

Appendix B
Historical Hazards

DRAFT



RWA Watersheds Historical Hazards Technical Memorandum

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1. Purpose and Scope

This technical memorandum summarizes significant historical weather-related hazards in the American River Watershed (ARW). The purpose of preparing a summary of historical weather-related hazards is to provide context and understanding for vulnerabilities in the watershed that are likely to be exacerbated by climate change. This technical memorandum summarizes the most significant historical weather-related events that could be identified from a review of publicly available sources. The weather-related events are organized according to the type of hazard, including extreme precipitation and flooding, wildfire, extreme heat, and drought.

2. Key Weather-Related Events and Impacts in the Watershed

The ARW faces a clear trend of growing climate hazards, primarily driven by increasing temperatures and shifting precipitation, leading to more intense floods and wildfires, prolonged droughts, and significant alterations to water resources and ecosystems (DWR 2024, ARBS 2022). Table 1 overviews some of the major weather-related events that have impacted the ARW over the past decade. A full matrix of the events that were compiled for this assessment is also submitted with this memo.

Table 1. Significant Weather-Related Events

Event Name	Impact	Sectors Affected	Economic Damage	Declaration
2023 Sacramento County Flood	Widespread flooding, property damage, and at least 22 fatalities. About 200,000 homes and businesses lost power. 6,000 individuals were ordered to evacuate. Parts of Sacramento almost had catastrophic flooding after pumping plants lost power.	Flood control, transportation, emergency response, water infrastructure, housing, agriculture	\$3B Statewide	State of Emergency
October 2021 Atmospheric River Storms	Precipitation totals: 5 – 12 inches in 24 hours in northern Sierra and Central Coast mountains; some locations received >15 inches total.	Flood control, transportation, emergency response, water infrastructure, housing, agriculture	>\$300M in CA and Pacific Northwest based on insurance losses	State of Emergency proclaimed for 16 counties
February 2019 Atmospheric River Storms	Brought record-breaking rainfall to the ARW, causing flooding, landslides and infrastructure damage. Rapid runoff led to high river flows, prompting Folsom Dam releases to prevent major flooding.	Flood control, transportation, emergency response, water infrastructure, housing, agriculture	\$1.1B (annual average for Atmospheric Rivers in CA)	Governor State of Emergency
January – February 2017 Atmospheric Rivers	Widespread flooding, infrastructure damage. The Cosumnes River reached its second-highest peak flow in recorded history. Sacramento received 192% of normal wet-season rainfall. Multitude of atmospheric river events that occurred in winter (Dec – Feb) of 2017 resulted in record seasonal precipitation for the Northern Sierra 8-station index.	Flood control, transportation, emergency response, water infrastructure, housing, agriculture	\$1.55B (Oroville Dam crisis alone >\$1B)	State of Emergency
2020-2022 Drought	Reduced water supply, economic impacts. Directly cost the California agriculture sector about \$1.1 billion and nearly 8,750 full- and part-time jobs. The 2022–2023 water year saw statewide precipitation at 141% of average from October 2022 – April 2023, a significant increase from the previous year.	Water supply, groundwater, agriculture, fisheries, urban conservation, vulnerable communities	\$3b ((2021: \$1.3B + 2022: \$1.7B)	State Drought Emergency
2012-2016 Drought	Severe impacts on water supply reliability, affecting agriculture, urban water use, and environmental flows in the American River. Folsom Reservoir dropped to a record low of 135,000 acre-feet in December 2015.	Water supply, groundwater, agriculture, fisheries, urban conservation, vulnerable communities	\$2.7B (2016 alone; higher cumulative multi-year losses)	State Drought Emergency

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Event Name	Impact	Sectors Affected	Economic Damage	Declaration
2021 Caldor Fire	Burned 221, 000 acres, leading to increased erosion, sediment runoff, in South Fork American River and Cosumnes River.	Forests, air quality, water quality, public safety, utilities, recreation, vulnerable communities, housing	\$14.7B in estimated long-term losses, according to El Dorado County	Presidential Emergency
2022 Mosquito Fire	Largest wildfire in 2022, burning over 76,000 acres in Placer and El Dorado counties.	Forests, air quality, water quality, public safety, utilities, recreation, vulnerable communities, housing		State of Emergency
September 2022 Heat Wave	Record-breaking temperatures, increased mortality. \$19 million in hospitalization costs related to heat related illnesses.	Energy, public health, agriculture, vulnerable communities, emergency response	\$7.7B (statewide, all heat events; September 2022 likely a major share)	State of Emergency
August 2020 Heat Wave	Statewide extreme heat, power outages.	Energy, public health, agriculture, vulnerable communities, emergency response	\$2 – 3B (statewide; includes economic losses from blackouts, grid strain, and wildfire ignitions)	State of Emergency

3. Extreme Precipitation and Flooding

The ARW has a long history of flooding and extreme precipitation events driven by a combination of atmospheric rivers, intense winter storms, and snowmelt. The watershed has continued to experience significant flooding, such as the 2017 and 2023 flood events, which have further stressed the flood management infrastructure. In 2017, atmospheric rivers produced nearly a quarter of California's annual precipitation in just six days, with events in January and February contributing significantly to record-breaking flooding. Levee breaches have been a recurring issue during major floods, particularly along the lower American River and tributaries like the Cosumnes River. These failures have led to extensive flooding in urban areas, such as Sacramento and surrounding communities. Major events included:

- **Early 2023 Bomb Cyclones:** In January 2023, a series of atmospheric rivers caused significant flooding across California, with economic costs estimated at \$5 to \$7 billion. Communities in the ARW were flooded while under an active statewide drought emergency. The storms exceeded the design capacity of local stormwater systems, leading to major localized flooding and property damage.
- **February 2019 Atmospheric River Storms:** These storms brought record-breaking rainfall to the ARW, causing flooding, landslides, and infrastructure damage. Rapid runoff led to high river flows, prompting Folsom Dam releases to prevent major flooding.

Levee breaches along the lower American River and tributaries, like the Cosumnes River, are recurring issues because of aging infrastructure and lack of upstream reservoirs. Folsom Dam, while critical for flood control, has been overwhelmed during extreme events, exposing its limited capacity relative to runoff volumes. The increased early season runoff, resulting from more precipitation falling as rain and earlier snowmelt, has increased flood risks along the lower American River, particularly in the heavily populated urban areas of Sacramento where further setback levees are not feasible.

4. Wildfire

Wildfire has been a significant historical and ongoing factor shaping the ARW and the broader Sierra Nevada region, with impacts ranging from ecological processes to human infrastructure and health. Decades of aggressive fire suppression have contributed to denser forests and a buildup of fuel, leading to adverse effects on snowpack retention and increased wildfire threats.

Much of the upper (UARW) is classified as being in "very high" or "high" Fire Hazard Severity Zones. Over half a million acres have burned in the UARW since 2000, with the Caldor and Mosquito fires accounting for much of the damage in 2021 and 2022, as detailed:

- **Caldor Fire (2021):** This fire burned approximately 221,835 acres across El Dorado, Alpine, and Amador counties, including large portions of the Eldorado National Forest. The fire destroyed 1,003 structures and damaged 81 others, leading to the evacuation of over 50,000 residents. Severe erosion from the fire impacted water quality in the South Fork of the American River and posed long-term risks to Lake Tahoe's watershed. The fire burned for 69 days and required extensive firefighting efforts to defend critical areas like the Lake Tahoe Basin. Runoff from the burn scar of the Caldor Fire, exacerbated by subsequent extreme precipitation events in early 2023, led to degraded water quality, which impacted surrounding watersheds, including the ARW.
- **Mosquito Fire (2022):** This was the largest wildfire in California for 2022, burning over 76,000 acres in Placer and El Dorado counties. The fire started on September 7, 2022, and was contained by October 22, 2022.

- **King Fire (2014):** This fire burned approximately 97,000 acres, including large portions of the Eldorado National Forest, causing severe erosion that affected water quality in the South Fork of the American River.

Both fires combined have caused an estimated \$14.7 billion in losses to ecosystem goods and services in the UARW, including long-term ecological damage and carbon emissions. The 2014 King Fire in the UARW shows that fire-scarred landscapes are slow to recover, with an 86% reduction in value from forestland to shrubland in ten years (Soares, Batker, & Batker-Pritzker, 2025).

5. Extreme Heat

Extreme heat in the ARW contributes to ecosystem degradation through multiple, interconnected pathways, primarily by directly stressing aquatic life via increased water temperatures and reduced dissolved oxygen, intensifying drought conditions that harm terrestrial and aquatic habitats, increasing the frequency and severity of damaging wildfires, and altering natural streamflow patterns essential for ecosystem health. Some of the recent extreme heat events are listed below:

- **September 2022 Heat Wave:** This heat wave brought record-breaking temperatures, with Sacramento reaching 116°F on September 6. It cost \$600 million in impacts on the economy, including agriculture and manufacturing. This heat wave had the largest cost impact, over \$3 billion, much of which is attributed to premature mortality impacts.
- **August 2020 Heat Wave:** This heat wave had temperatures 10 to 20°F above normal, affecting more than 8.6 million people.
- **2017 California Central Valley Heat Wave:** This heat wave affected over 8.6 million people, with associated costs of \$798 million. Impacts included:
 - Sacramento County: 16,166 excess emergency room visits (5 times the baseline), with disproportionate impacts on outdoor workers
 - El Dorado County: South Fork American River flows dropped to 15 percent of average, requiring emergency fish rescues

The anticipated temperature increases in the American River Basin are projected to fundamentally alter hydrological patterns, with cascading impacts on water management and ecosystems. The American River Basin Study projects that climate change will further intensify these challenges. By the end of the century, summer temperatures are expected to rise by up to 7.3°F, with peak runoff shifting from March–May to December–March, due to earlier snowmelt and increased rainfall. This shift will strain Folsom Reservoir's limited storage capacity, forcing earlier water releases for flood control and reducing availability for dry-season supply. These changes also will elevate water temperatures in the lower American River, threatening critical fish habitats during spawning seasons. The September 2022 event exemplifies these challenges, with Sacramento reaching 116°F and the highest increases in deaths among people aged 25–64, Hispanic Californians, and of the South Coast region. Governor Gavin Newsom proclaimed a state of emergency for Riverside, El Dorado, and Placer counties due to the Fairview and Mosquito fires.

6. Drought

The American River as a water source, including its inflow to Folsom Reservoir, makes the watershed vulnerable to drought-related water shortages affecting agriculture and other sectors. The ARW has experienced significant droughts, notably those during 2012–2016 and 2020–2022:

- The 2012–2016 drought reached its peak in 2014 and 2015, with Folsom Reservoir dropping to a record low of 135,000 acre-feet in December 2015. This led to increased groundwater extraction, causing land subsidence in nearby areas. These were the driest four consecutive water years on record for statewide precipitation. The longest drought in modern California history severely impacted Folsom Reservoir levels and the lower American River. Water shortages affected fish populations, such as Chinook salmon and steelhead trout, which rely on adequate flows and temperatures for survival.
- The 2020–2022 drought saw conditions approaching Conference Year levels (i.e. a baseline hydrologic year used for planning and modeling water availability) in 2021, with unimpaired inflow to Folsom Lake reaching 674,000 acre-feet and a significant increase in dry wells statewide; 1,200 dry wells were reported in 2022, a 50% rise from the previous year. The Sacramento Valley faced unusually dry conditions, leading to water right curtailments and reduced Central Valley Project deliveries, including unprecedented cutbacks to senior contractors¹⁰. These drought events caused significant economic losses, with the Sacramento Valley losing about 11% of crop revenues in 2021.

Changes in snowpack and altered runoff timing are anticipated to impact the volume and timing of water entering Folsom Reservoir, which is crucial for regional water supply. The 2012–2016 drought in the ARW exposed significant vulnerabilities, particularly for small rural water systems and private wells experiencing drinking water shortages. This prolonged dry period exacerbated existing water management challenges, including bank erosion, the need for riprap revetments, and channel degradation. Increased pressure on groundwater resources is also anticipated as droughts become more severe and frequent. The American River Basin Study (ARBS, 2022) suggests that to compensate for diminished snowmelt and runoff, the region may need to increase groundwater pumping by up to 155,000 acre-feet annually. The drought has also increased wildfire risk, degraded forest health, and put native species, like Chinook salmon, at greater risk due to warmer, lower river flows. Prolonged dry spells have degraded forest health, weakening trees and making them more vulnerable to pests and disease, which further exacerbates the risk of large-scale tree die-offs.

7. References

American River Basin Study (ARBS). 2022. American River Basin Study. Prepared in collaboration with the U.S. Bureau of Reclamation and regional water agencies. https://docs.pcwa.net/american-river-basin-study-2022_08.pdf.

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