4. Climate Change in the Watershed

4.1 Introduction

The Russian River watershed is characterized by a mediterranean climate, with much of its annual precipitation occurring between late fall and early spring and the remainder of the year experiencing drier conditions. A large portion of the surface water supplies received by the watershed are provided in the form of atmospheric rivers (ARs), or long, concentrated bands of moisture fueled by warming over the Pacific Ocean. While landfalling ARs can be beneficial for providing much needed water supplies or alleviating drought conditions for the watershed, they can also create catastrophic flood events when too much precipitation is received in a short amount of time. Conversely, when drier conditions persist for too long in the absence of sufficient precipitation, the watershed can experience severe, sometimes multi-year droughts. These rapid shifts between extreme wet and dry periods have resulted in some of the most intense floods and droughts in California's history.

The hydrologic and ecological responses to climate-driven hazards reflect both natural watershed characteristics and the extensive human modification that has occurred over the 20th century. Construction of levees and channels, gravel mining, and the expansion of agricultural and urban land have modified sediment transport, reduced floodplain connectivity, altered flow regimes, and many of the other natural buffers to extreme climate conditions to support human development in the watershed. Completion of Coyote Valley Dam in 1959 and Warm Springs Dam in1983 provided additional flood control and water supply benefits for the watershed, while also influencing downstream geomorphic processes and cold-water conditions vital for fisheries. These watershed-scale modifications ultimately seek to mitigate the effects of events induced by wet or dry climate conditions. However, as climate conditions change throughout the Russian River watershed, infrastructure and operational regimes must be reevaluated as well.

Understanding historical climate trends and how these conditions may evolve over the current century is vital to informing improvements to infrastructure, shifts in resource management, and subsequent planning efforts and analyses. This chapter explores historical climate conditions across the Russian River watershed and presents projected changes in temperature, precipitation, and associated watershed responses, including flooding, droughts, and wildfires.

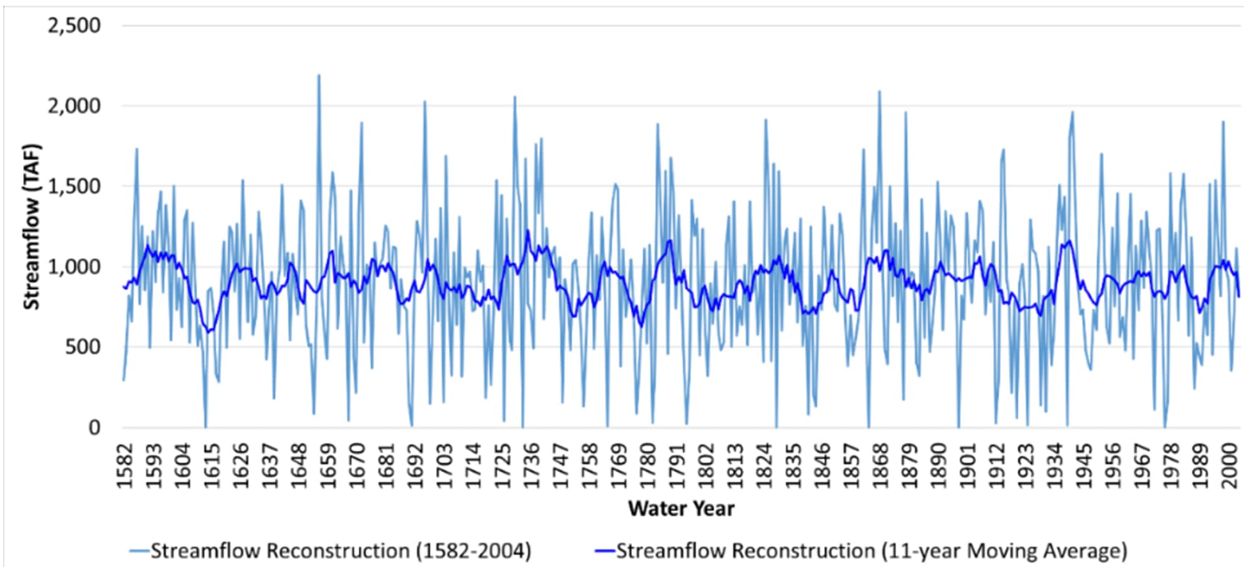
4.2 Historical Climate

Historical climate conditions can be viewed from two perspectives: large-scale trends in climatic observations and event-based, climate-driven hazards. Historical observations demonstrate how climate conditions, such as temperature, precipitation, and streamflow, have changed over the last century and beyond. Historical hazards, such as floods, droughts, and wildfires, offering insight into the frequency and magnitude of these events alongside historical observations.

4.2.1 Long-term Historical Trends

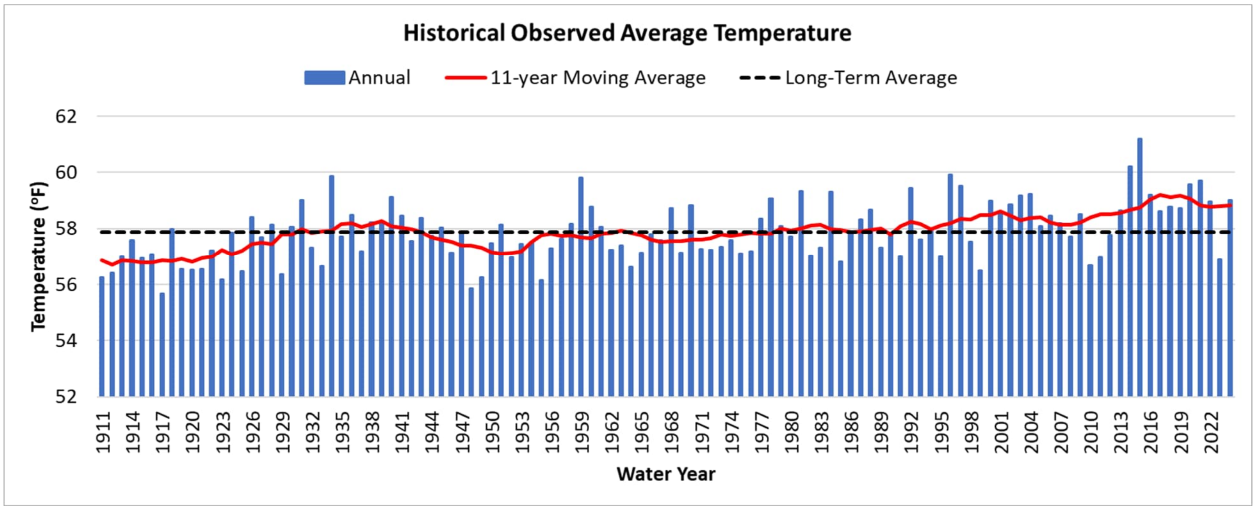
Reconstruction of streamflow in the Russian River using tree-ring records allow the historical record of streamflow to be extended back to 1582, providing a long-term perspective on hydrologic variability prior to the stream gage measurements (beginning in 1911). These streamflow reconstructions are based on correlations between annual tree ring-width patterns in moisture-sensitive tree species and observed streamflow, allowing estimation of past droughts, wet periods, and multi-decadal trends. The resulting 423-year record (1582 through 2004) captures a wide range of hydrologic extremes and enhances understanding of natural climate variability relevant to water-resource planning and resilience assessments (Woodhouse and Griffin 2008). The paleo-reconstructed period for the Russian River at Healdsburg between 1582 and 2004 (Figure 4-1) exhibits a median annual flow of about 897 thousand acre-feet (TAF), with a wide range of annual flows between 0 to 2,188 TAF, reflecting the natural historical climate variability in the watershed and episodes of both severe drought and major floods.

Figure 4-1. Paleo-reconstructed Total Flow for the Russian River at Healdsburg between 1582 and 2004



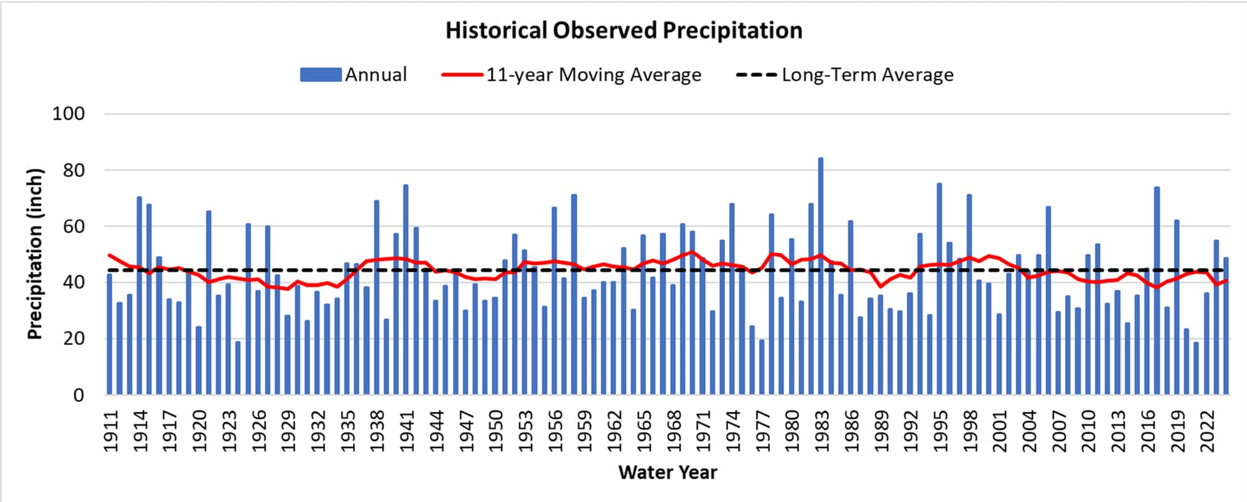
Historical measurements between 1911 and 2024 offer a more limited window into the history of the watershed, but provide higher precision for evaluating trends in temperature, precipitation, and streamflow for the Russian River watershed over the last century. Historical temperature and precipitation trends are evaluated using gridded historical meteorological data developed from daily station data and monthly data from the Parameter-elevation Regressions on Independent Slopes Model (Daly et al. 2008). Spatially averaged historical temperatures over the Russian River hydrologic watershed demonstrate a long-term warming trend, despite considerable year-to-year variability (Figure 4-2). Annual average temperatures fluctuate between 55 and 60 degrees Fahrenheit (°F), with cooler periods noted in the early and mid-1900's. The warmest years appear clustered after 2000, indicating that the Russian River watershed has experienced more frequent and sustained warm temperature conditions in the beginning of the 21st century.

Figure 4-2. Spatially Averaged Historical Average Temperatures between 1911 and 2024 over the Russian River Hydrologic Watershed



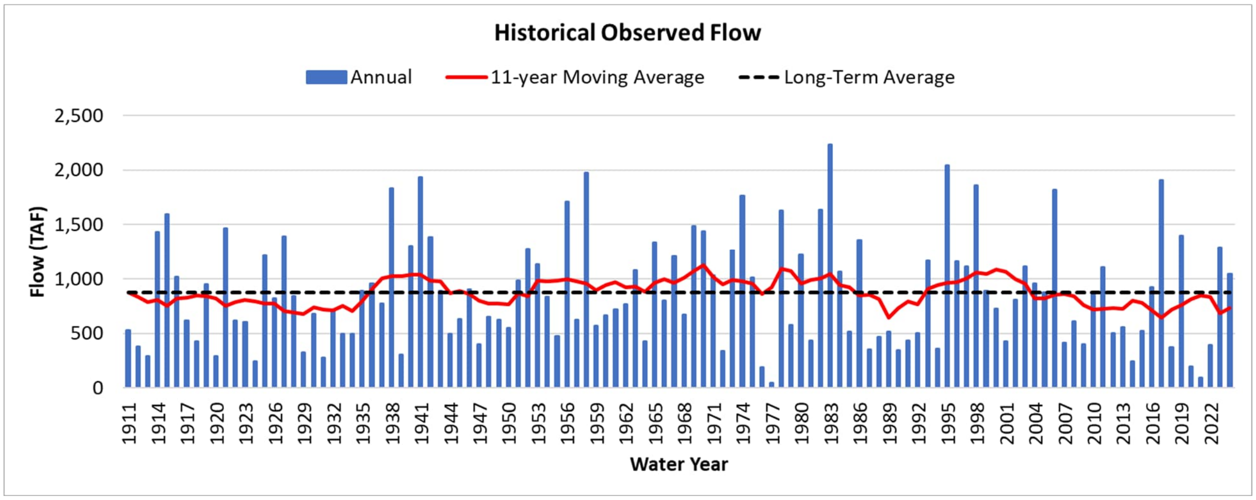
The spatially averaged historical precipitation record for the Russian River hydrologic watershed between 1911 and 2024 shows substantial interannual variability, characteristic of the highly dynamic climate within the region (Figure 4-3). Annual precipitation fluctuates widely for the watershed, with less than 20 inches of rainfall in extreme dry years to exceeding 70 inches in extreme wet years. Long-term trends highlight multi-decadal oscillations between wet and dry conditions, including a generally wetter period in the early 20th century that gradually transitions into drier conditions leading up to wetter years in the mid-century. In recent decades, precipitation trends show heightened variability rather than a clear trend, reflecting the increasing frequency of both very dry and very wet years.

Figure 4-3. Spatially Averaged Historical Precipitation between 1911 and 2024 over the Russian River Hydrologic Watershed



The historical record of observed total flow for the Russian River at Healdsburg (Flint et al. 2014) between 1911 and 2024 shows substantial interannual variability, closely reflecting the watershed response to swings in precipitation (Figure 4-4). Annual flows demonstrate a wide range of fluctuations from extremely dry years with less than 200 TAF to exceptionally wet years exceeding 2,000 TAF. In more recent decades, the flows at Healdsburg exhibit notable variability, but suggest no strong directional trend, mirroring the alternating patterns of severe drought and intense wet years that have characterized the early 21st century.

Figure 4-4. Historical Total Flow for the Russian River at Healdsburg between 1911 and 2024



4.2.2 Historical Hazards

The Russian River watershed has experienced major weather-related events in recent decades. Rising temperatures and greater variability in precipitation have contributed to more frequent and intense floods and wildfires, prolonged droughts, and significant disruptions to water resources and ecosystems. Figure 4-5 provides a timeline of a selection of significant climate-driven weather events following 1976. It is important to note that this figure does not convey the full range of historical hazard events over the last five decades; additional information is provided in Appendix G. Understanding these historic patterns is essential for identifying current vulnerabilities and developing effective resilience strategies.

Figure 4-5. Timeline of Selection of Historical Hazard Events

Year	Event	Sectors	Economic Damage
2020-2022	**Drought** Driest three-year period on record for California; record low reservoir levels in Sonoma County; severe water restrictions and 17% reduction in water use. Emergency drought regulations enacted, including curtailments of water diversions and modified reservoir releases to protect water supply for health, safety, and endangered fish species.	**Sectors:** Water supply, groundwater, agriculture, fisheries	Economic Damage: $148M crop revenue loss State/Federal Declarations issued
2020	**Glass Fire** Burned 67,484 acres across Napa and Sonoma counties. Destroyed 1,555 structures, including 334 homes in Sonoma County. Major impacts in eastern Santa Rosa and Sonoma Valley.	**Sectors:** Agriculture, water supply, public infrastructure, housing, air quality, water quality	Economic Damage: $3.1B in insured losses statewide Federal Declarations issued
2019	**Flood (February)** Russian River crested at 45.38 feet; widespread evacuations. Guerneville and Monte Rio were isolated due to flooding of transportation routes.	**Sectors:** Flood control, transportation, emergency response, housing, infrastructure	Economic Damage: $155M county-wide ($91.6M homes, $35M businesses, $23M infrastructure, $2.2M response) Federal Disaster Declaration issued
2018	**Mendocino Complex Fire (Ranch and River Fires)** Burned 459,123 acres, 280 structures and 1 fatality. Smoke impacts, evacuations, and air quality crisis region-wide.	**Sectors:** Forestry, agriculture, air quality, housing, public safety, vulnerable communities	Economic Damage: $56M insured property damage in Sonoma County Federal Disaster Declaration issued
2017	**Sonoma Complex Fires (Tubbs, Nuns, and Pocket Fires)** Burned over 110,000 acres; destroyed more than 6,900 structures and killed dozens of residents in Sonoma and Napa counties.	**Sectors:** Forestry, agriculture, air quality, housing, public safety, vulnerable communities	Economic Damage: $7.8B in damages across Sonoma and Napa counties State/Federal Declarations issued
2012-2016	**Drought** Driest four-year period on record for the watershed, with the two warmest years in state history.	**Sectors:** Agriculture, hydropower, forestry, recreation, ecosystems	Economic Damage: $1.6B-2B a year statewide Statewide drought emergency declared; multiple state and federal disaster declarations
2008	**Frost (Spring)** 2008 frost season was the worst in over 30 years, with freezing temperatures. Widespread use of water for frost protection in vineyards, led to drops in river flow. Combination of drought and frost led to fish stranding and death of juvenile coho and steelhead trout.	**Sectors:** Agriculture, water resources, ecosystems	Economic Damage: $156M in at-risk crops; up to $2.1B-$6.7B in lost business income if 10-30% crop loss region-wide State Frost Protection Regulation
1986	**Flood (February)** Record-breaking atmospheric river event caused Russian River to crest at 49.5 feet, the highest recorded level.	**Sectors:** Housing, recreation and tourism	Economic Damage: $89M in Sonoma County ($280M statewide) Federal Disaster Declaration issued
1976-1977	**Drought** The driest single year in California's measured hydrologic record occurred in 1977. Severe impacts to reservoirs and groundwater supplies; agricultural losses; increased reliance on emergency water sources.	**Sectors:** Agriculture, water utilities, rural communities, tourism	Economic Damage: $200M in Sonoma County ($3.5B statewide) Federal Disaster Declaration issued

4.2.2.1 Extreme Temperatures and Drought

The Russian River watershed is susceptible to rising temperature extremes. In addition to acute heat waves, chronic warming trends are evident: the region now experiences more days above 100 °F than in past decades and the majority of the top 10 hottest periods on record between July and September have occurred within the last 20 years (California Department of Insurance 2024). These rising temperatures impact crop productivity, human health, water quality, and stream temperatures that are necessary for aquatic species survival.

The Russian River watershed is also highly vulnerable to extreme drought, which poses significant challenges to both water availability and quality. Droughts in this region develop gradually over multi-year periods, with recent severe events occurring from 2012 to 2015 and 2020 to 2022, and historical droughts recorded in 1976 to 1977, 1987 to 1992, and 2007 to 2009. These droughts resulted in reduced reservoir storage, impaired streamflows, increased groundwater reliance, and losses for both the agricultural community and ecosystems.

4.2.2.2 Wildfires

The Russian River watershed has also experienced several significant wildfires in recent years, including the Mendocino Complex Fire, Kincade Fire, Sonoma Complex Fires, Walbridge Fire, and Glass Fire. Fire regimes have intensified in recent years due to fuel accumulation, invasive vegetation, hotter summers, and expansion of development into fire-prone areas. These events have had profound impacts on regional communities and the watershed, including impairments to water quality, destruction of infrastructure, and degraded ecosystems.

4.2.2.3 Extreme Precipitation and Flooding

All major Russian River floods in recent decades, including the catastrophic events of 1986, 1995, 2006, and 2019, have been linked to AR conditions, which account for over 99 percent of flood damages in Sonoma County (Sonoma Countywide Flood Risk Management Assessment 2024; CW3E 2021). AR-driven flooding represents the majority of economic flood losses in Sonoma County, historically exceeding hundreds of millions of dollars per event in documented cases (Corringham et al. 2019). Channel confinement, urban development, and the loss of conveyance capacity from sediment buildup has further exacerbated flood risk in the watershed.

4.2.2.4 Frost Events

Spring frost events pose significant risks to frost sensitive crops and fish habitat. The 2008 frost season caused large simultaneous water withdrawals for frost protection, reducing river flows and, resulting in widespread salmonid stranding and mortality. Subsequent regulatory and technological interventions, including off stream storage ponds, coordinated water demand management plans, and adoption of wind machines, have reduced, but not eliminated, frost-related hazards.

4.3 Projected Climate Conditions

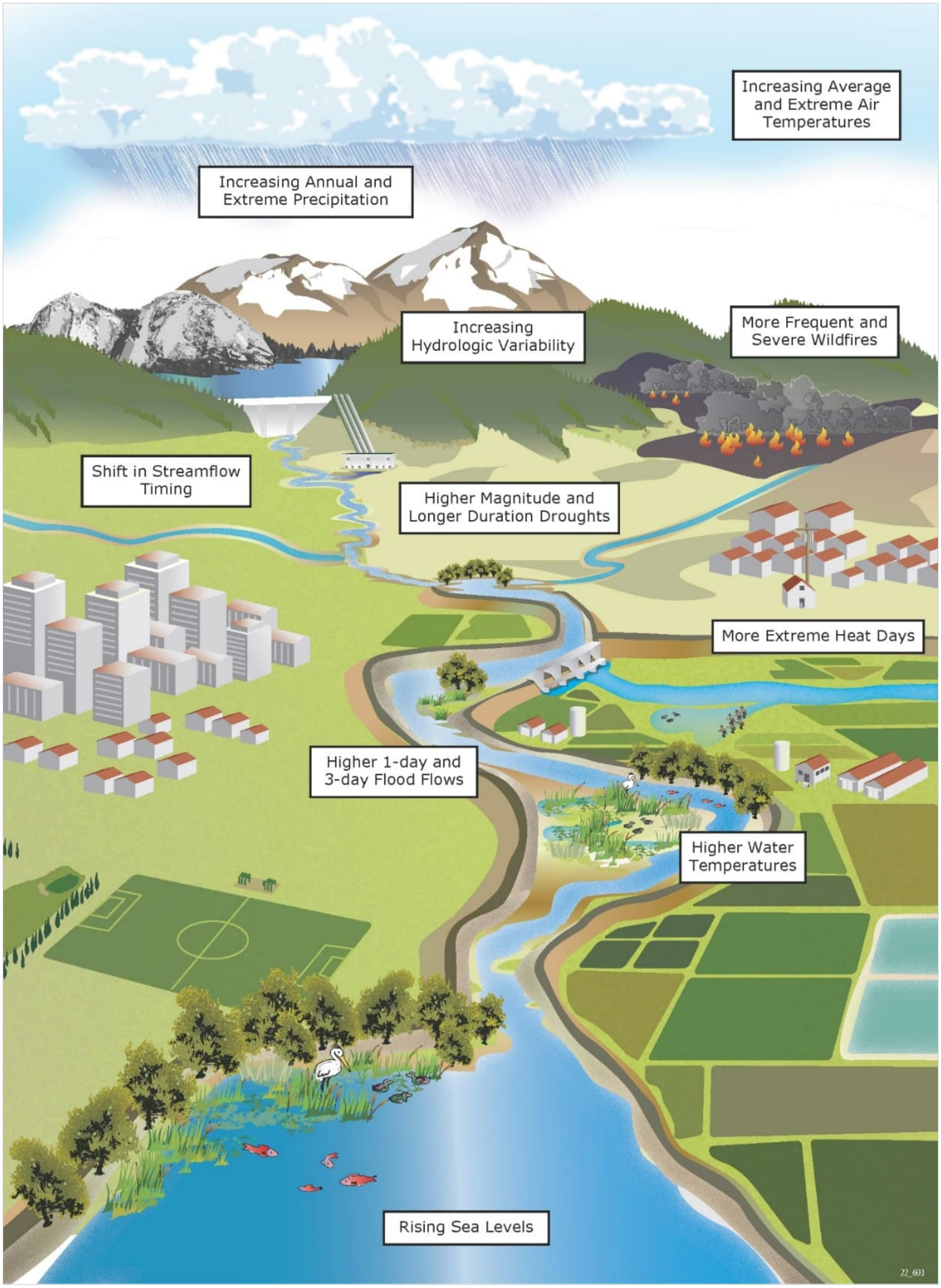
Future climate change is anticipated to affect the Russian River watershed in several ways as shown in Figure 4-6. Climate projections indicate that the following significant changes are likely to occur:

- Average and extreme temperatures will increase
- Extreme precipitation will increase
- Hydrologic variability, both seasonally and interannual, will increase
- Wildfires frequency will increase
- The number of extreme heat days will increase
- Extreme flood magnitudes will increase
- Water temperatures will increase
- Sea levels will rise

This section provides a summary of the future climate projections and the main drivers for future climate vulnerability in the watershed.

Evaluation of future climate conditions relies on a suite of global climate models (GCMs), large-scale representations of the Earth's climate systems that are used to simulate future conditions. The Russian River Watershed Resilience Pilot leverages Coupled Model Intercomparison Project Phase 6 (CMIP6) GCMs from the Sixth Assessment Report of the United Nations Intergovernmental Panel on Climate Change (IPCC 2021). CMIP6 also considers a set of Shared Socioeconomic Pathways (SSPs), scenarios used to investigate how global societal trends (population growth, economic trends, policy considerations, etc.) might influence future greenhouse gas emissions and subsequent changes in climate. To translate the coarse resolution of GCMs into higher resolution for regional applications, the Localized Constructed Analogs Version 2 Hybrid (LOCA2-Hybrid) dataset from Scripps Institution of Oceanography was used (Pierce et al. 2023), offering a 3-kilometer resolution over California with temporal coverage between 1950 and 2100. For this dataset, downscaling is performed using a selection of GCMs that best capture the relevant characteristics of the climate in California. In total, 41 distinct climate projections were generated to assess future climate conditions over the Russian River watershed. Projected changes in temperature, precipitation, and watershed responses are highlighted for mid-future (2041 to 2070) and late-future (2071 to 2100) conditions relative to a historical (1981 to 2010) period. Additional details on methodologies for evaluating future climate metrics are discussed in Appendix B.

Figure 4-6. Overview of Projected Climate Changes in the Russian River Watershed



4.3.1 Temperature

Future climate projections for the Russian River watershed indicate a substantial and consistent rise in average temperatures relative to the historical record (Figure 4-7). This warming trend is evident across all climate projections, though the magnitude varies by individual climate model projection. Across the planning area, annual average temperatures are projected to increase by 3.7 °F during the mid-future and 6 °F during the late-future relative to the historical reference value of 57 °F (Figure 4-8). Similarly, extreme heat days (days with maximum temperatures above 95 °F) are projected to increase by 17 and 32 days per year under mid-future and late-future conditions, respectively, as compared to the 15 days per year for the historical reference period. Higher temperatures and a greater prevalence of extreme heat days are expected to directly affect surface water supplies, groundwater supplies, and ecosystems by intensifying evaporation, increasing water demand, and reducing dissolved oxygen. Warmer temperatures may also play a role in future coastal fog dynamics, an important phenomenon that provides moisture to coastal ecosystems and communities during summer months. However, more research is needed to fully understand the complexities between shifting atmospheric and oceanic processes that drive the occurrence and characteristics of coastal fog (Dye et al. 2024; Grantham 2018; Ackerly et al. 2018).

Figure 4-7. Trends in Future Temperature Projections Relative to the Observed Historical Record

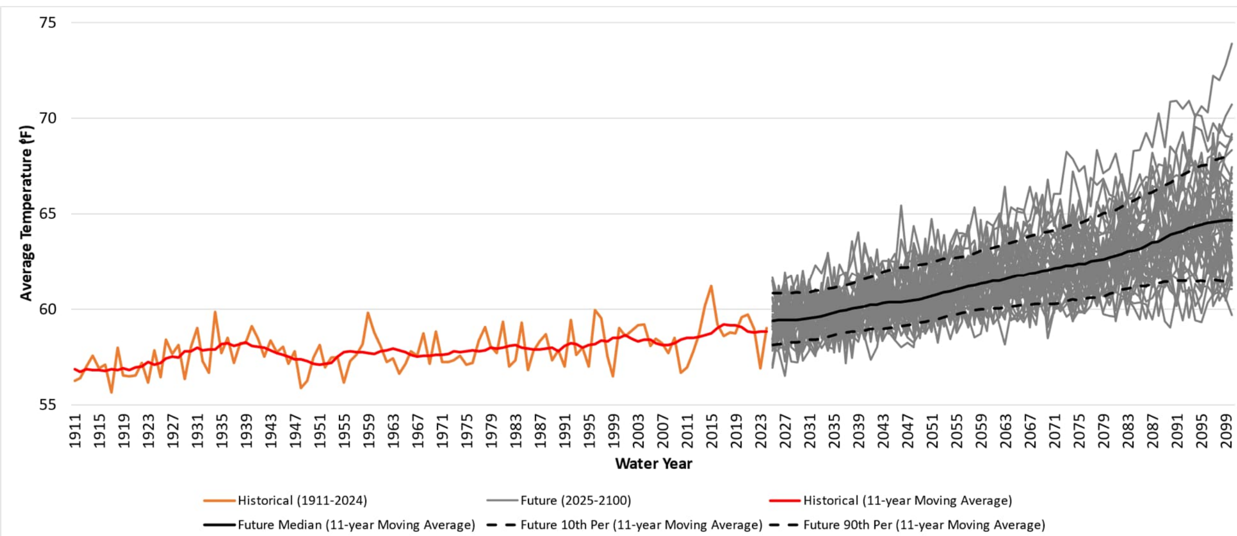
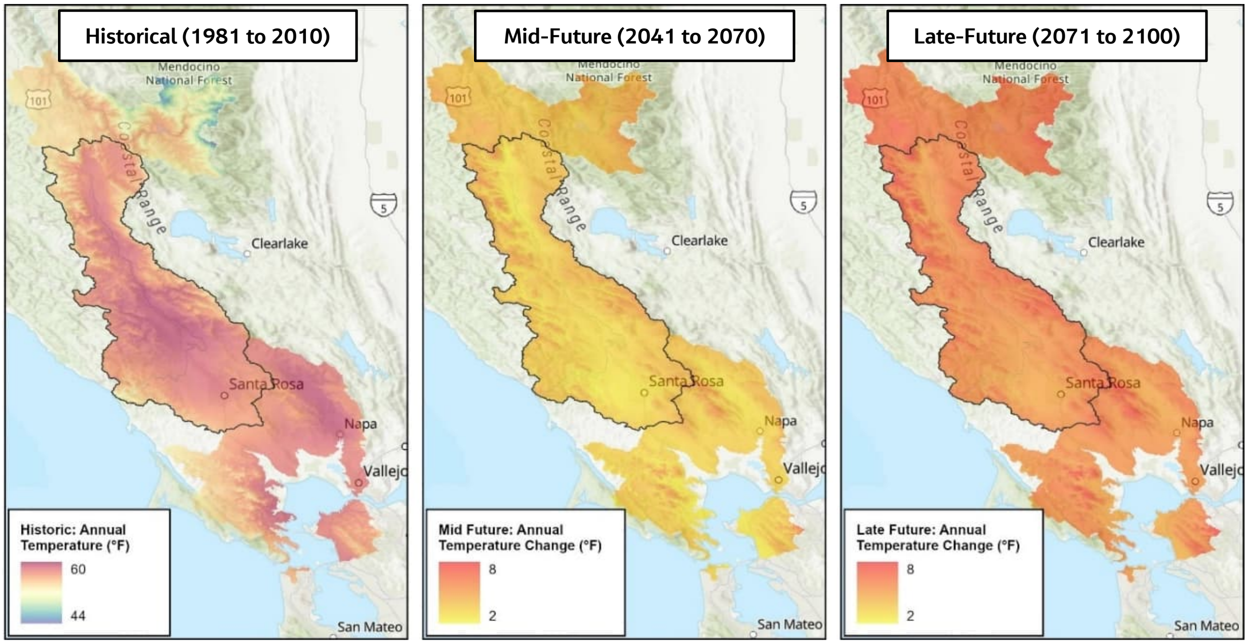


Figure 4-8. Change in Annual Temperature under Mid-Future (2041 to 2070) and Late-Future (2071 to 2100) Conditions Relative to a Historical Period (1981 to 2010)



4.3.2 Precipitation

Future climate projections for precipitation over the Russian River watershed continue to show variability between wet and dry conditions that are characteristic of the instrumental period, with the magnitude and frequency of these swings increasing over time (Figure 4-9). Spatially, total annual precipitation is projected to increase by 2.9 percent during the mid-future and 5 percent during the late-future as compared to the historical reference value of 43 inches (Figure 4-10). While climate projections for most of the Russian River watershed indicate an increase in annual precipitation quantities across most of the planning area, localized areas may experience declines in precipitation, highlighting spatial variability in climate responses. Changes in extreme (99^{th} percentile) daily precipitation demonstrates similar trends, with increases of 6 and 17 percent under mid-future and late-future conditions, respectively. Increases in extreme precipitation are likely to be driven by higher magnitude ARs fueled by warmer temperatures and higher evaporation over the Pacific Ocean. These changes have implications for flood management, surface water supplies, groundwater recharge, hydropower production, recreation, and ecosystem health, each of which is sensitive to variability in annual and extreme precipitation patterns.

Figure 4-9. Trends in Future Precipitation Projections Relative to the Observed Historical Record

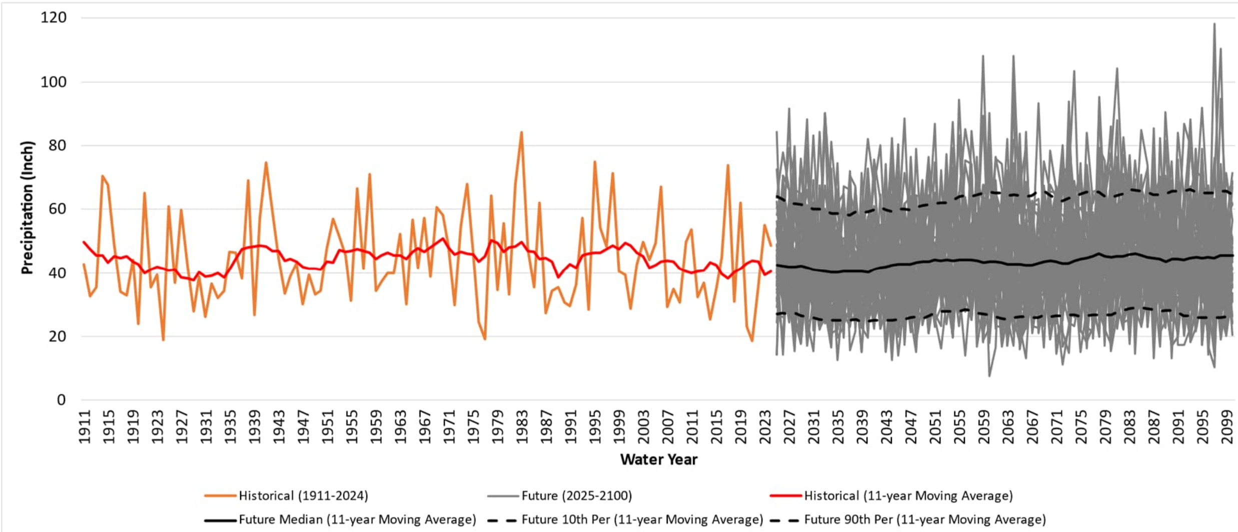
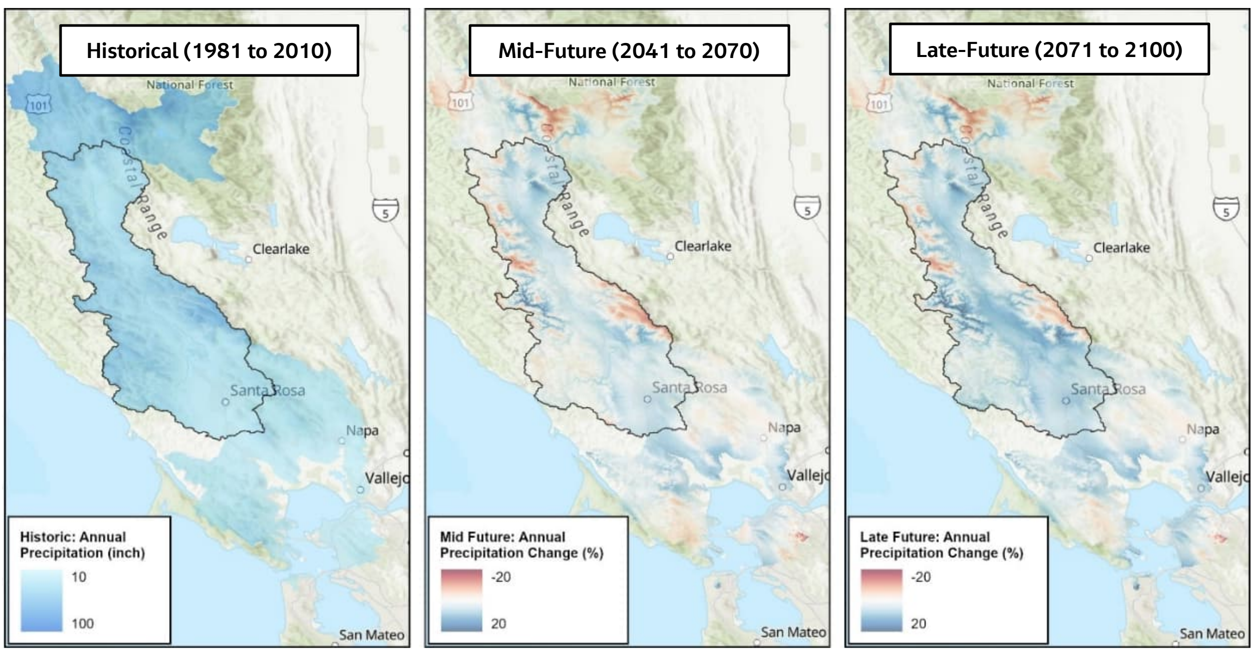


Figure 4-10. Change in Annual Precipitation under Mid-Future (2041 to 2070) and Late-Future (2071 to 2100) Conditions Relative to a Historical Period (1981 to 2010)



4.3.3 Sea Level Rise

Sea levels in the Pacific Ocean influence conditions in the lower Russian River watershed, altering the hydrology of the Russian River Estuary and the quantity of suitable habitat for aquatic species in this area. Since 1975, the Russian River watershed (measured at Point Reyes) has experienced 0.35 feet of sea level rise (NOAA 2026). Melting ice sheets and glaciers as well as the thermal expansion of seawater associated with increased global temperatures are the primary causes for increase in global mean sea levels in the past century. Development of sea level rise projections is typically performed by incorporating SSPs to model the physical processes associated with sea level rise. Under future conditions, the Russian River watershed (modeled at Point Reyes) could experience further rise in sea level of between 0.8 to 1.3 feet by 2050, and 3.1 to 6.6 feet by 2100 (California Ocean Protection Council 2024).

4.3.4 Watershed Responses

Climate projections represent trajectories of temperature and precipitation changes over the planning area, but do not characterize watershed-specific responses to climate change. As temperature and precipitation patterns evolve under future climate conditions, the Russian River watershed responds to these shifts through changes in runoff volumes, the timing of peak flows, evaporative demands, and more. To understand these considerations under future climate conditions, a hydrologic model must be used. The Russian River and Upper Eel River Basin Characterization Model (BCM) was developed by USGS in 2009 and serves as a regional water balance model that simulates unimpaired streamflows and evapotranspiration under historical and future climate conditions. Outputs from the BCM are discussed below; in some cases, alternative datasets are considered to characterize future conditions. Additional information on the BCM and other datasets utilized for this evaluation are provided in Appendix B and Appendix C.

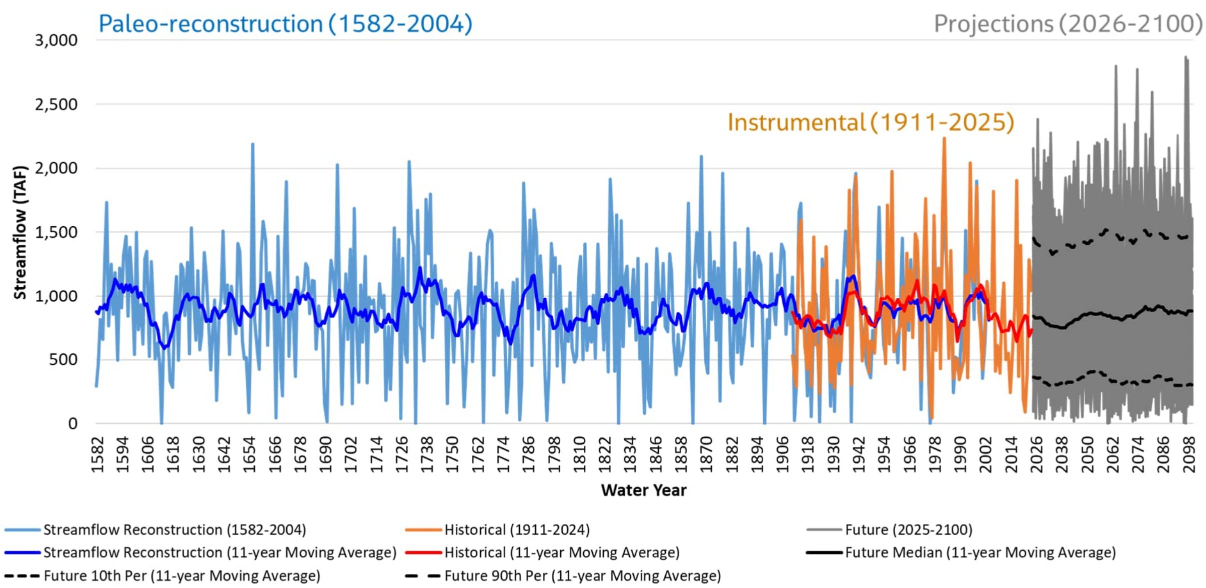
Responses from the Russian River watershed to shifts in temperature and precipitation patterns vary spatially, temporally, and across individual simulations of future conditions. At a high level, the following watershed-scale conclusions have been identified through evaluation of these conditions:

- **Extreme Conditions:** Future projections for temperature and precipitation both indicate a higher frequency and magnitude of extreme conditions, with a rising number of annual extreme heat days and more severe occurrences of heavy rainfall. These shifts in extreme conditions are the primary drivers for several climate-induced hazards, including droughts, wildfires, and flooding, that have dramatic, potentially long-lasting impacts on the Russian River watershed and its communities. As such, the frequency of these events is likely to increase as future climate conditions worsen.
- **Soil Moisture:** As temperatures continue to rise across the Russian River watershed, soil moisture is projected to decrease and conditions become increasingly dry. Drier conditions have implications for ecosystem health, wildfire susceptibility, groundwater recharge, and soil stability, with drier soils reducing the resilience of vegetation and increasing the potential for erosion.
- **Climatic Water Deficit:** Climatic water deficit is a measure of unmet atmospheric evaporative demand. As conditions become warmer and drier, the atmospheric water demand increases and the availability of moisture to meet this demand decreases. As such, future trends indicate an increase in climatic water deficit, intensifying stress for species and habitats and elevating the potential for water supply and landscape drought conditions.
- **Runoff:** Despite increases in total annual precipitation, total annual runoff is projected to decrease slightly by mid-century relative to historical conditions. This discrepancy is primarily driven by increases in evaporative demand and reductions in soil moisture across the watershed, resulting in a greater quantity of losses to infiltration and evaporation. Reductions in runoff reduce the reliability of surface water supplies, opportunities for groundwater recharge, and sufficient flows for ecosystems. By the late-century, a small increase runoff is projected relative to historical conditions, potentially providing water supply benefits depending on the timing and magnitude of flows.
- **Streamflow Timing:** The timing of streamflow has important implications for water supply, flood management, and ecosystems. Shifts in precipitation patterns indicate a consolidation of streamflow to earlier in the year, with reductions in flows in the fall, spring, and summer. This results in higher peak flows and a greater overall volume of surface water during the wet season. Shifts in precipitation and peak flows to earlier in the season can also present challenges for reservoir operations within the watershed.

4.3.4.1 Drought

Paleo-reconstructed flows for the Russian River at Healdsburg show large natural variability, characterized by repeated multi-decadal wet and dry periods and a long-term average that broadly resembles the modern historical record (Figure 4-11). The instrumental period captures most of this variability with improved precision and includes several occurrences of extreme drought and flood events. While future climate projections indicate a continuation of year-to-year variability, greater magnitudes for very wet and very dry years are noted. These trends suggest an increase in hydrologic volatility under a changing climate and a higher potential for more frequent extreme events, some of which may exceed the events highlighted in the historical variability over the last several centuries.

Figure 4-11. Total Flow for the Russian River at Healdsburg for Paleo-reconstructed Records (1582 to 2004), Historical Observations (1911 to 2025), and Future Climate Projections (2026 to 2100)



For drought events, paleo-hydrologic reconstructions reveal that the Russian River watershed has historically experienced droughts of both greater duration and magnitude than those captured in the instrumental record. While the 1976 to 1977, 1988 to 1992, and 2020 to 2022 droughts remain among the most severe short-duration droughts in recent history, the paleo record highlights longer, multi-decadal drought episodes, most notably the prolonged drought of 1610 to 1619, indicating that the watershed is climatically predisposed to extended dry periods (Figure 4-12). These reconstructed patterns broaden the understanding of natural variability and provide context for assessing future drought risk under climate change.

In comparison to future climate projections, an increase in both the severity and duration of drought events in the Russian River watershed relative to historical conditions is noted (Figure 4-13). Future droughts are expected to exceed historical events in terms of cumulative deficit, duration, and frequency, with more sustained multi-year droughts becoming increasingly common. These projected changes reflect the combined influence of higher ambient air temperatures, higher variability in precipitation patterns, and earlier seasonal drying. These findings underscore the increasing vulnerability of water supplies, ecosystems, and hydrologic reliability as drought conditions intensify over the 21st century.

Figure 4-12. Drought Severity and Duration estimated from Natural Flows for the Russian River at Healdsburg over the Paleo-reconstructed Period (1582 to 2025)

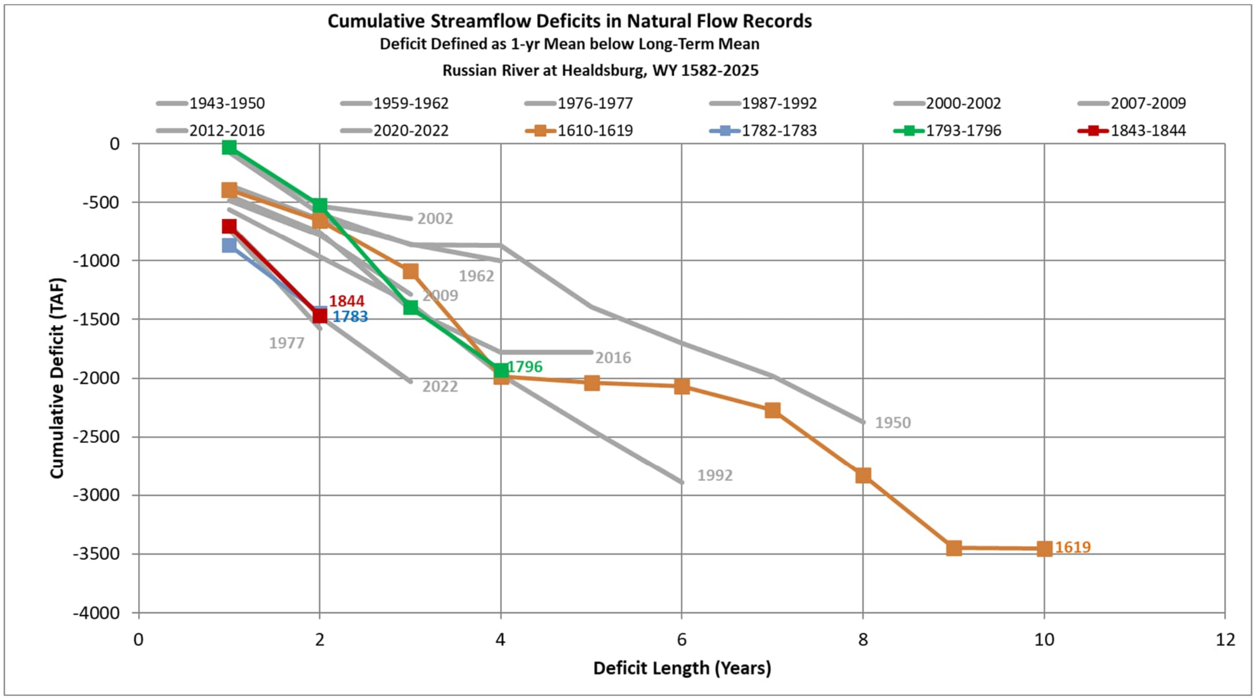
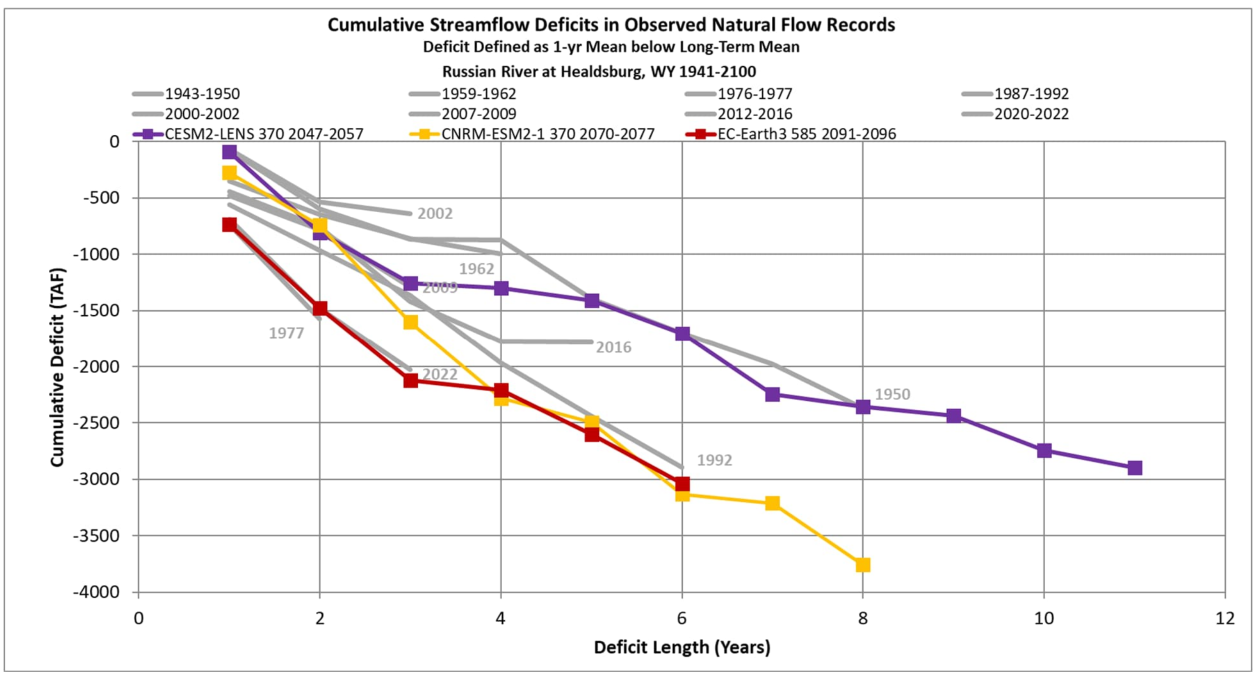


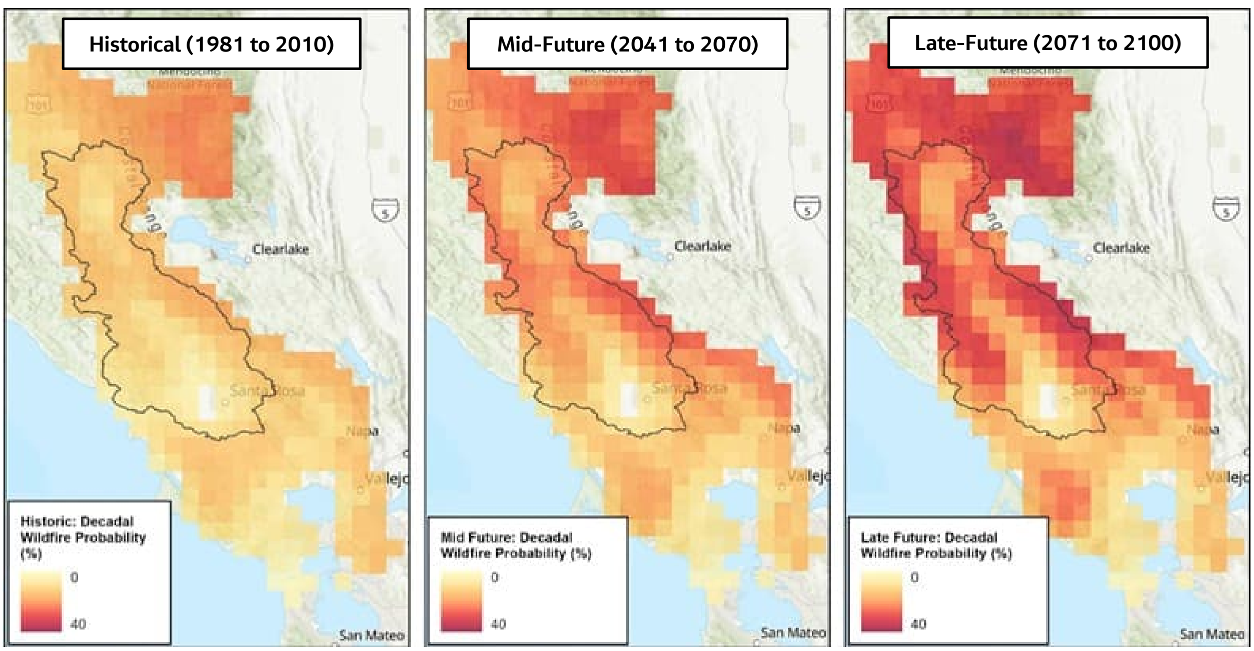
Figure 4-13. Drought Severity and Duration estimated from Natural Flows for the Russian River at Healdsburg under Future Climate Projections (1941 to 2100)



4.3.4.2 Wildfires

While the historical record has shown both periods of extreme wet and dry conditions, assessment of the frequency and magnitude for potential weather-driven events is important for evaluating the inherent risk faced by the Russian River watershed and informing areas where improvements and strategies are needed. Beyond increases in drought severity and duration, rising temperatures, higher climatic water deficit, decreased soil moisture, and localized reductions in runoff intensify the prevalence of drier conditions across large swaths of the watershed, particularly in regions that do not display in increase in annual precipitation volumes. These conditions are projected to result in increases in both the frequency and severity of wildfire events. As such, the probability of a wildfire occurring each decade is projected to rise by 18 percent by the mid-future period and 22 percent by the late-future period relative to historical conditions (Figure 4-14). Heightened risks of wildfires pose threats to ecosystems, water quality, flooding, and regional communities.

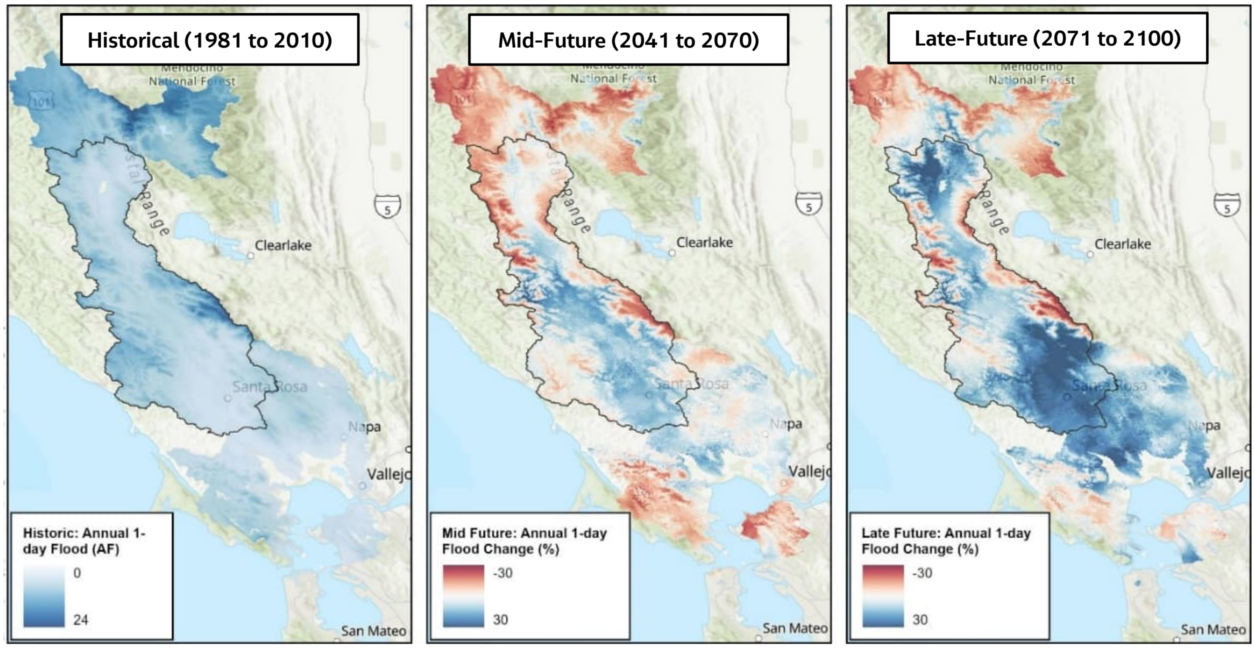
Figure 4-14. Change in Decadal Wildfire Probability under Mid-Future (2041 to 2070) and Late-Future (2071 to 2100) Conditions Relative to a Historical Period (1981 to 2010)



4.3.4.3 Flooding

Consistent with increases in extreme precipitation across the Russian River watershed, peak 1-day flood magnitudes are projected to increase by 1 percent under mid-future conditions and by 8.6 percent under late-future conditions (Figure 4-15). Projected changes for 3-day flood magnitudes are slightly lower, with estimated increases of 3.5 and 8.1 percent for the mid-future and late-future periods, respectively. Although 1-day and 3-day flood flows generally increase across the majority of Russian River watershed, several sub-regions, particularly on the western and eastern extents of the planning area, exhibit decreases in these metrics under future conditions. Changes in 1-day and 3-day flood magnitudes are largely driven by increases in extreme precipitation under future conditions. As such, spatial patterns of change resemble those of precipitation, with the most pronounced increases occurring in the southern portion of the watershed.

Figure 4-15. Change in 1-Day Flood Magnitudes under Mid-Future (2041 to 2070) and Late-Future (2071 to 2100) Conditions Relative to a Historical Period (1981 to 2010)



4.4 Summary

Over the coming decades, the Russian River watershed is projected to experience increases in average ambient air temperatures, a greater number of extreme heat days per year, and a higher frequency and magnitude of extreme precipitation events. Ultimately, hydrologic variability is anticipated to increase, with more frequent swings between dry and wet periods. These shifts are projected to alter conditions across the watershed and exacerbate many of the historical hazards that have affected the region over the last century, including droughts, wildfires, and flooding, resulting in more common and more severe occurrences of these events. Understanding the sensitivities and adaptive capacities and identifying the associated vulnerabilities to these changes for the built and natural systems throughout the Russian River watershed is vital to informing future strategies to adapt to and mitigate impacts.