orland

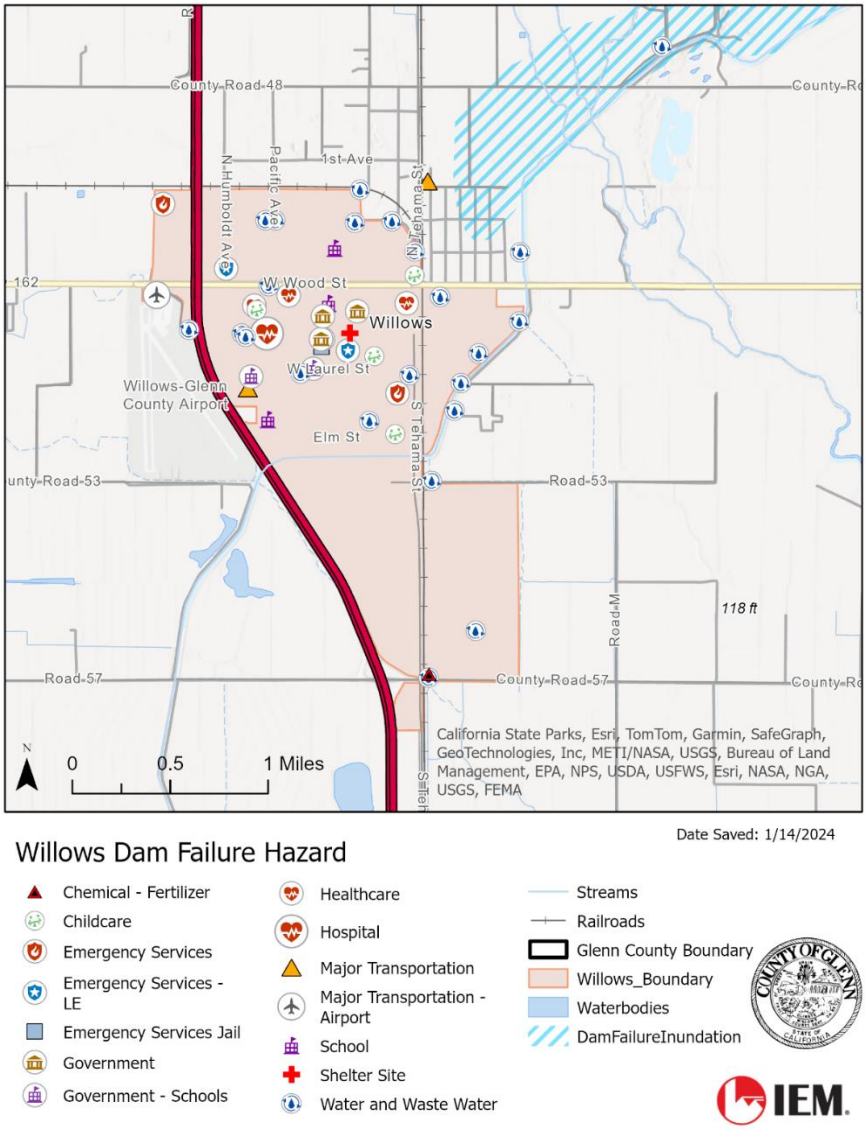


Figure 54: Critical Facilities and Potential Dam Inundation in Willows

Riverine Flooding

The National Risk Index ranks Glenn County as relatively moderate for flooding, with a score of 59.8 on the national percentile with an expected annual loss of $546,856. The relatively low value of past flood losses has impacted the overall flood risk score. However, because of the large area in flood hazard zones and the population and structures potentially exposed, the flood risk is believed to be more significant.

Multiple approaches were used to analyze riverine flood hazards. First, the National Hazard Flood Layer for Glenn County was downloaded from FEMA's Map Service Center. GIS overlay analysis was used to determine which critical facilities and other assets were in special flood hazard Zones A. These results are summarized in Table 35 through 38.

In addition, Hazus 6.0 Level 1 analysis was run for both 100-year and 500-year return periods. Hazus uses a digital elevation model to generate flood depth grids and then uses these depth grids, general

building stock data, and damage functions to estimate the level of damage to structures and other social and economic impacts on the region. These results are summarized in Table 39 and 40.

Table 35: Community Lifelines in Flood Hazard Zones by Jurisdiction

Lifeline	County	Orland	Willows
Communications	0	0	0
Energy	1	0	0
Food, Hydration, Shelter	0	0	0
Hazardous Materials	1	0	0
Health and Medical	1	1	1
Safety and Security	8	0	6
Transportation	0	0	1
Water Systems	5	1	13
Total	**16**	**2**	**21**

Table 36: County Critical Facilities in Flood Hazard Zones

Facility	Jurisdiction	Description	FEMA Community Lifeline	Flood Zone
Artois Fire District	Artois	Emergency Services	Safety And Security	Zone X
California Water Service Company – Water Station	Hamilton City	Water and Waste Water	Water Systems	Zone X
DWR – Ord Water Gauge	Glenn	Water and Waste Water	Water Systems	Zone A
Glenn–Cordera Fire Protection District	Glenn	Emergency Services	Safety And Security	Zone A
Glenn Growers Radio Voter Site	NA	Emergency Services Communications	Safety And Security	Zone A
Glenn–Colusa Fire District (Butte City)	Butte Creek	Emergency Services	Safety And Security	Zone A
Grindstone Rancheria	Elk Creek	Government – Tribal	Safety And Security	Zone A
Hamilton City Community Service District	Hamilton City	Government	Safety And Security	Zone X
Hamilton City Fire District	Hamilton City	Emergency Services	Safety And Security	Zone X
Hamilton Union High State Preschool	Hamilton City	Childcare	Safety And Security	Zone X
Levee District 1 – Ord Ferry	Glenn	Water – Flood Control	Water Systems	Zone A
Levee District 3 – Butte City	Butte	Water – Flood Control	Water Systems	Zone A
Nutrien Ag Solutions	Hamilton City	Chemical – Fertilizer	Hazardous Materials	Zone X

Facility	Jurisdiction	Description	FEMA Community Lifeline	Flood Zone
RD 2140 – HC Levee	Hamilton City	Water and Waste Water	Water Systems	Zone AE
Riverside Assisted Living Facility	Glenn	Healthcare	Health and Medical	Zone A
Stony Gorge Hydroelectric	Elk Creek	Energy Sector	Energy	Zone A

Table 37: Facilities in a Flood Hazard Zone in Orland

Facility	Jurisdiction	Description	FEMA Community Lifeline	Flood Zone
Walgreens Pharmacy	Orland	Healthcare	Health and Medical	Zone X
City of Santa Clara Water	Orland	Water and Waste Water	Water Systems	Zone X

Table 38: Critical Facilities in Flood Hazard Zones in Willows

Facility	Description	FEMA Community Lifeline	Flood Zone
Willows Pharmacy	Healthcare	Health and Medical	Zone X
Willows Fire Department	Emergency Services	Safety and Security	Zone AH
County Administration Memorial Hall	Shelter Site	Safety and Security	Zone X
Glenn County Planning Department	Government	Safety and Security	Zone X
Joyful Noise Preschool	Childcare	Safety and Security	Zone X
Butte St Head Start	Childcare	Safety and Security	Zone AH
Tehama St Children's Center	Childcare	Safety and Security	Zone AH
Glenn County Public Works Agency – Willows Yard	Major Transportation	Transportation	Zone X
North Willows CSD – Glenwood Pump	Water and Waste Water	Water Systems	Zone AH
North Willows CSD – French Street Pump	Water and Waste Water	Water Systems	Zone AH
North Willows CSD – Cherry Street Pump	Water and Waste Water	Water Systems	Zone AH
North Willows CSD – Cemetery Pump	Water and Waste Water	Water Systems	Zone X
California Water Service Company	Water and Waste Water	Water Systems	Zone AH
California Water Service Company	Water and Waste Water	Water Systems	Zone X
California Water Service Company – Water Station	Water and Waste Water	Water Systems	Zone AH
California Water Service Company – Well	Water and Waste Water	Water Systems	Zone X

Facility	Description	FEMA Community Lifeline	Flood Zone
City of Willows – Sewer Lift Station	Water and Waste Water	Water Systems	Zone AH
Glenn–Colusa Irrigation District (GCID)	Water and Waste Water	Water Systems	Zone AH
GCID	Water and Waste Water	Water Systems	Zone A
GCID	Water and Waste Water	Water Systems	Zone A
GCID – Office	Water and Waste Water	Water Systems	Zone AH

Of the 167 bridges in Glenn County, 91 are in Flood Zones A, AE, AH, or AO. No bridges are in Zone X (shaded), which has 0.2% annual chance of flooding. Of the 1,590 culverts in the county, 325 are in A zones, and 8 are in Zone X (shaded). A very large number of these are in the southeast corner of the county. State Highway 45 and State Highway 162, numerous county roads, and approximately 13 miles of railroad segments are in a flood zone A.

Hazus

Hazus estimates that the 12,296 buildings in the region have a total replacement value of $6.5 billion (excluding contents). Hazus 6.0 references Census 2020 data, which state that 28,889 people reside in Glenn County.

100-Year Return Period Scenario

Hazus estimated that about 67 buildings would be at least moderately damaged by a 100-year flood (see Figure 55). Total building losses for this scenario, including structure, contents, and inventory, total $84.74 million, or 62% of the estimated losses. Business interruption losses, such as relocation costs, income losses, rental income losses, and wage losses, account for 37% of the losses. These losses are summarized by jurisdiction in Table 39.

In addition to building and indirect losses, Hazus estimates damage to other critical facilities and infrastructure. For the 100-year scenario, the report showed no estimated losses to essential facilities, such as fire stations, police stations, hospitals, emergency operations centers, and schools. A total of 24 bridges are projected to be damaged, with estimated costs of $431,400. The model did not project any losses for utility facilities or systems. However, flooding could generate 1,066 tons of debris.

Damage to residences accounted for 25% of the loss and left 1,054 people displaced, with 147 of those seeking public shelter.

	1-10		11-20		21-30		31-40		41-50		>50	
Occupancy	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Agriculture	16	100	0	0	0	0	0	0	0	0	0	0
Commercial	1	33	2	67	0	0	0	0	0	0	0	0
Education	0	0	0	0	0	0	0	0	0	0	0	0
Government	1	100	0	0	0	0	0	0	0	0	0	0
Industrial	0	0	2	100	0	0	0	0	0	0	0	0
Religion	0	0	0	0	0	0	0	0	0	0	0	0
Residential	14	18	40	52	9	12	14	18	0	0	0	0
Total	32		44		9		14		0		0	

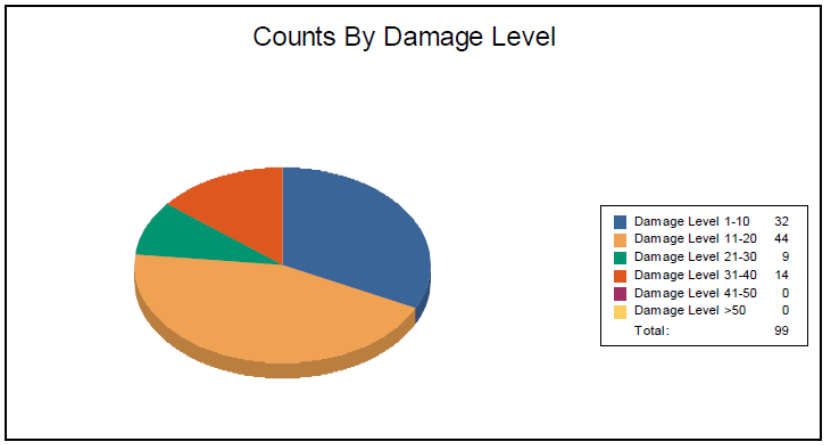


**Figure 55: Hazus 100-Year Scenario:
Expected Building Damage by Occupancy**

500-Year Return Period Scenario

Building losses and business interruption losses for a 500-year scenario are shown in Figure 56 and summarized in 40. The total building-related losses were $93.23 million; 59% of losses were direct building losses (including contents and inventory), and 41% were related to business interruption. Flooding could generate 1,066 tons of debris.

Residences comprised 21% of the losses, which caused an estimated 1,019 people to be displaced and 145 to seek shelter from 340 affected households.

Again, the model did not estimate any losses for essential facilities or utilities. Because the overlay analysis shows facilities in the flood plain, additional analysis may be needed to understand the potential loss impacts of flooding on those structures.

Category	Area	Residential	Commercial	Industrial	Others	Total
Building Loss						
	Building	14.52	3.12	4.35	5.32	27.31
	Content	7.54	8.04	13.62	18.69	47.89
	Inventory	0.00	1.94	2.18	13.92	18.04
	Subtotal	**22.07**	**13.10**	**20.15**	**37.92**	**93.23**
Business Interruption						
	Income	0.37	9.31	0.88	7.20	17.76
	Relocation	7.86	3.02	0.74	3.14	14.76
	Rental Income	2.81	2.22	0.33	0.20	5.56
	Wage	0.87	8.81	1.36	16.33	27.37
	Subtotal	**11.92**	**23.35**	**3.30**	**26.88**	**65.44**
ALL	**Total**	**33.99**	**36.45**	**23.45**	**64.80**	**158.68**

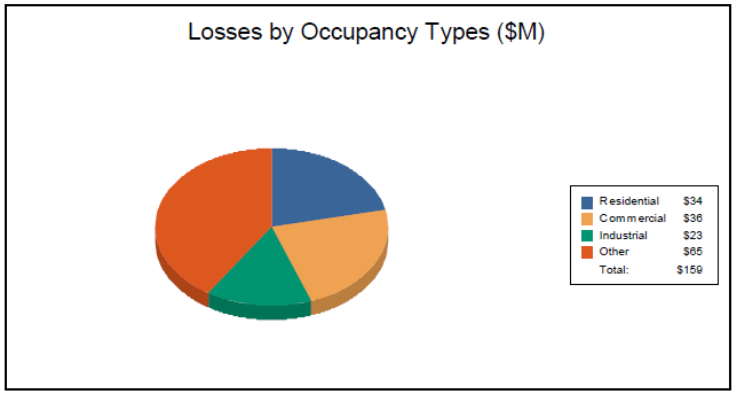


Figure 56: Hazus 500-Year Flood Scenario: Building Loss Estimates by Occupancy

Table 39: Hazus 1% Annual Chance Flood Loss Estimates

	Building Loss	Contents Loss	Inventory Loss	Relocation Loss	Income Loss	Rental Income Loss	Wage Loss	Total Loss	Loss Ratio
Orland	$3,742,000	$2,464,000	$23,000	$1,094,000	$471,000	$371,000	$207,000	$8,372,000	0.36%
Willows	$518,000	$946,000	$212,000	$445,000	$1,207,000	$327,000	$563,000	$4,218,000	0.2%
County	$22,147,000	$40,311,000	$14,381,000	$10,769,000	$14,175,000	$4,230,000	$16,765,000	$122,778,000	1.63%
Total	$26,407,000	$43,721,000	$14,616,000	$12,308,000	$15,853,000	$4,928,000	$17,535,000	$135,368,000	1.13%

Table 40: Hazus 0.2% Annual Chance Flood Loss Estimates

	Building Loss	Contents Loss	Inventory Loss	Relocation Loss	Income Loss	Rental Income Loss	Wage Loss	Total Loss	Loss Ratio
Orland	$626,000	$400,000	$3,000	$552,000	$247,000	$180,000	$1,295,000	$3,303,000	0.14%
Willows	$600,000	$1,150,000	$278,000	$510,000	$1,268,000	$364,000	$724,000	$4,894,000	0.23%
County	$26,082,000	$46,337,000	$17,758,000	$13,695,000	16,240,000	$5,016,000	$25,353,000	$150,481,000	1.99%
Total	$27,308,000	$47,887,000	$18,039,000	$14,757,000	$17,755,000	$5,560,000	$27,372,000	$148,678,000	1.24%

Jurisdiction-Specific Vulnerabilities

Glenn County

According to the Glenn County General Plan Existing Conditions Report, the planning area is subject to flooding problems along the natural creeks and drainages that traverse the area. The primary flood hazard is the Sacramento River and its tributaries. The 100-year flood plain is largely confined to the southern and eastern portions of the county and along tributaries of the Sacramento River. Moreover, the 500-year flood plain generally includes developed portions of the county, including the Artois, Bluegum, Hamilton City, Orland, and Willows planning areas.

Glenn County's primary drainages are Stony (and Hambright) Creek, Walker Creek, Willow Creek, and the Sacramento River. Stony Creek flows from the mountainous uplands through the foothills and enters the Sacramento Valley just west of the Orland Buttes. It runs southwesterly into the Sacramento River about five miles southeast of Hamilton City. Walker Creek and Willow Creek drain the foothills west of Stony Creek. Walker Creek flows southeasterly, joining Willow Creek east of Willows. Willow Creek continues into Colusa County, eventually entering the Colusa Basin Drainage District. The Sacramento River, which is the chief source of surface irrigation water in the county, flows southward through the center of the Sacramento Valley, joins the San Joaquin River in the delta, and then flows into San Francisco Bay and the Pacific Ocean. Other streams draining Glenn County include French Creek, Hunter Creek, Logan Creek, and Wilson Creek. For additional information on water resources, see Chapter 5.0 (Conservation), and for additional information on local drainage and flood infrastructure, see Chapter 3.0 (Community Services and Facilities).

Some areas of the county adjacent to local waterways are subject to flooding during heavy rainfall. The largest floodplain consists of a narrow area parallel to the Sacramento River. Many old meander scars and oxbow lakes are found near the river. Dams control the flow of Stony Creek and the Sacramento River, preventing severe flooding. Annual flooding occurs in the levee system that borders the river.[57]

The county has two main basin areas, the Colusa Basin and the Butte Sink, which lie east of the river. Both areas experience occasional flooding in winter because their terrain is nearly level and the soils drain poorly. In many places, they contain excess salts and alkali, and their water tables are high from time to time. In large areas, drainage ditches have been constructed, and the soils have been partly reclaimed. However, agricultural and other modifications to local drainage may increase localized flooding.

Most of the mountains and foothills drain well, but parts of the intervening valleys drain poorly. The Black Butte River, Corbin Creek, and many other streams drain the area west of the crest of the Coast Ranges. These streams flow into the Eel River, one of the major streams draining the northern part of the Coast Ranges.

Small creeks drain the mountains east of the crest of the Coast Range. These creeks empty into Stony Creek, which flows northeast through the foothills into Black Butte Lake and then the Sacramento Valley drainage basin. The foothills are drained by French, Hunter, Logan, Walker, Willow, and Wilson Creeks and by streams that flow only during the wet winter and spring months. These streams flow east and southward into the Colusa Basin.

[57] Glenn County General Plan Update Existing Conditions Report. 2020. https://static1.squarespace.com/static/5c8a73469b7d1510bee16785/t/5e556b56c253f84cdc287783/1582656403698/GlennCounty-ECR-Final-Feb2020.pdf

The Glenn County Public Works Agency manages special districts for flood control, stream cleaning, and street lighting. These measures are designed to control floods and the flow of storm water in designated areas of the special districts to protect the land, properties, facilities, and people in the county from damage.

Dam failures could impact a significant area of Glenn County; 25 critical facilities and over $6 billion in buildings are in potential dam inundation areas.

City of Orland

Areas adjacent to Stony Creek and Hambright Creek are subject to flooding during heavy rainfall. Severe flooding is prevented in the Orland Planning Area by flood control dams on Stony Creek and the Sacramento River. A designated floodway has been mapped and adopted by the State Reclamation Board for Stony Creek. The state's jurisdiction in this designated floodway supersedes local control.

According to the FIRMs, most of the northwest portion of the city and areas along its northern edge are in either Flood Zone A or Flood Zone X (Shaded), which means the area may be subject to flooding. Areas directly adjacent to Stony Creek and Hambright Creek are in Flood Zone A, which is defined as in the 100-year floodway. Areas north and south of Stony and Hambright creeks, but not immediately adjacent to them, are generally designated as being in Flood Zone X, which is in the 500-year floodway. Flood Zone X covers part of the northwest corner of Orland. It should be noted that FIRMs are designed to determine flood insurance needs and do not necessarily show all areas subject to flooding.

In extremely wet years, the capacity of the Lely Aquatic Park may be exceeded, and stormwater flows southeasterly on and along County Road 200. Localized flooding occurs when Orland's storm drainage system is operating at capacity. It can also be attributed to obstructions or blockages in the system, sometimes caused by illegal dumping. Localized flooding can be an unintended result of flood irrigation of adjacent agricultural land. The amount of flooding varies depending on the difference in road and field elevations, but it can be a temporary hazard to traffic.

As a result of proximity, dam inundation maps show that the risk of dam failure is more severe in Orland than in Willows and other parts of Glenn County. All of Orland is subject to flooding should the Black Butte Dam fail. Maps from the U.S. Army Corps of Engineers show a three-hour contour line just east of the city, which advises that inundation is expected to occur within three hours of dam failure. Forty-one critical facilities and $2.35 Billion in building values are in the potential inundation area of Orland.

City of Willows

Willows has hot, dry summers with cool winters, similar to Orland. The mean annual rainfall is approximately 19 inches, and the mean annual rainfall in the drainage area of Willow Creek is approximately 20 inches. Storms causing flooding occur in the winter seasons, generally from December through February. In storms of 100-year frequency, water from the South Fork Willows Creek and Wilson Creek ponds north of the city and then flows south along Highway 99 and southeast along Willow Creek. The 100-year frequency flows from the South Fork of Willows Creek, Walker Creek, and Wilson Creek Pond behind the levee of the Glenn–Colusa Canal northeast of the city and flows southward, causing flooding between Ventura Street to the west, the Glenn Colusa Canal to the east, and Walnut Street to the south. Local drainage from direct runoff has been a problem in the city's eastern section and in areas north of French Street, between Butte and Lassen Streets. The existing storm drain system carries this flow into the Glenn Colusa Canal. The canal traverses south along the eastern portion of Willows and is higher than the surrounding elevation (when full). Winter flood waters may be pumped in to the canal in the winter when it is empty; e.g. not irrigating. These areas are both subject to 100-year storm frequency ponding and shallow flows from the South Fork Willows Creek.

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Section 3.4 Geologic Hazards

Geologic hazards in Glenn County include earthquakes, expansive soils, and subsidence. These are profiled in the following subsections.

Earthquake

An earthquake occurs when two blocks of the earth suddenly slip past one another. The surface where they slip is called the fault or fault plane.[58] Most major active faults in Glenn County are strike–slip faults, in which one side of a fault line slides past the other. The rupture from this type of fault extends almost vertically into the ground.

Earthquakes are a concern to Glenn County, though no earthquake greater than a magnitude 5.5 (M5.5) has occurred in the county in over 200 years. Glenn County sits on two notable faults: Cleveland Hills and Sierra Nevada,[59] and it is seismically active because it is situated on the boundary between two tectonic plates. Earthquakes can cause serious structural damage to buildings, overlying aqueducts, transportation facilities, and utilities, leading to loss of life. Earthquakes can cause ground shaking, soil liquefaction, landslides, fissures, avalanches, fires, and tsunamis, depending on their magnitude, intensity, and duration; the local geology; the time of day that they occur; building and industrial plant design and materials; and the risk-management measures put in place.[60] Seismic shaking is the greatest cause of damage from an earthquake in Glenn County, followed by liquefaction.

Expansive Soils

Expansive soils are characterized by a high clay content, which swells with increased moisture content and contracts during dry periods. This change in volume, usually associated with seasonal changes, can damage building foundations, roads, and concrete pavement. On slopes, it can bury or break utility poles. Expansive soil types have been associated with landslide risk and rockfall, as the increased volume of expansive soil layers on slopes can create ground shifts and downslope movement of materials. Such soils expand in wetter months and contract over the summer. With regard to warning time, maps that show expansive soils can guide future building and development on this potential hazard.

Subsidence

Land subsidence refers to the gradual or sudden sinking of the Earth's surface caused by the displacement or removal of subsurface materials. The primary causes of land subsidence include the compaction of aquifer systems from withdrawing groundwater, drainage of organic soils, underground mining activities, and natural compaction or collapse, such as sinkholes and thawing permafrost.[61] Land subsidence can lead to several issues, including changes in the elevations and slopes of streams, canals, and drains and damage to bridges, roads, railroads, storm drains, sanitary sewers, canals, levees, and

[58] United States Geological Survey," The Science of Earthquakes." https://www.usgs.gov/programs/earthquake-hazards/science-earthquakes
[59] California Earthquake Authority. "Understanding the Earthquake Risk Where You Live." https://www.earthquakeauthority.com/California-Earthquake-Risk/Faults-By-County
[60] World Health Organization, "Earthquakes." https://www.who.int/health-topics/earthquakes#tab=tab_1
[61] United States Geological Survey, "Sinking Earth." https://www.usgs.gov/mission-areas/water-resources/science/land-subsidence#:~:text=Land%20subsidence%20is%20a%20gradual,drainage%20of%20organic%20soils

private and public buildings. Moreover, the forces generated by the compaction of fine-grained materials in aquifer systems can cause well casings to fail.[62]

Regulatory Environment

Earthquake

Numerous building and zoning codes exist at the state and local levels to decrease the impacts of earthquakes on residents and infrastructure. These codes include the Alquist–Priolo Earthquake Fault Zoning Act of 1972, the Seismic Hazards Mapping Act of 1990, the 2022 California Standards Building Code (CSBC), and the 2023 Glenn County General Plan (GP). To protect lives and infrastructure in Glenn County, Orland, and Willows, the Building Division of each jurisdiction ensures that codes regarding hazards are met.

The 1971 San Fernando Earthquake destroyed numerous structures in its path and led to the passage of the Alquist–Priolo Earthquake Fault Zoning Act. This Act prohibits the construction of buildings for human occupancy across active faults in the State of California. Similarly, extensive damage caused by ground failures during the 1989 Loma Prieta Earthquake focused attention on decreasing the impacts of landslides and liquefaction. This led to the creation of the Seismic Hazards Mapping Act. This Act increased construction standards at locations where ground failures during earthquakes are probable. Active faults in Glenn County have been included under the Alquist–Priolo Geologic Hazards Zones Act and the Seismic Hazards Mapping Act.

The CSBC is based on the International Building Code, which is widely used in the United States. CSBC was modified for California's conditions to include more detailed and stringent building requirements. Glenn County uses the CSBC to regulate the infrastructure in the county. This includes unreinforced masonry buildings. Glenn County includes earthquake safety provisions for new buildings, with enhancements for essential services buildings, hospitals, and public schools.

The 2023 Glenn County General Plan (GP) includes the following policies for lowering the impacts of earthquakes on infrastructure in the county:

- Promote sound agricultural soil and development practices that conserve soil resources and avoid or mitigate the impacts from erosion.
- Require erosion control plans for development proposed on sloping land.
- Require a site-specific geological investigation before development in areas of high landslide risk.
- Monitor gas and water well production to evaluate subsidence activity.
- Enforce the requirements of the Uniform Building Code for all development to protect people, property, and improvements from seismic and other geologic hazards.
- Require geotechnical investigation of buildings meant for public occupancy in earthquake fault zones.
- Require geotechnical evaluation and recommendations for new development in moderate or higher-earthquake fault zones.

[62] United States Geological Survey, "Land Subsidence from Ground-Water Pumping." https://geochange.er.usgs.gov/sw/changes/anthropogenic/subside/#:~:text=Land%20subsidence%20causes%20many%20problems,from%20forces%20generated%20by%20compaction

- Require new development to incorporate project features that avoid or minimize the impacts of earthquakes.

The 2021 City of Orland GP Safety Element 4.0 includes the following policies for lowering the impacts of earthquakes on infrastructure:

- Policy 4.6.A.1: The city may require that a soil report, prepared by a licensed soil engineer, be required for all projects in areas of identified soil imitations; soil reports shall evaluate the shrink–swell and liquefaction potential of sites and recommend measures to minimize unstable soil hazards.
- Policy 4.6.A.2: Public buildings and areas designed for assembly will be constructed to meet seismic standards.
- Policy 4.6.A.3: Work with existing building owners to encourage structural improvements to meet current seismic standards.
- Policy 4.6.A.4: Consider funding options to assist property owners with costs related to seismic safety structural improvements.
- Policy 4.6.B: The city shall work with landowners and interested parties to address seismic safety concerns for older and historic buildings in the downtown area.
- Policy 4.6.B.1: Explore options to amend existing development codes where feasible to facilitate the reuse and development of existing structures in the downtown area relative to seismic safety standards.
- Policy 4.6.C: The city shall require applications for projects that extract groundwater, oil, or gas to include a report evaluating the potential for subsidence. Reports shall discuss appropriate mitigation measures to reduce the potential for subsidence.[63]

Expansive Soils

The Safety Element of the 1993 Glenn County GP and the 2010 City of Orland GP address risks associated with seismically induced surface rupture, ground movement, ground failure, slope instability leading to mudslides and landslides, erosion, and soil expansion. The policies it lists to cope with these issues include the following:

- PSP-28: Promote sound agricultural soil and development practices, which conserve soil resources and avoid or mitigate impacts associated with erosion.
- PSP-29: Protect valley stream courses from the effects of erosion.
- PSP-30: Require erosion control plans for development proposed on sloping land.
- PSP-31: Require a site-specific geological investigation before development in areas of high landslide risk.
- PSP-33: Enforce the requirements of the Uniform Building Code for all development to protect people, property, and improvements from seismic and other geologic hazards.
- Policy 4.6.A: The city shall consider the potential for expansive soils and earthquake-related hazards when reviewing applications for development.

[63] City of Orland, “4.0 Safety Element.” https://www.cityoforland.com/wp-content/uploads/2022/04/GPA-2021-01-Safety-Element.pdf

Subsidence

The 1993 Glenn County GP and the 2010 City of Orland GP state that geologic hazards in the county include the potential for landslides, erosion, and subsidence. The associated policies to deal with these hazards are as follows:

- PSP-30: Require erosion control plans for development proposed on sloping land.
- PSP-31: Require a site-specific geological investigation before development in areas of high landslide risk.
- PSP-32: Monitor gas and water well production to evaluate subsidence activity.
- PSP-33: Enforce the requirements of the Uniform Building Code for all development to protect people, property, and improvements from seismic and other geologic hazards.
- Policy 4.6.C: The city shall require applications for projects that extract groundwater, oil, or gas to include a report evaluating the potential for subsidence. Reports shall discuss appropriate mitigation measures to reduce the potential for subsidence.

Location/Geographic Extent

Earthquake

Fault zones are areas around active faults where future movement is likely to occur and where most earthquakes originate. The Pacific Rim Region, including California, is one of the Earth's most seismically active areas. Glenn County, in particular, is at risk of earthquakes. California's geographic features are dominated by the juncture of two tectonic plates: the North American and Pacific plates. The San Andreas Fault runs the entire length of the state, north to south. the San Andreas Fault is not the only fault system that can cause considerable loss of life and property and environmental damage.

Six earthquake fault systems exist in and near Glenn County. These fault systems have produced or have the potential to produce seismic events of moderate to major impact. The longest of these are the Bartlett Springs (Coast Range) Fault and the Great Valley (Willows) Fault. The Bartlett Springs Fault runs generally north and south beyond the western side of Glenn County in the Mendocino National Forest, a small portion is visible in the lower left corner of the map in Figure 57. The Bartlett Springs Fault System contains several faults running through the western portions of Glenn County, Tehama County, and the eastern portions of Lake and Mendocino Counties. The Great Valley Fault enters the county at the southern end and traverses the county in a north-westerly direction, just west of Highway 5.

This system has several small fracture faults, including the Stony Creek Fault, which is parallel to the reservoir and tributary of the same name and terminates in the town of Stonyford. The Corning Fault branches off from the Willows Fault, where the two pass under the Colusa Canal, and the Corning Fault continues up along the central part of the county, following the path of Highway 5.

In the south-eastern region of the county, Indian Valley and Resort Faults have been inactive for more than 50 years but are significant enough in potential to be cause for concern. The last major seismic activity affecting Glenn County, the Oroville Dam Earthquake, occurred in the Oroville Dam area on August 1, 1975. This earthquake was an M5.7 and produced only minor damage in Glenn County.

Figure 57 shows the ground shaking potential for Glenn County, based on California Geological Survey Map Sheet 48, which shows the relative intensity of ground shaking in California from anticipated future earthquakes. Shaking potential is calculated as the level of ground motion that has a 2% chance of being exceeded in 50 years. Considerations also include historic earthquakes, slip rates on major faults and deformation in the region, and potential for wave amplification by surface geology. The figure also includes fault lines from the California Geological Survey Fault Activity Map.

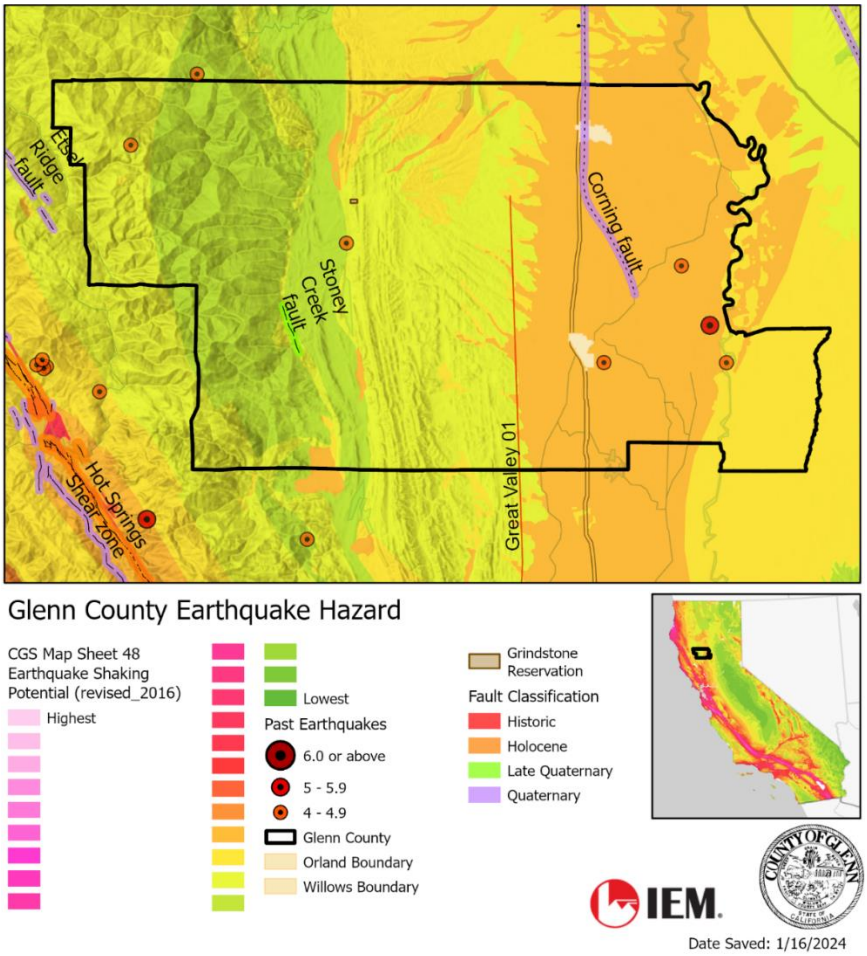


Figure 57: Glenn County Earthquake Hazard

Expansive Soils

Soils rich in clay undergo volume changes in response to variations in moisture content. This phenomenon is known as shrink–swell, and it considerably impacts the stability of structures built on such soils. Specifically, swelling pressures can cause heave, lifting structures, and shrinkage can lead to settlement or subsidence, which may be nonuniform. Therefore, it is important to account for shrink–swell effects when designing structures on clay-rich soils to ensure longevity and safety. Glenn County contains soils with low, medium, and high shrink–swell potential, as shown in Figure 58. As Figure 59 shows, Orland has soils with predominantly low to medium shrink–swell potential, while Willows contains soils with higher expansive potential (see Figure 60). Figure 61 shows the shrink–swell potential for all of Glenn County.

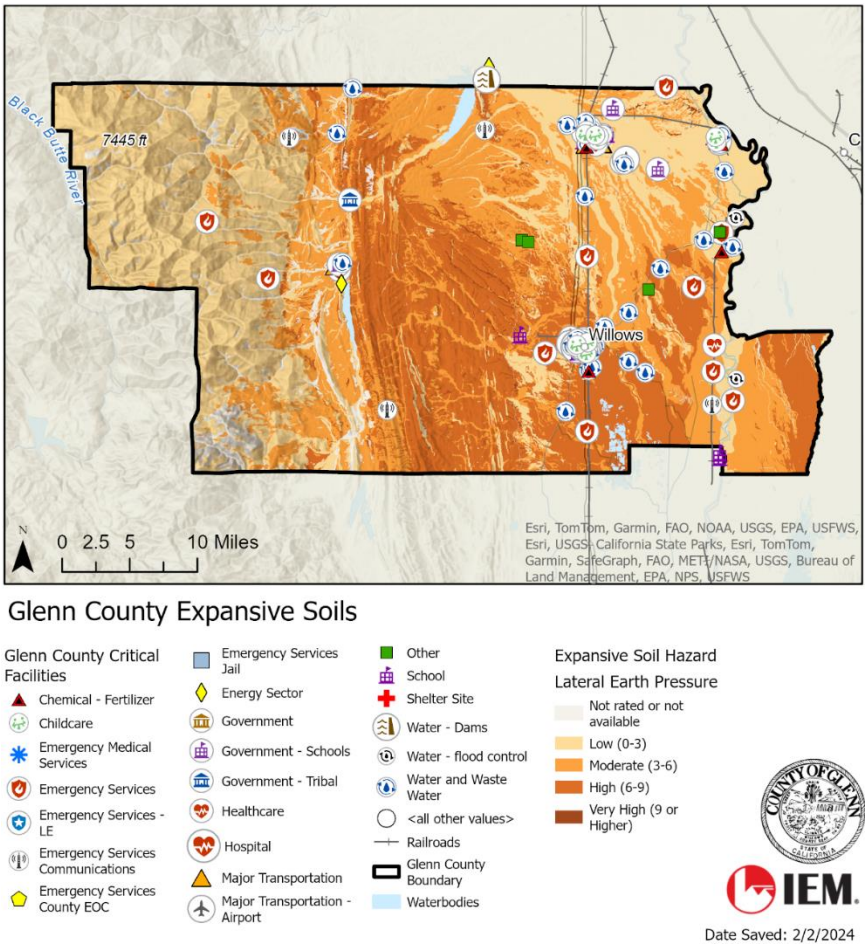


Figure 58: Expansive Soil in Glenn County

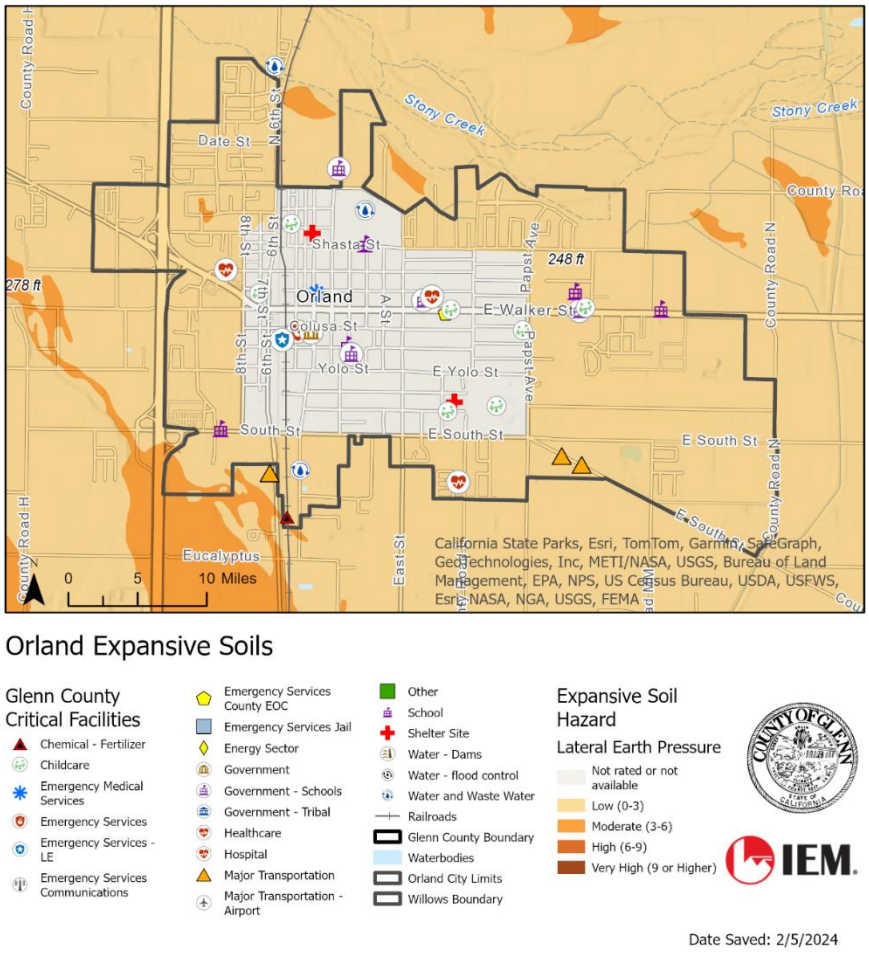


Figure 59: Expansive Soil in Orland

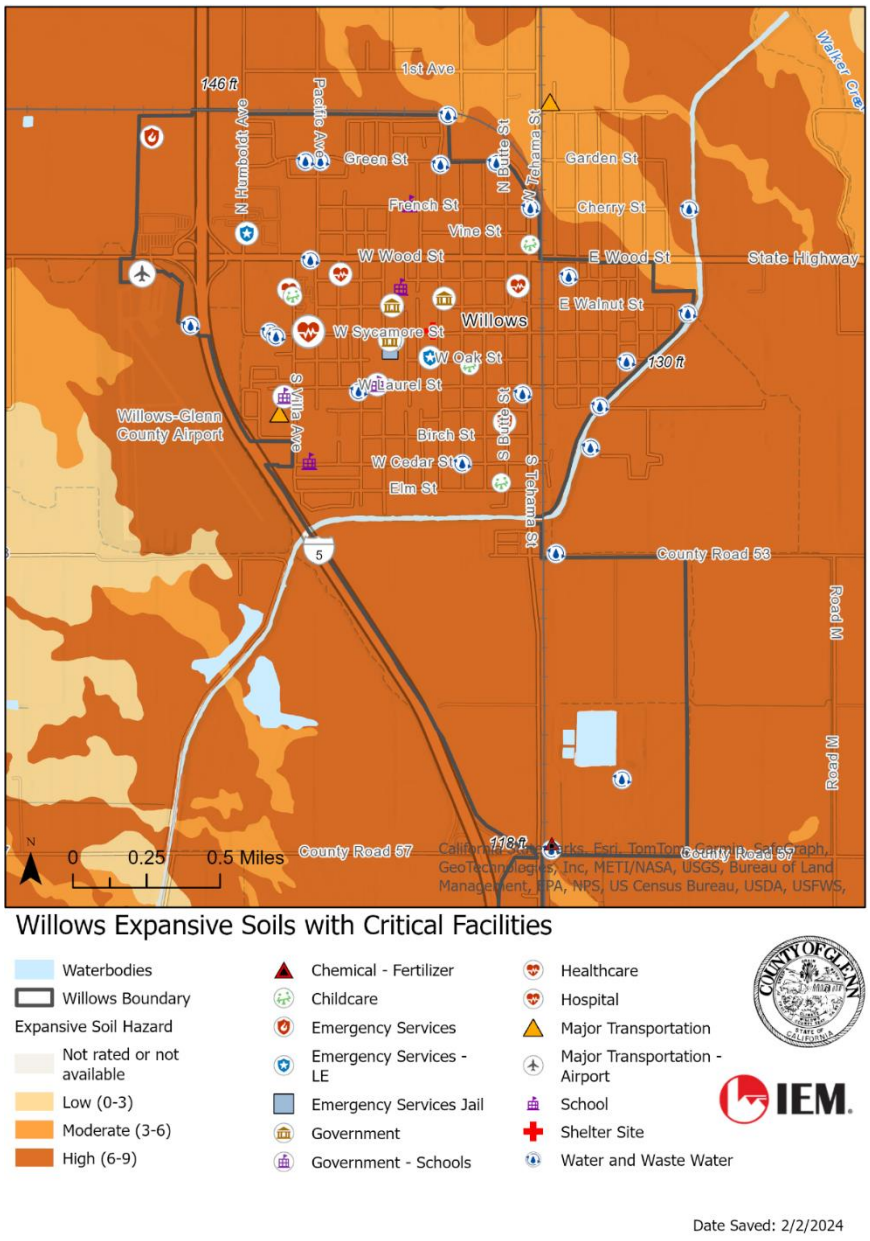


Figure 60: Expansive Soil in Willows

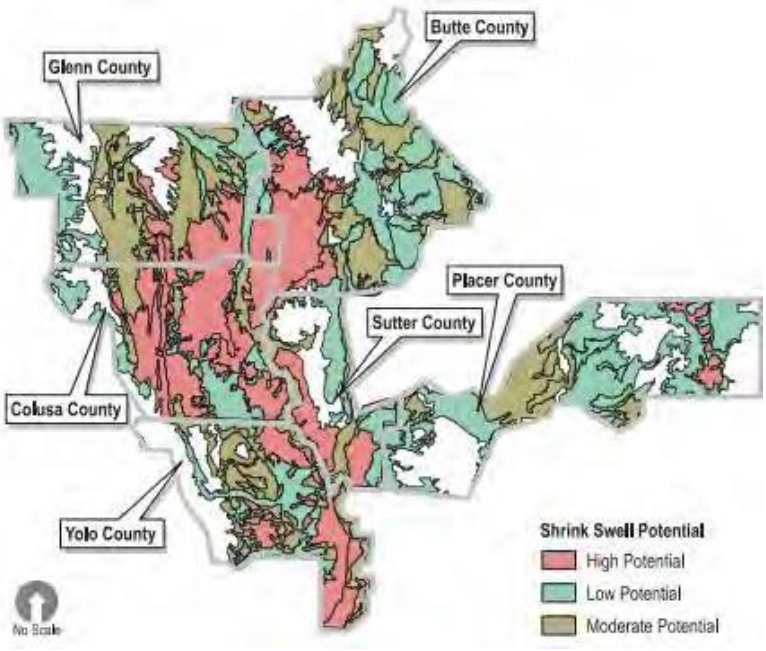


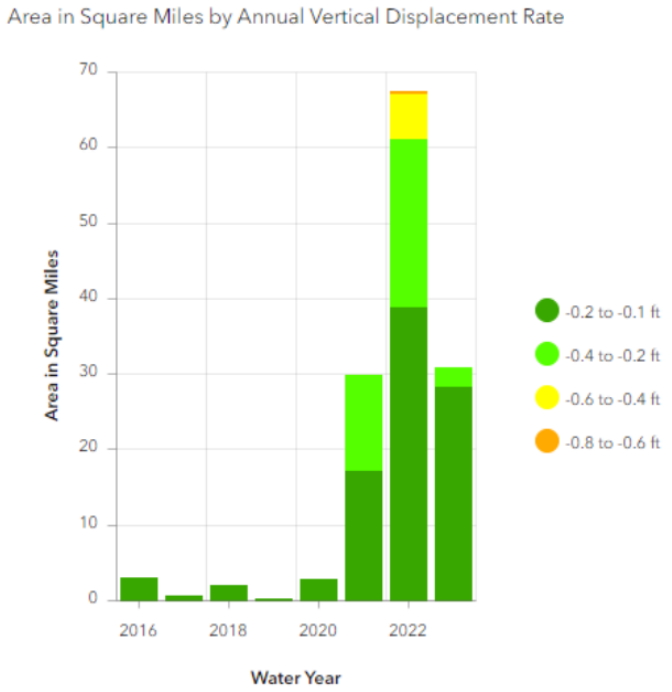
Figure 61: Glenn County Shrink–Swell Map

Subsidence

The geological makeup of the land in southern, central, and eastern Glenn County is mainly a mixture of old and new alluvium and old stream channels and fan deposits. Because of this, the soil is not well consolidated and hence prone to strong ground surface subsidence and displacement. As Figure 62 shows, there was a significant increase in vertical displacement in 2021–2022, when Glenn County experienced drought conditions. It was the sixth driest county in California from December 2021 to November 2022.

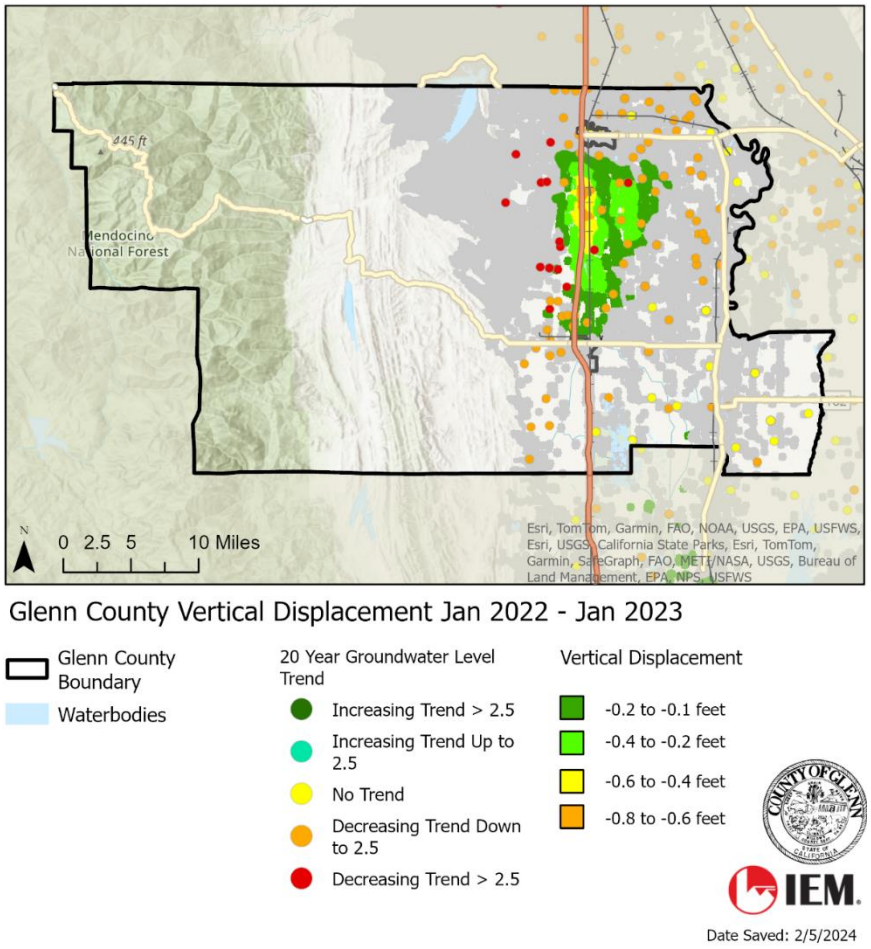
Vertical displacement estimates are derived from Interferometric Synthetic Aperture Radar data, a remote sensing technique that can detect small changes in surface elevation. Figure 63 shows where land subsidence occurred from January 2022 to January 2023. It also includes wells where the depth of groundwater is measured. Groundwater conditions can contribute to subsidence. Many of the wells have been on a decreasing trend over the last 20 years.

Figure 64 shows the same vertical displacement data at a smaller scale to show details of roads and facilities in the area where displacement has occurred.



Source: City of Orland, "4.0 Safety Element." https://www.cityoforland.com/wp-content/uploads/2022/04/GPA-2021-01-Safety-Element.pdf

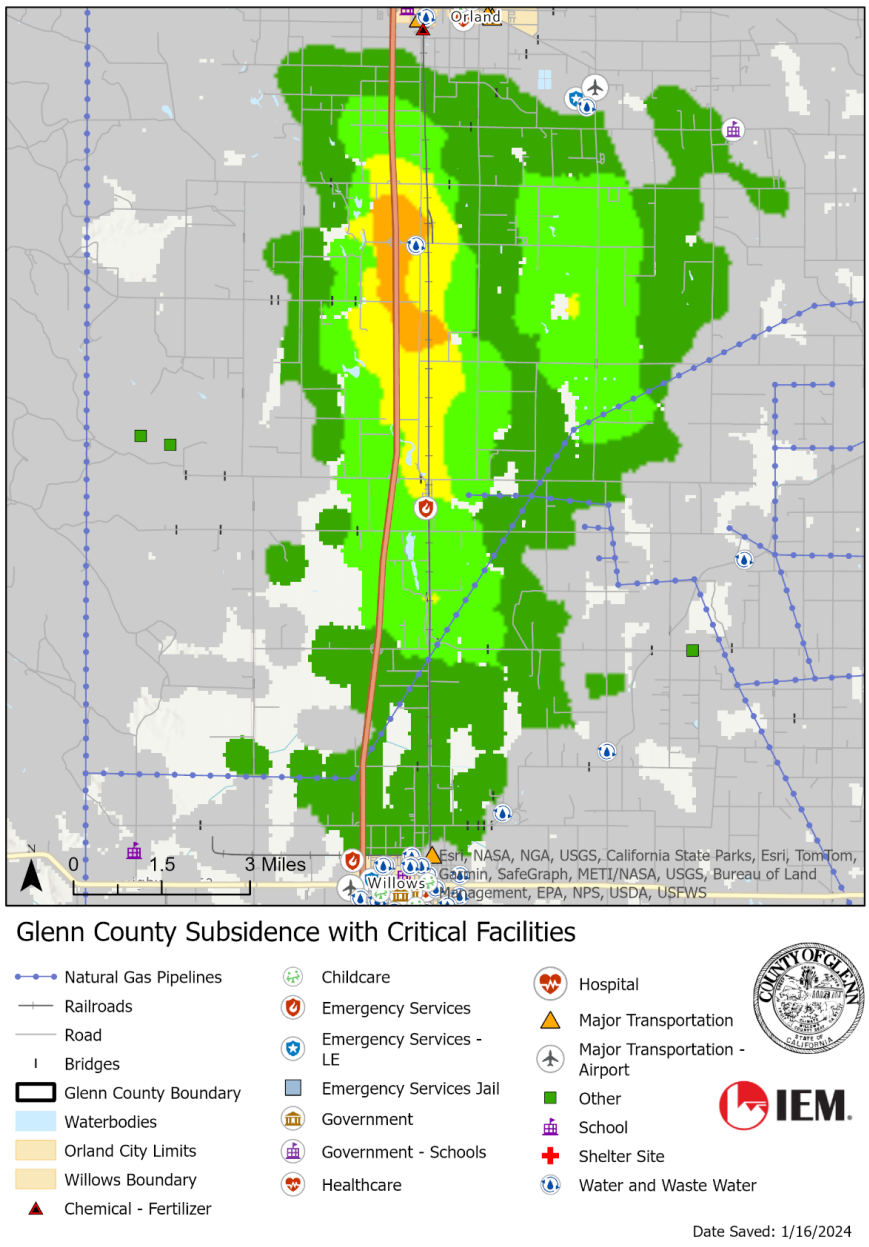
Figure 62: Displacement, 2016–2022



Source: California Department of Water Resources, California's Groundwater Live, InSAR Land Subsidence Remote Sensing Data.

Figure 63: Glenn County Vertical Displacement, January 2022–January 2023

Figure 64 indicates where critical facilities are located relative to areas of subsidence.



Source: California Department of Water Resources, California's Groundwater Live, InSAR Land Subsidence Remote Sensing Data.
https://storymaps.arcgis.com/stories/41574a6d980b4e5d8d4ed7b90f9698d2

Figure 64: Critical Facilities and Vertical Displacement in Glenn County

A significant phenomenon that is most responsible for the potential loss of life and property damage is ground failure (subsidence/liquefaction). The County and the Cities of Orland and Willows will monitor any potential subsidence events and include this information in future iterations of the MJHMP.

Magnitude/Extent

Earthquake

The most common method for gauging an earthquake is magnitude, which measures its strength. Although the Richter scale is familiar as the measurement for magnitude, many scientists currently use either the Mw Scale or the Modified Mercalli Intensity (MMI) Scale. The effects of an earthquake in a particular location are measured by intensity. Earthquake intensity declines as distance from the epicenter of the earthquake increases.

The magnitude of an earthquake is related to the total area of the fault that ruptures and the amount of offset (displacement) across the fault. Table 41 lists the seven earthquake magnitude classes, ranging from great to minor. An earthquake of great magnitude can cause tremendous damage to infrastructure, while a minor one might cause little or no such damage. The county's western portion has strong and very strong shaking potential, while most of its eastern area has moderate shaking potential. A map of shaking intensity specific to the Glenn County area is shown in Figure 57.

Table 41: Earthquake Magnitude Classes

Magnitude Class	Magnitude Range	Potential Damage
Great	8 or Larger	Significant
Major	7.0-7.9	Damage expected
Strong	6.0-6.9	Damage may occur
Moderate	5.0-5.9	Minor damage may occur
Light	4.0-4.9	Likely felt
Minor	3.0-3.9	May be Felt

Source: California Earthquake Authority, "Earthquake Measurements: Magnitude vs Intensity." https://www.earthquakeauthority.com/Blog/2020/Earthquake-Measurements-Magnitude-vs-Intensity

The MMI Scale measures earthquake intensity, as shown in Table 42. The MMI Scale has 10 intensity levels. Each level is defined by a group of observable earthquake effects, such as ground shaking and/or damage to infrastructure. Levels I through VI describe what people see and feel during a small to moderate earthquake. Levels VII through X describe damage to infrastructure during a moderate to catastrophic earthquake.

Table 42: Modified Mercalli Scale

Intensity	Shaking	Description/Damage
I	Not Felt	Not felt except by a very few under especially favorable conditions.
II	Weak	Felt only by a few persons at rest, especially on the upper floors of buildings. Delicately suspended objects may swing.
III	Weak	Felt quite noticeably by persons indoors, especially on the upper floors of buildings. Many people do not recognize it as an earthquake. Standing motorcars may rock slightly. Vibration is like the passing of a truck. Duration estimated.

Intensity	Shaking	Description/Damage
IV	Light	Felt indoors by many and outdoors by few during the day. At night, some awakened. Dishes, windows, and doors are disturbed; walls make cracking sounds. Sensation like a heavy truck striking a building. Standing motorcars rocked noticeably.
V	Moderate	Felt by nearly everyone; many awakened. Some dishes and windows broken. Unstable objects overturned. Pendulum clocks may stop.
VI	Strong	Felt by all, many frightened. Some heavy furniture moved, a few instances of fallen plaster. Damage slight.
VII	Very Strong	Damage is negligible in buildings of good design and construction, slight to moderate in well-built ordinary structures, considerable damage in poorly built or badly designed structures, and some broken chimneys.
VIII	Severe	Damage is slight in specially designed structures, but there is considerable damage to ordinary substantial buildings, including partial collapse. Damage is great in poorly built structures. Chimneys, factory stacks, columns, monuments, and walls may fall. Heavy furniture is overturned.
IX	Violent	Damage is considerable in specially designed structures; well-designed frame structures are thrown out of plumb. Damage is great in substantial buildings, with partial collapse. Buildings shifted off foundations.
X	Extreme	Some well-built wooden structures were destroyed; most masonry and frame structures were destroyed with foundations. Rails are bent.

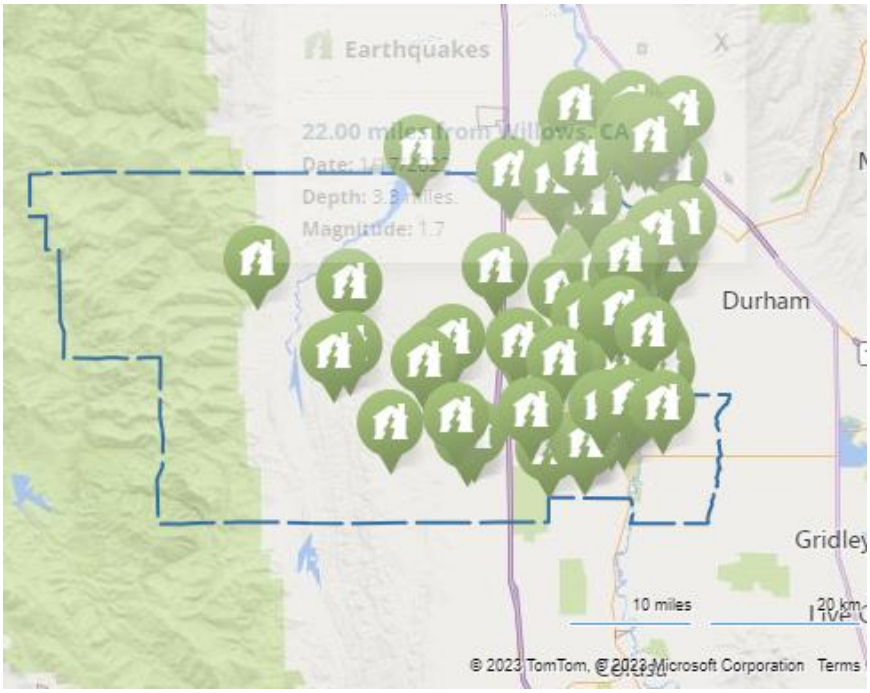
Source: California Earthquake Authority, “Earthquake Measurements: Magnitude vs Intensity.” https://www.earthquakeauthority.com/Blog/2020/Earthquake-Measurements-Magnitude-vs-Intensity

Table 43 and Figure 65 provide additional information on recent earthquakes in the Glenn County area.

Table 43: Earthquakes in or near Glenn County, 2023

Date	Magnitude	Depth in Miles	Location
12/20/2023	2.7	29.2	4 miles from Hamilton City
09/23/2023	2.9	4.9	13 miles from Willows
09/08/2023	2.9	4.4	11 miles from Willows
08/30/2023	2.8	4.9	6 miles from Willows
08/29/2023	2.5	3.1	9 miles from Willows
08/28/2023	2.6	29.5	12 miles from Willows
08/16/2023	2.5	3.2	5 miles from Willows
07/29/2023	3.0	15.5	7 miles from Willows
07/16/2023	2.6	0	10 miles from Willows
03/06/2023	1.5	0.5	13 miles from Willows
03/05/2023	2.8	4.5	14 miles from Willows
02/28/2023	2.8	4.6	13 miles from Willows
02/21/2023	2.0	0.0	4 miles from Willows

Source: Home Facts. “Earthquake Information for Glenn County, California.” https://www.homefacts.com/earthquakes/California/Glenn-County.html



Source: Home Facts. "Earthquake Information for Glenn County, California." https://www.homefacts.com/earthquakes/California/Glenn-County.html

Figure 65: Earthquakes in and near Glenn County, 07/22/2018–12/20/2023

Expansive Soils

Expansive soils are able to undergo considerable changes in volume, either shrinking or swelling, with changes in moisture content. Shrink–swell capacity refers to the soil's potential contract when desiccated and expand when rehydrated. Shrinking and swelling can damage roads, dams, building foundations, and other structures, and it can harm plant roots (Soil Conservation Service 1986). Several factors influence the magnitude of shrinking or swelling in expansive soils:

- Amount of expansive silt or clay in the soil;
- Thickness of the expansive soil zone;
- Thickness of the active zone (depth at which the soils are not affected by dry or wet conditions); and
- Climate (variations in soil moisture content attributed to climatic or human-induced changes).

Soils composed primarily of sand and gravel are not considered expansive soils (the soil volume does not change with a change in moisture content). Soils containing silts and clays may possess expansive characteristics. The Natural Resource Conservation Service classifies soils as having low, moderate, or high potential for volume changes, as noted below.

- Low – This class includes sands and silts with relatively low amounts of clay minerals. Sandy clays may also have low expansion potential if the clay is kaolinite, a common clay mineral.
- Moderate – This class includes silty clay and clay-textured soils if the clay is kaolinite and includes heavy silts, light sandy clays, and silty clays with mixed clay minerals.
- High – This class includes clays and clay with mixed montmorillonite, a clay mineral that expands and contracts more than kaolinite.

Data on expansive soils include lateral earth pressure (LEP), which is categorized as low, moderate, high, and very high hazard. LEP refers to the pressure exerted by soil against a retaining structure, such as a wall or a basement. This pressure comes from the weight of the soil and any external loads acting on it.[64]

Subsidence

Subsidence occurs at great depths below the surface when the subsurface pressure is reduced by the withdrawal of fluids (i.e., groundwater and natural gas). This may create a void that gradually leads to the sinking of the ground. Between 2020 and 2022, Glenn County reported hundreds of dry wells in the area, which may have contributed to vertical land subsidence in 2022. In January 2023, due to groundwater recharge projects, the Orland–Artois Water District, the Glenn County Groundwater Authority, the City of Orland, and local landowners worked together to deliver over 650 million gallons of water to the area.[65] In the Winter of 2023–2024, no persons were affected by drought in Glenn County.

Past Occurrences

Earthquakes

Nearly all of California has a >95% chance of a damaging earthquake in the next century according to the United States Geological Survey National Seismic Hazard Model 2023.[66] However, past earthquake activity in Glenn County has been significantly lower than California's state average. No federally declared earthquake event has occurred in Glenn County since 1950. In 1975, an M5.7 earthquake occurred 48.4 miles from the county center, and in 1998, an M5.4 earthquake occurred 69.0 miles from the county center at a depth of 14.5 miles. The largest earthquake within 30 miles of Glenn County was an M4.6 in 1995 at a depth of 13 miles. On October 30, 2015, a minor earthquake (M3.5) struck approximately 10 miles south of Hamilton City.

Expansive Soils

Expansive soils have been known to cause problems for building foundations and roads, but no specific data on past occurrences and damage are available. Glenn County, Orland, and Willows will monitor any potential expansive soil events and include this information in future iterations of the MJHMP.

Subsidence

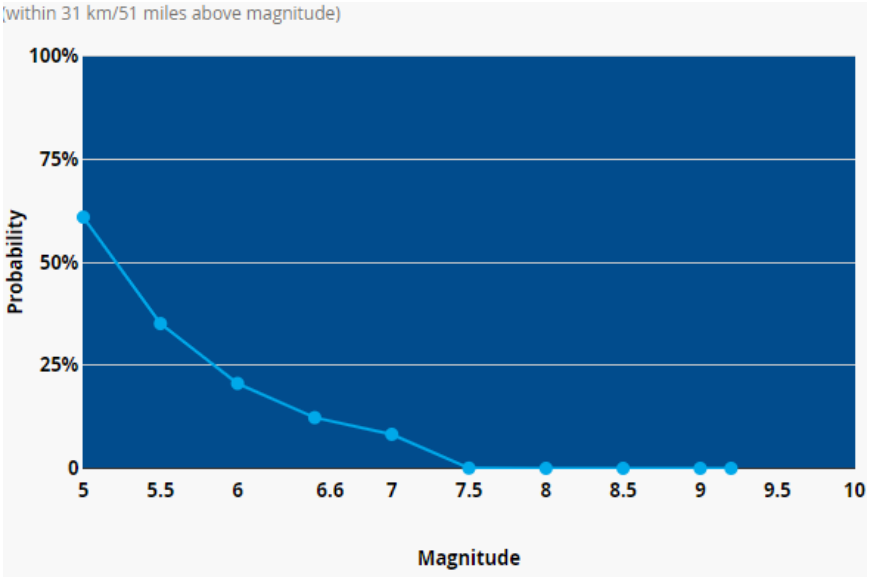
Extensive groundwater pumping of San Joaquin Valley aquifers is increasing the rate of land subsidence in the Northern Sacramento Valley. Between 1926 and 1970, groundwater pumping caused widespread aquifer compaction and land subsidence in the valley. Subsidence in some areas of Southern California exceeded 28 feet (USGS, 2013). Increased pumping has caused additional land subsidence and land shifting in areas most impacted by subsidence. Exact data on past occurrences and damage are not available. Figure 62 shows that subsidence has occurred in Glenn County from 2022 to 2023.

[64] Understanding Lateral Earth Pressure. https://civilengpro.com/understanding-lateral-earth-pressure/
[65] KRCR, "Glenn County fights drought aftermath with over a dozen groundwater recharge projects." https://krcrtv.com/news/local/glenn-county-groundwater-recharge-project
[66] National Seismic Hazard Model 2023 – Chance of Damaging Earthquake Shaking. https://www.usgs.gov/media/images/national-seismic-hazard-model-2023-chance-damaging-earthquake-shaking

Frequency/Probability of Future Occurrences

Earthquake

Earthquakes occur less frequently than other natural hazards, but they have caused the greatest losses in terms of deaths, injuries, and damages in California since 1950. They also have the highest potential for catastrophic disasters. According to CalOES 2010, the likelihood of an M5.0–9.2 earthquake in Glenn County in the next 50 years is 60.91%, as shown in Figure 66. Probability of earthquake is Likely.



Source: Home Facts, "Earthquake Information for Glenn County, California." https://www.homefacts.com/earthquakes/California/Glenn-County.html

Figure 66: Probability of a Magnitude 5.0–9.2 Earthquake in Glenn County in the Next 50 Years

It is important to recognize that earthquakes can devastate infrastructure, communities, and economies, resulting in costly and time-consuming repairs. Therefore, it is crucial to mitigate their impact through appropriate measures, such as creating earthquake-resistant building codes and improving emergency response capabilities. By understanding the likelihood of earthquakes, Glenn County can prepare and take the necessary measures to minimize losses and damages.

Expansive Soils

The potential for soil shrinkage and expansion depends on the amount and types of clay in the soil. The presence of certain clay types can lead to an expansion of the soil when wet and a disproportionate contraction when dry. Expansive soils respond to changes in precipitation and temperature conditions. This hazard is widespread across the county, but it is not expected to threaten life. Damage from expansive soils can be reduced by building practice standards, such as designing foundations to withstand the contraction and expansion of the soil. However, it is important to note that the impact of this hazard is expected to increase because of climate change and continued development in these areas. Therefore, it is key for builders and planners to take steps to minimize the risk of damage from expansive soils. Probability of future events is Occasional.

Subsidence

The depletion of groundwater reserves and its impact on subsidence has been a cause for concern in the Northern Sacramento Valley. A reduction in groundwater pumping since the 1970s has moderated the occurrence of subsidence events. However, the recent drought diminished the region's groundwater reserves drastically. Despite the current stabilization of water levels, subsidence persists because of past stresses on aquifer systems. This phenomenon is expected to continue in the long term but at a slower rate. Given projected population growth, increasing water demands, and the influence of climate change, it is anticipated that groundwater depletion and subsequent subsidence in and near the county will persist. Although there is not sufficient data to determine a recurrence interval, past and ongoing events indicate that the probability of subsidence in Glenn County is Likely.

Changes in Development

Glenn County

Subsidence has and will continue to fluctuate with changing conditions. Drought, extreme heat, and other effects of climate change may contribute to increased demand for ground water, which could exacerbate subsidence. Glenn County and the California Department of Water Resources are monitoring groundwater and subsidence conditions to understand how they change and identify potential actions. Based on current efforts vulnerability is expected to stay the same, but extended drought in the future would cause vulnerability to increase.

Soil conditions can also be impacted by extended drought and heat and other changes in precipitation. The presence of expansive soils can also limit or complicate future development, as additional considerations, such as special grading or more costly construction techniques, may be needed when building on expansive soils. It can also be more complicated to install utilities, such as sewers and water lines. This may limit development, particularly commercial use, in areas west of I-5.[67] There is no change in vulnerability to expansive soil.

Compared to many communities across California, the earthquake risk to Glenn County is relatively moderate. New development may increase the number of people or buildings exposed to earthquake hazards, but new construction must also adhere to modern building codes, which will help reduce risk. Older construction remains at higher risk of earthquakes. There is no change in the vulnerability to earthquake since the last plan update because there has not been much development.

Orland

Like the rest of the county, Orland has had no change in vulnerability to geologic hazards.

Willows

Similarly, Willows has had no change in vulnerability to geologic hazards.

[67] City of Orland, "General Plan November 2021 4.0 Safety Element" https://www.cityoforland.com/wp-content/uploads/2022/04/GPA-2021-01-Safety-Element.pdf

Vulnerability Assessment

Earthquake

Hazus 6.0 was used to produce two earthquake scenarios for Glenn County. One is based on an M6.8 earthquake on the Great Valley 1 fault. The second is a 100-year probabilistic model based on an M5.8 earthquake. The earthquake model in Hazus aggregates data by census tract. Although census tracts do not exactly line up with city boundaries, the tracts aligning most closely to the Orland and Willows city boundaries were used to determine the building loss results for the county and the cities in the following sections.

Hazus 100-year Probabilistic Scenario of an M5.8 Earthquake

Over $200 million in building losses is projected in this scenario. Residences account for 26% of the loss, and 19% of losses were related to business interruptions in the region. A breakdown of direct economic losses for Glenn County, Orland, and Willows is provided in Table 44. The loss ratio is the percentage of total direct economic losses for each jurisdiction compared to the total building exposure in the county.

An estimated $1.77 million in transportation losses is expected from damage to highway bridges, and railways. Roadway segments, and railroad tracks are assumed to be damaged by ground failure only. Ground failure maps were not included in this scenario, so damage estimates for these components were not computed. Although this model did not reveal significant impacts, it can be anticipated that there may be damage to these structures that could disrupt travel in the area. Economic losses from utility systems total $9.16 million from wastewater systems, electric power facilities, and potable water systems and a minor amount from natural gas distribution lines and communications facilities.

45 shows the amount of damage estimated for different building occupancy types. Government, educational, and religious/nonprofit facilities make up a small percentage in all damage categories. Agricultural and commercial buildings make up a larger percentage of structures damaged in the extensive and complete damage states, but these categories have a lower count overall. Single-family residences make up a significant portion of buildings with slight or moderate damage. Multi-family residences are of particular concern because they represent a large percentage of damage in all categories, from slight to complete.

Hazus estimates that 60 households will be displaced by this scenario earthquake, with 37 persons seeking temporary public shelter. Hazus does not identify specific locations of persons displaced by an earthquake, so it is unknown which communities these persons may be displaced from. This number is based on a fraction of the amount of structural damage to dwelling units, and there are different weights for single-family homes and multi-family rental properties. Shelter needs are based on a function of displaced persons that also considers income, ethnicity, ownership, and age. Those seeking public shelter typically have lower incomes and have fewer options. They also tend to have young children or are over age 65.

Table 44: Loss Estimate Summary for a Hazus 100-Year Probabilistic Scenario of an M5.8 Earthquake

	Building Loss (Structural and Non-Structural)	Contents Loss	Inventory Loss	Relocation Loss	Income Loss	Rental Income Loss	Wage Loss	Total Loss	Loss Ratio
Orland	$26,505,760	$7,508,160	$759,900	$3,790,620	$2,401,620	$1,918,460	$2,811,150	$45,695,660	0.70%
Willow	$24,018,060	$6,662,430	$464,310	$3,643,800	$2,245,570	$1,901,670	$3,096,060	$42,031,900	0.65%
County	$69,203,860	$20,628,550	$7,623,640	$7,443,150	$2,523,900	$2,689,060	$2,723,290	$112,835,450	1.73%
Total	$119,727,680	$34,799,140	$8,847,850	$14,877,570	$7,171,090	$6,509,190	$8,630,500	$200,563,010	3.08%

Table 45: Expected Building Damage by Occupancy for a Hazus 100-Year Probabilistic Scenario of an M5.8 Earthquake

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Agriculture	984.56	10.66	201.44	10.00	138.26	15.85	37.75	22.82	2.99	28.45
Commercial	562.67	6.09	164.12	8.15	123.17	14.12	32.51	19.65	2.52	23.98
Education	25.70	0.28	4.79	0.24	3.51	0.40	0.92	0.56	0.07	0.69
Government	63.93	0.69	17.30	0.86	14.16	1.62	3.31	2.00	0.30	2.82
Industrial	168.26	1.82	38.95	1.93	35.25	4.04	10.81	6.53	0.73	6.95
Other Residential	1408.85	15.26	410.49	20.37	274.69	31.48	54.50	32.94	3.48	33.11
Religion	60.54	0.66	14.88	0.74	10.88	1.25	2.49	1.51	0.21	2.01
Single Family	5958.15	64.53	1162.94	57.72	272.56	31.24	23.14	13.99	0.21	2.00
Total	9,233		2,015		872		165		10	

Hazus M6.8 Great Valley Earthquake Scenario

Of the almost $520 million in general building losses expected in this scenario, 22% were from residences. Table 46 shows the estimates of losses by jurisdiction. This includes direct losses to buildings, contents, and inventory and indirect losses from business interruption.

An estimated $5.35 million in transportation losses is expected from damage to highway bridges, railways, and port facilities. Roadway segments, railroad tracks, and light rail are assumed to be damaged by ground failure only. Ground failure maps were not included in this scenario, so damage estimates for these components were not computed. Economic losses from utility systems total $32.5 million from wastewater systems, electric power facilities, potable water systems, and communications facilities.

Building damage for different building occupancy types is similar to that in the previous scenario (see 47). Single-family and multi-family residences show the highest percentages of damage, with single-family becoming a smaller percentage in the higher damage categories, and multi-family replacing it as the highest percentage in the extensive and compete damage categories. Agriculture and commercial buildings also make up a high percentage of the extensive and complete damage categories.

Hazus estimates that 170 households would be displaced by this scenario earthquake, with 106 persons seeking temporary public shelter. As mentioned in the previous scenario, this number is a function of the number and extent of damage to dwellings, and it also considers demographic factors, such as income, ethnicity, ownership, and age, in estimating how many people will seek public shelter.

Table 46: Loss Estimate Summary for a Hazus M6.8 Great Valley Earthquake Scenario

	Building Loss (Structural and Non-Structural)	Contents Loss	Inventory Loss	Relocation Loss	Income Loss	Rental Income Loss	Wage Loss	Total Loss	Loss Ratio
Orland	$53,286,520	$17,985,870	$1,864,420	$7,005,800	$4,787,520	$3,518,800	$5,546,860	$93,995,790	1.44%
Willow	$74,604,790	$22,513,480	$1,686,410	$10,510,910	$6,895,230	$5,392,680	$9,479,900	$131,083,400	2.01%
County	$175,634,380	$60,669,000	$20,775,550	$16,982,800	$6,648,080	$6,580,330	$7,389,240	$294,679,380	4.53%
Total	$303,525,690	$101,168,350	$24,326,380	$34,499,510	$18,330,830	$15,491,810	$22,416,000	$519,758,570	7.99%

Table 47: Expected Building Damage by Occupancy in a Hazus M6.8 Great Valley Earthquake Scenario

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Agriculture	786.75	10.21	259.17	9.84	222.48	15.25	83.78	19.43	12.81	19.56
Commercial	370.86	4.81	190.19	7.22	215.19	14.75	91.17	21.14	17.59	26.84
Education	20.37	0.26	5.97	0.23	5.78	0.40	2.44	0.57	0.45	0.69
Government	38.83	0.50	19.69	0.75	25.98	1.78	11.91	2.76	2.59	3.95
Industrial	108.11	1.40	47.40	1.80	62.77	4.30	30.49	7.07	5.23	7.98
Other Residential	1092.94	14.18	480.41	18.24	408.30	27.98	147.03	34.10	23.33	35.60
Religion	43.88	0.57	17.53	0.67	18.52	1.27	7.65	1.77	1.43	2.18
Single Family	5244.48	68.06	1613.31	61.26	500.36	34.29	56.75	13.16	2.10	3.20
Total	**7,706**		**2,634**		**1,459**		**431**		66	

Subsidence

The area in Glenn County experiencing vertical displacement from subsidence varies from year to year and is related to drought, extreme heat, and groundwater use. When the region experiences prolonged periods of drought, reliance on groundwater for water supply and agriculture increases. Climate change is expected to lead to an increasing frequency and severity of drought, which could further increase subsidence.

In general, the trend appears to be that displacement is occurring between Orland and Willows on either side of I-5. The community of Artois is an area where displacement has been occurring. Roads, bridges, railroads, utility lines, and other structures have been damaged in other parts of California and could be impacted by continued displacement in Glenn County.

Continued ground subsidence may lead to increased flood risk in low-lying areas. Changes in topography can impact sewer lines, stormwater drainage, and other conveyance systems. Topography changes can also add strain to levee systems, requiring maintenance and strengthening. Compaction of aquifers can permanently decrease their capacity to store water.

Jurisdiction-Specific Vulnerabilities

Glenn County

Earthquake: The potential vulnerabilities discussed along with the Hazus scenarios in the previous section apply to all of Glenn County. The highest potential for ground shaking is in the central to eastern portion of the county, roughly following I-5 north to south. This is also where much of the population of Glenn County is concentrated, including the cities of Orland and Willows and several other small towns. According to Hazus, costly damage to residences and other structures should be expected, as well as economic losses from business interruption.

The impact of an earthquake can be widespread depending on its magnitude and intensity. While it cannot be determined where a future earthquake may occur and which areas may experience the greatest shaking, several concentrations of vulnerable populations in the county may experience more severe effects from an earthquake. The northeast portion of the county has a higher percentage of Hispanic or Latino populations, many who primarily speak Spanish. Orland, Willows, Hamilton City, and much of eastern Glenn County have a higher percentage of people with an income below the poverty level. These populations roughly overlap the area with a higher ground shaking potential. There is not a high concentration of individuals with disabilities in the area of highest shaking potential, but there are individuals with various disabilities or access and functional needs that may require additional assistance following an earthquake.

Subsidence: Based on the vertical displacement data shown in Figure 64, the Artois Fire District Station, the Artois Water District, and Artois Water Mains and Storm Drain systems are in areas recently affected by subsidence. Railroad lines, I-5, Natural Gas Pipelines, and numerous county roads also are in this area. Although it is uncertain at what rate subsidence may continue, monitoring these areas and efforts to moderate the use of groundwater supplies will be critical to avoiding damage.

Expansive Soils: Expansive soils can shrink and swell because of changes in the moisture content of clay-rich soils. Changes in climate, including extreme heat and drought and changes in precipitation patterns, could cause soils to shrink or expand. These changes can cause damage to the walls and foundations of structures as pressure from the surrounding soil changes. Expansive soils are found in many parts of Glenn County, including its central, south, and southeast areas, as shown in Figure 58. The

county has 55 critical facilities in areas of high risk of expansive soils affecting these community lifelines: 25 Water systems, 21 Safety and Security facilities, 4 Health and Medical facilities, 2 Transportation facilities, and 1 each for Communication, Food, Hydration and Water, and Hazardous Materials.

City of Orland

Earthquake: Orland has no record of damaging shaking events during the last century. However, the Corning Fault could impact Orland. The I-5 freeway overlays it for more than 30 miles. Orland is susceptible to strong shaking from periodic earthquakes in the region. The Hazus scenarios provide insight into the types of damage that can be anticipated if a large earthquake were to occur. Homes would be damaged, and some residents would be displaced. Damage to transportation and utility systems could disrupt services to the area. Businesses also would be damaged, leading to various economic losses from lost income and other business interruption costs.

Subsidence: Vertical displacement has occurred to the south of Orland, and changing conditions could cause displacement in the city. Subsidence could affect various transportation and infrastructure systems in or leading to Orland. As discussed in Section 3.1. Drought, dry wells have been reported in the area, which shows that water use may be contributing to displacement. Climate change may make drought and extreme heat events more common, which can lead to increased dependence on groundwater and further subsidence.

Expansive Soil: Orland has a low potential for expansive soils. A map of expansive soils in the General Plan shows that most of the expansive soils are west of I-5. Detailed geologic investigations may be necessary for areas with moderate to high shrink–swell potential. Development on expansive soils may require special grading and construction techniques. This type of soil also increases the cost of installing sewer and water lines and affects the design of storm drainage facilities, since percolation is slow. This may present challenges in developing commercial uses in areas west of I-5.

City of Willows

Earthquake: There is no record of damaging earthquakes in Willows in the last century, and no recent earthquake epicenters have occurred in the city. Fault lines and maps of ground shaking potential suggest the potential for damaging earthquakes in the area. The Hazus scenarios provide insight into the types of damage that can be anticipated if a large earthquake were to occur. Homes would be damaged, and some residents would be displaced. Damage to transportation and utility systems could disrupt services to the area. Businesses also would be damaged, leading to various economic losses from lost income and other business interruption costs.

Subsidence: Subsidence has not caused damage in Willows. However, vertical displacement has occurred just north of the city. If extended drought, heat, and dependence on groundwater continue, the area of subsidence may expand or show greater amounts of vertical shift. Subsidence north of Willows could affect important transportation routes to and from the city, including I-5, the railroad, and utility lines. Ongoing monitoring of their conditions should continue to assess changes in risk.

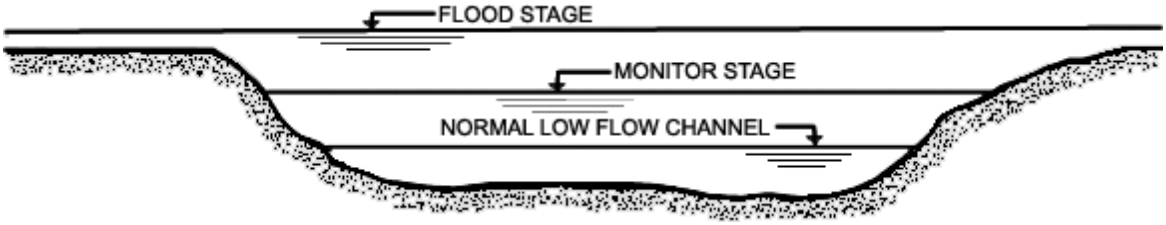
Expansive Soils: All of Willows has been mapped as having high potential for expansive soils. The soils in Willows are generally considered shallow. Clays expand and contract when they go through wet–dry cycles. Foundations on clay soils can be impacted by changes in soil volumes over time. This phenomenon can be most directly seen in roadway surfaces that fail and must be patched repeatedly. Clays also have significant shrink–swell potential. Sections of I-5 in Orland and Willows are built on fine silt and alluvium, which can cause subsidence along the roadway. In Willows, the following community lifeline facilities are in areas with high expansive soil hazards: 19 Safety and Security Facilities, 17 Water systems, 4 Health and Medical facilities, 2 Transportation facilities, 1 Hazardous Materials facility.

Section 3.5 Levee Failure

The National Flood Insurance Program (NFIP) defined a levee in Title 44, Chapter 1, 59.1 of the Code of Federal Regulations (44 CFR 59.1) as a human-made structure, typically an earthen embankment, which is created in accordance with sound engineering practices. Its purpose is to contain, control, or divert the flow of water to minimize the risks of temporary flooding.[68] NFIP regulations define a levee system as a flood-protection system that comprises one or more levees and associated structures, such as drainage and closure devices, which are constructed and operated according to sound engineering practices.

River Stage Definitions

These definitions are used by the California Department of Water Resources (DWR) Flood Center in Sacramento in correspondence and alerts provided to local governments and posted on the California Data Exchange Center (CDEC) and National Oceanic and Atmospheric Administration (NOAA) web pages. The following definitions apply streams that do not have levees (see Figure 67).



Source: 2018 Glenn County, CA, Multi-Jurisdiction Hazard Mitigation Plan.

Figure 67: Typical Stream without Levees

Monitor Stage: The stage at which initial action must be taken by concerned interests (livestock warning, removing equipment from the lowest overflow areas, or general surveillance of the situation). This level may produce overbank flows sufficient to cause minor flooding of low-lying lands and local roads.

Flood Stage: The stage at which overbank flows are of sufficient magnitude to cause considerable inundation of land and roads and/or threat of significant hazard to life and property.

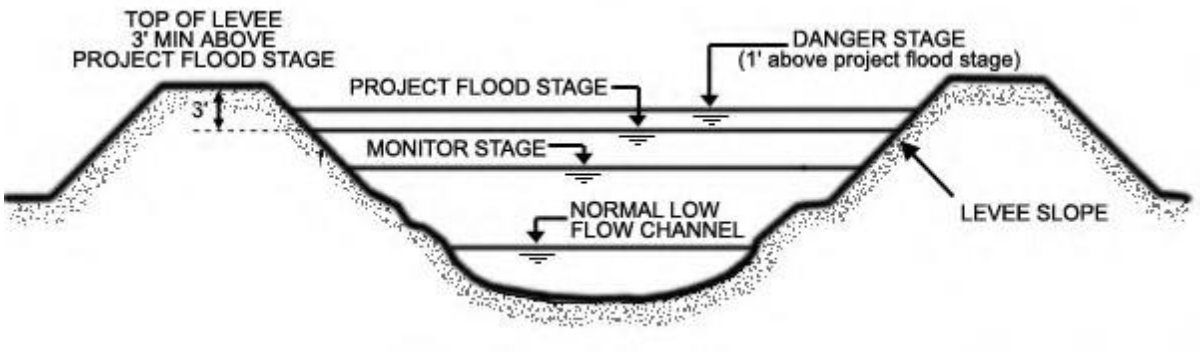
The following definitions apply streams with levees (see Figure 68).

Monitor Stage: The stage at which the responsible levee maintenance agency must patrol flood control project levees, or the stage at which flow occurs into bypass areas from project overflow weirs.

Project Flood Stage: The stage at which the flow in a flood control project is at maximum design capacity (US Army Corps of Engineers “Project Flood Plane”). At this level, there is a minimum freeboard of 3 feet to the tops of the levees.

Danger Stage: The stage at which the flow in a flood control project is greater than maximum design capacity and where there is extreme danger and a threat of significant hazard to life and property if the levee fails. This is 1 foot above the project flood stage.

[68] FEMA, “NFIP and Levees: An Overview.” https://www.fema.gov/sites/default/files/documents/fema_nfip-levees.pdf



Source: 2018 Glenn County, CA, Multi-Jurisdiction Hazard Mitigation Plan.

Figure 68: Typical Stream with Levees

Every year, flooding results in the loss of life and causes millions of dollars of damage to property. Except for flash flooding, most floods occur slowly and have a buildup period of several days. This period provides an opportunity for emergency responders to reduce the damage that flooding will cause.

Regulatory Environment

The U.S. Department of Homeland Security (DHS) considers levees to be part of the nation's critical infrastructure and collaborates with its public and private partners to identify levees that present the greatest risk to the nation. DHS also coordinates protective programs that use an all-hazards approach to risks (considering human-made and natural incidents). This collaboration highlights the importance of protecting and ensuring the safety of the nation's levees, with contributions from all levels of government and the private sector.

Levee regulatory requirements at federal, state, and local levels are critical for the safeguarding of agriculture, economy, power supply, and quality of life in the unincorporated areas of Glenn County. One local policy pertaining to levees in Glenn County is listed in the 1993 General Plan. CDP-16 states:

Recognize that because of discrepancies arising from the original land surveys conducted in the state, which resulted in acreage shortages in sections of land, the existence of physical barriers, such as canals, roads, streams, levees, etc., and parcel configuration, exceptions to minimum parcel size for properties zoned to exclusive agricultural categories may be necessary and appropriate to promote the spirit and intent of the General Plan.

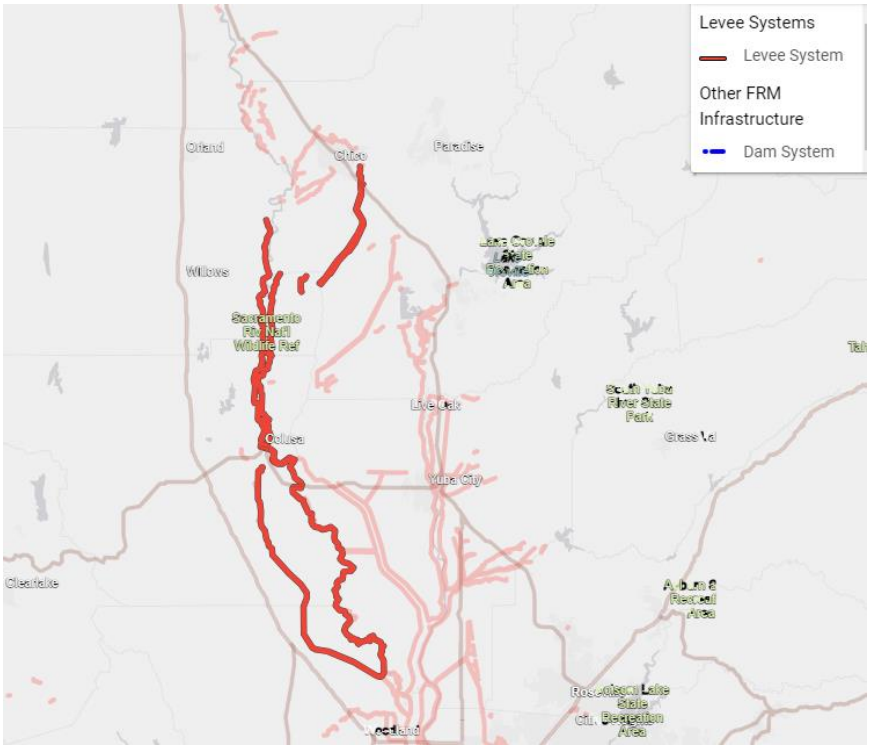
A slow-rise flood situation resulting from a levee breach could evolve through a series of four stages. Emergency actions will be based on the following four stages of response actions:

- Stage 1 – Planning & Preparation (incoming storms, flooding possible)
- Stage 2 – Monitor Stage (high water levels)
- Stage 3 – Emergency Stage (Flood Stage)
- Stage 4 – Danger Stage (extensive flooding is imminent)

Location/Geographic Extent

Glenn County has five levee systems: Glenn County Levee System 2205, MA05 Unit 1 – Butte Creek left bank, MA 05 Unit 2 – Butte Creek right bank, Sacramento River East Levee – LD 3 Glenn County, and LD 1 (Sacramento River northwest bank) and LD 2 (Sacramento River southwest bank, Sacramento River west bank). These systems are located along Butte Creek, Elk Creek, French Creek, Grindstone Creek, Hambright Creek, Logan Creek, Stony Creek, Walker Creek, Wilson Creek, and Willow Creek and

their tributaries. The Glenn–Colusa Canal and Tehama-Colusa Canal are other sites where levees could fail and impact surrounding communities. The maps in Figure 69 through Figure 74) provide more information on where levee failure might occur.



Source: National Levee Database. https://levees.sec.usace.army.mil/#/levees/search/in=@county%20state:Glenn,%20California&sg=@AUTHORIZATION_CATEGORY_ID:(1%7C2%7C3%7C4%7C5)&viewType=map&resultsType=systems&advanced=true&hideList=false&eventSystem=false

Figure 69: Levee Systems Glenn County

Source: National Levee Database. https://levees.sec.usace.army.mil/#/levees/search/in=@county%20state:Glenn,%20California&sg=@AUTHORIZATION_CATEGORY_ID:(1%7C2%7C3%7C4%7C5)&viewType=map&resultsType=systems&advanced=true&hideList=false&eventSystem=false

Figure 70: Glenn County Levee System 2205

Source: National Levee Database. https://levees.sec.usace.army.mil/#/levees/search/in=@county%20state:Glenn,%20California&sg=@AUTHORIZATION_CATEGORY_ID:(1%7C2%7C3%7C4%7C5)&viewType=map&resultsType=systems&advanced=true&hideList=false&eventSystem=false

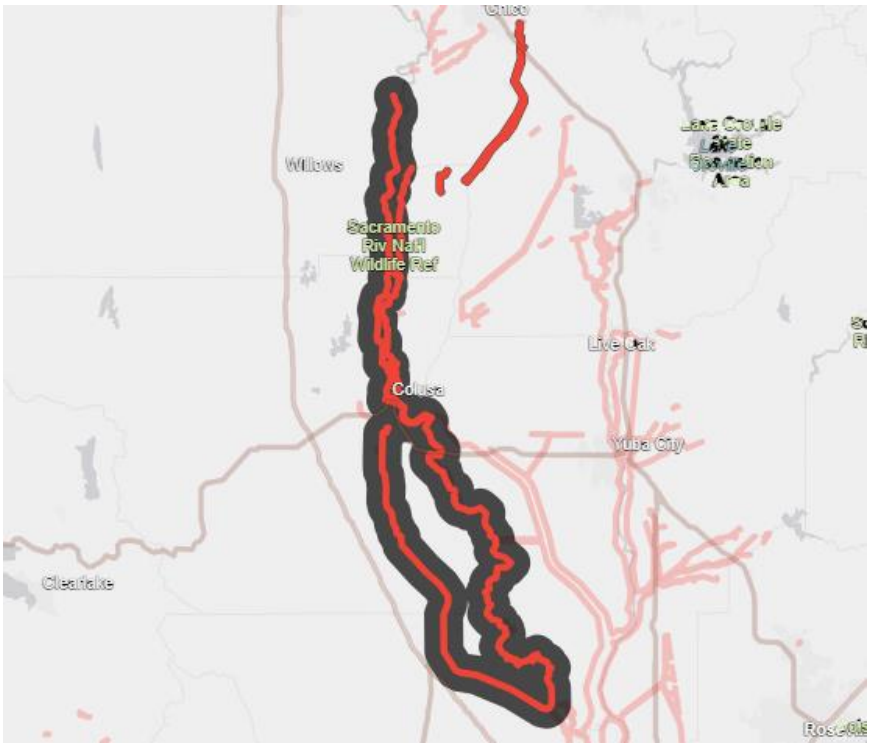
Figure 71: MA 05 Unit 1 – Butte Creek Left Bank

Source: National Levee Database. https://levees.sec.usace.army.mil/#/levees/search/in=@county%20state:Glenn,%20California&sg=@AUTHORIZATION_CATEGORY_ID:(1%7C2%7C3%7C4%7C5)&viewType=map&resultsType=systems&advanced=true&hideList=false&eventSystem=false

Figure 72: MA 05 Unit 2-Butte Creek Right Bank

Source: National Levee Database. https://levees.sec.usace.army.mil/#/levees/search/in=@county%20state:Glenn,%20California&sg=@AUTHORIZATION_CATEGORY_ID:(1%7C2%7C3%7C4%7C5)&viewType=map&resultsType=systems&advanced=true&hideList=false&eventSystem=false

Figure 73: Sacramento River East Levee – LD 3
Glenn County (Butte, Colusa, Sutter)



Source: National Levee Database. https://levees.sec.usace.army.mil/#/levees/search/in=@county%20state:Glenn,%20California&sg=@AUTHORIZATION_CATEGORY_ID:(1%7C2%7C3%7C4%7C5)&viewType=map&resultsType=systems&advanced=true&hideList=false&eventSystem=false

Figure 74: Sacramento River West Bank (Colusa, Glenn, Yolo)

Water levels in the Sacramento River are primarily controlled by the release of water from upstream dams. Heavy rainfall, accompanied by high releases from the Shasta and Keswick dams, can raise the river to flood levels. When water levels exceed the monitor stage of 142 ft at Hamilton City, the J Levee there is stresses. This can cause bank erosion in the northern section, which is managed by Reclamation District 2140. If the water reaches the flood stage, which is 147 ft, the erosion may impact the northern section. The midsection of the J Levee at Irvine Finch State Park also will be affected if the water rises above the first embankment. However, this section of the levee has been given wave wash protection to limit erosion.

When the water reaches the flood stage, it is also released to the east into Butte County. At this point, water pools in orchards and flows into Pine Creek, but it typically does not have an impact on State Road 32. The lower section of the J Levee system has recently been replaced and has a system of dikes to relieve pressure on the levee and allow for outflow into the flood management basin. Significant water enters the basin between the monitor stage and the flood stage. The park entrance on County Road 23 will likely flood and close.[69]

Levee Flood Protection Zone (LFPZ) maps were developed by DWR to increase awareness of flood risks associated with state and federal Levees. These maps estimate the maximum area that may be flooded if

[69] County of Glenn, "Glenn County OA EOP 2019 Annex K: Hazard Specific Procedures." https://www.countyofglenn.net/sites/default/files/Office_of_Emergency_Services/Annex%20K%20-%20Hazard%20Public%20V%202019.pdf

a state or federal levee fails or is overtopped.[70] Lands not in an LFPZ also may be subject to flooding. Figure 75 and Figure 76 show the LFPZs in Glenn County.

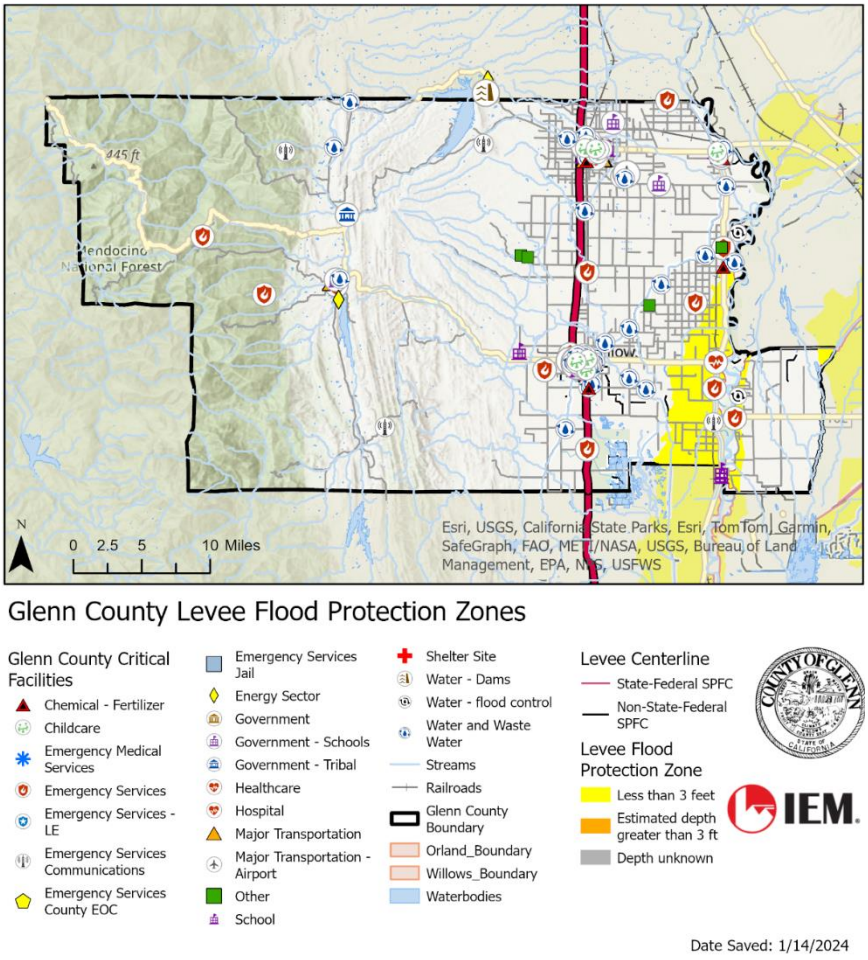


Figure 75: Levee Flood Protection Zones in Glenn County

[70] California Department of Water Resources. https://gis.lfpz.water.ca.gov/lfpz/

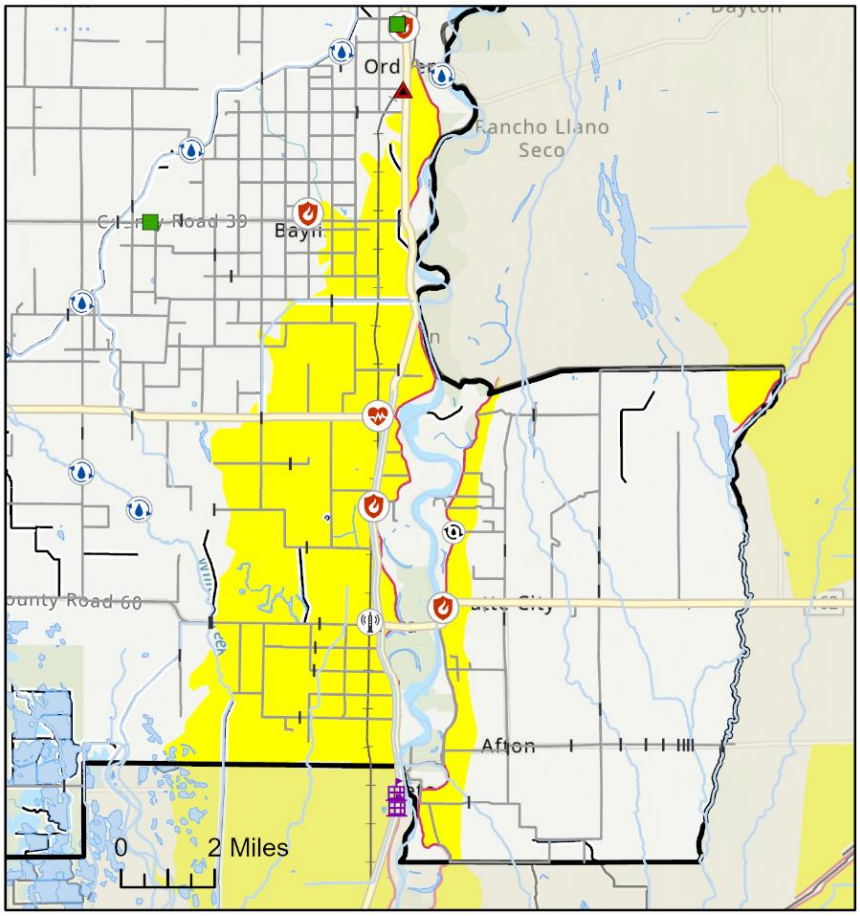


Figure 76: Levee Flood Protection Zones, Small Scale

Magnitude/Extent

Several factors can contribute to the extent of levee failure, which is usually measured according to the nature of the breach (overtopping the levee crown versus a failure along the slope), the affected area, flow volume and velocity, and depth of flooding. As shown in Figure 73 and Figure 74, flooding from a levee failure in Glenn County is anticipated to be less than 3 feet deep. The onset is typically slow as the river rises, but if a levee fails, the warning times are short for those in the inundation area. Flow volume and velocity are typically highest at the site of the failure. The water then slows and becomes less deep as it spreads over a larger area. Levee failures can last hours to weeks, depending on the river flows beyond the levee and the nature of the breach.

Past Occurrences

Portions of Hamilton City and the surrounding area flooded in 1974. Extensive flood fighting was necessary in 1983, 1986, 1995, 1997, and 1998 to avoid the failure of the private 100-year-old J levee. Residents of the town were evacuated six times in the past 20 years: 1983, 1986, twice in 1995, 1997, and 1998 (Sacramento River Conservation Area Forum, 2003). A plan participant shared that floods in the 1940s were strong enough to carry homes away. In February 2019, a muscle wall and sandbag temporary structure were built to address a boil that developed during storms on the J Levee in Hamilton City. A new setback levee was built by USACE and put into service at this location in 2021–2022.

Various historical crests have occurred along the Sacramento River in Hamilton City:

1. 150.92 ft. on 01/02/1997
2. 150.80 ft. on 01/24/1970
3. 150.77 ft. on 03/01/1983
4. 150.65 ft. on 01/10/1995
5. 150.53 ft. on 02/18/1986
6. 149.3 ft. on 02/19/2017
7. 148.3 ft. on 02/27/2019

Additional historical crests have occurred along the Sacramento River at Butte City:

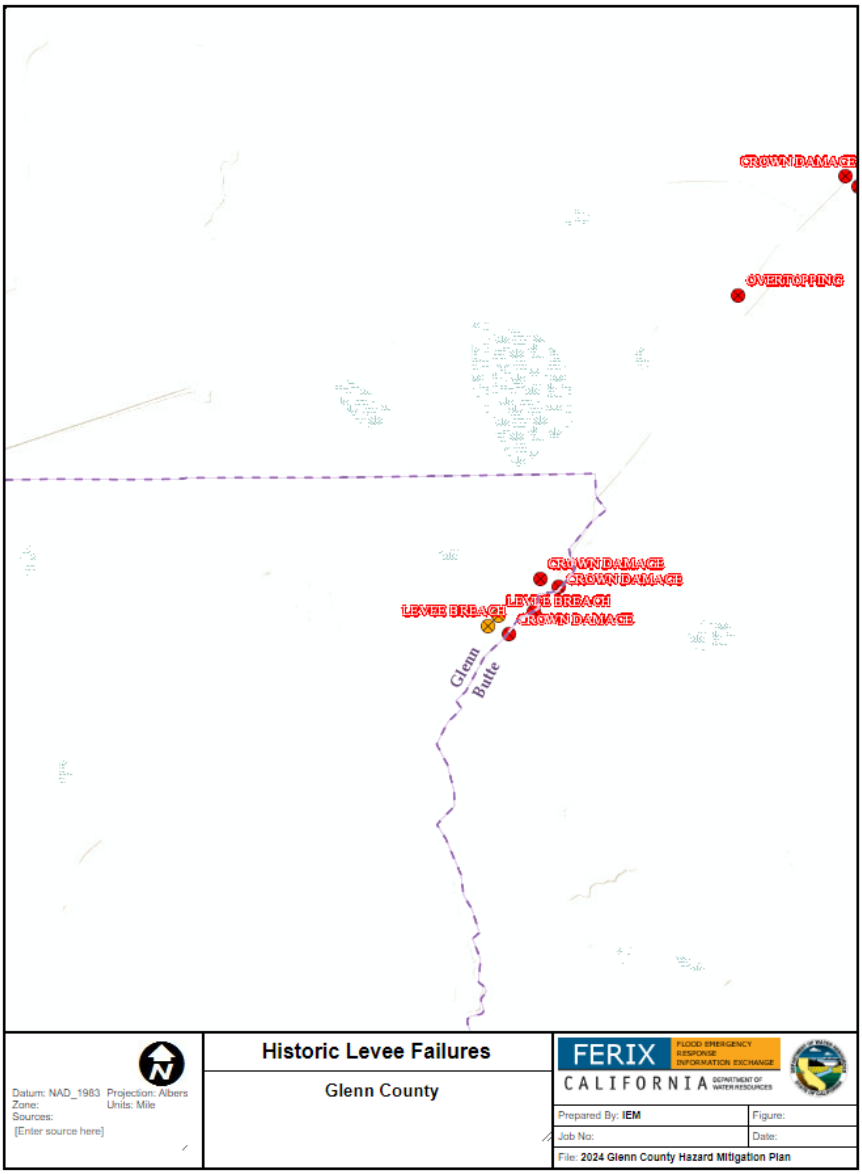
1. 96.87 ft. on 02/07/1942
2. 96.70 ft. on 02/20/1958
3. 95.89 ft. on 03/02/1983
4. 95.17 ft. on 02/12/1941
5. 95.15 ft. on 02/04/1998
6. 95.15 ft. on 02/28/2019
7. 92.47 ft. on 02/19/2017

Historical crests along the Sacramento River at Ord Ferry include:

1. 121.70 ft. on 02/28/1940
2. 121.20 ft. on 02/06/1942
3. 121.10 ft. on 12/11/1937
4. 120.10 ft. on 02/25/1958
5. 119.79 ft. on 01/24/1970
6. 117.00 ft. on 02/19/2017
7. 116.00 ft. on 02/28/2019

The DWR Flood Emergency Response Information Exchange (FERIX)[71] lists six incidents along the border of Glenn and Butte Counties. They are shown in Figure 77, and their details are listed in Table 48.

[71] Flood Emergency Response Information Exchange (FERIX). California Department of Water Resources. https://ferix.water.ca.gov/webapp/fmo/?d=CZ1qoTSsw92ad21245f5a9a2cdf33a57d4b9ad8ce8



Source: California Department of Water Resources Flood Emergency Response Information Exchange (FERIX) – FMO. https://ferix.water.ca.gov/webapp/fmo/

Figure 77: Levee Failures on and near the Border of Butte and Glenn Counties

Table 48: Levee Failures in Glenn County, according to FERIX

Date	Description	Type	Details
2/25/1997	Levee breach	Rotational slope failure	Levee break on agricultural land. 4321
2/25/1997	Crown damage	Overtopping	Levee was overtopped causing moderate to heavy erosion on the landside slope. 4320
2/25/1997	Crown damage	Overtopping	Levee topped in numerous locations causing moderate to heavy erosion on the landside slope. 4323

Date	Description	Type	Details
2/25/1997	Crown damage	Overtopping	Levee was overtopped and completely eroded the landside slope. 4319
2/25/1997	Crown damage	Overtopping	Levee was overtopped causing heavy erosion on the landside slope. The entire landside slope was gone in spots and erosion cuts into the levee crown. 4318
4/1/1998	Levee breach	Rotational slope failure	Levee break repair site. 4322

A catastrophic failure of various levees along the Sacramento River in the region would significantly impact portions of Glenn County. Although relevant federal agencies coordinated and collaborated during the March 2023 winter storms, it was demonstrated that the possibility of breaching levees and subsequent flooding from intense atmospheric rivers and snowmelt still exists, despite elaborate protection and safety programs. During the week of March 20, 2023, Glenn County experienced extensive flooding and debris flows from severe storms. The natural bank of Hambright Creek, located to the west of Orland, was breached, which quickly widened the channel to about 100 feet. As a result, water flowed out of the channel and spread across property, roads, and into an irrigation canal, causing flooding around County Roads DD, E, and FF.[72]

County of Glenn, “Hambright Creek Response.” https://www.countyofglenn.net/news/emergency-preparedness-public-information/20230320/hambright-creek-response

Figure 78: Levee break 03/14/2023 Hambright Creek

Frequency/Probability of Future Occurrences

Levee failures do not occur in regular intervals but are often related to heavy rain and other flooding events. Factors, such as the levee’s age and construction materials, and other signs that it is deteriorating, also may influence the probability of failure. Historic records indicate that seven events have occurred in the last 100 years in Glenn County, with an average of approximately every 14 years or

[72] County of Glenn, “Hambright Creek Response.” https://www.countyofglenn.net/news/emergency-preparedness-public-information/20230320/hambright-creek-response

a 7% chance annually. However, levee failures could happen more or less frequently than that. Ongoing maintenance is necessary to reduce the probability of failure. As a result, the levees are monitored and checked on a periodic basis. When a levee is recognized as having a potential failure, monitoring protocols and notification procedures for communicating levee status to emergency response personnel are carried out.

Changes in Development

Glenn County

In response to a known weakness in the J Levee in Hamilton City, a new setback was installed in 2021, which reduced the risk of possible failure. However, the overall risk to the county remains unchanged. The same overall hydrologic conditions, concerns from heavy precipitation, and possibilities of deterioration, failure, or breach of a levee and the impacts that would follow are still present.

No areas of significant new development or changes in land use in potential levee flood zones were identified. Much of the area in the LFPZs is intensive agricultural use, with a few small communities, such as Bayliss, Cordera, Glenn, Jacinto, and Ordbend. These communities are not currently experiencing significant growth. However, any future changes in land use or an increase in development could alter the assets potentially at risk of levee failure. Although levees can be useful for floodplain management, there is a concern that they can also reduce people's perceptions of flood risks. Future development projects should seek to objectively consider the risk of floods from levee failures.

The county's population is in a period of slight decline between 2022 and 2020, and no other significant changes in demographics are apparent. Levee failure is not expected to be directly impacted by climate change, but any future changes in precipitation patterns or the severity of weather events could indirectly contribute to levee failure if they lead to higher flows in rivers. Overall, there is no change in vulnerability to levee failure in the county.[73]

City of Orland

Orland has not experienced changes in development that affect vulnerability to levee failure. Land use and population have remained predominantly the same.[74] Building in the floodplain is strongly discouraged, and no additional development has occurred since the last plan update. Climate change could indirectly affect the risk of levee failure because of changes in future precipitation patterns or the intensity of heavy rain events. The overall vulnerability to levee failure in Orland has remained the same.

City of Willows

Willows has not experienced changes in development that affect its vulnerability to levee failure. Land use has remained the same, and the population has had a slight decrease.[75] Climate change could indirectly affect the risk of levee failure because of changes in future precipitation patterns or the intensity of rain events. The overall vulnerability to levee failure in Willows has remained the same.

[73] United States Census, "Quick Facts Willows City, California; Orland City, California; Glenn County, California." https://www.census.gov/quickfacts/fact/table/orlandcitycalifornia,glenncountycalifornia/BZA010221
[74] Ibid.
[75] Ibid.

Vulnerability Assessment

The impacts of levee failure would be very similar to those from a flood event, but the areas likely to be flooded by a levee failure do not necessarily align with 1% and 0.2% annual chance flood hazard zones. Heavy precipitation events and high flows in rivers can contribute to the overtopping or failure of levees. Areas otherwise protected from flooding by levees could experience flooding if a levee fails or is breached. A levee failure could cause significant loss of life and property.

For structures that may be closer to the source of a levee failure, the force of fast-moving waters can damage foundations, walls, and siding. As the water spreads and slows down, it can still damage structures, building contents, utility systems, and vehicles exposed to standing water for a prolonged time.

Land use in areas of Glenn County that could be impacted by levee failure is primarily agricultural. General impacts could include scouring previously protected land as water rushes into an area. As the water spreads and slows down, it can deposit sediment or debris across a wide area that could include pollutants or other contaminants. Crops could be damaged or destroyed, and it may be necessary to restore the land by removing the deposited material, causing further loss of productivity.[76]

Climate change could affect long-term precipitation and runoff patterns. If heavy rain events increase in frequency or intensity, the risk of levee failure also would increase because of the risk of overtopping during high runoff.

Jurisdiction-Specific Vulnerabilities

Glenn County

LFPZs in Glenn County cover 48 square miles (31,364 acres) and have an estimated depth of less than 3 feet. The zones are near the Sacramento River in the southeast portion of the county (Figure 75). To estimate the potential impacts of levee failure, census blocks and building stock values were exported from Hazus and overlaid with the LFPZs in GIS. Table 49 lists the values of exposed structure in the LFPZs. The National Structure Inventory indicates that 210 residential, 98 commercial, 8 industrial, and 6 public structures are in the LFPZ. If the 210 residential structures hold an average household of 2.8, approximately 588 people in this area could be affected by levee failure. Glenn County has significant agricultural interests. Business income loss, wage loss, and other economic impacts caused by agricultural losses from levee failure could be particularly difficult for lower-income households.

Eight critical facilities were identified in the hazard zone (see Table 50). Among these is the Riverside Assisted Living Facility. Its residents are likely to have access or functional needs that could make evacuating or closing the facility difficult. Two fire stations and Levee District 3 also are in the hazard area, which may inhibit their ability to respond if a levee breach or failure causes flooding or road closures nearby. State Routes 162 and 45 and multiple county roads are in the potential flood zone. Levee failure could inundate these roads, leading to closures that would limit access in the area. The Southern Pacific Railroad line also traverses the hazard area.

The 100-year-old J Levee upstream of Hamilton City is currently undergoing renovation to protect Hamilton City from flooding when the Sacramento River surges its banks. Portions of this area have flooded on several occasions since 1974 (Sacramento River Forum, 2015). The project area lies just north of the levees of the Sacramento River Flood Control Project and in the area of the Chico Landing to Red Bluff bank protection project. This project will construct a setback levee, degrade an existing levee,

[76] Agricultural Lands: Flooding and Levee Breaches. Encyclopedia of Soil Science. 2017 http://www.ngrrec.org/uploadedFiles/Pages/Research_Program/Levee%20breaches%20E-ESS3-120053228.pdf

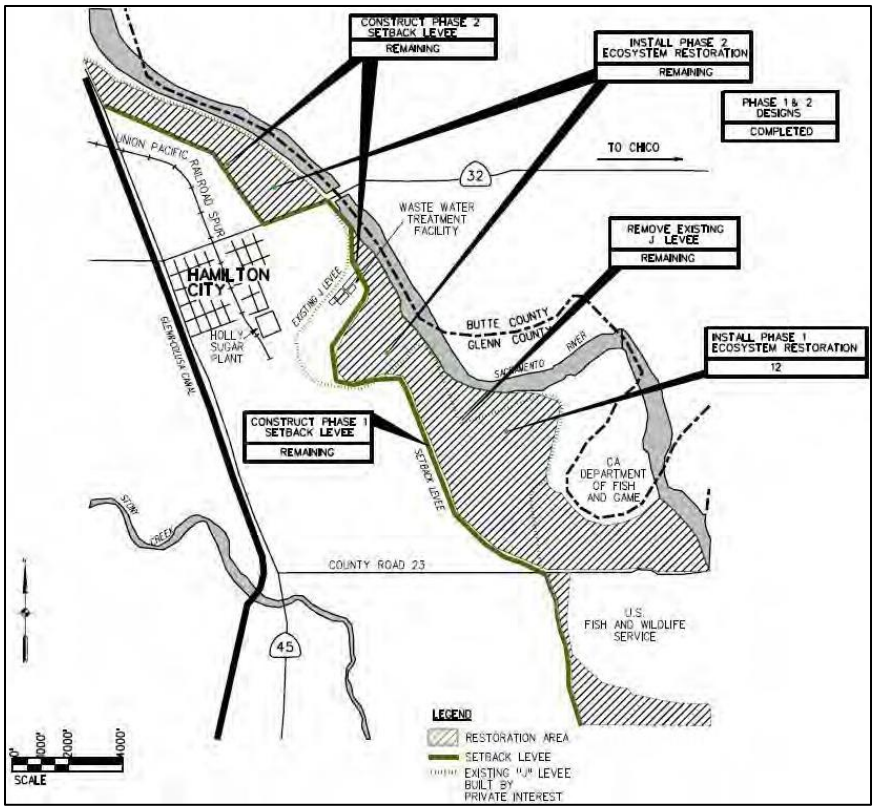
and revegetate the setback area to restore 1,145 acres of riparian woodland, 261 acres of riparian shrub, and 70 acres of floodplain meadow. This project will reduce flood risk for Hamilton City and bordering agricultural lands (Hamilton City Justification Sheets, 2011). Figure 79 is a diagram, and Figure 80 is an aerial photograph of the J Levee along the Sacramento River near Hamilton City.

Table 49: Estimated Losses from State/Fed Levee Failure in Glenn County

	Residential	Commercial	Industrial	Agricultural	Religions/NP	Government	Education	Total
Orland	$0	$0	$0	$0	$0	$0	$0	$0
Willow	$0	$0	$0	$0	$0	$0	$0	$0
County	$149,663,000	$71,366,000	$70,205,000	$168,882,000	$13,594,000	$396,000	$6,824,000	$480,930,000
Total	$149,663,000	$71,366,000	$70,205,000	$168,882,000	$13,594,000	$396,000	$6,824,000	$480,930,000

Table 50: Critical Facilities in Levee Flood Protection Zones

Facility Name	Jurisdiction	Description	FEMA Community Lifeline
Glenn Growers Radio Voter Site	Unincorporated	Emergency Services Communication	Safety and Security
Glenn–Colusa Fire District – Butte City	Unincorporated	Emergency Services	Safety and Security
Glenn–Cordera Fire Protection District	Unincorporated	Emergency Services	Safety and Security
Levee District 3 – Butte City	Unincorporated	Water – Flood Control	Water Systems
Princeton Elementary School	Unincorporated	School	Safety and Security
Princeton High School	Unincorporated	School	Safety and Security
Riverside Assisted Living Facility	Unincorporated	Healthcare	Health and Medical
Wilbur Ellis	Unincorporated	Chemical – Fertilizer	Hazardous Materials



Source: www.orovillemr.com/news

Figure 79: Diagram of the J Levee along the Sacramento River

Figure 80: Aerial Photograph of the J Levee along the Sacramento River

City of Orland

Orland does not have any properties in the LFPZs, but residents could be affected by levee failures elsewhere in the county. Agricultural or economic losses could have impacts outside the immediately affected area, including Orland residents who are employed in that sector. Disruptions to roadways and other transportation routes could disrupt travel and affect people's ability to access a variety of services. State Route 32 is a primary transportation route between Orland and Chico, and it could be damaged or forced to close by a levee failure.

City of Willows

Willows does not have any properties in the LFPZs, but there are levees in or near Willows that are not state or federally owned and do not have an LFPZ. No other mapped inundation area was obtained. Potential flood areas are primarily along the Glenn–Colusa Canal, operated by the Glenn–Colusa Irrigation District. It enters Glenn County in the northeast corner and flows roughly south and southwest until it reaches the eastern border of Willows. It turns and passes through Willows south of Elm Street, and then continues south.

The Glenn–Colusa Canal was constructed through Willows in the late 1800s, and water began flowing in 1905 when construction was completed. The main canal is earth lined and 64 miles long. It begins north of Hamilton City, running south and ending south of the city limits of the City of Williams in Colusa County. Historical records show only minor seepage problems, which were repaired immediately with no impact on Willows. The canal is designed with many safety benefits, such as safety dams, yearly maintenance, and the Glenn–Colusa Irrigation District Emergency Response Plan. Safety dams are located at Walker Creek and Willow Creek and are manually controlled. Yearly maintenance procedures include rodent control, herbicide application to control weed growth, and bank inspections performed continually along

the main canal. There is no history of significant levee failure affecting Willows, but most of the city is in a floodplain, so damage could occur if a levee were to fail.

Similar to Orland, residents could experience impacts from levee failures that occur elsewhere in the county. Agricultural or economic losses could have impacts outside the immediately affected area, particularly for Willows residents who are employed in that sector. Disruptions to roadways and other transportation routes could disrupt travel in the county and affect people's ability to access a variety of services. State Routes 162 and 45 provide important transportation access to the city and are in potential levee flood zones.

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Section 3.6 Severe Weather

Severe weather is any destructive storm event that can damage property or cause the loss of life. Moreover, excessive localized precipitation over a short period may cause flash floods that threaten life and property. Severe weather usually occurs in Glenn County as localized storms that include heavy rain. Additionally, hazards associated with the term “severe weather” like hail, strong wind, and lightning have a Very Low probability of occurring according to the NRI. Given the very low risk to the planning area and limited opportunities for mitigation for such a low probability hazard, the plan participants requested only heavy rains will be profiled in this plan as “severe weather”.

Heavy rain is most common in Glenn County between December and February and may be associated with atmospheric rivers, long, concentrated regions in the atmosphere that transport moist air from the tropics to higher latitudes. They can produce heavy rain and snowfall in short periods. These extreme precipitation events can lead to flooding, mudslides, and damage to life and property. Some 30–50% of annual precipitation in the west coast states occurs in just a few atmospheric river events.[77]

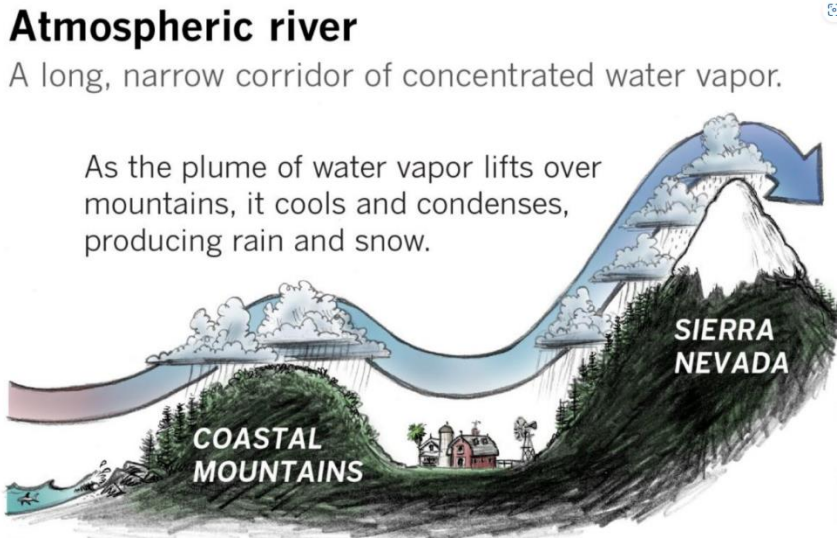
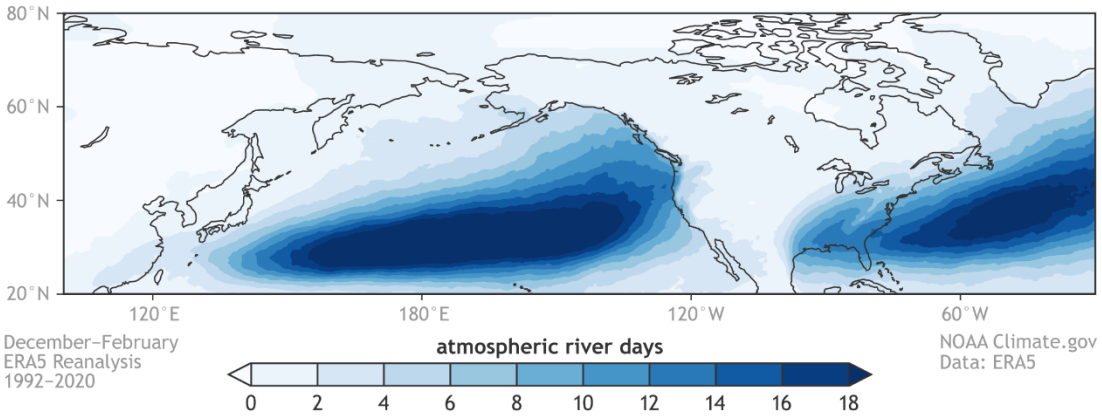


Figure 81: Visualizing Atmospheric Rivers[78]

Figure 82 shows the numbers of days with atmospheric rivers.

[77] NOAA “Atmospheric Rivers: What are they and how does NOAA study them?” https://www.climate.gov/news-features/feed/atmospheric-rivers-what-are-they-and-how-does-noaa-study-them

[78] Yahoo News.com, Times Reporting, January 4, 2023, https://www.yahoo.com/news/atmospheric-river-hitting-california-seen-024342000.html?guce_referrer=aHR0cHM6Ly93d3cuYmluZy5jb20v&guce_referrer_sig=AQAAAGKg6TueeEpjlRnSZuoIfN8sW96Okit1BJ9R-JrR0N7laVCfvcolL1t3038CFYlCxUrtkESc_KIgqtceJJXM4CthXfISKUwaaBjT2rFMpeR1kn8-vnhR9CG7pNN4EYLXAnoxL_OGsw1nDFfsZ87dv4zAsqL5EPAdOfsESqfNxZBo



Source: Climate.gov. "When Rivers Reach the Sky," 2022. https://www.climate.gov/news-features/blogs/enso/when-rivers-reach-sky

Figure 82: Average Number of Days with an Atmospheric River

Regulatory Environment

Very few formal regulations pertain to severe weather events in general.

Location/Geographic Extent

Heavy precipitation can occur anywhere in Glenn County, and the extent can vary greatly. It can impact large areas simultaneously because of the widespread nature. Historical records indicate that heavy precipitation events can occur in an isolated part of Glenn County or throughout the planning area. Geographical barriers do not restrict inclement weather events, which may affect all parts of Glenn County.

Magnitude/Extent

Glenn County's climate is classified as Mediterranean, with nearly 90% of the annual precipitation occurring in a relatively narrow window of about 16 weeks. The most severe storms occur from late fall to early spring. The climate pattern can generate severe and prolonged periods of heavy rain. Glenn County normally experiences heavy rains on an annual basis. Some severe winter storms may also contain thunderstorms. Thunderstorms are typically few and are more likely to occur in the spring or late fall.

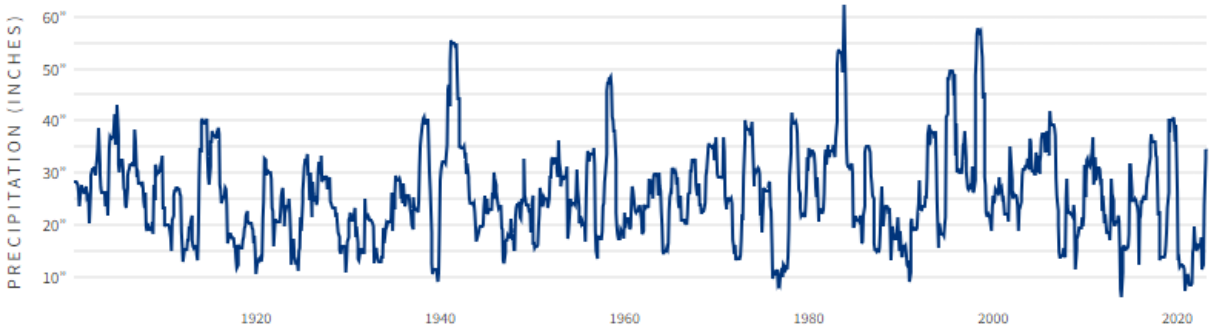
A variety of metrics can be used to describe the magnitude and severity of severe weather in Glenn County. Typically, rainfall rate can be used to describe the amount of rain that could fall at any given time. According to the Manual of Surface Weather Observations (MANOBS), the following categories can describe rainfall intensity or extent:

Table 51: Rainfall Intensity Scale

Description	Rate
Light Rain	Less than 0.1"/hour
Moderate Rain	0.1 to 0.3"/hour
Heavy Rain	0.3 to 2"/hour
Violent Rain	>2 in/hour

Source: Rain rate intensity classification.
https://www.baranidesign.com/faq-articles/2020/1/19/rain-rate-intensity-classification

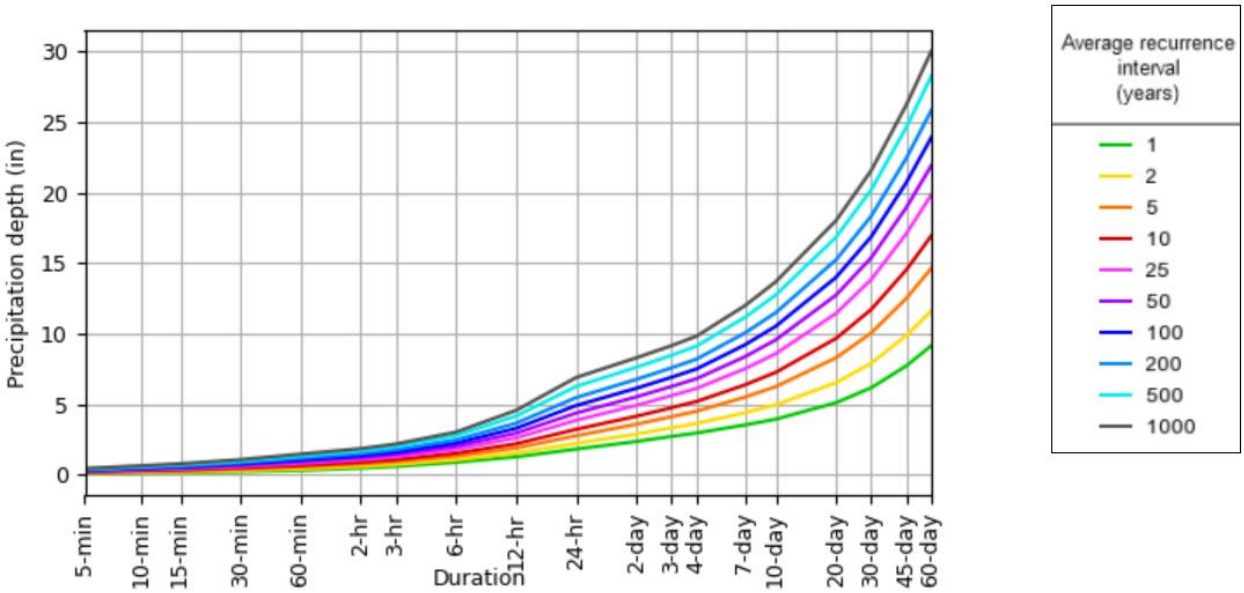
Data from NOAA, the National Weather Service, the Spatial Hazard Events and Losses Database for the United States (SHELDUS), and the National Centers for Environmental Information (NCEI) Storm Events Database can be used to develop the big picture about weather in Glenn County. Figure 83 shows annual precipitation rates for Glenn County. The wettest 12-month average was in 1983, with a total of 62.3 inches. The lowest was in 2013, with only 6.1 inches. Average rainfall varies in different regions of the county, but the equivalent of 2–3 inches of rain in the northern Central Valley and 4–11 inches in the mountainous areas have been reported in heavy rainstorms.



Source: USA Facts, Climate in Glenn County, California.
https://usafacts.org/issues/climate/state/california/county/glenn-county/?endDate=2023-09-01&startDate=1900-02-01#precipitation

Figure 83: 12-Month Precipitation Values in Glenn County

Figure 84 shows the precipitation frequency for Glenn County.



Source: NOAA Atlas 14 Point Precipitation Frequency Estimates: CA. Orland station.
https://hdsc.nws.noaa.gov/pfds/pfds_map_cont.html?bkmrk=ca

Figure 84: Precipitation Frequency for Glenn County, California

Past Occurrences

Since 1950, 7 federally declared major severe storm events have occurred in Glenn County, as shown in Table 52. According to Cal OES Disaster Proclamations, three executive orders have been issued for Glenn County for severe storms (see Table 53). Figure 85 shows damage from a storm in 2019.

Figure 85: CR 45 x CR D Damaged During DR4434

Table 52: Federal Disaster and Emergency Declarations by FEMA

Disaster #	Declaration Date	Incident Subcategory	Information
Federal Declarations			
4699	04/03/2023	Severe Storm	Winter storms, straight-line winds, flooding, landslides, and mudslides
4434	05/17/2019	Severe Storm	Winter storms, flooding, landslides, and mudslides
4308	05/17/2019	Severe Storm	Severe winter storms, flooding, mudslides
1203	02/09/1998	Severe Storm	Winter storms and flooding
1155	01/04/1997	Severe Storm	Flooding
1046	03/12/1995	Severe Storm	Winter storms, flooding, landslides, mud flows
1044	01/10/1995	Severe Storm	Winter storms, flooding, landslides, mud flows

Source: FEMA, “Disaster Declarations for States and Counties.” https://www.fema.gov/data-visualization/disaster-declarations-states-and-counties

Table 53: Cal OES Disaster Proclamations and Executive Orders, 2015–2024

Cal OES Disaster Proclamation/ Executive Order #	Date	Incident Subcategory	Information
Executive Order	June 21, 2024 (February 2024 storms)	Atmospheric river storms	Heavy rains, flooding, erosion, debris flows, roads, and infrastructure damage
Executive Order	03/23/22 (October 2021 storms)	Storms	Flooding, erosion, debris flows, roads, and infrastructure damage.
Executive Order (statewide)	03/17/2017	Atmospheric river storm	High winds, flooding, erosion, mud and debris flow, and damage to roads and highways.

Source: Cal OES Governor's Office of Emergency Services, "Open State of Emergency Proclamations." https://www.caloes.ca.gov/office-of-the-director/policy-administration/legal-affairs/emergency-proclamations/

Table 54: Governor-Proclaimed Disasters for Glenn County, October 20, 1991–Present

Date	Event
October 2021	Storms
January 2008	Extreme winds, heavy rains

Source: California State Board of Equalization, "Chronological List of Governor-Proclaimed Disasters for Property Tax Purposes." https://www.boe.ca.gov/proptaxes/disaster-list.htm

Table 55: 2018 Multi-Jurisdiction Hazard Mitigation Plan, "Other Disasters"

Date	Event	Description
10/26/1982	Severe Storms	Rains causing agricultural losses
03/05/1980	Severe Storms	Rain, Winds, Mudslides, & Flooding
02/1973	Storms/flooding	N/A
02/26/1958	Flood	Heavy rains and flooding
05/20/1957	Heavy rains	State of Emergency for producing areas of Northern California
11/21/1950	Flood	Statewide flooding

Storm Events Database

The Storm Events Database maintained by NOAA tracks 49 types of natural hazards in the United States at the county level. The database records events that caused property and crop losses, disruptions to commerce, injuries, and fatalities between 1950 and 2023. It also records rare or unusual weather phenomena that attract media attention. Other noteworthy meteorological events, such as record-breaking high or low temperatures or precipitation that occur in connection with another weather event also are included. Relevant heavy rain events for Glenn County include:

- January 12, 1998: Heavy rains caused widespread but minor flooding across the Sacramento and Northern San Joaquin Valleys.

- January 18, 1998: In Sacramento, 0.75 inches of rain fell in 6 hours; 27,000 customers across the area lost power, and numerous traffic accidents occurred.
- December 17–22, 2005: A series of powerful winter storms brought heavy rainfall to Northern California. Reports of rainfall in the Sacramento and Northern San Joaquin Valleys ranged from 1 to 6 inches.
- January 14, 2023: A wet weather system caused heavy rainfall and flooding. Heavy rainfall caused mudslides, flash floods, and widespread flooding on roadways. Some areas were ordered to evacuate.[79]

Table 56 lists the effects of storms in Glenn County from 1950 to 2023.

Table 56: Glenn County Storm Events, 1950–2023

Date	Location	Event	Fatalities	Injuries	Property Damage	Crop Damage
03/04/2023	Chrome	Flood	0	0	600,000	0
01/01/2023	Capay	Flood	0	0	5,000,000,000	0

Source: National Centers for Environmental Information, "Storm Events Database." https://www.ncdc.noaa.gov/stormevents/listevents.jsp?eventType=ALL&beginDate_mm=09&beginDate_dd=01&beginDate_yyyy=1950&endDate_mm=09&endDate_dd=30&endDate_yyyy=2023&county=GLENN%3A21&hailfilter=0.00&tornfilter=0&windfilter=000&sort=DT&submitbutton=Search&statefips=6%2CCALIFORNIA

Local Records of Disaster Impacts

The following summaries describe the types of impacts the most significant recent hazards have had on Glenn County.

2023:

- March Storms and Floods
  - March 10-23, 2023
    - Presidential Major Disaster Declaration
  - Approximately $400,000 in County public works related response and recovery costs due to significant damage to infrastructure.
  - Response included public safety closure of approximately 30 roadways, rescue of stranded motorist in flooded roadways, Hambright Creek breach that required a temporary structure of sandbags and muscle wall, and damage to 6 roads.

2022:

- September 2022 Atmospheric River and Debris Flows
  - Severe storms impacted northern California region bringing excessive rainfall, flash flooding and debris flows, and rock and mud slides September 18-22, 2022. Significant impacts were sustained in the area of the August Complex burn scar on the west side of Glenn County.

[79] NOAA, "Storm Events Database." https://www.ncdc.noaa.gov/stormevents/eventdetails.jsp?id=1078459

The storms resulted in damage to county infrastructure and road systems, estimated at $1 million

- This storm resulted in significant debris flows on CR 309 and FH7 which eroded the roadway and clogged more than 90 culverts.

2021:

- October 2021 Atmosphere River and Debris Flows
  - Atmospheric River impacted northern California region bringing high winds, excessive rainfall, flash flooding and debris flows, and rock and mud slides October 22-25, 2021. The storms resulted in damage to county infrastructure including CR 309, 313, 303, and the Glenn County Landfill, total cost $300,000.

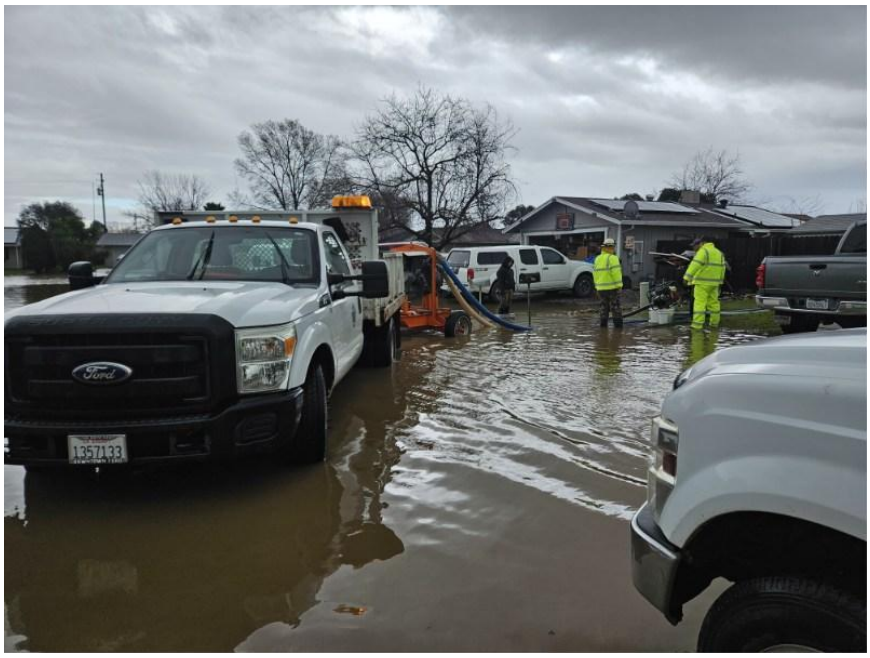


Figure 86: A Severe Storm in Willows in February 2024 Overwhelms the City's Drainage Systems

Frequency/Probability of Future Occurrences

Severe weather will continue to occur annually in Glenn County. The frequency and probability of future occurrences are highly likely (near 100% probability in the next year). Because of past weather patterns and global warming, increases in the probability of future occurrences of severe weather events in unincorporated areas of the county are anticipated.

Glenn County, located in the Sacramento Valley, is prone to flooding because of its numerous creeks and streams and the Sacramento River. During high water years, reservoir releases in the county and to the north lead to increased waterway flows. The 2022–2023 water season in California was marked by over 30 atmospheric rivers, leading to significant flooding and damage to public infrastructure in Glenn County.[80]

[80] County of Glenn, “Winter Storms.” https://www.countyofglenn.net/dept/sheriff/office-emergency-services/winter-storms

Changes in Development

Climate change is expected to increase the frequency and strength of storms across the US, causing severe flooding and damage to water infrastructure. The quality of source water may be at risk, and untreated sewage and stormwater can be discharged into nearby water bodies, threatening human health and water quality. Heavier storms can also damage drinking water and wastewater facilities, disrupting service. Moreover, as the climate warms, hurricane intensity may increase, leading to a higher risk of coastal flooding from storm surges.[81] Glenn County has seen an increase in heavy rain events since the last plan update and while structures and populations may be similar, this increase in frequency and severity indicates the County's overall vulnerability to this hazard has increased.

Vulnerability Assessment

Because of the widespread nature of weather hazards, all populations, structures, critical facilities, infrastructure, natural environments, and economies in the planning area can be impacted by heavy rains. The specific areas impact, and the severity of damage can vary significantly between events.
Critical infrastructure sites risk damage from heavy rain and the resulting flooding. The damage can cause secondary effects, such as delayed emergency response and sanitation threats. Business closures and lost work time caused by severe weather can also cause economic losses. Heavy rain could also contribute to crop damage and subsequent agricultural losses.

Rapid runoff of water can cause upstream rivers to overflow into low-lying areas.[82] Heavy rain has caused localized flooding and subsequent water damage to nearby structures. Flooding from heavy rain can damage residential, commercial, industrial, and agricultural building types. Prolonged heavy rain can overwhelm storm drainage systems.

Flooding can require the closure of major transportation routes. Vehicles may lose traction or may be unable to safely traverse roadways. Impacts on roadways may cause delays for emergency responders.

Outdoor events such as sporting activities, farmers' markets, and community festivals can be disrupted by storms, and participants may have difficulty seeking shelter from a fast-moving storm. Outdoor workers may be particularly vulnerable to fast-moving storm events. Those working in rural agricultural areas may lack nearby places to seek shelter.

Jurisdiction-Specific Vulnerabilities

Glenn County

All of the nearly 29,000 residents of Glenn County are at risk of severe weather. Water, electric, fuel, transportation, and communication infrastructure could be damaged or services disrupted by heavy rain.

Hazus modeling cannot quantify potential damage to property, critical facilities, or infrastructure in the planning area. Physical damage and service disruptions depend on the size and severity of the weather event. Although the exact location and intensity of weather events make it difficult to identify the physical assets at risk, possible impacts can be inferred from historical records and similar events in the area.

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[81] United States Environmental Protection Agency, "Climate Adaption and Storms & Flooding." https://www.epa.gov/arc-x/climate-adaptation-and-storms-flooding
[82] Cybersecurity & Infrastructure Security Agency, "Severe Storms." https://www.cisa.gov/topics/critical-infrastructure-security-and-resilience/extreme-weather-and-climate-change/severe-storms#:~:text=NASA's%20Earth%20Observatory%3A%20Severe%20Thunderstorms,of%20potential%20severe%20storm%20days

The Cities of Orland and Willows

Like the unincorporated areas of Glenn County, Orland and Willows are subject to severe weather and hazards associated with heavy rain. Typical storms associated with the rainy season (late fall, winter, and early spring) cause different issues depending on elevations. Weather severe enough to cause damage can occur any time of the year, but it usually occurs during the rainy season (which generally runs from mid-fall through spring).

Due to the variability in severity and duration of heavy rain events, quantifying potential losses to Orland and Willows is difficult. Past events provide an indication of where localized flooding may occur in future heavy rain events, but impacts are possible in any part of each city. Similar to the rest of the Glenn County, all populations, structures, critical facilities, infrastructure, natural environments, and economies in the planning area can be impacted by heavy rain.

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Section 3.7 Wildfire

Wildfires are uncontrolled blazes that devastate wildland vegetation, often in rural settings. These fires are not confined to a particular region or environment and can occur in various ecosystems, such as forests, oak woodlands, and grasslands. Wildfire hazards are a significant and recurrent threat in Glenn County. They can destroy buildings, cause damage to vital infrastructure, injure people, and result in loss of life, agricultural land, and animals. The region of the county within the Mendocino National Forest is subject to the greatest threat from wildfires. California's wildfire season in the past occurred between early spring and late fall—the hotter and dryer months. Because of climate change, a key factor in the increasing risk and extent of wildfires in the Western United States during the last two decades, the lines have become indistinct on how long the fire season lasts. Traditionally, it peaked during the summer; however, more recently, it has peaked in September and early October, which follow the dry season but may be year-round.[83] The rise in temperature, extended drought, and a thirsty atmosphere are some of the contributing factors to this phenomenon. These factors have strong direct or indirect ties to climate variability. Other causes of wildfires include the following:

- Lightning (and possible volcanic and meteoric sources);
- Camping, including cooking, warming, and bonfires;
- Smoking cigarettes, cigars, and pipes and the matches/lighters used for lighting tobacco;
- Fire use, including burning debris and burning ditches, fields, or slash piles;
- Railroads, including exhaust, brakes, railroad work;
- Incendiary incidents, including arson and illegal or unauthorized burning;
- Equipment, including vehicle and aircraft exhaust, flat tires, dragging chains, and brakes;
- Juveniles including playing with matches and lighters; and
- Miscellaneous, including burning buildings, fireworks, power lines, shooting (ammunition or exploding targets), spontaneous combustion (hay baled while still wet, compost piles, oily rags), and blasting.[84]

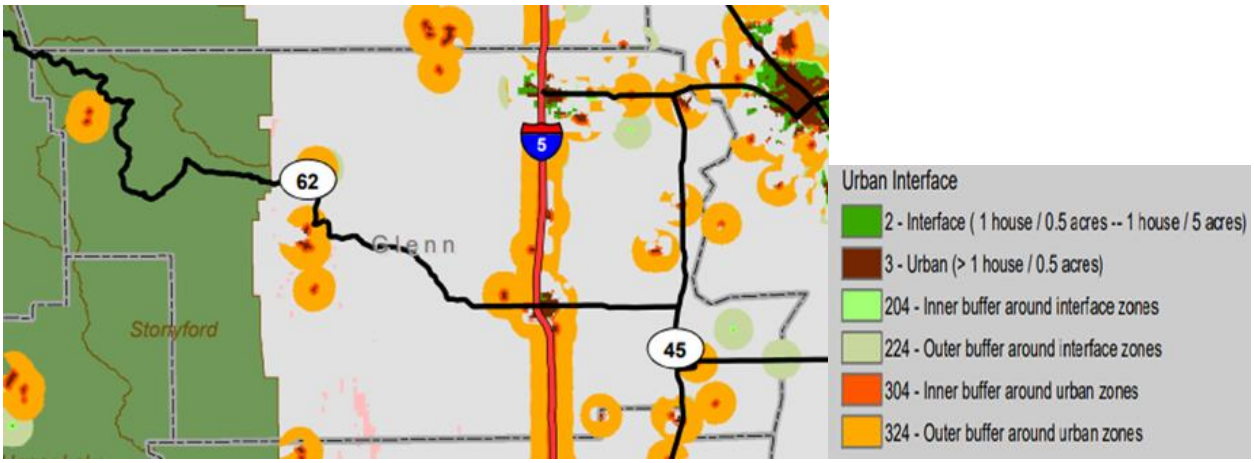
Figure 87 shows the effects of a recent fire.

[83] NBC news, "There's no more typical California wildfire season. It may be year-round, experts warn." https://www.nbcnews.com/news/us-news/there-s-no-more-typical-wildfire-season-california-it-may-n934521
[84] U.S. Department of Indian Affairs, "Wildfire Investigations." https://www.bia.gov/service/wildfire-prevention/wildfire-investigations

Source: Glenn County

Figure 87: Red Mountain Fire Following the August Complex Fire

The topography, weather, and vegetation in areas of the county provide ideal conditions for wildfires to spread rapidly and pose a severe risk. Development overtime through the expansion of small communities in Glenn County has further intensified the risk by placing people in wildfire hazard areas. Long-term fire management practices, like the suppression of naturally occurring burns, has influenced the natural wildfire processes and allowed flammable brush and vegetation to accumulate. Moreover, such developmental undertakings have moved the urban–wildland interface, where human development meets undeveloped wildland, closer to higher-risk wildfire hazard areas. This move has increased the number of people and buildings at risk, as illustrated in Figure 88.



Source: Bureau of Land Management, “Map of Northern California Urban Wildland Interface Areas.” https://www.blm.gov/or/plans/surveyandmanage/files/mr-fire_amendment-va-li-br-fu-2002-08-att6.pdf

Figure 88: Glenn County Urban Interface

From 2020 to 2022, many western states experienced extraordinary wildfire seasons, with all three years far exceeding the average since 2016 of 1.2 million acres burned. Research shows that climate change creates warmer and drier conditions, leading to longer and more active fire seasons. Increases in temperatures and atmospheric aridity because of climate change have made forest fuels drier during the fire season. These factors have caused over half the decline in fuel moisture content in western U.S. forests from 1979 to 2015 and doubled the area burned by forest fires from 1984 to 2015.

Studies show that an annual increase of 1 degree Celsius would increase the median burned area per year by up to 600% in some types of forests in the U.S. West. Increased temperatures and extended droughts are two of the drivers that increase the risk and extent of wildfires in the western United States.[85]

Wildfire releases carbon dioxide and other greenhouse gases (GHG) that can contribute to climate change. Determining how much wildfire alters GHG concentrations is a challenging task undertaken by the California Air Resources Board. Wildfire smoke contains a harmful mix of air pollutants, particulate matter, and toxic contaminants. Smoke can cause minor irritations such as burning eyes and lung irritation but can also increase the severity of asthma or other respiratory diseases.[86]

Prescribed fires may lesson some of these effects of wildfire smoke. The Glenn County Community Wildfire Protection Plan (CWPP) notes that prescribed fires provide an opportunity to control the intensity and time of fire to reduce the impact of fire emissions. Prescribed fire allows for monitoring of weather conditions and utilization of smoke management practices that reduce the amount of GHG and other polluting emissions and the associated health impacts.[87]

Regulatory Environment

The State of California and Glenn County have established wildfire regulatory requirements, which must be adhered to. Fire-safe regulations for the State Responsibility Areas (SRAs) for wildfires outline fundamental standards for wildland fire protection that local jurisdictions must follow. If enforced, these regulations could significantly decrease the risk of wildfire events at the wildland interface. However, it is important to note that the SRA fire safe regulations do not supersede local regulations that match or exceed the minimum state requirements. The Public Resources Code, Section 4290, is the state statute for wildfire protection. It includes specific requirements for the areas below that must be followed to mitigate the risk of wildfire events.[88]

1. Road standards for fire equipment access.
2. Standards for signs identifying streets, roads, and buildings.
3. Minimum private water supply reserves for emergency fire use.
4. Fuel breaks and greenbelts.

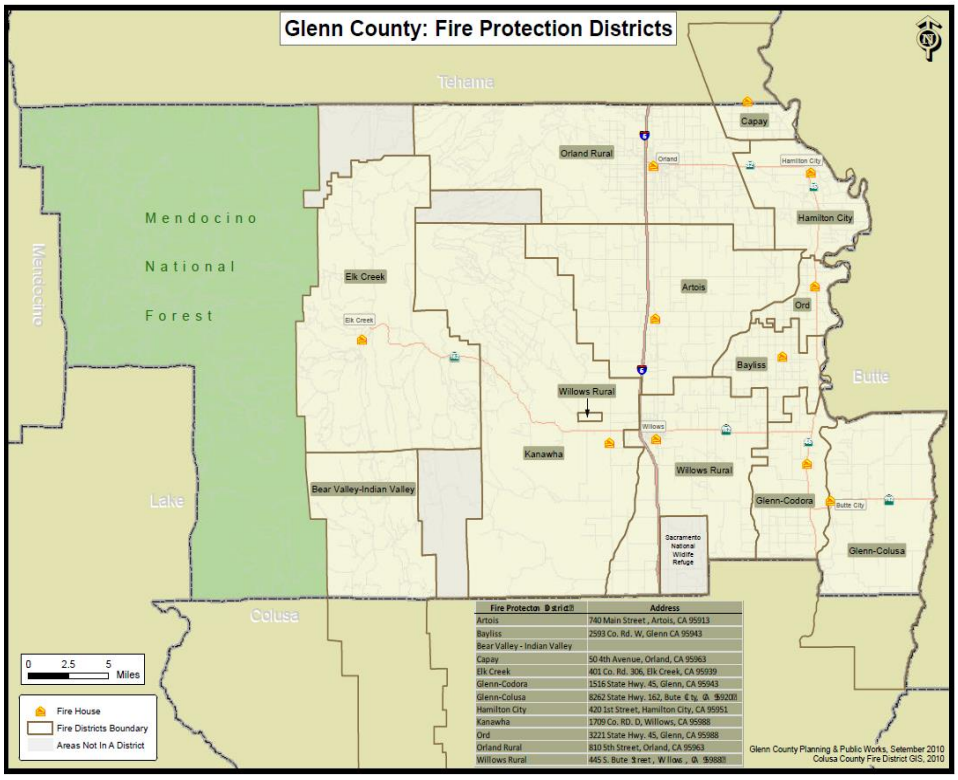
Glenn County's building codes incorporate specific provisions of Public Code 4291, which governs individuals who own, lease, control, operate, or maintain any building or structure in, on, or adjacent to mountainous terrain, forested areas, shrub-covered zones, grassy plains, or other land susceptible to combustion.[89] Orland has established three fire protection policies as part of its 2021 4.0 Safety Plan. Policy 4.3.A. mandates that the city uphold current levels of fire protection by compelling new developments to provide and/or finance fire protection facilities, operations, and maintenance. Policy 4.3.B specifies that the city continue to support the needs of the Orland Volunteer Fire Department and aid it as needed to maintain a highly efficient and functional fire service operation. Lastly, Policy 4.3.C

[85] National Oceanic and Atmospheric Administration, "Wildfire Climate Connection." https://www.noaa.gov/noaa-wildfire/wildfire-climate-connection
[86] California Air Resources Board. FAQ: Wildfire Emissions. https://ww2.arb.ca.gov/sites/default/files/classic/cc/inventory/Wildfire%20Emissions%20FAQ%202022.pdf
[87] Glenn County Community Wildfire Protection Plan 2023. https://www.glenncountyrcd.org/files/9c6de6d21/GCRCD_CWPP_2023_Update_FINAL_10-16-2023.pdf
[88] U.S. Federal and State Cases, Codes, and Articles, "California Code, Public Resources Code-PRC 4290." https://codes.findlaw.com/ca/public-resources-code/prc-sect-4290/
[89] California Legislative Information, "Code Section." https://leginfo.legislature.ca.gov/faces/codes_displaySection.xhtml?sectionNum=4291.&lawCode=PRC

states that the city should strive to improve the current Insurance Service Office (ISO) rating of four for safety and associated economic benefits.[90]

In Willows, Municipal Code 15.15 regulates fire codes for buildings and construction, including adopting California State Fire Codes.[91]

The unincorporated regions of Glenn County are subject to the authority of county fire protection districts: Artois, Bayliss, Bear Valley-Indian Valley, Capay, Elk Creek, Glenn-Codora, Glenn-Colusa, Hamilton City, Kanawha, Ord, Orland Rural, and Willows Rural (see Figure 89).[92] County officials or officers can notify the relevant fire protection district of flammable materials or conditions on unoccupied or developed parcels. Fire protection districts are responsible for managing dangerous conditions on privately owned properties, among other public safety duties. They are authorized to clear or mandate land clearance, including removing dry grass, stubble, brush, rubbish, litter, or other flammable material as a preventive measure against wildfires.



Source: Granicus, "Glenn County: Fire Protection Districts." https://glenncounty.granicus.com/MetaViewer.php?view_id=8&clip_id=999&meta_id=87165

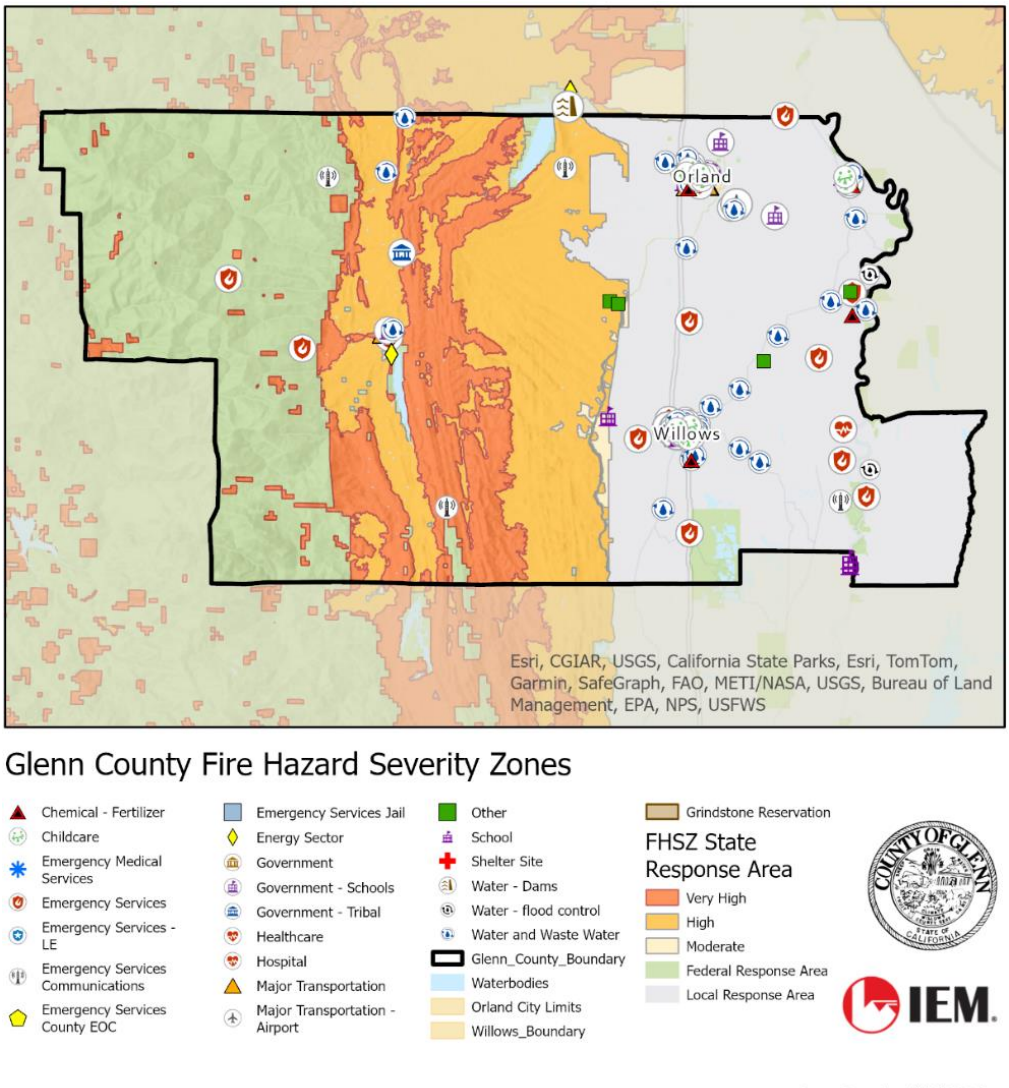
Figure 89: Glenn County Fire Protection Districts

[90] City of Orland, "4.0 Safety Element." https://www.cityoforland.com/wp-content/uploads/2022/04/GPA-2021-01-Safety-Element.pdf
[91] City of Willows California, "Willows Municipal Code Chapter 15.15 Fire Code." https://www.codepublishing.com/CA/Willows/#!/Willows15/Willows1515.html#15.15
[92] Granicus, "Glenn County: Fire Protection Districts." https://glenncounty.granicus.com/MetaViewer.php?view_id=8&clip_id=999&meta_id=87165

Location/Geographic Extent

Figure 90 is a map of Fire Hazard Severity Zones (FHSZs), which delineate areas at risk of wildfire, based on data from the Office of the State Fire Marshal.[93] In Glenn County, the western regions exhibit the highest degrees of susceptibility to wildfire. Notably, they encompass an eastern section of the Mendocino National Forest, which includes Alder Springs, Copper City, Lee Logan Camp, Lone Star, Sky Hi, and Smith Camp. These areas are designated as very-high-risk fire zones. The Elk Creek area, situated in the west-central portion of the county, is home to Chrome, Fruto, Grindstone Rancheria, and Newville, which are primarily designated as high-risk areas. In contrast, the eastern valley section of the county, which is home to Hamilton City, Orland, Willows, and other small cities, is predominantly designated as non-fuel and represents the least vulnerable area to fire.

[93] Office of the State Marshal, “Fire Hazard Severity Zones Map 2022.” https://osfm.fire.ca.gov/media/aovewf2b/fhsz_county_sra_11x17_2022_glenn_ada.pdf



Source: Office of the State Marshal, "Fire Hazard Severity Zones Map 2022." https://osfm.fire.ca.gov/media/aovewf2b/fhsz_county_sra_11x17_2022_glenn_ada.pdf

Figure 90: Fire Hazard Severity Zones, 2022

Magnitude/Extent

In November 2007, CAL FIRE adopted FHSZ maps as a means of assessing SRA fire hazards. Fire hazard mapping is a critical tool for predicting the damage a fire may cause by measuring physical fire behavior. Assessing fire hazards includes evaluating vegetative fuels, the probability of wildfire spread, the amount of heat produced, and most notably, the burning firebrands (burning wood or debris) that a fire releases ahead of the flaming front. FHSZ maps provide a methodical analysis of fire hazards and are a vital tool for future planning and decision-making. They have been under revision since 2022. Figure 90 uses intermediary 2022 FHSZ data available in December 2023.

The severity of a fire is contingent on various factors, including topography and particularly the steepness of slopes. Fires tend to burn more rapidly as they move up slopes. Moreover, weather elements, such as temperature, humidity, and wind, significantly influence fire behavior. Consequently, the FHSZ map depicts vast areas in the unincorporated regions of the county, categorized as moderate, high, and very-

high fire hazards in Figure 90. “Hazard” is based on the physical conditions that create a likelihood and expected fire behavior over a 30- to 50-year period without considering mitigation measures, such as home hardening, recent wildfires, or fuel reduction efforts. Both Willows and Orland show very low probabilities of wildfire hazards in FHSZs.

Past Occurrences

Over the past few decades, Glenn County has witnessed 20 wildfire incidents, ranging from the small-scale Edward fire in 2022 to the massive Elk Fire/August Complex fire in 2020 that engulfed over 1,032,648 acres. Of these events, 11 eleven burned more than 200 acres of land. The first wildfire of such magnitude occurred in 1953 and is known as the Rattlesnake Fire. It originated in the Grindstone Canyon, 5 miles northwest of Elk Creek in the Mendocino National Forest. Although the main fire was contained that evening, the wind shifted direction while the 24 firefighter volunteers were having dinner, causing the fire to jump its line and head down the canyon. The fire lasted for two days, and 15 firefighters lost their lives when they were overrun by the rapidly moving fire. This tragedy prompted significant changes in wildfire safety standards, training, awareness of weather conditions, and fire behavior among firefighters.[94]

On August 16–19, 2020, a rare weather pattern moved slowly through northern California, bringing moist unstable air from Tropical Storm Fausto that collided with a high-pressure ridge during a heat wave. The “Siege of ’20,” as it is known, caused over 2,500 lightning strikes and more than 600 fires. Unfortunately, many of these thunderstorms produced little or no rain, so dry fuels were ignited, causing the fires to spread rapidly. This overwhelmed the suppression capabilities of local, state, and federal fire organizations. Some fires were not staffed for days, and for weeks, most incidents struggled with fewer resources than they needed.

The August Complex fire is the largest fire in California’s history, covering over 1,032,648 acres. It is the result of 37 separate fires that started on August 17 and eventually burned together in the Mendocino National Forest. It spanned approximately 72 miles by 32 miles, which is larger than the state of Rhode Island (988,832 acres).[95] There were 4,075 personnel assigned to the fire, including 65 hand crews, as well as 353 fire engines and 31 helicopters. The August Complex fire lasted 86 days until November 11, 2020, and it destroyed approximately 100 residences and 104 other structures. 188,741 acres were lost. However, the destruction was limited because of the rural nature of the area. The cost of the fire has been estimated around $166 million.[96] Figure 91 shows the Sherrif’s patrol monitoring the fire.

[94] United States Department of Forestry, “Rattlesnake Firefighter Trailhead.” https://www.fs.usda.gov/recarea/mendocino/recarea/?recid=25300#:~:text=The%20brush%20fire%20burned%20over,fire%20weather%20and%20fire%20behavior.
[95] Wildfire Today, “Since 2008 Wildfire News & Opinion.” https://wildfiretoday.com/tag/august-complex/
[96] CAL FIRE, “August Complex (Includes Doe Fire).” https://www.fire.ca.gov/incidents/2020/8/16/august-complex-includes-doe-fire

Source: Glenn County

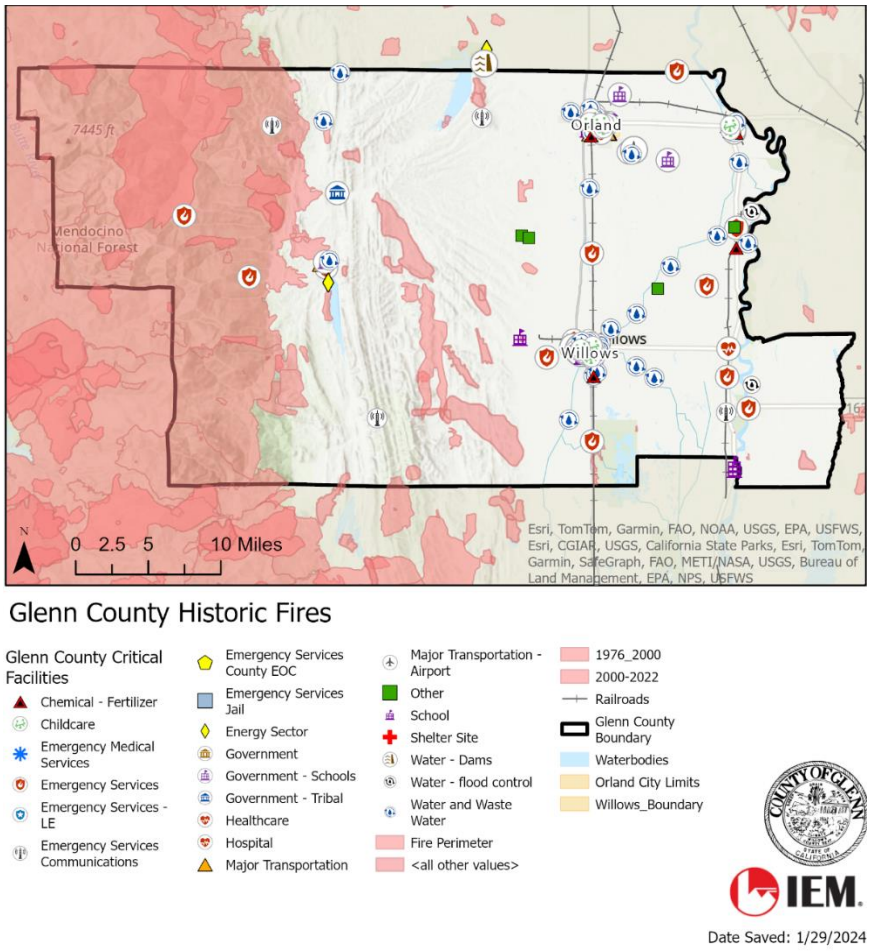
Figure 91: Jeep near August Complex Fire

Figure 92 shows the areas impacted by past wildfire events. CAL FIRE's Fire and Resource Assessment Program (FRAP) has fire perimeter data from 1878 to 2022. To show areas that have burned multiple times, these data were grouped in fires from 1878 to 1950 (including events with no year recorded), 1950–1975, 1976–2000, and since 2001. A transparency was applied, and then the grouped perimeters were overlaid. Darker areas indicate fire perimeters that covered the same area more than once.

A recent example is the Thirty-Five Fire, a vegetation fire that occurred on August 17th, 2023, and consumed 109 acres near County Road 35, west of Road D, and west of Artois in Glenn County.[97] CAL FIRE has still not determined the cause of the fire, and it is still under investigation.[98]

[97] Action news Now, "CAL Fire, Willows Fire Department Contain Thirty Five Fire." https://www.actionnewsnow.com/news/cal-fire-willows-fire-department-contain-thirty-five-fire/article_4240fb44-3d3d-11ee-97b2-d3f1ad5715e4.html

[98] CAL Fire, "Thirty Five Fire." https://www.fire.ca.gov/incidents/2023/8/17/thirty-five-fire



Source: Historic Fire Perimeters, 2022. CALFIRE, Fire Resource Assessment Program https://www.fire.ca.gov/Home/What-We-Do/Fire-Resource-Assessment-Program/GIS-Mapping-and-Data-Analytics

Figure 92: Historic Fires in Glenn County

Table 57 lists significant wildfires in Glenn County, with the numbers of acres burned by each one.

Table 57: Wildfires in Glenn County, 1953–2023

Incident	Date	Acres Affected
Rattlesnake Fire	July 9, 1953	1300
Thunder Fire	July 7, 2012	167
Elk Fire	August 29, 2012	125
306 Fire	May 1, 2013	217
Dave's Fire	June 12, 2013	226
Creek Fire	July 19, 2017	Unknown
Chrome Fire	May 28, 2018	75
Open Fire	June 1, 2018	127
Chrome Fire	June 9, 2018	2,290

Incident	Date	Acres Affected
Ranch Fire (Mendocino Complex)	July 27, 2018	410,203
Elk Fire	October 4, 2019	63
Baseball Fire	February 25, 2020	211
Grizzly Fire	March 2, 2020	154
Elk Fire	August 16, 2020	727
Elk Fire/August Complex Fire	August 16, 2020	1,032,648
4-8 Fire	August 17, 2020	275
Butte/Tehama/ Glenn Lightning Complex Fire	August 17, 2020	19,609
Edward Fire	May 24, 2022	50
Burrows Fire	June 28, 2022	317
Stony Fire	July 18, 2023	89
Thirty-Five Fire	August 17, 2023	109

Source: California Department of Forestry and Fire Protection, "Glenn County." https://www.fire.ca.gov/Search-Results?search=Glenn%20county&programsCategoryFilters=&activeFilters=&page=&contenttype=&type=incidents

Table 58 shows the acres affected by wildland fires in Glenn County by decade. Information for 2010 through the 2020's is taken from Table 57.

Table 58: Glenn County Fires by Decade

Decade	Number of Fires	Acres Affected	Decade	Number of Fires	Acres Affected
1900	1	948	**1970**	8	103,188
1920	7	59,518	**1980**	11	12,023
1930	12	61,254	**1990**	17	12,892
1940	32	59,914	**2000**	14	10,844
1950	18	13,234	**2010**	10	411,203
1960	12	5,758	**2020**	10	1,054,189

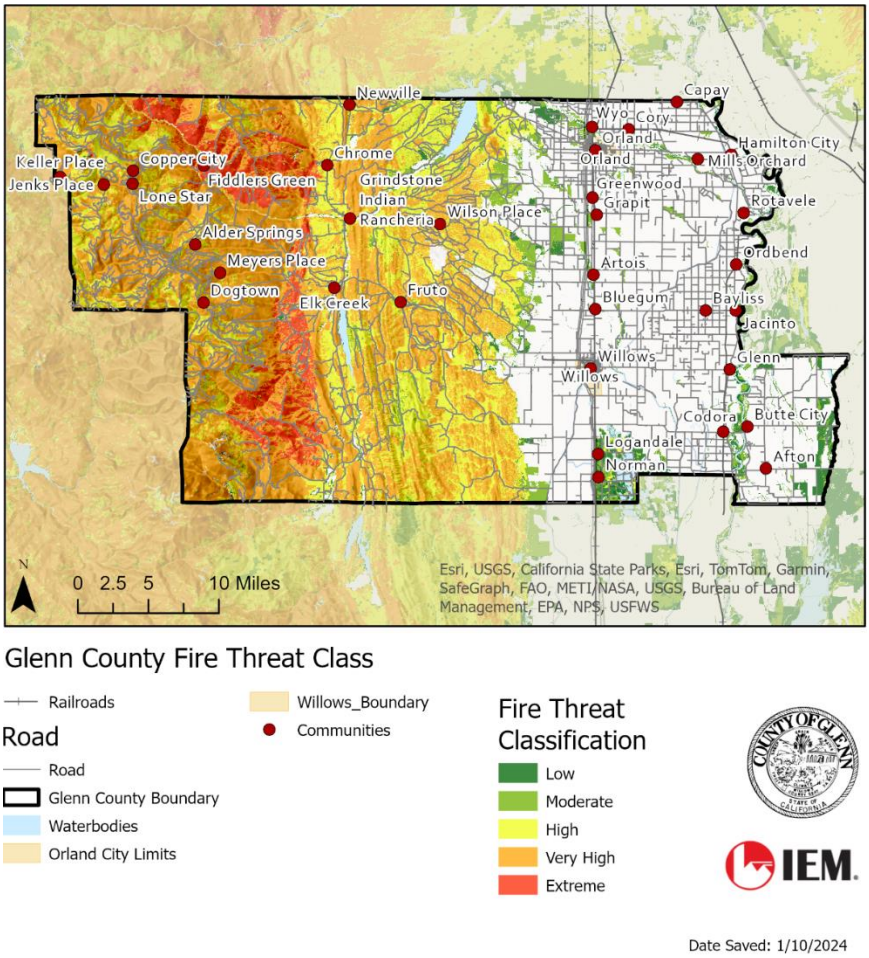
Source: County of Glenn, "Glenn County, CA Multi-Jurisdiction Hazard Mitigation Plan." https://www.countyofglenn.net/sites/default/files/Planning/Glenn%20County%20MJHMP%20100918.pdf

Frequency/Probability of Future Occurrences

The National Risk Index reports and annualized frequency of .42% chance per year. Twenty fires occurred in Glenn County between 2012 to 2023, an average of 2 per year. The probability of future occurrences of wildfire is Likely.

The risk of fire in Glenn County and its surrounding regions is increasing because of the expansion of development, wildland–urban interface areas, dense forests, and climate change. In recent decades, Glenn County has witnessed many notable wildfire occurrences, along with structure fires in Orland and Willows. More than half of the county is in moderate-, high-, and very-high-risk fire zones (see Figure 90).

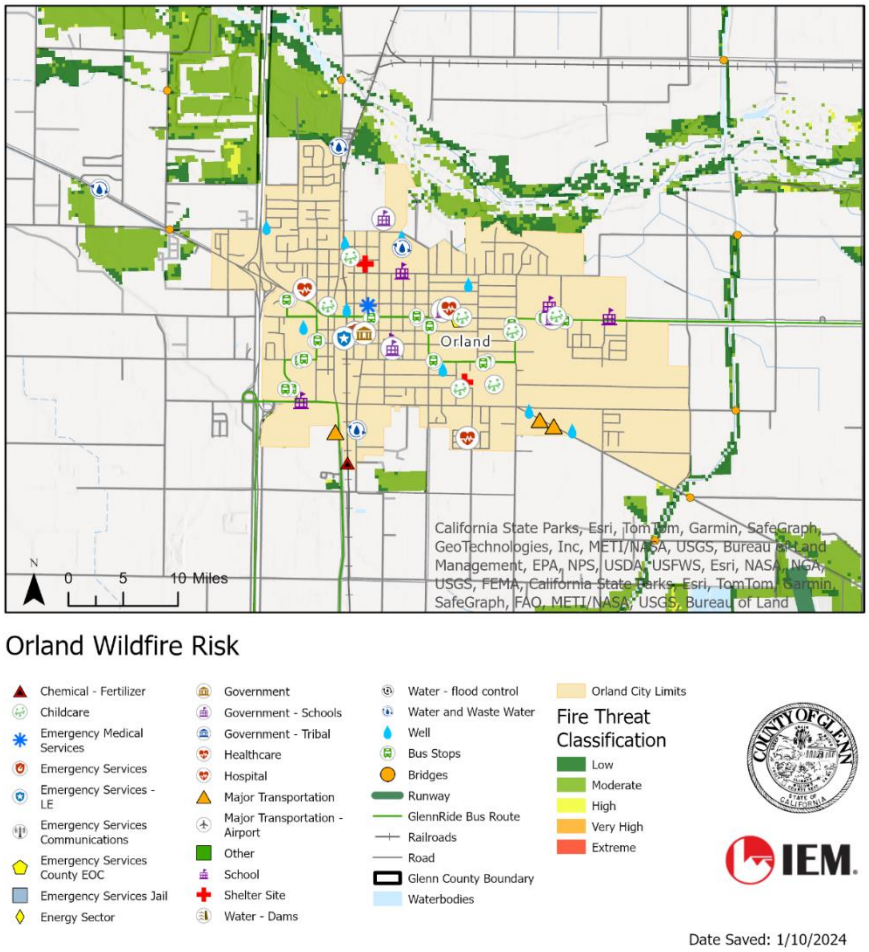
Fire threat is a measure of fuel conditions and fire potential, representing the likelihood of wildfires that are "damaging" or difficult to control. This classification can be useful for assessing potential impacts on various assets. Impacts are more likely to occur and/or increase in severity for higher threat classes. It is based on a combination of fire probability—the likelihood of a given area burning—and potential fire behavior or hazard. Figure 93 shows the 2019 update of the FRAP 2017 Forest and Rangeland Assessment for Glenn County.[99] Figure 94 and Figure 95 show the threats for Orland and Willows, respectively.



Source: FRAP GIS Mapping and Data Analytics. https://www.fire.ca.gov/Home/ What-We-Do/Fire-Resource-Assessment-Program/GIS-Mapping-and-Data-Analytics

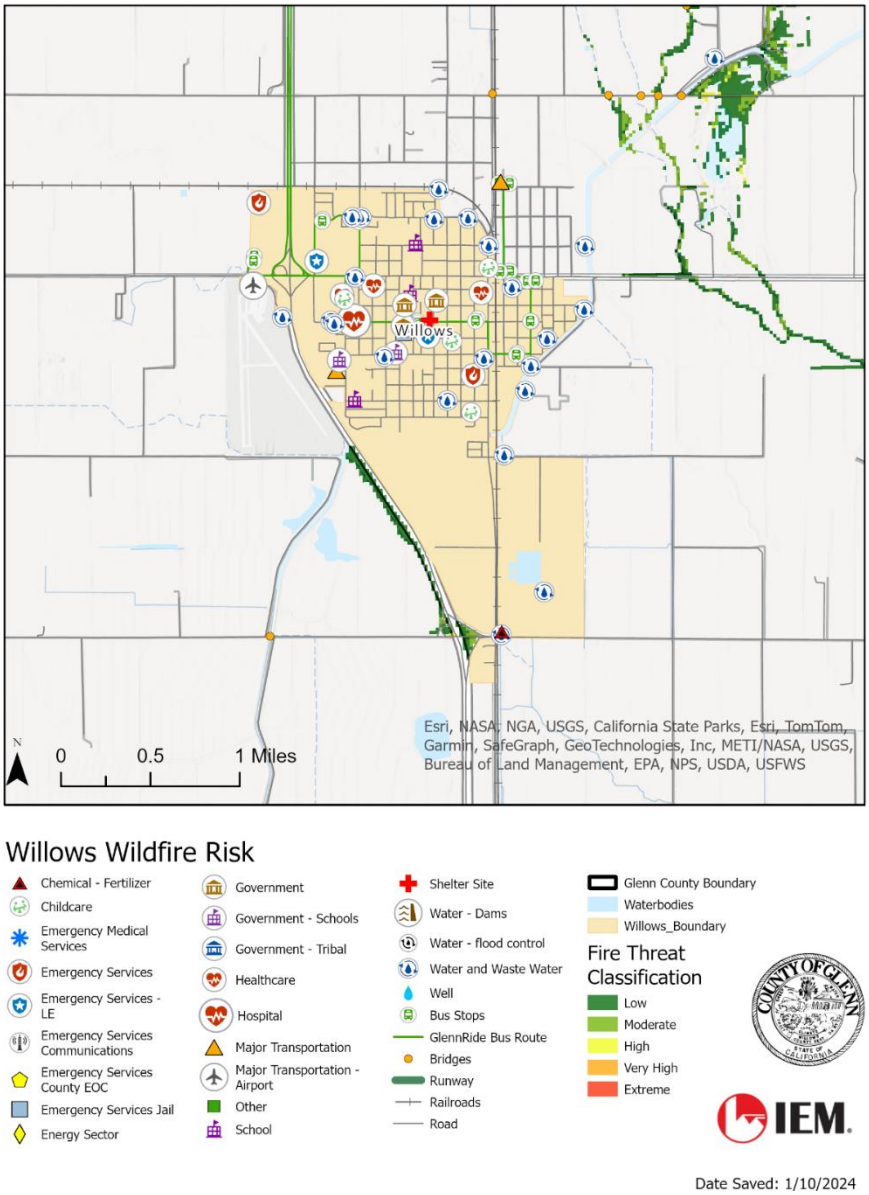
Figure 93: Glenn County Fire Threat

[99] California Department of Forestry and Fire Protection Fire and Resource Assessment Program, "California's Forests and Rangelands 2017 Assessment." https://34c031f8-c9fd-4018-8c5a-4159cdff6b0d-cdn-endpoint.azureedge.net/-/media/calfire-website/what-we-do/fire-resource-assessment-program---frap/assessment/assessment2017.pdf



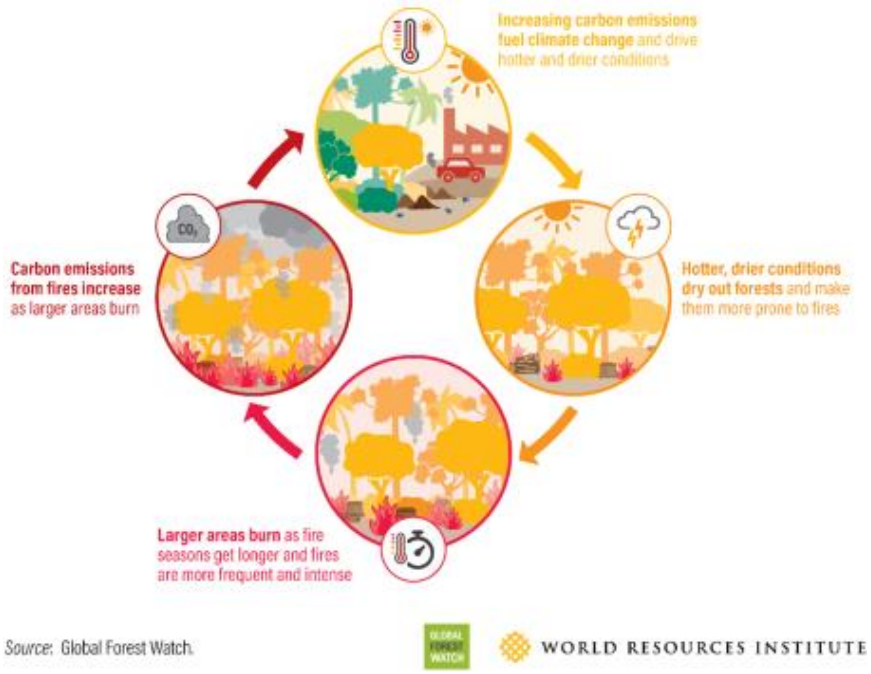
Source: Source: FRAP GIS Mapping and Data Analytics. https://www.fire.ca.gov/Home/ What-We-Do/Fire-Resource-Assessment-Program/GIS-Mapping-and-Data-Analytics

Figure 94: Threat of Wildfires in Orland



Source: Source: FRAP GIS Mapping and Data Analytics. https://www.fire.ca.gov/Home/ What-We-Do/Fire-Resource-Assessment-Program/GIS-Mapping-and-Data-Analytics

Figure 95: Risk of Wildfires in Willows



Source: World Resources Institute, "The Latest Data Confirms: Forest Fires Are Getting Worse." https://www.wri.org/insights/global-trends-forest-fires#:~:text=Climate%20Change %20Is%20Making%20Fires,the%20planet%20continues%20to%20warm

Figure 96: Feedback Loop of Fires and Climate

Climate change is a significant factor in the increasing number of fires. Today, extreme heat waves are five times as likely than they were 150 years ago, and they are expected to become even more frequent as the planet continues to warm. Higher temperatures cause the land to dry out, creating an ideal environment for larger and more frequent forest fires. This, in turn, leads to increased emissions from these fires, exacerbating climate change and contributing to a "fire–climate feedback loop" that leads to even more fires.

Over the last 40 years, there has been an increase in both the annual costs and the numbers of deaths from wildfires in the United States. As anthropological activities continue to contribute to global warming and alter the natural landscape, it is likely that such devastating and expensive disasters will become even more frequent.

Climate change is a significant factor in the occurrence of frequent and intense fires. Therefore, it is impossible to reduce the level of fire activity to what it used to be without significantly reducing greenhouse gas emissions and breaking the fire–climate feedback loop. Even though it is still feasible to mitigate the worst effects of climate change, achieving it will require rapid and substantial transformations across all systems.[100]

Though already critical, the nature and impacts of wildfires are only expected to worsen. Wildfire frequency, size, and severity are projected to increase, along with the multitude of associated impacts, from smoke emissions to watershed function. Congress took bipartisan action to establish the Wildland

[100] World Resources Institute, "The Latest Data Confirms: Forest Fires are Getting Worse." https://www.wri.org/insights/global-trends-forest-fires#:~:text=Climate%20Change%20Is%20Making%20Fires,the%20planet%20continues%20to%20warm

Fire Mitigation and Management Commission, which has the ambitious task of creating policy recommendations to address nearly every facet of the wildfire crisis, including mitigation, management, and post-fire rehabilitation and recovery.

The report emphasized the critical need to shift the approach of addressing wildfire risk toward proactive actions intended to better prepare for wildfire impacts, reduce those impacts, and build resilience for the future.

> *Only through significant investments in proactive planning, mitigation, risk reduction, and the workforce needed to accomplish these tasks can we break the current cycle of increasingly severe wildfire risk, damage, and loss. Importantly, these upfront actions must encompass both the built and natural environment. While significant funding has been put toward hazardous fuels reduction work in recent years, there have not been equivalent national-scale investments and efforts to reduce risk in the built environment and prepare communities before, during, and after a wildfire. Addressing this gap is essential to a comprehensive approach to wildfire.* [101]

Changes in Development

The Glenn County Community Wildfire Protection Plan (CWPP) noted the following concerns regarding changes in development: In Glenn County and California as a whole, communities in and near wildlands have experienced growth and increases in public access and use. Development in these areas has taken a number of forms. Remote residences and areas of development are often created without many of the infrastructure components and fire safety features that are integral to fire protection. Significant among these deficiencies are insufficient access on two-lane roads for ingress and egress of firefighting equipment, inadequate water supply systems, and the use of mobile homes as residences on small rural parcels. Considering that mobile homes are often installed with little or no vegetation removal, this type of residence is at an increased risk of flash fires.

The recent revision of the state's FHSZs included significant changes in Glenn County. Much of the area previously categorized as moderate hazard has been changed to high risk, and some areas previously identified as high hazard are now very-high risk. The changes in the mapping process incorporates new science in local climate data and improved fire assessment modeling in determining hazard ratings. Drought, extreme heat, and diseases affecting tree mortality have also increased risk of wildfire. The August Complex Fire also resulted in an increase in hazard trees. These factors indicate an increase in vulnerability to wildfire in Glenn County.

The City of Orland has experienced not experienced a wildfire since the last plan update. Currently, the city has close to 500 hydrants that can pass approximately 700 gallons per minute. However, volunteer fire protection services in the area could be strained as the city continues to expand. Overall, vulnerability to wildfire has not changed.

The City of Willows does not intersect with FHSZs, and therefore the development there would not increase the city's wildfire risk. If anything, the city has become a refuge for residents relocating after the 2018 Camp Fire. However, much of the city is at risk of flooding, and housing costs are comparatively high. Therefore, city officials have noted that annexing more land could provide opportunities to build additional housing. Current wildfire vulnerability is unchanged.

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[101] Report of the Wildland Fire Mitigation and Management Commission. 2023. https://www.usda.gov/sites/default/files/documents/wfmmc-final-report-09-2023.pdf

Vulnerability Assessment

The danger posed by wildfires to both residents and property is a matter of significant concern in forested areas with high fuel loads. These factors, combined with natural weather conditions such as drought, low relative humidity, and strong winds, create the potential for both natural and human-caused fires that can result in property damage and the loss of life. It is noteworthy that any such fire has a high potential for becoming uncontrollable and catastrophic. Wildfires can create water repellant soils, which make landscapes vulnerable to post-fire erosion and debris flows. Smoke from wildfire can cause dangerous air quality conditions for areas far outside the communities closest to the fire.

Fire suppression can be costly, and the financial toll borne at the community level can overwhelm local resources. Much of the time, the impacts of wildfires and post-fire events impose the heaviest toll on people with lower incomes, people of color, the elderly, individuals with disabilities, those with limited English proficiency, and other social vulnerabilities.

To determine the distribution of critical facilities in each wildfire severity zone, community assets, and wildfire hazard severity zone data were overlaid and analyzed.

The data on critical facilities compiled by Glenn County were overlaid with the 2022 Intermediary FHSZs to determine which facilities are in areas at risk of wildfire. Table 59 groups these facilities according to FEMA Community Lifelines and identifies the number of facilities in each of the three hazard zones and the unzoned areas. 60 presents a summary of the critical facilities present in each wildfire severity zone.

The Fire Threat map in Figure 93 gives additional information on fire risk outside the State Responsibility Area FHSZs. One additional fire station, Elk Creek, and the Red Mountain Radio repeater site are in a very high fire threat class in the Federal Response Zone.

Local data on the locations and replacement values of individual structures were not available, so the National Structure Inventory (NSI) was used to estimate the potential structural losses in the FHSZs. The NSI uses a variety of data to estimate structure locations and characteristics nationwide. A summary of building counts, occupancy types, and loss estimates is provided in Table 64.

The size and shape of census geographies relative to the FHSZs pose a challenge in estimating the population exposed to wildfire risk. Using the number of residential structures identified in the NSI and the average household size of 2.8, an estimated 90 people are in the Moderate FHSZ, 442 in the High FHSZ, and 313 in the Very High FHSZ.

Table 59: Vulnerability of Critical Facilities to Wildfire

Community Lifeline	Number in Very High Fire Severity Zone	Number in High Fire Severity Zone	Number in Moderate Fire Severity Zone	Number in Unzoned Area	Total
Communications	1	1	0	1	3
Energy	1	0	0	2	3
Food, Hydration, Shelter	0	0	0	3	3
Hazardous Materials	0	0	0	4	4
Health and Medical	0	0	0	11	11
Safety and Security	1	4	1	64	70
Transportation	1	0	0	7	8

Community Lifeline	Number in Very High Fire Severity Zone	Number in High Fire Severity Zone	Number in Moderate Fire Severity Zone	Number in Unzoned Area	Total
Water Systems	0	4	0	44	48
TOTAL	**4**	**9**	**1**	**136**	**150**

Table 60: Critical Facilities At Risk of Wildfire

Facility Name	Description	FEMA Community Lifeline	Fire Hazard Severity Zone
Black Butte Radio Repeater Site	Emergency Services Communication	Communication	High
CAL FIRE – Elk Creek Station	Emergency Services	Safety and Security	Very high
Division of Water Resources	Water and Waste Water	Water Systems	High
Elk Creek Community Service	Water and Waste Water	Water Systems	High
Elk Creek Fire District	Emergency Services	Safety and Security	Very High
Glenn County Landfill	Other	Safety and Security	High
Glenn County Public Works Agency Elk Creek Yard	Major Transportation	Transportation	Very High
Glenn County Transfer Station	Other	Safety and Security	High
Grindstone Rancheria	Government – Tribal	Safety and Security	High
Needham Radio Repeater Site	Emergency Services Communication	Communication	Very High
Red Mountain Repeater	Emergency Services Communication	Communication	Very High
Stony Creek Joint Unified School District	Government – Schools	Safety and Security	High
Stony Gorge Hydro Electric	Energy Sector	Energy	Very High
Tehama-Colusa Canal Authority	Water and Waste Water	Water Systems	High
USACE – Headquarters Black Butte	Water and Waste Water	Water Systems	High
Willow Creek Christian School	School	Safety and Security	High

Table 61 shows the overall area, in square miles and acres, at risk of wildfires, while Table 62, Table 63, and Table 64 show the values of buildings, their contents, and related vehicles that are in areas of moderate, high, and very high severity of fire hazards, respectively.

Table 61: Extent of Wildfire Hazard Areas in Glenn County

Hazard Severity	Square Miles	Acres
Moderate	7.33	4,692
High	290.33	185,811
Very High	167.05	106,911
Total at Risk	464.71	297,414

Table 62: Buildings in Areas of Moderate Fire Hazard Severity

Occupancy Type	Building Count	Structure Value	Contents Value	Vehicle Value	Total Value
Commercial	16	$8,528,122	$8,528,122	$576,000	$17,632,244
Industrial	0	0	0	0	0
Public	1	$3,875,893	$3,875,893	$27,000	$7,778,786
Residential	32	$6,732,762	$3,366,381	$864,000	$10,963,143

Table 63: Buildings in Areas of High Fire Hazard Severity

Occupancy Type	Building Count	Structure Value	Contents Value	Vehicle Value	Total Value
Commercial	109	$65,355,607	$65,355,607	$3,852,000	$134,563,214
Industrial	8	$8,037,453	$11,446,075	$585,000	$20,068,528
Public	5	$6,683,892	$6,683,892	$252,000	$13,619,784
Residential	158	$36,019,792	$18,009,896	$4,644,000	$58,673,688

Table 64: Buildings in Areas of Very High Fire Hazard Severity

Occupancy Type	Building Count	Structure Value	Contents Value	Vehicle Value	Total Value
Commercial	20	$17,689,873	$17,689,873	$846,000	$35,225,746
Industrial	2	$2,998,127	$4,497,191	$126,000	$7,621,318
Public	5	$3,687,086	$3,687,086	$225,000	$7,599,172
Residential	112	$24,710,553	$12,355,276	$3,942,000	$41,007,829

Table 65 lists the numbers and values of buildings at risk of fire by occupancy type.

Table 65: Total Building Exposure

Occupancy Type	Building Count	Total Value
Commercial	145	$188,421,204
Industrial	10	$27,689,846
Public	11	$28,997,742

Occupancy Type	Building Count	Total Value
Residential	302	$41,007,829

Jurisdiction-Specific Vulnerabilities

Glenn County

A significant land area in Glenn County is in moderate to very high FHSZs. This is mostly in the western, rural area of the county, where land use is primarily agricultural and forestry based. Several small, isolated pockets of development along Highway 162 and County Road 306 have high risk of wildfires, including Chrome, Elk Creek, Fruto, Newville, and the Grindstone Indian Reservation. These two-lane roads provide the primary transportation access to these communities and recreation sites, and alternative routes are limited. County roads, Forest Service routes, and other minor roads in the western area of the county are often unpaved and close to vegetation, isolated from response resources, and may be constrained by hilly terrain. Some roads are too narrow for firefighting equipment to pass, and they may become impassable if wildfires spread near or across them, which could block potential evacuation routes from more isolated structures.

Much of the western region of the county is steep and rocky, which has placed the development of residences on areas that are relatively flat. Because of these conditions, residences are widely scattered, and firefighting resources have had to disperse to protect isolated structures. Such distances can allow fires to spread and intensify more rapidly, and they make rescue and evacuation difficult. These scattered areas of development are often created without many of the infrastructure components and fire safety features that are integral to fire protection. Significant among these deficiencies are access to two-lane roads for evacuating residents and the ingress of firefighting equipment, water supply systems that can provide adequate fire protection, and parks and other large areas of cleared space between developed lots.

A total of 302 residences are currently in areas of wildfire hazard. Besides the risk of property damage or personal injury from wildfires, people who work or reside in these remote locations may have limited options for receiving communications about wildfire incidents. Distance from response facilities may create longer response times, which allows the fire to spread for a longer time before containment or suppression efforts begin, and they make rescue and evacuation difficult. Smoke from wildfires can affect air quality over a large region, which results in health consequences, particularly for those with underlying conditions, the very young, and the elderly.

Sixteen critical facilities are exposed to moderate to very high wildfire risk. Damage to these facilities may disrupt the services they provide, such as water, hydroelectric energy, and communications, which could impact a large number of people outside the immediate risk area.

The economy of rural Glenn County is largely agricultural, based on crop and livestock production. This area is also important for ranching, timber production, and watershed resources. The resources can be damaged or destroyed by wildfire, resulting in economic losses and restoration costs.

In addition to the forested west side of the county, high amounts of vegetative fuels are found along riparian areas of Lower Stony Creek, the Sacramento River, and in the Sacramento River National Wildlife Area. If left unmanaged, fuels in these areas can burn and threaten structures and communities in the eastern and southern portions of the county. Fire can damage sensitive habitats in these areas.

Prescribed fires are an opportunity to control the intensity and timing of fires, but they can be risky if they escape containment in areas of scattered development. Fuel breaks, fuel reduction projects, and other management efforts to reduce severity and spread of wildfire were identified as the top priority in the

CWPP. Costs for identifying, planning, developing, and conducting fuel management and other wildfire risk reduction projects strain local capabilities.

Some rural areas of the county have limited water supplies for firefighting. Water tank installations, water delivery infrastructure, and other improvements have been identified as priorities for addressing wildfire risk in the CWPP.

There is only one access point into the Grindstone Rancheria along County Road 306 via County Road 305. If County Road 305 became restricted or blocked during a wildfire event, it could prevent ingress by firefighting personnel and egress for residents evacuating the area. A second access route out of the property could address this issue.

Wood shake roofing is more susceptible to burning but is still often used in both new construction and roof replacement. Eliminating shake roofs increases the likelihood that a building will withstand a wildfire. Efforts to educate property owners about the importance of replacing shake roofs and changing building regulations and policies regarding roofing materials would reduce wildfire risk.

Public outreach, education, and engagement are low-cost ways to inform residents about wildfire risk, potential efforts at fire management, and fuel reduction and inform them of their roles in maintaining fire-safe landscapes.

Elderly, disabled, and low-income persons in rural communities may need assistance managing fuels and creating defensible space around their properties. Assistance programs, such as publicly sponsored chipping days, provide no- or low-cost assistance to eligible persons to develop defensible spaces, which could reduce risk to these individuals.

City of Orland

Orland does not intersect the FHSZs. However, fires do not understand boundaries on maps, and they still pose a threat to the city. Areas close to the city at risk of fire include riparian areas near Stony Creek, along the north of the city. The growth of Arundo and Tamarisk poses a risk of fire in this interface between the city and surrounding open space. The threat classifications are low to moderate, cover a relatively small area, and do not contain any critical facilities. A few residential streets are near these low-risk areas, including Gable Drive and Stony Creek Drive.

The threat of wildland fire is considered minimal in the city, based on land use. Fire protection services are provided by the Orland Volunteer Fire Department. This department has a mutual aid agreement with the Orland Rural Fire District, a separate special district that provides fire protection services to the unincorporated county areas that surround the city. Both fire protection services are staffed primarily by volunteers. Few properties have only one point of access, and multiple routes exist to evacuate if required, although these routes have not been standardized by the city.

Urban fires, including structural fires in a residence or small business or urban conflagration (multiple simultaneous structural fires), are possible in the city. Potential sources of urban fires include transportation incidents, such as an operational failure of rail service or traffic accidents on the interstate; fires or explosions at a processing plant; and hazardous materials incidents.

City of Willows

Willows has 1,815 acres in its planning area. Of these, 220 acres are undeveloped around the outskirts of the city and, therefore, susceptible to wildfire. However, the FHSZ and Fire Threat maps in Figure 93 and Figure 95 show that there is little threat to Willows. However, residents could be impacted if facilities or services in the unincorporated county are disrupted by wildfires, and they may be subject to poor air quality from wildfires that occur in the region.

There have been four major fires in Willows. One changed the city entirely, and another led to the creation of the Willows Fire Department. On May 30, 1882, the most destructive fire in Willows' history occurred, and it nearly destroyed the entire downtown. Thirty-three buildings were lost, most of them thriving businesses, and the loss was estimated at $200,000 (the equivalent of $4.5 million today). In 1887, the Willows Fire Department was established with two hose companies. Each company had carts that held fire equipment, including axes, ladders, nozzles, and hoses. The Willows Fire Department has grown from the bucket brigade and hose companies to having nine apparatuses in the rural and city departments. There are five paid staff: the Chief, a Captain, and three Engineers.

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Section 4. Capabilities Assessment

In preparing the mitigation actions, the participating jurisdictions were asked to consider their overall capability to mitigate identified hazards. The capabilities assessment included evaluations of Glenn County's and the Cities of Orland and Willows' planning and regulatory, administrative and technical, financial, and education and community outreach abilities to complete the mitigation actions. In addition, it involved evaluating these capabilities to determine how they could be expanded upon or improved. By evaluating existing and potential capabilities, it is hoped that the participating jurisdictions will be able to select mitigation actions which are feasible for them to complete.

Planning and Regulatory

Planning and regulatory capabilities are the plans, policies, codes, and ordinances that prevent and reduce the impacts of hazards. Glenn County and the Cities of Orland and Willows have several plans and programs in place that guide their mitigation of development in hazard-prone areas. Table 66 lists the planning and land management tools typically used by Glenn County to implement hazard mitigation activities. Table 67 indicates the planning capabilities of Orland, and Table 68 lists those for Willows.

Table 66: Glenn County Planning Capabilities

Plan	Does the plan address hazards? (Y/N)	How can the plan be used to implement mitigation actions?	Last update? Next update?
General Plan	Yes	Implementing the actions identified in the Safety Element.	2023; no targeted timeframe
Capital Improvement Plan	Yes	There is a schedule of bridges that needs to be repaired and is currently included. Includes recovery projects from disasters that have a funding source.	Annually updated
Climate Change Adaptation Plan	N/A	The county does not have one but needs to develop one.	No timeline yet – still seeking funds from the Integrated Climate Adaptation and Resiliency Program (ICARP)
Community Wildfire Protection Plan	Yes	The Resource Conservation District uses this plan as a resource when applying for grants and completing mitigation projects.	2023; Probably not until at least 2028.
Economic Development Plan	Yes - briefly	Notes challenges and unknows from wildfire impacts (Camp Fire).	Glenn County Economic Development Strategy 2019-2022
Land Use Plan	Yes – flooding	Yes, it is in the General Plan and can support floodplain management.	2023

Plan	Does the plan address hazards? (Y/N)	How can the plan be used to implement mitigation actions?	Last update? Next update?
Local Emergency Operations Then	Yes	The plan currently has no reference to mitigation but references the MJHMP.	It is updated on a five-year cycle; 2024
Stormwater Management Plan	Storm Drain Districts exist but no formal plans in place	Storm Drainage studies need to occur in multiple storm drain districts and the City of Willows sphere of influence.	Undetermined
Transportation Plan	Yes	Emergency preparedness guidelines and procedures. The most likely events in the County include forest fire, earthquakes, and flooding	2020
Substantial Damage Plan	N/A	N/A	N/A
Other? (please describe)	N/A		

Table 67: City of Orland Planning Capabilities

Plan	Does the plan address hazards? (Y/N)	How can the plan be used to implement mitigation actions?	Last update? Next update?
General Plan	Y	In pursuit of grant funding and during discretionary actions	2023; Unknown
Capital Improvement Plan	N	Unknown	Unknown
Climate Change Adaptation Plan	N	Unknown	Unknown
Community Wildfire Protection Plan	Unknown	In pursuit of grant funding and during discretionary actions	Unknown
Economic Development Plan	Unknown	Unknown	Unknown
Land Use Plan	N	Unknown	2023 Unknown
Local Emergency Operations Plan	Unknown	Unknown	Unknown

Plan	Does the plan address hazards? (Y/N)	How can the plan be used to implement mitigation actions?	Last update? Next update?
Stormwater Management Plan	Unknown	Unknown	Unknown
Transportation Plan	Unknown	Unknown	2023 Unknown
Substantial Damage Plan	Unknown	Unknown	Unknown
Other? (please describe)			

Table 68: City of Willows Planning Capabilities

Plan	Does the plan address hazards? (Y/N)	How can the plan be used to implement mitigation actions?	When was it last updated? When will it next be updated?
General Plan	Y	Ensures that development has examined potential hazards and that they are mitigated beforehand	November 2022; Updated periodically
Capital Improvement Plan	Y	Improvements of drainage, roads, wastewater and other infrastructure	Yearly
Climate Change Adaptation Plan	N/A		
Community Wildfire Protection Plan	Yes	Fuel reduction	As funding allows
Economic Development Plan	No		
Land Use Plan	N/A		
Local Emergency Operations Plan	Glenn County		
Stormwater Management Plan	N/A		
Transportation Plan	Glenn County		
Substantial Damage Plan	N/A		
Other? (Describe)			

Table 69 through Table 74 list the regulatory capabilities of Glenn County, Orland, and Willows, respectively.

Table 69: Glenn County Regulatory Capabilities

Plan	Does it reduce hazard impacts?	Is it adequately administered and enforced?	Last update? Next update?
Building Code	The 2022 California Building Code has been adopted and has added significantly to this capability, particularly when it comes to addressing flooding.	Yes – The building department is small and has to work to keep up with constantly changing requirements, but overall, it has been successful.	2022; Anticipate updating in 2025.
Flood Insurance Rate Maps	No – need additional information on areas that do not have base flood elevations	Yes – Planning and Building staff are proficient in reading flood maps and requiring appropriate permits, certifications, etc.	A broad, across the board update in 2010; A Letter of Map Revision (LOMR) would enable citizens to revise their property if concurred by FEMA, but no overall changes to the map are anticipated at this time.
Floodplain Ordinance	Yes – However, the FEMA Community Assistance Visit (CAV) noted that the ordinance should be updated with additional language.	Yes	2006; It is currently being updated.
Subdivision Ordinance	N/A	N/A	N/A
Zoning Ordinance	Yes – existing Zoning Code; Floodplain Management Title 15.54.030	Yes	2006
Natural Hazard-Specific Ordinance (Stormwater, Steep Slope, Wildfire)	Title 15 identifies limits on areas with steep slopes. Analysis form the California Environmental Quality Act is not in any ordinance, but it helps with this.	There is little development going on in areas with steep slopes.	2006
Acquisition of Land for Open Space and Public Recreation Use	N/A	N/A	N/A
Prohibition of Building in At-Risk Areas	N/A	N/A	N/A