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*Communication*

# Water Supply and Firefighting: Early Lessons from the 2023 Maui Fires

**Robert B. Sowby *** **and Braxton W. Porter**

Department of Civil and Construction Engineering, Brigham Young University, Provo, UT 84602, USA
* Correspondence: rsowby@byu.edu

**Abstract:** Even though drinking water utilities are not meant to fight wildfires, they quickly become stakeholders, if not first responders, when their resources are needed for firefighting. The August 2023 wildfires on the island of Maui, Hawaii, USA, have highlighted weaknesses at this intersection. While attention has focused on the wildfire causes or water quality impacts afterward, few studies have analyzed the response. We review this extreme case to support disaster-response lessons for water utilities and to guide further research and policy. First, emergency water releases were not available in a timely manner. Second, fire and wind toppled power lines, causing power outages that inhibited pumping water. Third, many structures were a total loss despite water doused on them, consuming valuable water. Finally, water was lost through damaged premise plumbing in burned structures, further reducing system pressure. These conditions emphasize that water utilities need to access emergency water supplies quickly, establish reliable backup electricity, coordinate with firefighters on priority water uses, and shut valves in burned areas to preserve water. While further research will certainly follow, we present these early lessons as starting points.

**Keywords:** drinking water; wildfire; emergency response; disaster; utility management; fire flow



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## 1. Introduction

The August 2023 wildfires on the island of Maui, Hawaii, USA (Figures 1 and 2), were the deadliest in more than a century in the United States. The disaster killed over 100 people, burned 1040 ha, damaged or destroyed over 2200 structures (mostly residential), and caused an estimated $5.5 billion in damage [1,2]. The situation has highlighted weaknesses at the intersection of public water supply and firefighting. Firefighters could not find hydrants with enough water pressure, residents' own hoses were going dry as they struggled to keep their homes from burning, and authorities later warned residents not to drink the water because it may have been contaminated during the fire [3–5].

The Maui fires occurred at a wildland–urban interface (WUI), a classic risk zone for catastrophic wildfires because of the proximity of humans and infrastructure to the natural environment [6]. In addition to the placement, there were many contributing factors to the devastation, such as high winds stoked by a passing hurricane [7], warning sirens not sounding [8], severe drought [9,10], and poor land stewardship that spawned a tinderbox of non-native grasses [10,11].

Water utilities worldwide have the public safety responsibility of providing water to fight fires. For these reasons, government and industry standards dictate levels of flow, pressure, and storage that water utilities need to have. In the United States, the requirements are determined by local fire officials or state water regulators. Regardless, the firefighting requirements in question are for short-duration, isolated fires in the water suppliers' service areas, not dayslong wildfires that consume an entire town or countryside. The current Hawaii code says that wherever possible, "a water supply . . . capable of supplying the required fire flow for fire protection shall be provided to all premises upon which facilities or buildings, or portions thereof, are hereafter constructed," but does not specify wildfire protection [12]. The fire flow may be provided through fire hydrants (Figure 3), fire sprinklers in buildings, or other means.

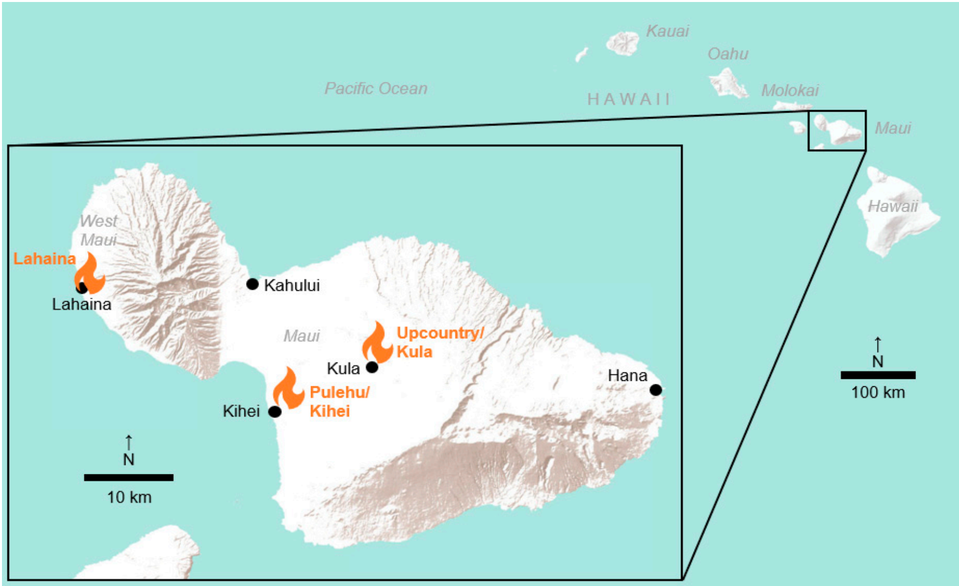


**Figure 1.** Overview of Maui fires.

**Figure 2.** Fire damage in Lahaina (photo by State Farm via Flickr. CC BY 2.0).

According to one survey, only 39% of western U.S. water utilities consider themselves responsible for mitigating wildfire risk [13]. However, while water utilities are not meant to fight wildfires, they quickly become stakeholders—if not first responders—when their watersheds are threatened, wildfires encroach into their service areas, or their resources are needed for firefighting. The same survey indicated that 68% of western U.S. water utilities are concerned about how wildfires affect their operations [13], especially as wildfire risks to human populations in the United States are at an all-time high [14].

Water systems need to continue service not just despite but especially during disasters [15]. While attention has focused on the Maui wildfire causes or water quality impacts afterward, few studies have analyzed the response and the intersection between water supply and firefighting. In this paper, we report on the performance of water systems involved in the firefighting response in Maui and discuss lessons for water managers, firefighters, researchers, and policy makers to consider in order to make communities more resilient.

**Figure 3.** A typical Hawaiian fire hydrant (photo by NAVFAC via Flickr. CC BY 2.0).

## 2. Materials and Methods

The Maui County Department of Water Supply, organized in 1949, provides water to over 36,000 connections in 12 service areas on 2 islands. The water system in Lahaina, where the fire was concentrated, is supplied by one stream and two wells [16]. The stream is treated with microfiltration, one well is treated with granular activated carbon, and all three sources are treated with chlorine.

We had already been studying wildfires and drinking water impacts in other work. As the scale of the Maui wildfire disaster became apparent, we recognized it could be what policy theorists call a focusing event [17], bringing attention to a problem and eventually leading to informed decisions that improve it.

Beginning in the days immediately after the fires, we followed news media and searched for coverage of the water supply conditions, the firefighting activities, and particularly the interactions between them. We reviewed written, photographic, and video material for qualitative information from which to identify distinctive lessons. We compared the water systems' experiences to others documented in the literature and synthesized them into the discussion presented here.

While many factors contributed to the fires, we focus our review on factors related to the water supply and on the response during firefighting, rather than on antecedent conditions or long-term recovery. Because full academic investigation will take time, our purpose in this communication is to provide early but useful information to stimulate discussion about how water utilities and firefighters can better prepare and respond.

## 3. Results and Discussion

Our review identified four notable water system weaknesses in fighting the Maui wildfires: poor emergency water releases, power failures, water spent on lost causes, and premise plumbing leaks from destroyed buildings. For each one, we discuss observations in Maui, connections to other works of literature, and the beginnings of solutions.

### *3.1. Poor Emergency Water Supplies*

As the fires raged, local land managers requested the state to authorize emergency releases of water to support firefighting. A state water regulator initially denied the request, saying permission from downstream landowners was necessary first [18,19]. Water from streams was eventually released to nearby reservoirs, but the fires had already spread, and it was too late to help. One water manager said, "We could have made more water available to (the fire department) if our request had been immediately approved" [18]. The land company that requested the water later wrote to the state water regulator, "we need to act faster in an emergency" [20].

Speaking after the fires, but not specifically about the withheld release, Hawaii Governor Josh Green said, "There's been a great deal of water conflict on Maui for many years. . . . People have been fighting against the release of water to fight fires" [18]. Klein and Sproat [21] suggest that the real problem was allowing private interests like resorts, golf courses, and big corporations to gain control of water rights. Regardless, there is no clear protocol in Hawaii on releasing water for emergencies, whether the water in question is publicly or privately held. At the same time, there is a physical limitation: Maui's water infrastructure, particularly dams, has deteriorated, reducing the island's ability to store excess water for emergencies [22].

The Hawaii fires illustrate that water managers need a clear policy about emergency water supply as well as the partnerships and infrastructure to deliver it quickly. The American Water Works Association advises water suppliers to prepare by "establishing key partnerships with public health, law enforcement, relevant regulatory authorities, . . . and other emergency-response entities" [23]. As for infrastructure, the maintenance of storage such as tanks and reservoirs that contain backup water supplies is essential for dealing with such contingencies. Welter [24] and Lindovsky and Krocova [25] recommended preparing to provide emergency water supplies when public water systems fail, particularly for the critical needs of potable water use, firefighting, hospitals, and sanitation. Wang and Shih [26] identified fire agencies' preferences for alternative sources of firefighting water. Some communities install "dry hydrants" at raw-water reservoirs, lakes, and rivers, enabling fire crews to access extra water separate from the potable water system [27]; San Francisco, notably, has a separate firefighting water system altogether that can pump water from the ocean if necessary [28].

### *3.2. Power Failures*

A Maui County [7] press release on the day the fires started announced that hurricane-driven winds had been fueling a brush fire in Lahaina but that the fire was 100% contained. In the same press release, but not seeming to be related, was a statement that the winds were causing "power outages [that] are impacting the ability to pump water, and the public is asked to conserve water in West Maui" [7]. At some point, the fire became uncontained again and power continuity, water supply, and fire suppression became a cascading failure. While firefighters and others need water during an emergency, keeping power lines energized in a windstorm risks starting new fires, which begets more power outages and more water demand, and Hawaiian electric utilities are now facing the fallout of this impossible position [29]. Without grid power, the water system had to rely on on-site backup generators to keep the water flowing, according to the Maui County water director [4], who later speculated that more backup power might have solved the problem, but that the county water department lacked the funding [30].

Water systems are known to be too dependent on the electric grid, particularly in disasters [31]. Whelton et al. [32] summarized similar problems in their case study of the 2021 Marshall fire in Colorado, where water facilities' primary and backup power failed during the critical first 24 h of response. In another notable incident in 2021, winter storms in Texas knocked out power and disrupted water service for 13 million people for days [33,34].

For these reasons, the American Water Works Association has a policy statement that recommends water utilities have 72 h of backup power, whether mobile or permanent [35]. Other strategies include establishing interconnections with neighboring water systems, locating certain water facilities outside likely fire footprints, and coordinating with power providers for priority service restoration to water facilities. When the power goes out, the water should stay on.

### *3.3. Water Spent on Lost Causes*

The Lahaina fire started inland and swept downhill, not stopping until it reached the ocean. Given the high winds and abundance of fuel the fire had along the way, it is debatable whether any amount of water could have extinguished it. Several firsthand accounts from fires Lahaina and Kula report that even after some structures were doused, they reignited from overlooked hotpots, flames on neighboring structures, or sparks carried on the wind. Further, residents tried in vain to fight fires with their own garden hoses, robbing pressure from hydrants where firefighters needed it. Water spent on lost causes was then unavailable where it could have helped.

Water does not guarantee that structures will be saved. Schwartz and Spyhard [36] concluded that the most important factors explaining structure loss are human-caused ignitions, severe wind, and development patterns. Water still plays a role; small fire flows may save many buildings, but large fire flows may not save even one building. Gibson et al. [37] noted that North American minimum fire flow requirements for public water systems, around 1900 L/min, are about four times larger than European standards, around 500 L/min, with little defensible basis. Mac Bean and Ilemobade [38] concluded that of almost 4000 fires in South Africa, only 3 needed more than the minimum flow rate of 1200 L/min; in New Zealand, Davis [39] concluded that "a very large proportion of fires are extinguished with less than 10 L/s (600 L/min) of water". In addition to showing that smaller fire flows are generally effective, these sources agree that the most excessive fire flows are likely associated with situations where the buildings would have been lost anyway, regardless of how much water was available. After some minimum level of fire flow, whether a building survives appears to be independent of water availability. This is especially true for fires at the wildland–urban interface, and some countries have adopted policies prohibiting use of public water supplies for fighting wildfires and instead prefer airborne water bombing from reservoirs or dry methods [40,41].

It is then a matter of priority. Firefighters and water utility staff should coordinate how limited water resources should be used, perhaps in joint planning exercises to prepare for fires. While in many firefighting situations, there is little time for decision making, in an extended fire response like that seen in Maui, coordination could make a significant difference. The International Building Code's risk categories might be an appropriate guideline, where buildings like hospitals, schools, shelters, and critical infrastructure facilities receive priority [42]. Water personnel should monitor system performance and inform firefighters when capacity in certain areas is falling to critical levels. If it becomes apparent that a burning structure cannot be saved with water, there is probably a better use for that water somewhere else in the response effort.

### *3.4. Premise Plumbing Leaks from Destroyed Buildings*

In Maui and elsewhere, the same pipe network supplies fire hydrants and kitchen faucets. As buildings burned in Lahaina, premise plumbing collapsed or melted and "the water was leaking out of the system", according to the county water director [3]. Video footage showed this very behavior, and Figure 2 shows a burned water heater with exposed piping after the fact. With so much damage, leaks contributed to low pressure systemwide. Crews eventually shut valves to help repressurize the system.

Leaks from pipes in damaged structures may be an overlooked weakness in firefighting, especially for wildfires that spread to urban areas. In the 2021 Marshall fire in Colorado, water system staff "estimated that with 300 to 400 homes destroyed, they were losing . . . roughly 50% to 90% of the water they were producing" before they closed valves in the affected areas [32]. While background leaks are another matter, these types of severe, acute leaks from fire damage hinder further firefighting. The effect can be similar to that following an earthquake when pipes below and above ground are broken, but in a fire, the underground network usually remains unaffected and can be used to control the hemorrhaging.

As discussed above, whether a building survives a fire depends on more than water availability. Here, we add that once a building is destroyed, its water service should stop.

This is a key step to preserving pressure during and after firefighting. Water utilities need an emergency protocol for shutting off water service to buildings destroyed by fire. For individual properties, the shutoff may occur at customer laterals or meters; for broader areas, the shutoff may occur at isolation valves on main lines. Smart meters with remote shutoff capabilities may be part of the solution if they remain functional after damage.

## 4. Conclusions

After reviewing the information available early after the Maui fires, we identified four notable water system weaknesses. First, emergency water supplies were not available in a timely manner. Second, power outages inhibited pumping water when needed. Third, valuable water was expended on structures that were a total loss. Finally, water was lost through damaged premise plumbing in burned structures.

Maui paid a heavy price for these lessons, and we provide this information so others can learn from it. For water utilities to overcome these weaknesses in the future, we recommend that water managers adopt policies to access emergency water supplies quickly, establish reliable backup electricity, coordinate with firefighters on priority water uses, and shut valves in burned areas to preserve water. These recommendations align with guidance from professional associations as well as with recommendations of Tran et al. [43], who presented a "wildfire toolbox" of planning, response, and recovery actions for water utilities.

We present this review as an early contribution focused on firefighting and water utility management. Further research on the Maui fires will no doubt follow, perhaps focusing on the antecedent conditions, other emergency services during response, or long-term water quality in natural waterways and engineered systems. We agree with the literature that reacting with water is no longer a realistic solution for dealing with wildfires in a changing climate; sustainable solutions will also involve preventive planning, proactive land management, and effective leadership [44].

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