Wildfire Impacts on Water Delivery in Southern California
Research Summary (completed November 2022)

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Executive Summary

This report details our efforts to assess the effects of wildfire on water supply in Southern California, focusing in particular on impacts to Municipal Water Districts (MWDs) that are members of the Southern California Metropolitan Water District (Fig. 3) plus Santa Barbara and Montecito MWDs in the north. We interviewed 25 people from 19 different organizations. The assumption before undertaking the study was that wildfire related costs would be dominated by the cost of water treatment for residential use. However, interviews with staff from the MWDs reported three main types of wildfire related costs: (i) damage to water delivery infrastructure and buying water until repairs were made; (ii) water-related expenses during active fire suppression; and (iii) prevention and preparedness related costs.

Past exposure of MWDs to wildfire varied substantially depending on location relative to forest, topography, reservoir design, and location of water storage resources and delivery infrastructure. For example, highly urbanized districts such as Central Basin MWD have much less exposure than districts such as Las Virgenes or Calleguas that include significant areas of wildland. As a result, costs varied from predictable moderate annual costs in thousands of dollars range to control weeds and combustible vegetation to multimillion-dollar costs (up to $18 million) for revegetation and infrastructure repair following destructive wildfires, such as experienced in the Harris, Thomas and Woolsey Fires.

Interviews with MWD personnel revealed that many districts have limited ability to account for wildfire-related costs. That is, there may be expenditures in response to wildfire impacts, but cities or MWDs may not bill costs or have a specific budget code that refers to wildfire-related costs *per se*. As a result, tracking such costs is difficult. However, the lack of accounting structure and established ways of dealing with wildfire costs is changing. The potentially high cost of wildfire damage coupled with the increasing size and frequency of wildfires has created a need to apply for state or federal disaster reimbursement funds, consequently requiring a process to track associated costs. As such, a number of the districts interviewed had recently created or were in the process of creating a wildfire or emergency response liaison/manager position to deal with these issues, as well as to manage preventative measures.

In addition to direct wildfire damage-related costs such as repairing pipes and pumps, MWDs also incur costs related to wildfire suppression. These costs can be hidden or hard to estimate. Water districts often provide firefighters with all the water at their disposal during active suppression events. Such water use may not be metered, however, so districts may not have cost estimates for providing such support. Calleguas MWD, for example, allowed firefighting aircraft to pull water from Lake Bard, a surface reservoir that they own and operate, for the Woolsey and Easy Fires in 2018 and 2019,

respectively. While the amount of water used for such operations is not necessarily minimal, it is negligible in terms of annual water loss.

Wildfire preparedness and prevention costs are another category of MWD expenditures that may be hidden or hard to ascertain. Costs such as buying generators for back-up power supply can be in the hundreds of thousands of dollars. A generator, however, provides power security against any number of possible natural events (e.g., storms) or human-caused outages (e.g., power grid brown- and black-outs), and may thus understandably not be designated as a wildfire-related expense. Likewise, the justification and benefits of a vegetation control programs may not be designated as or limited to wildfire risk mitigation. They are nevertheless responding to specific wildfire-related vulnerabilities, such as reducing fuels and protecting water resources and infrastructure. For example, Calleguas MWD estimates that it has spent approximately $130K per year over the last three years on vegetation management and weed abatement, primarily to reduce wildfire risk exposure.

Through these interviews, we have attempted to compile the best available data on wildfire related costs impacting water resources. A key intention for these data is to try to assess the impacts of wildfire to help inform resource management decisions. For example, what are the different vegetation management options around reservoirs, how much do they cost, and how do those costs compare to past erosion-related damages following wildfires? Also, MWDs that are considering purchasing an alternative power supply in the case of electrical outages caused by wildfire can use this study to see which districts have made such purchases, how much it cost, and then contact those districts to get a first-hand report of how well these power supplies have worked out. Elsewhere, an MWD close to forested lands may want to know details about the support other MWDs provided to wildfire suppression efforts in the past. Such information could help them plan for having both the water capacity and the budget to provide such support. Our report provides answers to the questions above, as well as detail on other wildfire-related costs that water suppliers in Southern California have incurred. Although we have spoken with MWD staff, researchers and agency personnel from across the region to gather as much information on wildfire-related costs to water suppliers as possible, in many cases people were unaware of such costs, did not know where to find them, could only access information from the most recent wildfire, or were not authorized to share such information. As such, we expect that our report underestimates the magnitude and frequency at which MWDs experience wildfire-related costs, both in terms of preventative measures and post-fire response.

Introduction

Our objective in this report is to identify costs associated with wildfire impacts on drinking water provision in southern California. There are numerous pathways through which wildfire may result in increased costs to water providers and users (e.g., increased treatment costs, need for alternative sources, damages to infrastructure – Fig. 1). To keep this investigation manageable given time and cost restraints, we focused primarily on Municipal Water Districts across the region. As such, most of the information presented here came from interviews and documents provided by people in these agencies,

as well as from biologists, consultants and researchers whose work is related to them and the water they provide.

The study area includes the major urban areas and surrounding wildlands of coastal Southern California from southern Santa Barbara County south to the Mexican border. Much of this urban landscape is bordered by or interdigitated with coastal mountains or foothills where the natural vegetation is chaparral or coastal sage scrub with areas of mixed conifer forests in the more prominent mountain ranges (e.g., San Gabriel Mountains). The study area is characterized by a Mediterranean-type climate that is defined by an extended summer dry season and mild, wet winters. Southern California has long been characterized by wildfire prior to European settlement but in recent years wildfires have become increasingly frequent and large (Syphard et al. 2018). The occurrence of wildfires on the region's wildlands and its direct and indirect threats to water provision and associated infrastructure is particularly relevant given the proximity of heavily populated areas (Fig. 2).

Methods

To explore the impacts of wildfire on the storage and provision of water to urban areas and residential populations, we undertook a series of interviews with people from Municipal Water Districts (MWDs) that are members of the Southern California Metropolitan Water District – from the Calleguas MWD south to the San Diego MWD. Interviewees were primarily from the Los Angeles and San Diego counties (Fig. 3) and worked on drinking water supply issues. Although a small portion of the interviewees worked on storm water and the significant wildfire-related costs incurred, such as cleanout of debris catchment basins), we did not focus on this as it has been explored previously (Wohlgemoth and Lilley 2018). Several researchers were also interviewed, including people from San Diego State University, US Army Corps of Engineers, Southern California Coastal Water Research Project, and private consultants contracted by the City of Los Angeles.

We used a semi-structured interview approach to pose the questions listed below. Given that not all of the interviewees were from the MWDs, we asked them about their familiarity with wildfire-related damages, precautions and other pre- and post-fire responses to wildfire impacts. While most of the interviews were conducted one-on-one over the phone, some responses came from discussions in conference calls with multiple participants. Questions and discussions were on the following topics:

- What, if any, negative impacts have your MWD experienced as a direct or indirect result of wildfires since 2000?
- What were the fires that caused these impacts, in what years, and what was the nature of the damages? Do you have cost information associated with these impacts?
- What, if any, post-fire impacts have your MWD experienced with respect to water quality, storage facility capacity, temporary unavailability (taking offline) due to erosion, sedimentation, debris or other indirect post-fire effects? Did these impacts affect water delivery to users and were there any costs related to water purchase from alternative sources?

- Has your MWD had any prevention-related costs associated with fire-hardening measures taken, such as protection of reservoirs, alternative power sources or fire suppression capacity?
- Are there any other wildfire-related costs or impacts your MWD has experienced, such as support to fire-fighters, taking units off-line as a result of utility power shutdowns (e.g., 'red flag' events) or other remediation actions?

In total 24 people were interviewed, across 18 organizations.

Findings

The study area varies considerably between the northern and southern regions, owing to differing geographies and topographies that affect the vulnerability of their water resources to wildfire. For example, the coastal mountain ranges that border Santa Barbara and the Los Angeles (L.A.) basin are steeper and closer to the coastline than the flatter coastal plains of the more southerly San Diego region. Consequently, the L.A. region is more prone to erosion events and the L.A. reservoirs more prone to post-fire sedimentation. As a result, post-fire erosion control and the need to revegetate are more dominant issues around L.A. than San Diego, although these costs are not as widespread as one might expect.

Our assumption before undertaking the study was that wildfires result in major water treatment costs for providing residential water, due to costs associated with the removal of sediment and contaminants that enter the water supply network following fire. With a couple of exceptions, however, this proved not to be the case for reasons discussed below. Despite the natural, geographical differences between the northern and southern parts of the study area, both have been able to limit wildfire-related damages to water supply.

Based on interviews with MWD managers and the documents they provided, we found that the main reasons for the Southern California water supply's resistance and resilience to wildfire damage were:

1. The majority of all water used by the study area population is imported from either the California or Colorado River aqueducts. This water is delivered primarily via narrow canals or enclosed pipes and is minimally exposed to wildfire danger and related impacts.

2. Most of the water stored in Southern California reservoirs is: (a) backup supply for use in emergency or to cover peak flows, and therefore seldom critical for meeting immediate demand; and (b) stored in a network of reservoirs that is geographically extensive (Fig. 4) and thereby reducing the impact that a given wildfire would have on the collective supply. Furthermore, many of the reservoirs are covered, strategically located in areas of low fire risk, or otherwise designed to be minimally vulnerable to fire. For example, reservoirs located in areas with minimal vegetation at relatively higher elevations, combined with no- or low-angled slopes of the surrounding topography so they are minimally exposed to erosion, sedimentation, or direct fire damage (Fig. 5).

3. Sedimentation loading and the influx of contaminants into Southern California reservoirs as a result of wildfires is usually triggered by post-fire precipitation events that occur in the winter rainy season. During the rainy season, the emergency/backup nature of reservoirs is not typically being called upon, thereby allowing suppliers to take the affected units offline until turbidity and sediment loads decline to acceptable levels.

4. The L.A. basin and San Diego region span more than 1000 and 5000 square miles (more than 2500 and 13000 square km), respectively. The distribution of water supply reservoirs is spread broadly across these vast areas of intermingled urban, semi-arid and forest lands (e.g., Fig. 4). As a result of these configurations, to-date there has not been a wildfire that has put enough of the collective infrastructure at risk so as to threaten the entire water supply of either area.

Examples of wildfire-related costs

An unexpected outcome from the interviews was the limited number of records compiled on wildfire-related costs. In most water districts across the region, these costs are not systematically tracked (Feo et al. 2020). Interviewees generally gave two reasons for this lack of available documentation that were generally two-fold in nature: (i) there was network redundancy in the water supply, as well as fire-wise reservoir siting and design; and (ii) there were no policies or precedents in place requiring them or their predecessors to classify and track specific wildfire-related damages or costs. Thus, while records of expenditures related to wildfires likely do exist, they occurred infrequently and were not archived in a way that made them easily searchable. As a result, the majority of information provided came from personal knowledge and familiarity by interviewees with wildfires that occurred during their tenure. In some cases, the absence of information may have come from a genuine lack of fire history, but it was difficult to distinguish between these cases and those where files were absent, unindexed, institutional memory was lacking due to turnover of personnel, or where there was reluctance to share archival information for legal reasons.

The types of wildfire related costs that were reported relate to: water delivery infrastructure; water provision for control and suppression of wildfire; and wildfire prevention- and preparedness-related expenses. Out of interviews with 24 southern California water districts and suppliers we compiled 10 case studies detailing wildfire related costs (Table 1 and Appendix)

Those MWDs that did have wildfire-related impacts to report cited damage to water delivery infrastructure (e.g., pipes, pumps, generators, buildings; Fig. 6), reservoir covers, roads and adjoining landscapes (denuded areas or excessive post-fire debris), for example, following the 2007 Harris Fire the City of San Diego had to replace parts of the pump infrastructure. In another case, the 2017 Thomas fire caused extensive damage to Las Casitas MWD's reservoir and surrounding roads, bridges, fencing, utilities and emergency protection infrastructure (Table 1). The recovery/repair time from these impacts varied from 1-3 months (i.e., coinciding with the soonest significant rain events following the fire) to more than 6 years in the case of reparations to infrastructure for the Morena Reservoir owned by the City of San Diego.

In terms of the temporal scale of fire impacts, interviewees indicated that most non-infrastructure related impacts, such as those to vegetation, occurred in the rainy season immediately following the fire, occasionally extending to a second rainy season. Post-wildfire sedimentation, turbidity and water quality issues were cited by multiple MWDs, but in general, direct associated costs from these impacts were low-to-zero because of the design flexibilities mentioned above that allowed operators to take the unit off line at minimal-to-no expense until conditions improved.

Another cost type reported in the interviews is fire-specific water-related expenses, such as the cost of provisioning extra water for wildfire suppression needs. In 2013, for example, the City of San Diego requested the County purchase 2,127 acre-feet of water from its reservoirs at a cost of $1,716,489 to meet demand for firefighting. Similar requests were made by the cities of L.A. and Santa Barbara to fight the Woolsey and Thomas Fires, respectively.

The City of Santa Barbara, Goleta Water District and Montecito Water District have been impacted by wildfires in the nearby Los Padres National Forest. Goleta and Santa Barbara MWDs both installed more treatment (GAC and sludge handling facilities) to knock down the increased organic concentrations in their source water (Santa Ynez River). Because the Montecito MWD does not have the same treatment flexibility that Goleta and Santa Barbara do, LPNF wildfires have forced the Montecito MWD to stop using their local surface water reservoir because of increased organic material in the water supply. This contamination of the water supply resulted in additional costs associated with having to import water from other sources (unfortunately, cost estimates were not available).

Interestingly, few MWDs mentioned prevention-related expenses (and even fewer provided actual numbers). Interviewees who did discuss these expenses cited landscaping costs (e.g., clearing fire-prone vegetation as well as planting slope-stabilizing species). In addition, preparedness-related expenses were mentioned, such as the purchase of backup power sources like generators (as utility companies frequently shut off power supplies during wildfires or 'red flag' periods to reduce the risk of ignition).

Observations

Some wildfire-related costs incurred by MWDs are passed along to the cities closest to where the fires occur. For example, the City of Malibu paid some of the additional water provision expenses for suppression activities incurred by the West Basin and Las Virgenes MWDs following the 2018 Woolsey Fire (some of these costs may have eventually been reimbursed by state and/or federal agencies through special State of Emergency funds). We were unable to obtain cost estimates for these expenses, as the emergency response officer we spoke with, who is most familiar with the nature and timing of these expenses, does not track costs, and the financial records department did not return our calls.

In addition, some MWDs are essentially water retailers only, buying water from wholesale MWDs or from the aqueduct management agencies directly. As such, they have minimal infrastructure and little-or-no storage capacity. This means that they also have little-or-no exposure to wildfire and may not

have records on the topic, even if they supply extra demand as a result of, say, wildfire suppression efforts. Others, such as Orange County MWD, get any local capacity they have from groundwater and as such, have little-to-no exposure to above-ground wildfire effects.

This report serves as an overview of the direct and indirect costs (and associated observations) to water districts as a result of wildfires in Southern California. Based on the interviews conducted for this report, as well as our requests for additional interviews that we were unable to obtain, we expect that our estimates understate the costs to Southern California water districts due to wildfire. We believe we probably missed few, if any, major wildfire-related expenditures at the MWDs we interviewed, as there would likely be both records and widespread knowledge of these. However, the extent to which we under-report costs could be due to various reasons, including: our inability to identify and interview the people most knowledgeable about wildfire-related expenses; lack of institutional memory about wildfires that occurred prior to the tenure of current staff; the lack of archival expense data and/or the lack of specific wildfire-related codes or search terms that would facilitate querying financial databases. This last item – the difficulty or inability to search databases for wildfire-related expenses – would not be surprising, given that the number and extent of wildfires has grown markedly in recent years. Historically, wildfire damage would have been a rare event, and previous incidences of such may have occurred early on in the process of, or prior to, digitization of financial record keeping. As such, with the exception of impacts from recent fires, most people interviewed were unaware of wildfire-related costs to their district. This may be due in part to high turnover in personnel relative to the periodicity of wildfire events affecting most districts (e.g., employees might stay in their positions <10 years, while fire events occur on longer time scales). It also may reflect the relative newness of frequent, high-severity fires and expansion of the wildland-urban interface – prior to which wildfire impact to water resources may have been a rare event.

Going Forward

To better assess the impact of future wildfires on Southern California's drinking water supply and delivery, it would be useful to have a database that documented wildfire damages and other related costs (e.g. preventative measures) incurred by water providers across the region. Such a database, if accessible to water districts and/or the public, would help water providers anticipate and prepare for potential wildfire impacts, potentially reducing their magnitude and duration. Ideally, such a database would be accessible online and searchable by using a broad number of intuitive terms and common fields (e.g., fire name, specific date or date range, type of damage, type of remediation, cost category, neighboring districts or other entities affected, etc.). Given that there are more than 1000 water districts in the State that range in the number of clients they serve from as few as two to as many as 12 million, it is unlikely that such a database will exist anytime soon. Most of these are privately owned and not required to share their financial information. Ideally, some or all of this information could be made available on a database that utilities and water districts could access for the purposes outlined above.

Fortunately, the water supply networks for both the Los Angeles and San Diego regions are both fairly redundant, meaning that the temporary loss of one can be covered by other reservoirs or supply sources in the network. Also, most reservoirs and transport infrastructure are resistant to wildfire,

meaning that they are generally situated underground or in places that are unlikely to be directly impacted by wildfire. Nevertheless, ongoing vegetation management, upkeep of water delivery infrastructure and backup power supplies in the event of wildfire mean that the need for investments will be ongoing. The more such investments and upkeep costs are documented, the greater our understanding will be about the magnitude and extent of wildfire's impact on water supply, and the better we will be equipped to minimize and prepare for these impacts.

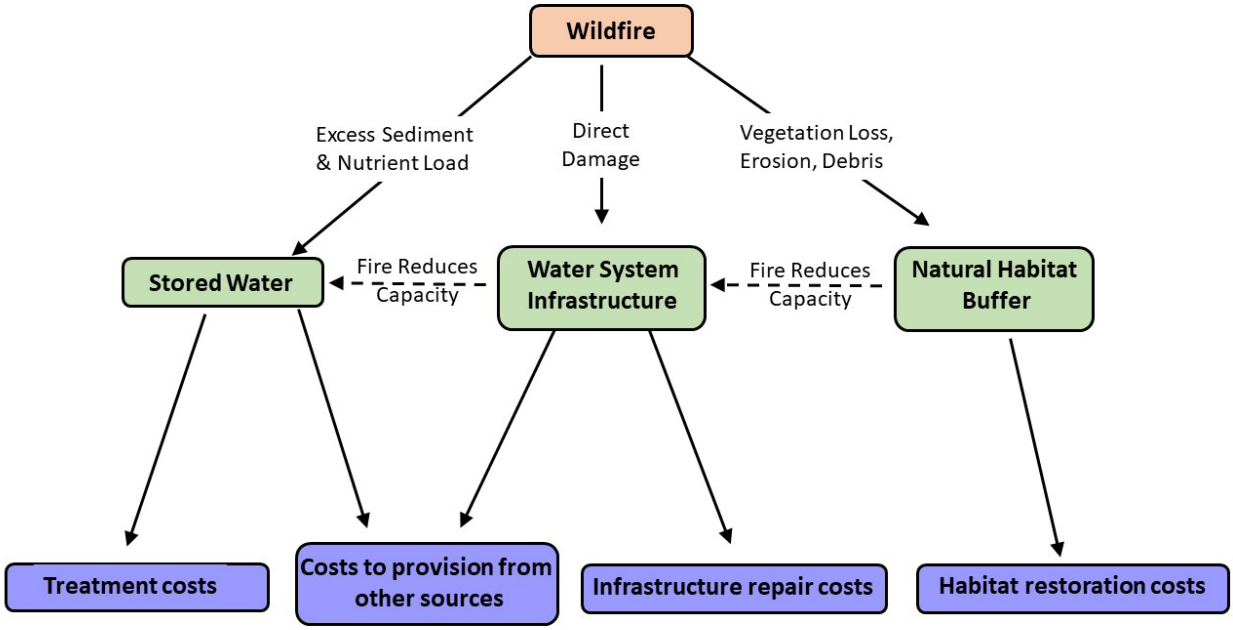

Fig. 1. Conceptual model of how wildfire impacts water quality and supply, ultimately resulting in monetary costs to society.

Fig. 2. Charred chaparral vegetation around Jameson Lake in the Santa Ynez mountains near Santa Barbara. The reservoir, which is part of Montecito Municipal Water District, sustained about $1.2 million in damages from the 2017 Thomas Fire, affecting water quality, delivery and destroying surrounding buildings and structures (Magnoli 2019). Photo: R. Topinka.

Fig. 3. Municipal Water Districts surveyed for wildfire-associated costs.

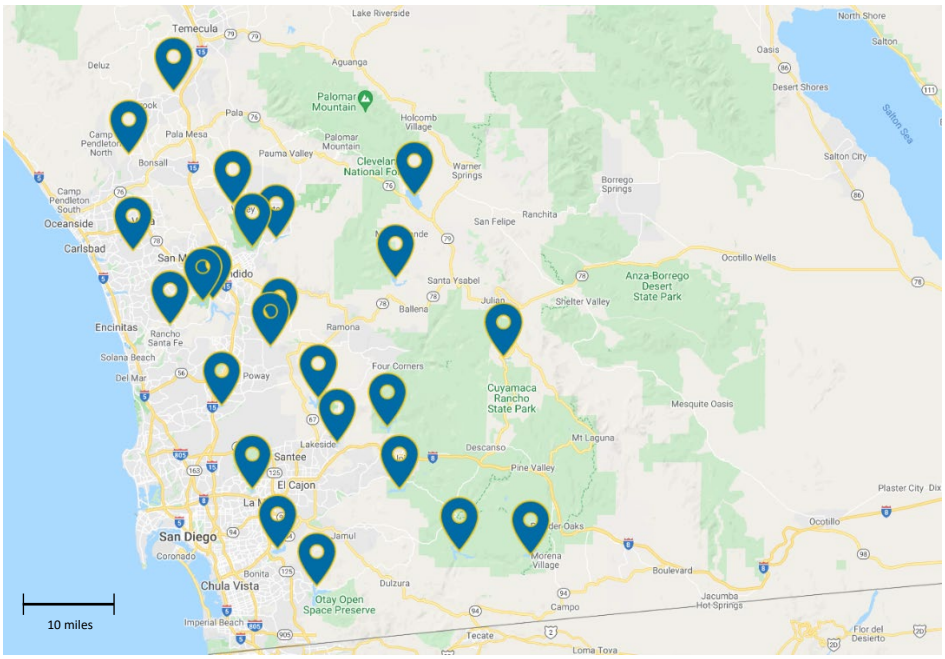

Fig. 4. Reservoirs and water storage facilities in San Diego County (source:www.sdcwa.org).

Fig. 5. Lake Henshaw Reservoir in San Diego County has minimal surrounding vegetation and flat topography, reducing the likelihood of direct wildfire damage or indirect post-fire sedimentation.

Fig. 6. Fire damage to section of the Sutherland Pipeline, owned by the City of San Diego, as a result of the 2007 Firestorm event in which as many as seven fires burned 369,000 acres or 13% of San Diego County (OES 2008).

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Table 1. Summary of wildfire-related expenditures reported by Southern California water districts and suppliers.

Administrative Unit	Wildfire Impact	Remediation/Prevention Description	Cost ($ M = millions; K = thousands)	Year(s)
Santa Barbara MWD	Yes	2007 **Zaca Fire** decreased Cachuma Lake Reservoir capacity from 15,374 to 5250 Acre-Feet; raised Total Organic Carbon to 165% above baseline; increased drinking water treatment costs over 2007 by $1.4M in 2008 and $1.6M in 2009; 2017 **Thomas Fire**	$ value not given for capacity; $3M increase in treatment for 2008 and 2009. (Anderson et al. 2018).	2007-09; 2018
Casitas MWD	Yes	Damage to reservoir and surrounding infrastructure post-2017 **Thomas Fire** including: Roads and Bridges Emerg Protective Measures Utility repair Fence and battery replacement Water control facilities	 $229,068 $328,327 $35,018 $8,858 $101,550	2018
Calleguas MWD	Yes	Water and support to wildland firefighters; prevention costs incl. weed abatement, back-up power supply/generators and associated costs (fuel, maintenance)	~$65K/yr	Ongoing
Las Virgenes MWD	Yes	-Revegetation for erosion/hillside stabilization post-2018 **Woolsey Fire** (burned 67% of watershed) -Filtering efficiency reduced 30% (no cost estimate)	$18M (for reveg component)	2019-20
City of Malibu	Yes	2018 **Woolsey Fire** caused heavy impacts on Malibu Creek water quality	$ value not given	
Metropolitan Water District of Southern CA	Yes	Financial assistance given to member MWDs	$ value not given	
Montecito MWD	Yes	2017 **Thomas Fire** caused loss of water supply and storage capacity at Jameson Lake and resulted in 2018 debris flow damages. Montecito MWD received $8M settlement from Southern California Edison. There were unspecified additional costs for importing water	$8M incl. $1.2M for repairs to Jameson Lake Res infrastructure. Cost estimates for imported water not available.	2019
West Basin MWD	No	Water wholesaler	No wildfire-related costs, but aware of risks and impacts to neighboring MWDs	
Three Valleys MWD	Yes	Reservoir cover damage from 2003 **Grand Prix Fire**; back-up power	$50-60K for damage to reservoir cover; $150-300K for generators	2003-04
Eastern MWD	No	Prevention: backup power supply in case of power outage caused by fire	~$150K for backup power supply	
City of San Diego	Yes	2007 **Harris Fire**: Pump infrastructure; purchase of 2,127 AF water due to Morena reservoir closure	$4,179,699 (removal, clean-up and repair). Plus $1,716,489 in water purchase	2007-13