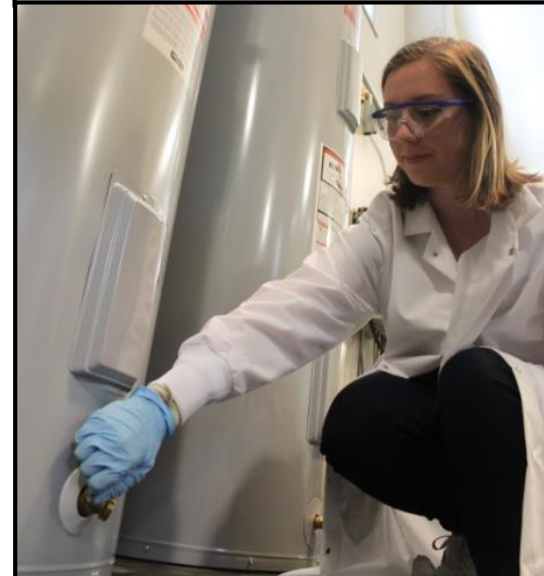


# After the Fire: How Can We Determine that the Drinking Water is Safe?

Andrew J. Whelton, Ph.D.  
Civil, Environmental, and  
Ecological Engineering

[awhelton@purdue.edu](mailto:awhelton@purdue.edu)

[www.PlumbingSafety.org](http://www.PlumbingSafety.org)



# *Our Focus*

## Water Safety and Disasters



## Infrastructure Construction and Repair Technologies

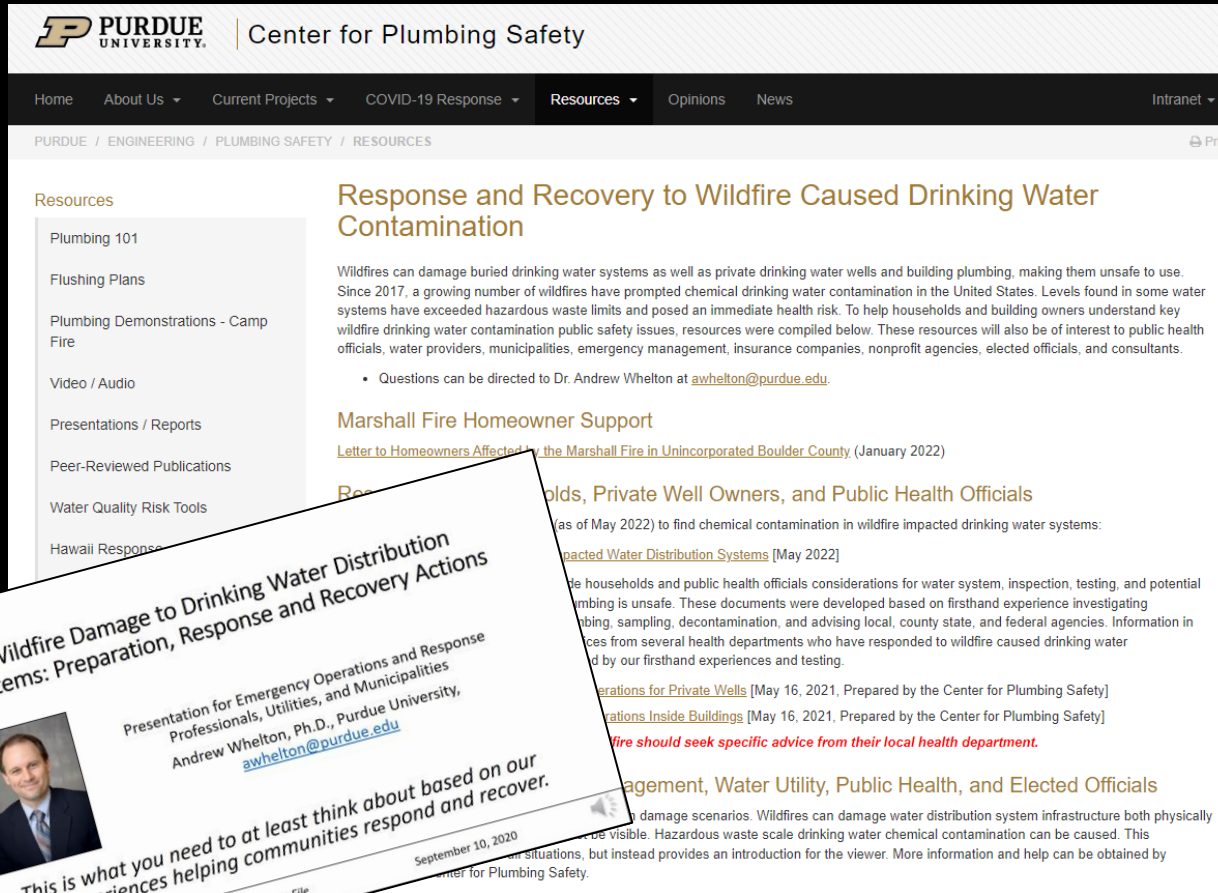


## Waste Materials and Management Solutions





# Wildfire Response and Recovery Guidance for Municipalities, Public Health and Elected Officials



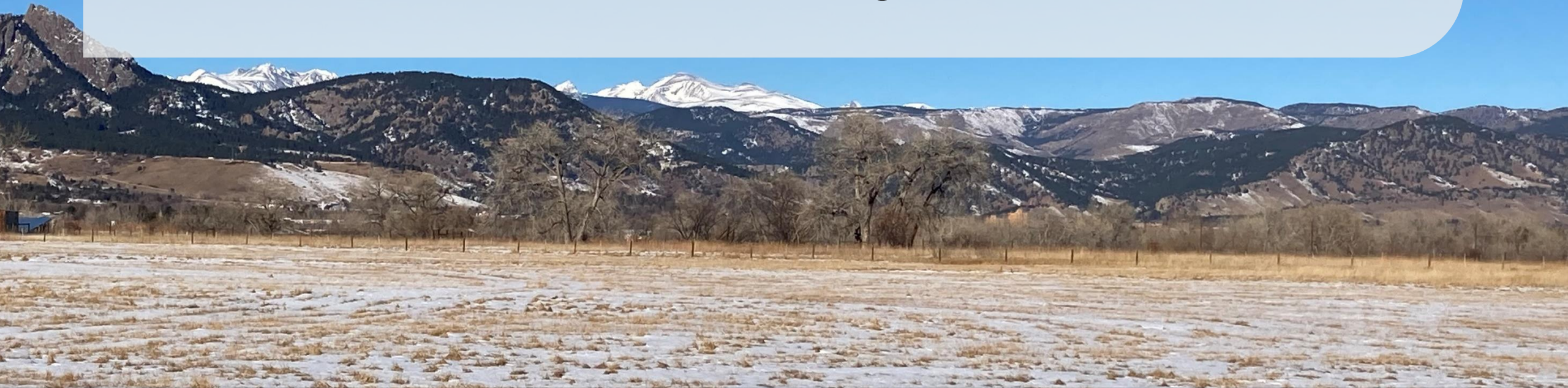
- ✓ Post-fire chemicals to test for
- ✓ Videos for emergency managers and health officials
- ✓ Guidance for private well owners
- ✓ Guidance for building owners
- ✓ Federal and state government agency resources
- ✓ FEMA mitigation guidance
- ✓ Other training resources

[www.PlumbingSafety.org](http://www.PlumbingSafety.org)

# Drinking water for the U.S. population

85%: “Regulated” public drinking water systems

15%: Private drinking water well



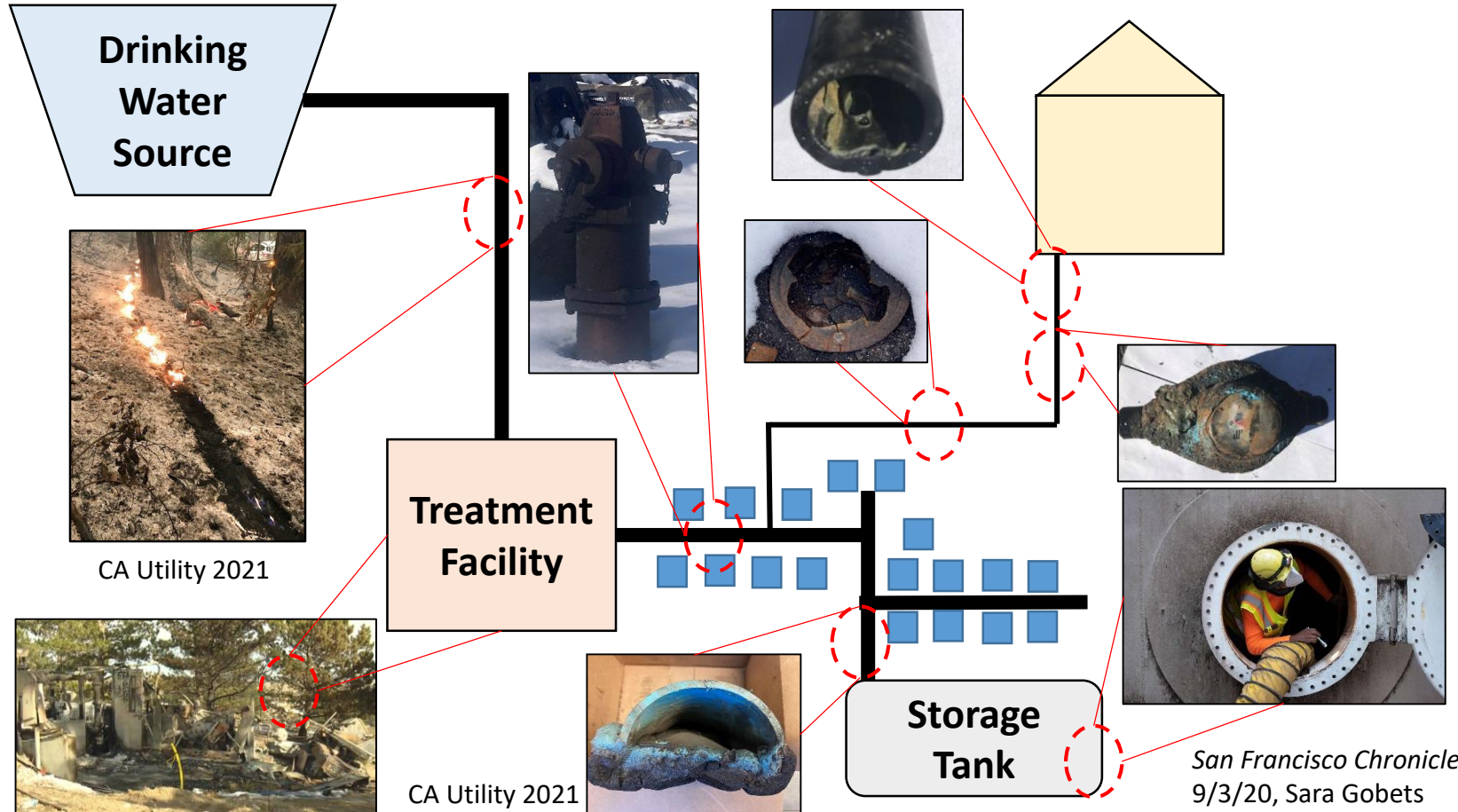
Follow Us [@TheWheltonGroup](https://twitter.com/TheWheltonGroup)



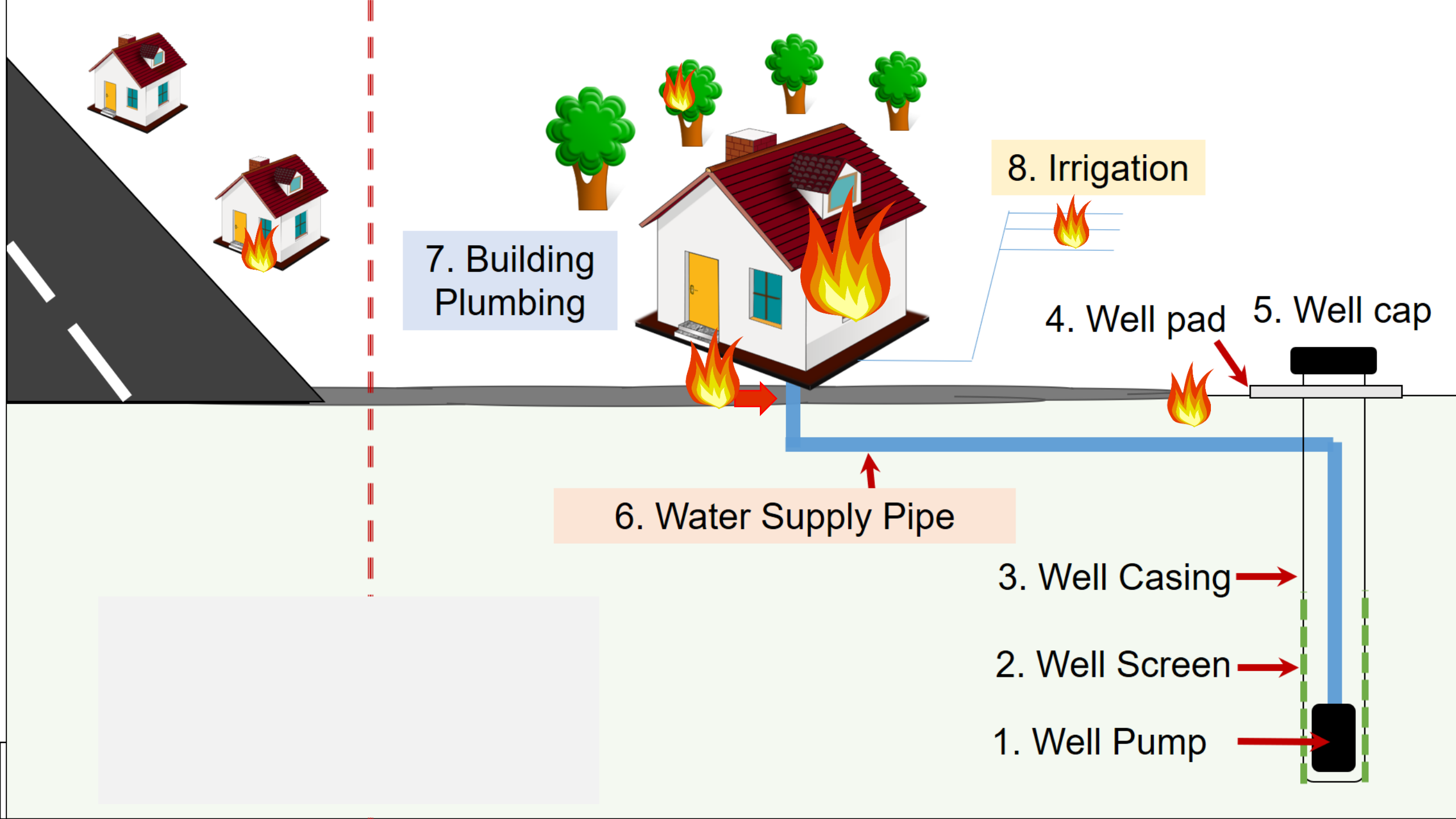


USGS 2009

# *Public drinking water systems and their assets are vulnerable to fire.*



Fires can physically and chemically damage infrastructure





# Lessons Learned from the 2017 Tubbs Fire and 2018 Camp Fire



**Wildfire caused widespread drinking water distribution network contamination**

*Download FREE here:*

<https://doi.org/10.1002/aws2.1183>

VOCs and SVOCs present, levels can exceed hazardous waste limits (40,000 ppb benzene, etc.)

Do Not Use water order should be issued

Protect homeowners and their plumbing



# November 8, 2018 Camp Fire

Public Water Systems (% Homes Gone)	Population	Source Water
Paradise Irrigation District (PID) (-96%)	26,032	Surface
Del Oro Water Company (DOWC) – Paradise Pines (-38%)	11,324	Surface
DOWC – Lime Saddle (-50%)	1,106	Surface
DOWC – Magalia (-89%)	924	Ground
DOWC – Stirling Bluffs (0%)	548	Surface
DOWC – Buzztail (-34%)	106	Ground
Foothill Solar Community	180	Ground
Forest Ranch Mobile Home Park	25	Ground
Forest Ranch Mutual Water Company	92	Ground
Gran Mutual Water Company	202	Ground
Humboldt Woodlands Mutual Water Company	75	Ground
Meadowbrook Oaks Mobile Home Park	50	Ground
Mountain Village Homeowners Association	40	Ground

Boil water advisories  
were issued to  
40,000 people



Private wells  
13,227 exist in Butte County  
2,438 wells in Camp Fire area



# February 2019: 3 day visit and briefing, called us 3 months post-fire



CalOES, SWRCB, BCHD, FEMA, PID, DOWC, Town, CalFire did not understand how to proceed

< 50 water samples had been collected total

Benzene testing only; State assumed benzene was the only chemical present

Our onsite recommendations:

- Find out what's in the water (not just benzene)
- Reevaluate water use restrictions
- Isolate → Test (72hr) → Decon/replace
- Population in homes needs help, they were left to fend for themselves

## Onsite Visit Response and Recovery Observations Presented to PID February 13, 2019

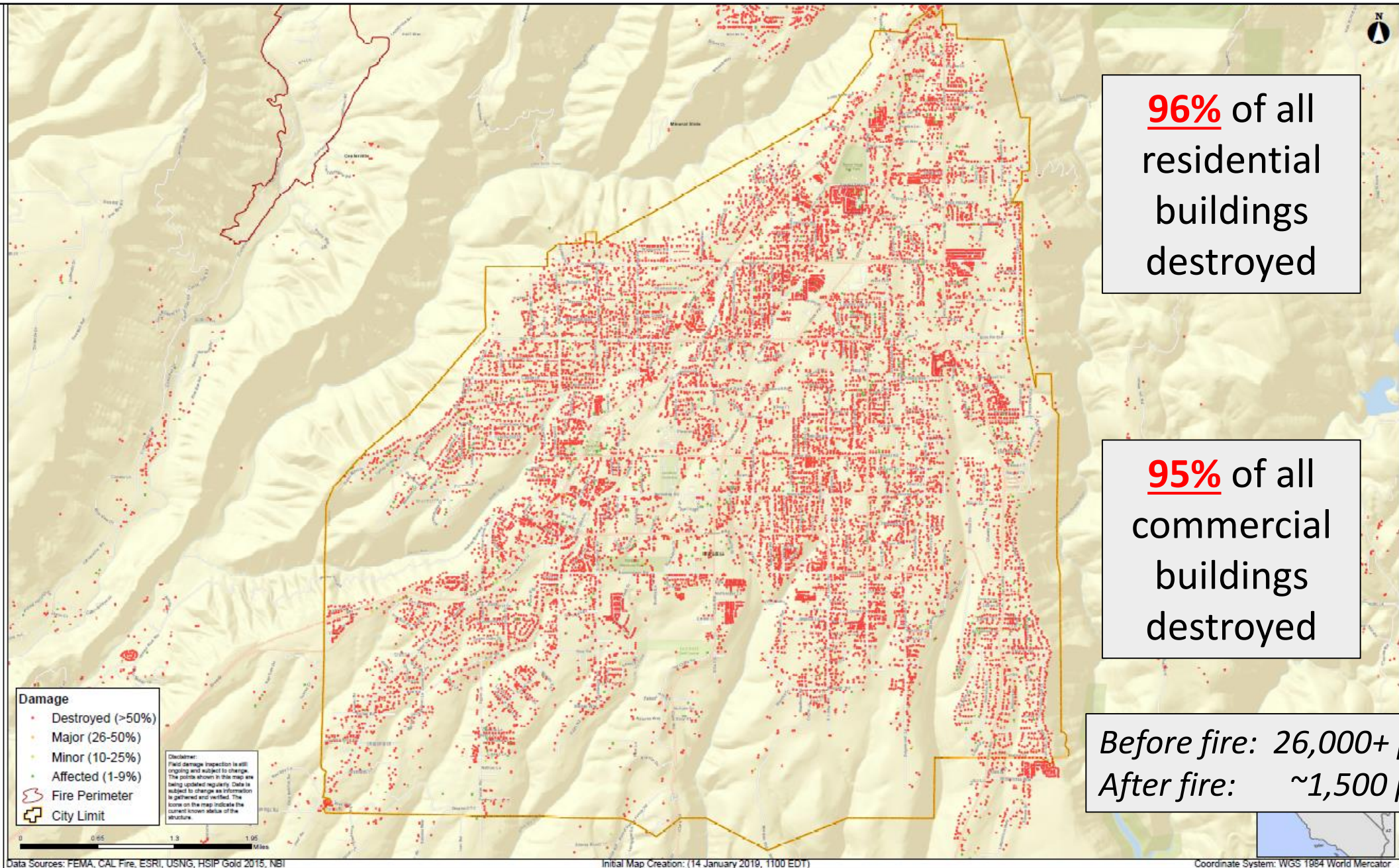
Purdue University & Manhattan College  
Andrew J. Whelton, Ph.D., Amisha Shah, Ph.D.,  
Juneseok Lee, Ph.D., P.E., Caitlin Proctor, Ph.D., David Yu, Ph.D.  
Questions: [awhelton@purdue.edu](mailto:awhelton@purdue.edu)

### A. Overall

- PID has done a good job in moving towards stabilizing their infrastructure. This includes repressurizing distribution systems, identifying damaged assets, fixing breaks/leaks, flushing out contaminated water, issuing appropriate water advisories, and other activities.
- The water system is still in the response phase because the system is not yet stabilized and there are many challenges to resolve: for example, how to test for contamination.
- Persons living in the disaster area have complicated the response because PID has had to take action to both respond to their system damage but also to requests of customers.
- A recommendation is that PID focus on completing the response and moving into recovery, but this is and will continue to be slowed by multiple demands on limited resources. For example, PID staffing has been reduced since the disaster took place and the disaster has created an enormous need for additional staffing for response and recovery.
- A critical element to moving forward in a timely manner will be clear and straight-forward recommendations from CalOES and FEMA regarding funding of response efforts.



## Town of Paradise Limits



**96%** of all  
residential  
buildings  
destroyed

**95%** of all  
commercial  
buildings  
destroyed

*Before fire: 26,000+ people*  
*After fire: ~1,500 people*



# Damage

90%+ of their  
172 mile water  
distribution  
system was  
depressurized for  
hours to weeks

100s+ of leaks

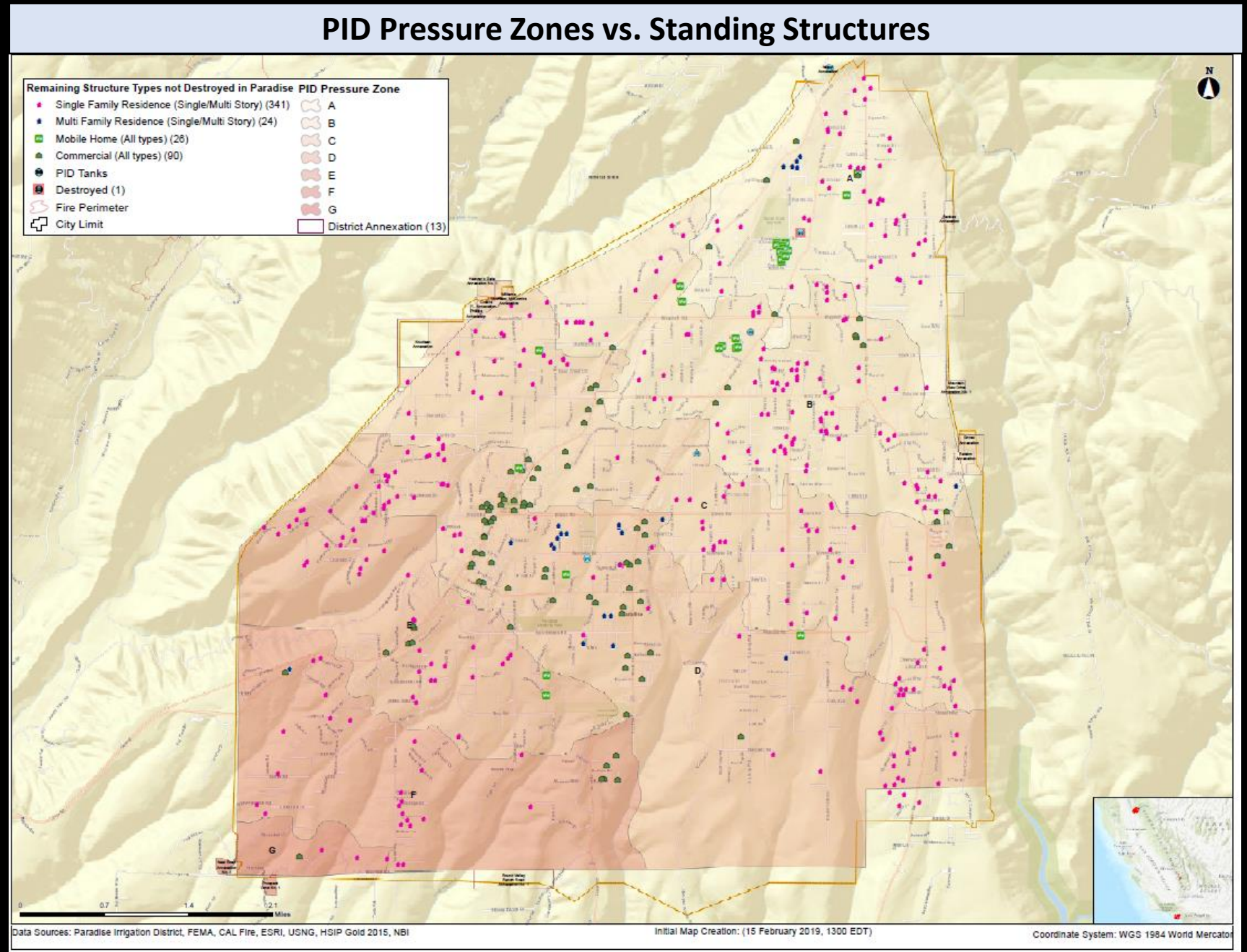




Standing homes were scattered throughout the contaminated water systems: PID Example

2 sources  
1 treatment plant

7 pressure zones  
172 miles of buried pipe  
PVC (35%)  
Steel (33%)  
CML (19%)  
AC (10%)  
Irons (6%)  
1,400 fire hydrants  
10,600 service lines and meters  
Cu, Brass, GIP,  
GSP, HDPE, PB







11,000+ homes



# Water Distribution System Contamination

**500 ppb benzene – U.S. Federal RCRA hazardous waste limit**

Chemical that Exceeded a Drinking Water Limit	2018 Camp Fire (8 months after the fire)				2017 Tubbs Fire (11 months after the fire)		
	PID	DOWC	Exceedance		Santa Rosa		
	Max, ppb	Max, ppb	Exceeded Long-Term Limit?	Exceeded <i>Short-Term</i> Limit?	Max, ppb	Exceeded Long-Term Limit?	Exceeded <i>Short-Term</i> Limit?
Benzene	>2,217	530	Yes	Yes	40,000	Yes	Yes
Methylene chloride	45	NA	Yes	No	41	Yes	No
Naphthalene	693	NA	Yes	Yes	6,800	Yes	Yes
Styrene	378	NA	Yes	No	460	Yes	No
<i>Tert</i> -butyl alcohol	13	NA	Yes	-	29	Yes	-
Toluene	676	NA	Yes	No	1,130	Yes	No
Vinyl chloride	1	NA	Yes	No	16	Yes	No

Long-term limit for an adult for 70 years

Short-term (1 day) limit for a 1 year old child

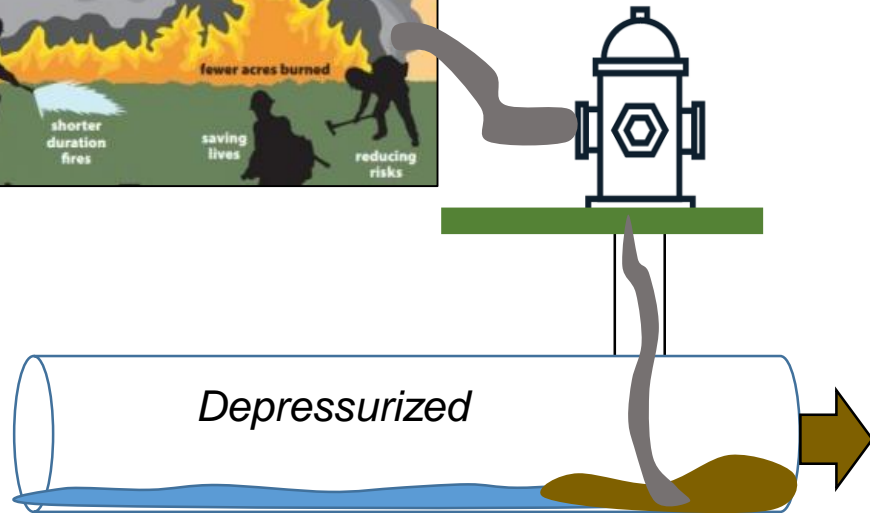
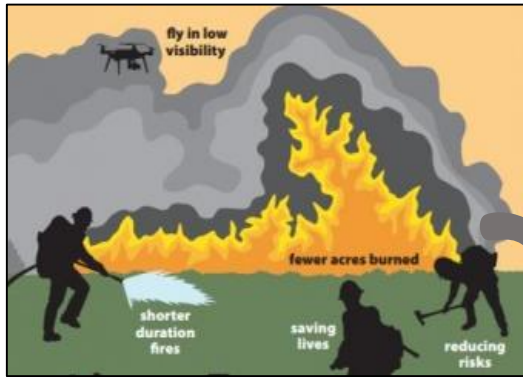
AWWA Water Science, Proctor et al. 2020

<https://doi.org/10.1002/aws2.1183>

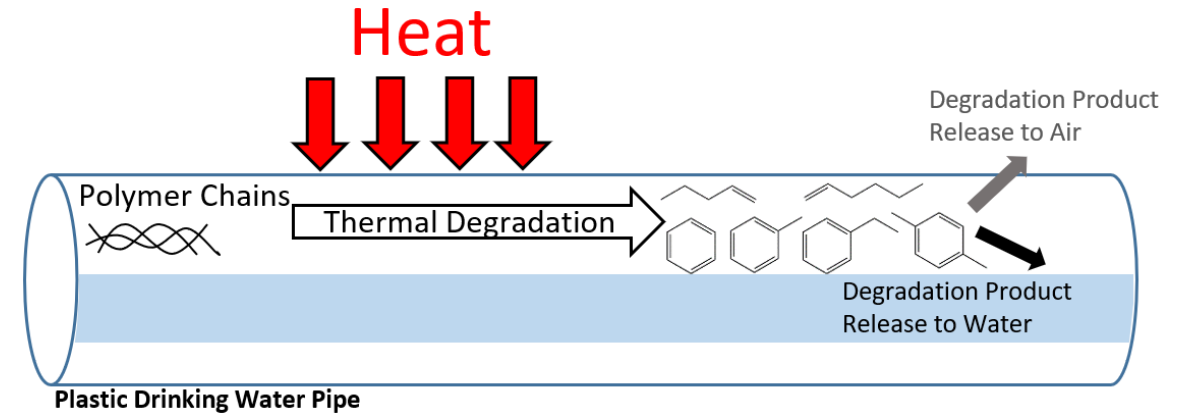


# Potential PRIMARY Sources

## 1. Forest biomass or structure combustion



## 2. Plastic thermal degradation



## 3. Contaminated water back siphonage

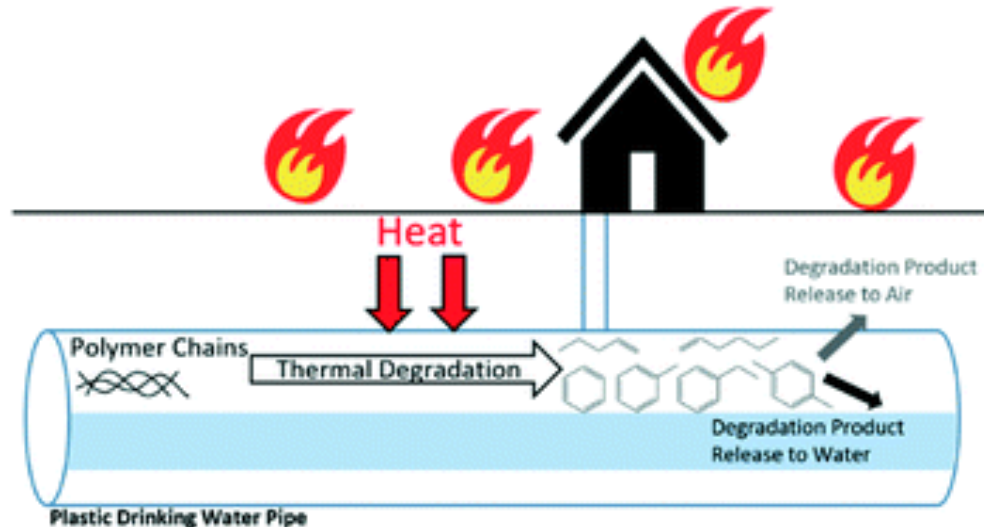


Secondary Sources: Infrastructure

# December 2020 Study: Thermally damaged plastic pipes can be a source of water contamination

Environmental  
Science  
Water Research & Technology

rsc.li/es-water



**Drinking water contamination from the thermal degradation of plastics: implications for wildfire and structure fire response,** *AWWA Water Science*

**Download FREE here:**

<https://doi.org/10.1039/D0EW00836B>

Heating new HDPE, PEX, PVC, CPVC, and PP pipes  $< T_{deg}$  generated VOCs and SVOCs

Benzene generated by heating all pipes except PP

Once plastic cooled, chemicals leached into water



<i>200-400°C</i>	Confirmation of BTEX				Number of TICs	
	Components in Water				in extract <sup>a</sup>	
Material	B	T	E	X	Water	<i>n</i> -Hexane
Cold water pipes						
PVC	✓	✓	–	–	4	41
HDPE	✓	✓	✓	✓	14	100
Hot and cold water pipes						
CPVC	✓	–	–	–	3	32
PEX-a1-a	✓	✓	✓	✓	19	123
PEX-a1-b	✓	✓	✓	✓	16	122
PEX-a2	✓	✓	✓	✓	22	117
PEX-b	✓	✓	✓	✓	18	127
PEX-c1-a	✓	✓	✓	✓	19	133
PEX-c1-b	✓	✓	✓	✓	17	134
PEX-c1-EVOH	✓	✓	✓	✓	20	109
PP	–	✓	–	–	6	95

*Fires are often >200°C, but ground temperature can be >100°C for hrs*

### **Chemistry:**

Polymer chain scission

Aromatization

The role of additives

The role of temperature

The role of RH

The role of O<sub>2</sub>

Partitioning after generation

*Building codes never considered heat damaged plastic water system materials becoming a 1° or 2° source of drinking water contamination.  
(est. 300,000 structure fires per year - **NFPA**)*



## Organic Chemical Contaminants in Water System Infrastructure Following Wildfire, *ES&T Water*

<https://doi.org/10.1021/acsestwater.1c00401>

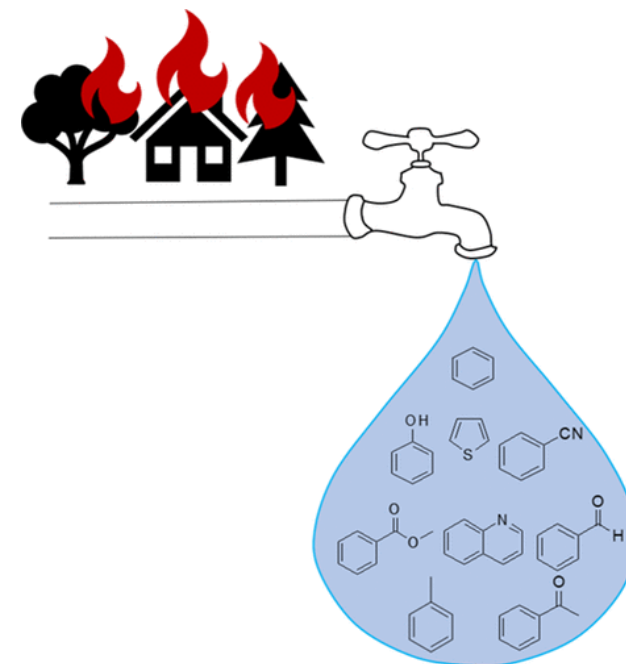
Characterized target and nontarget VOCs and SVOCs in water from 1 contaminated service line after the Camp Fire.

PVC, PEX, and HDPE pipe **heating experiments** conducted

Results:

- PVC heating: 32 compounds
- HDPE/PEX heating: 28 compounds
- Service line: 55 compounds associated with uncontrolled burning of biomass and waste materials.

*Findings support hypotheses that wildfires can contaminate drinking water systems both by thermal damage to plastic pipes and intrusion of smoke.*



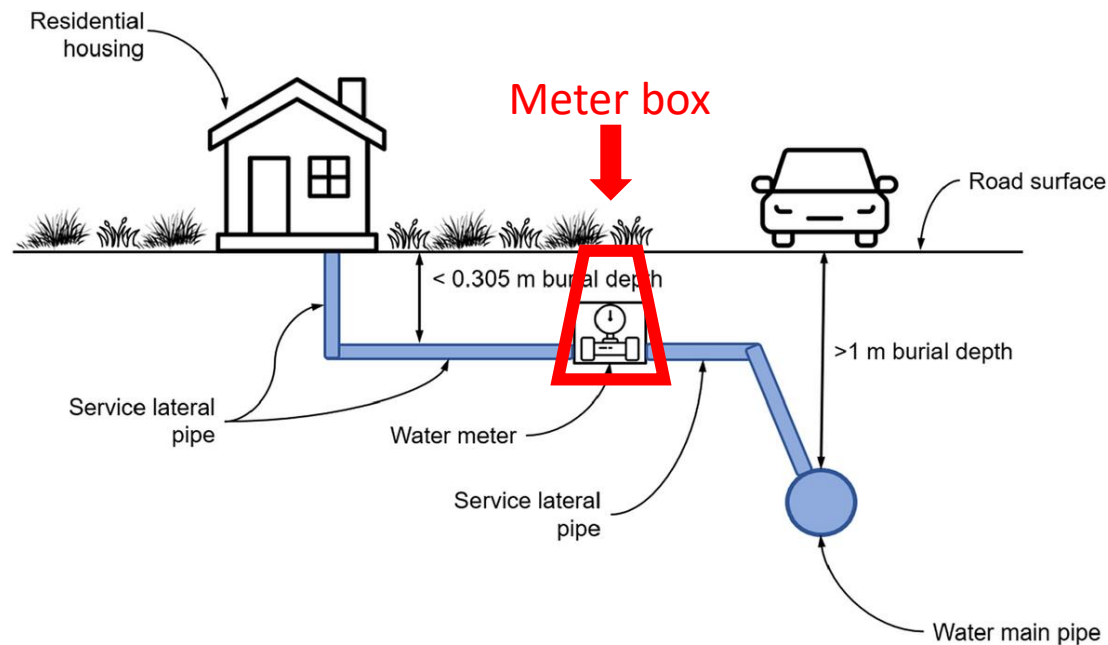


# Simulation of Heat Transfer Through Soil for the Investigation of Wildfire Impacts on Buried Pipelines, *Fire Technology*

<https://doi.org/10.1007/s10694-022-01232-3>



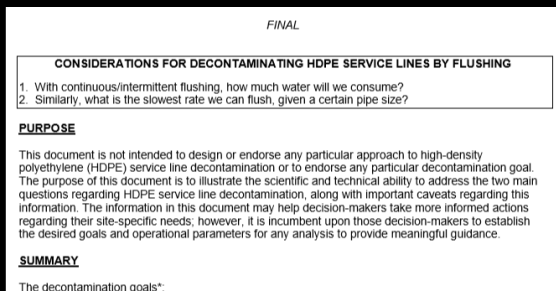
Oregon State  
University



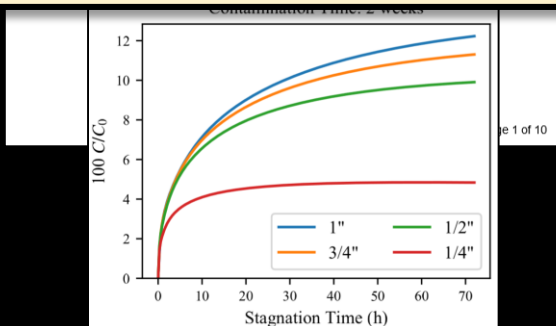
## Mathematical Modeling Results:

- The upper limit temperature for pressure service of the pipelines was exceeded at depths up to 0.45 m (1.5 ft).
- The upper limit temperature will be exceeded at least 50% of the time at depths up to 0.19 m (0.6 ft).

*Buried depth will impact thermal vulnerability*



Water Distribution System  
Decontamination  
*Collaboration between Us & USEPA*  
Hydraulics  
Polymer Science  
Environmental Engineering



*Numerical modeling:*  
Greater than 286 days vs.  
less than 64 days of  
continuous water flushing  
for 1-inch HDPE service line  
(Hauptert et al. 2019)

Science has been applied to  
some water distribution  
system testing and  
decontamination decisions,  
but more work is needed

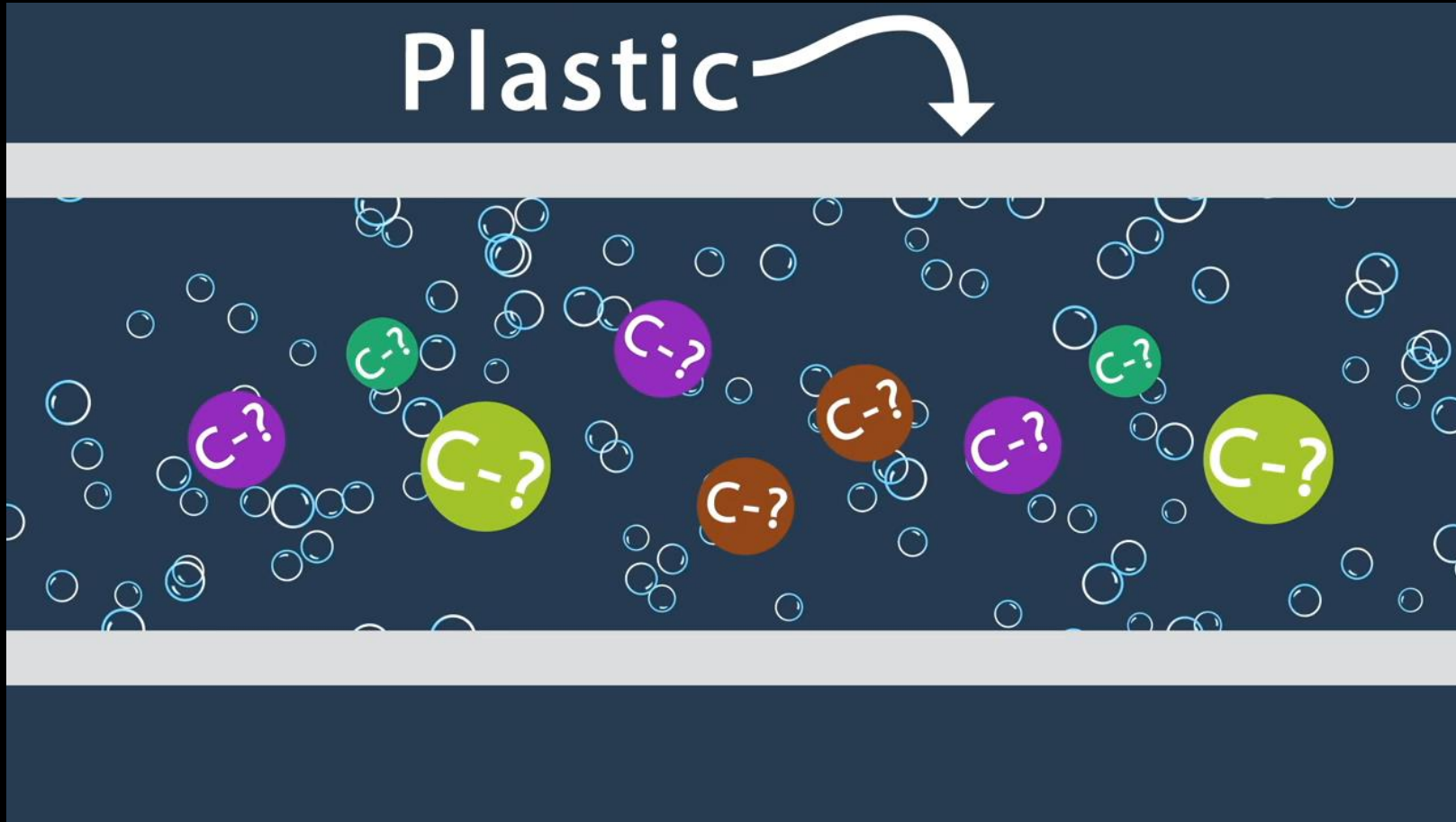


Initial measurement concentration ( $C_2$ )	Goal A (never above 0.5 ppb)		Goal B (only exceed 0.5 ppb after 72 hours of stagnation)	
	Continuous	Intermittent (once/72 hrs)	Continuous	Intermittent (once/72 hrs)
100 ppb	286	312	195	240
50 ppb	246	270	156	198
20 ppb	195	213	104	141
10 ppb	155	171	66	99
5 ppb	116	129	33	60
2 ppb	64	74	8	20

<https://engineering.purdue.edu/PlumbingSafety/opinions/Final-HDPE-Service-Line-Decontamination-2019-03-18.pdf>



# Chemicals can sorb into and leach from water system materials including plumbing components



For water samples,  
*Stagnation Time* is  
needed

Before you collect a  
water sample you  
must allow the  
chemicals to leach  
out into water.

Watch the video at <https://youtu.be/ythX2fP3-S4>  
*How chemicals contaminate plastic pipes and drinking water*



**CHICO  
STATE**



**PURDUE**  
UNIVERSITY



 **Butte College**



**Berkeley**  
UNIVERSITY OF CALIFORNIA



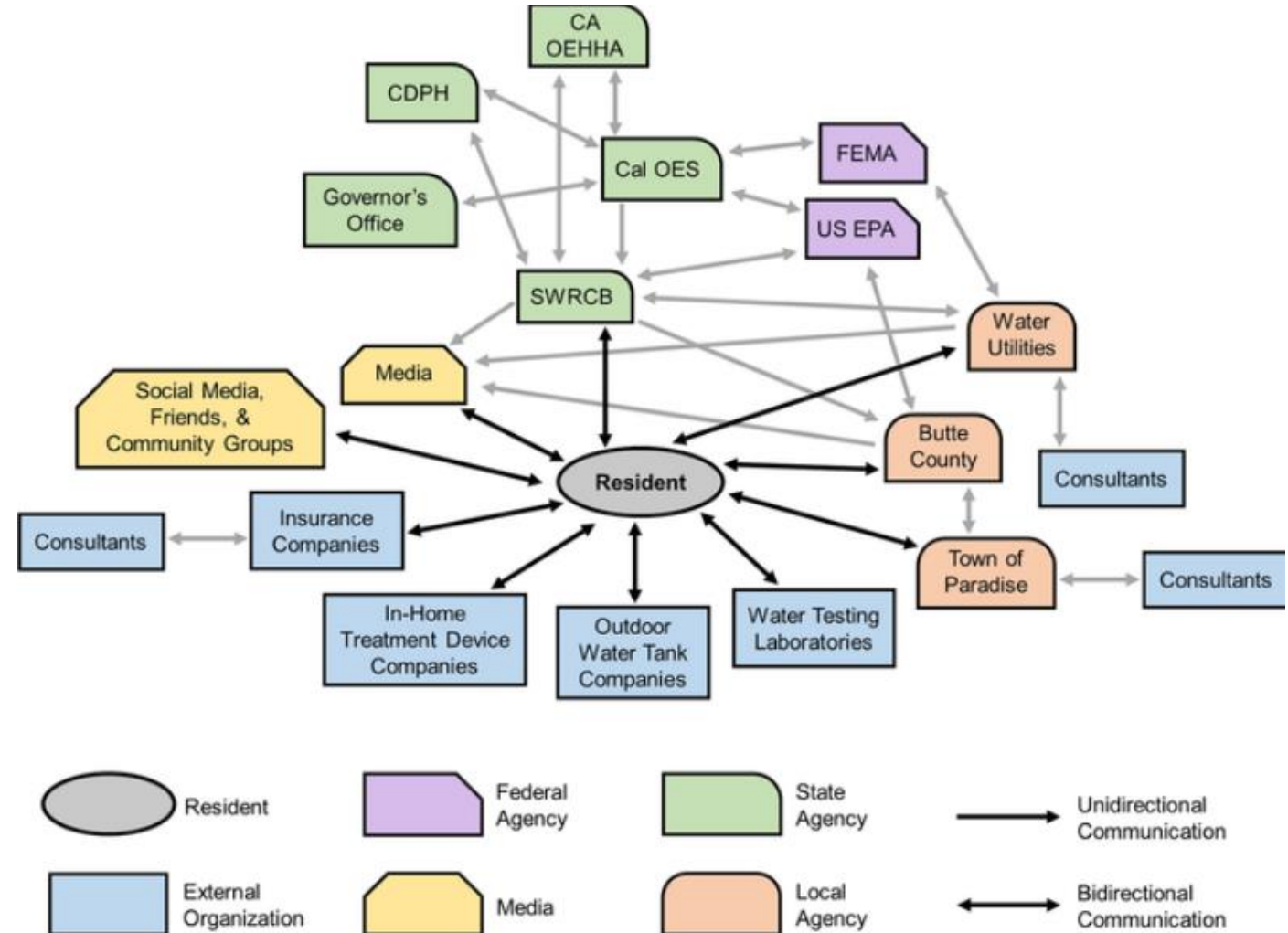
# Water safety attitudes, risk perception, experiences, and education for households impacted by the 2018 Camp Fire

*Natural Hazards, Published May 2021*

<https://doi.org/10.1007/s11069-021-04714-9>

## Critical Public Health Issues

- 1) Water use restrictions,
- 2) **Plumbing** sampling and testing,
- 3) **Plumbing** decontamination methods and validation,
- 4) Water tank selection and maintenance,
- 5) In-home treatment device selection and maintenance, and
- 6) **Plumbing** design and material selection for property repairs and new construction.





# **Q:** Should in-home POU water filtration devices be used to treat wildfire contaminated drinking water?

Water Collected and Analyze	Preliminary Results, ppb			
	Benzene	Toluene	Ethyl Benzene	Xylene
Entering the filter	713	911	87	212
Exiting the filter				
1 L	20	15	3	4
1.5 L	33	30	5	9
2 L	47	46	6	11
3 L	64	75	10	21
3.5 L	62	75	10	20
4 L	24	22	4	5
4.5 L	87	98	11	21
5 L	37	37	5	8

*In 2019, CA OEHHA concluded that short-term 26 ppb benzene exposure would prompt an increased risk of blood effects in children such as a decrease in lymphocytes and white blood cells; Benzene has a 5 ppb Federal MCL, 1 ppb CA MCL*



The devices are **NOT** designed for this.  
The range of contamination must be known + testing.

# Camp Fire: 'Standing Home' Public Health Issues

## Citizens must be warned and protected from contaminated water

- State officials told people to SMELL (not test) water to determine if its safe
- 2 systems contaminated --- no water restrictions (max. 530 ppb benzene)
- Some Paradise customers did not follow water use restrictions
- Home testing guidance by agencies defied hydraulics and chemistry
- Labs told people to flush taps for 10-15 min BEFORE taking water sample

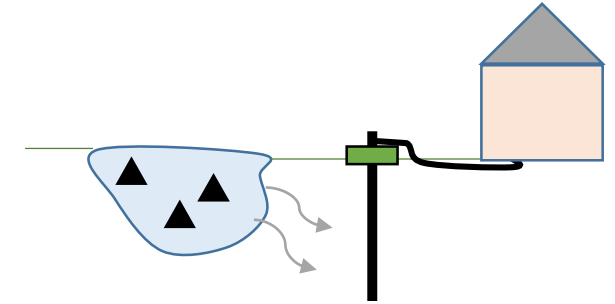
## Contaminated water entered home plumbing for 6+ months


- Benzene found in homes by residents, State said they had no knowledge (because they didn't credibly sample)
- Utilities were still trying to identify their contaminated assets
- Checkerboard recovery: Loss of pressure (main break, leak) *could move* contaminated water into a standing home service line

## Plumbing received 6+ months of contaminated water

Cold and hot water systems became nonpotable  
Trunk-and-branch vs. homerun designs  
In-home treatment devices (est. \$7 million)  
Paying for water testing, results not representative  
External water tank maintenance and microbiological growth  
Some had no economic capacity to purchase bottled water, devices

## Insurance companies made decisions (not USEPA, State or health department) about in-home treatment



 **Butte County Private Well Information**  
Post-fire well safety and testing guidelines.

Content updated on 5/14/19

**WARNING:** Recent testing conducted by the California State Water Board of creeks and rivers flowing from the fire affected areas on March 27th indicate elevated levels of heavy metals, including: Aluminum, Antimony, Arsenic, Cadmium, Selenium, Lead and Poly Aromatic Hydrocarbons (PAH's). Property owners who have private wells and also live near creeks or rivers should test for the presence of these heavy metals and PAH's in their well water. Residents in these areas should drink bottled water until well water is tested, treated and free of contamination.

**How to determine well water safety**

- If the casing or plumbing around the well was damaged by fire the water should be tested

**Recommended for  
private wells**

**Bacteria, heavy metals,  
PAHs, VOCs, SVOCs**

**72 hr stagnation on well**

Please note, the Public Health Laboratory only tests water for bacteria. If Benzene, PAH or heavy metal testing is needed, please contact one of the other labs listed below.

- **(Bacterial Only)** Butte County Public Health Laboratory: (530) 891-2747 | Oleander Ave. in Chico



In-home sampling 11 months later:  
PID system (101), Del Oro system (24)  
First draw, kitchen sink cold only,  
12+ hr stagnation  
Looked for more than benzene

Fire and Water: Assessing Drinking Water Contamination After a Major Wildfire. *ES&T Water*. 2021.

2 homes: benzene found, and less than 1 ppb CA MCL

4 homes: methylene chloride exceeded USEPA 5 ppb MCL (max. 9.2 ppb)

THF found above other state limits (no CA or federal limit)

H<sub>A</sub>: Galvanized iron pipes influenced methylene chloride levels

Homes not statistically representative, homeowner service lines not tested

Hot water systems are separate, where inhalation exposure occurs, but were not tested

Testing should occur as soon as possible



Max. Benzene, ppb	Event / Location	Pop.	System	Year
221	Marshall Fire/ Colorado	20,319	City of Louisville	2021
5.1	Marshall Fire/ Colorado	300	East Boulder County Water District	2021
5.5	Echo Mountain Fire/ Oregon	120	Whispering Pines Mobile Home Park	2020
11.3	Echo Mountain Fire/ Oregon	362	Hiland WC -Echo Mountain	2020
1.1	Echo Mountain Fire/ Oregon	760	Panther Creek Water District	2020
76.4	Almeda Fire/ Oregon	6,850	City of Talent	2020
44.9	Lionshead Fire/ Oregon	205	Detroit Water System	2020
1.8	CZU Lightning Complex Fire/ California	1,650	Big Basin Water Company	2020
42	CZU Lightning Complex Fire/ California	21,145	San Lorenzo Valley Water District	2020
>2,217	Camp Fire/ California	26,032	Paradise Irrigation District	2018
38.3	Camp Fire/ California	924	Del Oro Water Co.-Magalia	2018
8.1	Camp Fire/ California	1,106	Del Oro Water Co.-Lime Saddle	2018
530	Camp Fire/ California	11,324	Del Oro Water Co.-Paradise Pines	2018
40,000	Tubbs Fire/ California	175,000	City of Santa Rosa	2017

*Have there been more? Probably. Testing not always conducted correctly.*

Is **benzene** THE indicator of contamination?

--No

Is **BTEX** THE indicator of contamination?

--No

Is **VOC** THE indicator of SVOC contamination?

--Probably not, untested theory

**Oregon 2021:** Methyl ethyl ketone (138 ppm) exceeded the USEPA 1-day drinking water health advisory in the absence of benzene

*No shortcuts to chemical contamination decisions*





# Water Contamination and the December 2021 Marshall Fire, Boulder County, Colorado



Andrew J. Whelton, Ph.D., Caroline Jankowski, Kris Isaacson,  
Christian Ley, Ph.D., Myles Cook, Madeline Larsen, Deepika Solamathu

Email: [awhelton@purdue.edu](mailto:awhelton@purdue.edu)  
Web: [www.PlumbingSafety.org](http://www.PlumbingSafety.org)

Funded by:



2214580 RAPID: Drinking Water System  
Contamination Response & Recovery  
Following the 2021 Colorado Fires



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# Welcome to Boulder County



U.S. pop

331,893,745

\$62,843

\$217,500

32.1%

**Boulder Co., CO**

**330,758**

**\$127,292**

**\$592,000**

**62.1%**

Butte Co., CA

208,309

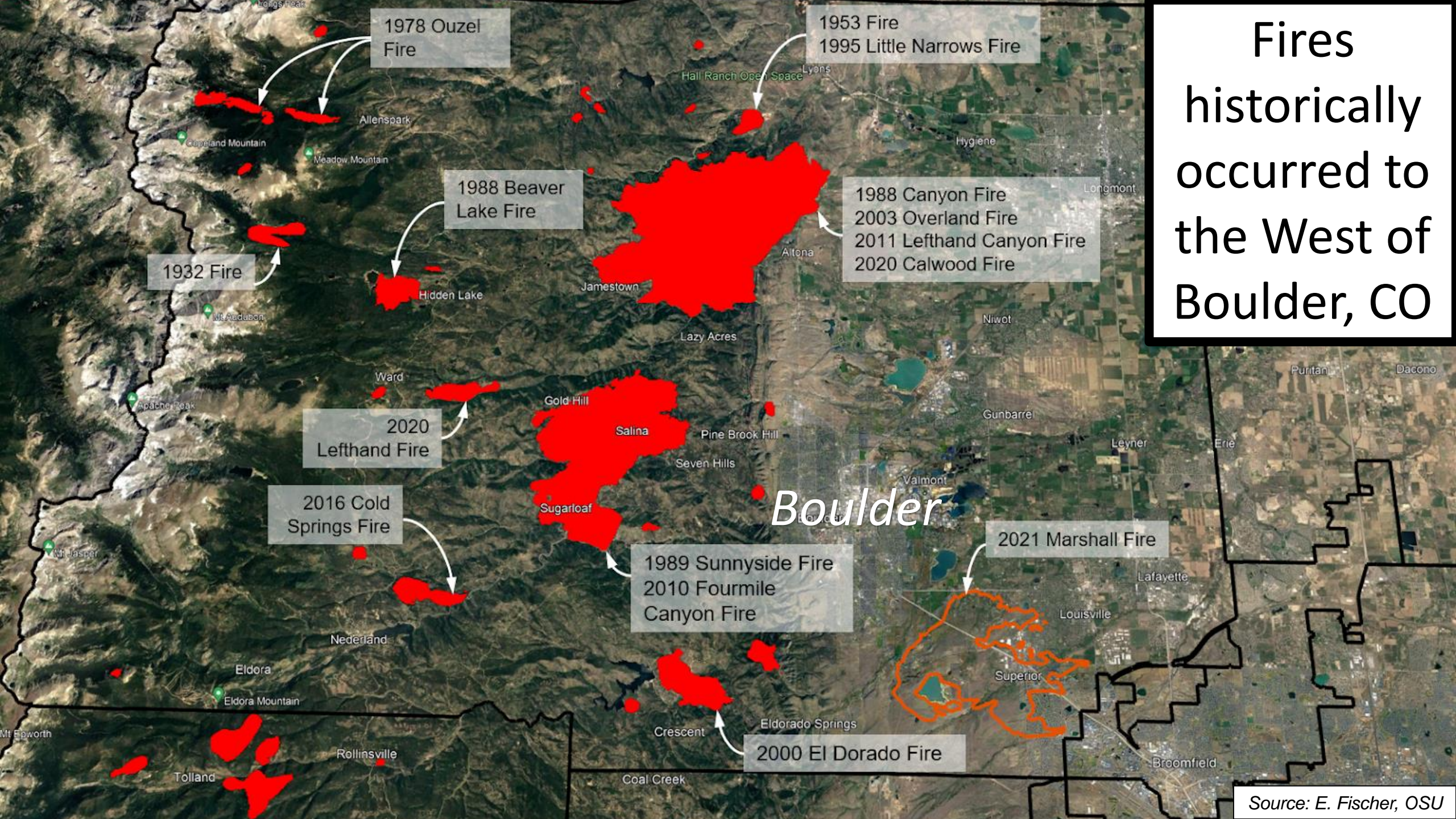
\$51,566

\$49,000

26.0%



Fires  
historically  
occurred to  
the West of  
Boulder, CO





Grass fire: 70 mph sustained, 90 to 102 mph wind gusts

December 30, 2021

11:06 am, Fire in Boulder Co.

12:10 pm, Fire in Superior

12:50 pm, Fire in Louisville

1:00 pm, 1,000 acres

40,000+ evacuation ordered

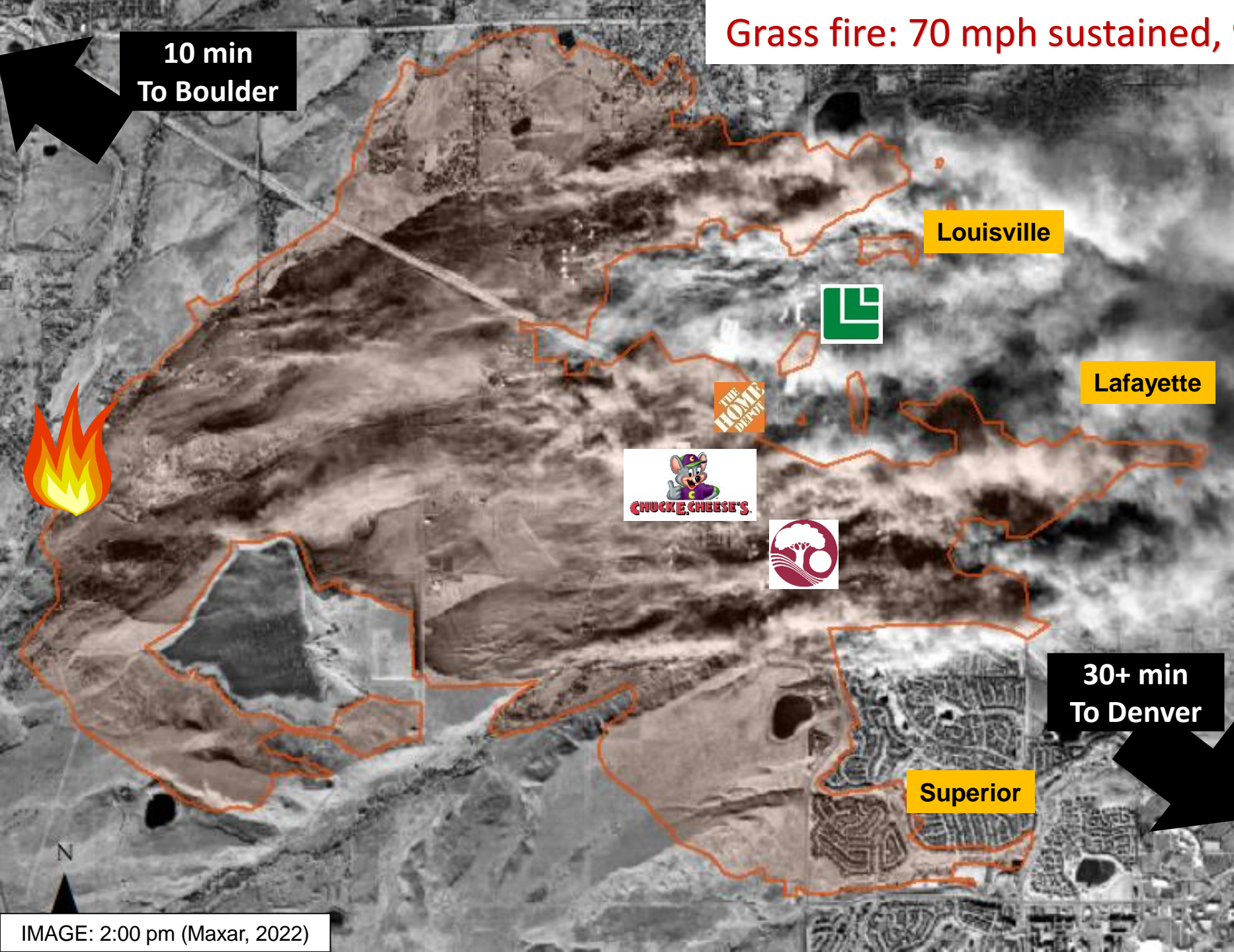
*The 3 largest communities*

Lafayette: 30,411

Louisville: 21,266

Superior: 13,094

Source: Fischer & Wham et al.  
GEER. The 2021 Marshall Fire,  
Boulder County, CO.



10 min  
To Boulder

Louisville

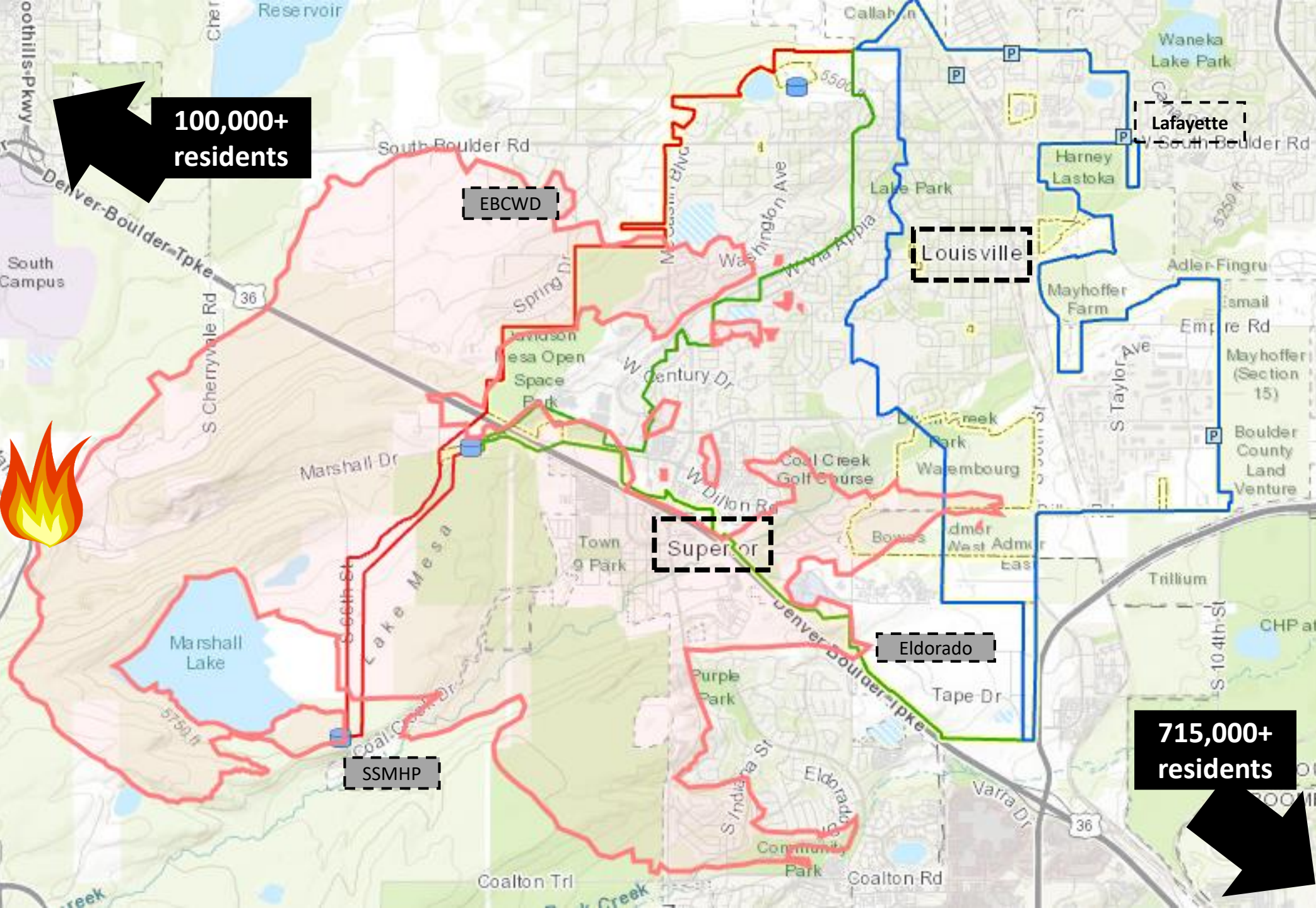
Lafayette

Superior

30+ min  
To Denver

IMAGE: 2:00 pm (Maxar, 2022)





100,000+  
residents

EBCWD

Louisville

Lafayette

6 public water  
systems were  
in the burn  
area

1. Louisville
2. Superior
3. Lafayette
4. EBCWD
5. Eldorado
6. SSMHP

Superior

Eldorado

SSMHP

715,000+  
residents



# ***The public water systems served about 60,000 people***

Public Water System (population)	Damaged/ Destroyed Properties	Water Mains, miles	Hydrants	Finished Water Storage, MG	Raw Water
Louisville (20,319)	593 of 7,339	120	1,200	7.5	Surface water
Superior (17,170)	436 of tbd	50	430	3.4	Surface water
Lafayette (28,700)	22 of 9,700	177	900	14	Surface water
EBCWD (300)	72 of 137	8	40	0.1	Lafayette
Eldorado Artesian Spring (259)	0	0	0	0	2 Wells, 1 Spring
S.S. Mobile Home Park (150)	3 of 61, wind	<1	None	None	1 Well

**Louisville:** VOC and SVOC contamination confirmed (benzene 221 ppb + others), decon underway

**Superior:** Smokey – ash tray drinking water odor, no VOC contamination so far, testing underway

**Lafayette:** No VOC contamination found (1 month stagnation, then sampled)

**EBCWD:** Paint thinner water odor, VOC contamination confirmed (benzene 5.1 ppb + others), decon underway

**The first 24 hours**

Fire reported, 11:06 am

Emergency declared, 3 pm

BWAs issued by State, 6 pm

LV

11–12, South WTP evacuated

12–1, Fire entered South WTP property

3–4, South WTP power loss. Interconnect opens for Superior.

5–7, Drove into fire zone, found tanks empty (2 ft), interconnect closed. Began sending untreated lake water through the North WTP

10–11, LNG tanks drove into South WTP, restored power, production and pressure

12–5, Shutoff curb stops to properties

611 of 7,339

SUP

2, Fire destroyed WTP emergency generator, WTP evacuated, asked LV for help

4, Sole WTP lost power, production stopped

6, Power returned, WTP restarted

6–830, Tanks est. 15% full, drove into fire zone, found hydrants open, began shutting curb stops

453 of 3,650

LAF

2, Booster station lost communications

3, Water storage tanks topped off, WTP evacuated.

5, Two gas generators did not kick on, but one diesel generator did

8, Hydrants connected to Louisville and 1.5 MGD delivery begins

12, Water meters at properties removed

18 of 9,700







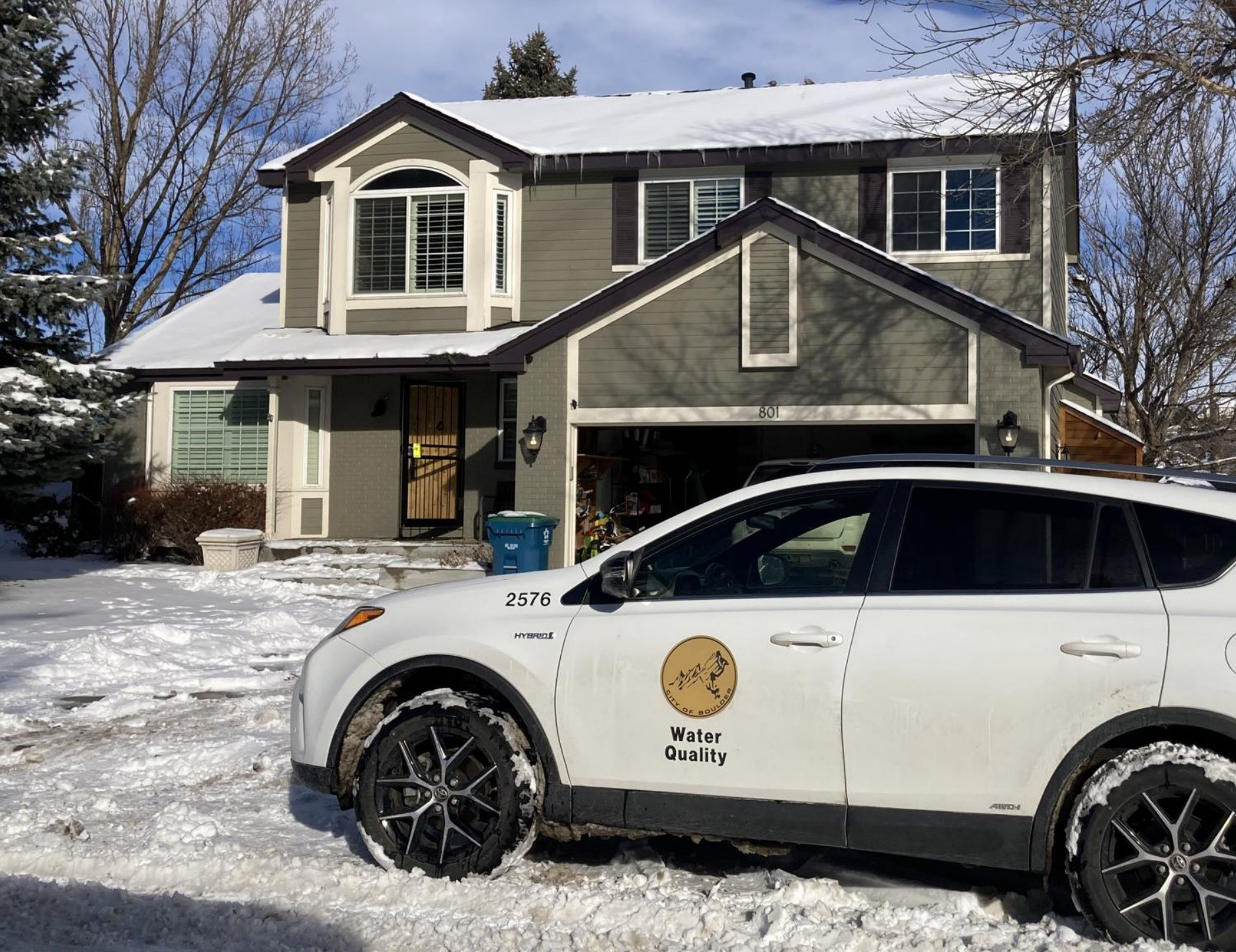




# ***To expedite contamination testing, we reviewed all literature and compiled a “fire package” list of chemicals***

Acetonitrile	Chlorodibromomethane	Ethyl- <i>tert</i> -butyl ether (ETBE)	1,2,4-Trichlorobenzene
Acetone	Chloromethane	Iodomethane	1,1,1-Trichloroethane
Acrolein	4-Chlorotoluene	Isopropylbenzene	1,1,2-Trichloroethane
Acrylonitrile	Dibromochloromethane	<b>Methylene chloride</b>	Trichloroethylene
<b>Benzene</b>	1,2-Dichlorobenzene	<b>Methyl ethyl ketone (MEK)</b>	Trichloromethane
Bromochloromethane	1,4-Dichlorobenzene	Methyl iso butyl ketone (MIBK)	1,2,4-Trimethylbenzene
Bromodichloromethane	1,1-Dichloroethane	<b>Methyl-<i>tert</i>-butyl ether (MTBE)</b>	1,3,5-Trimethylbenzene
Bromoform	1,2-Dichloroethane	<b>Naphthalene</b>	<b>Vinyl chloride</b>
<i>n</i> -Butylbenzene	1,1-Dichloroethene	<b>Styrene</b>	<i>ortho</i> -Xylene
<i>sec</i> -Butylbenzene	<i>cis</i> -1,2-Dichloroethene	<b><i>tert</i>-Butyl alcohol (TBA)</b>	<i>meta</i> -Xylene
<i>tert</i> -Butylbenzene	<i>trans</i> -1,2-Dichloroethylene	Tetrachloroethylene	<i>para</i> -Xylene
Carbon disulfide	1,2-Dichloropropane	<b>Tetrahydrofuran (THF)</b>	<div>NOTES: In the absence of benzene other chemicals have exceeded health-based limits; RED text indicates the chemical exceeded a short- or long-term health-based limit after a prior fire; SVOCs can also be present.</div>
Carbon tetrachloride	Ethanol	<b>Toluene</b>	
Chlorobenzene	Ethylbenzene	1,2,3-Trichlorobenzene	

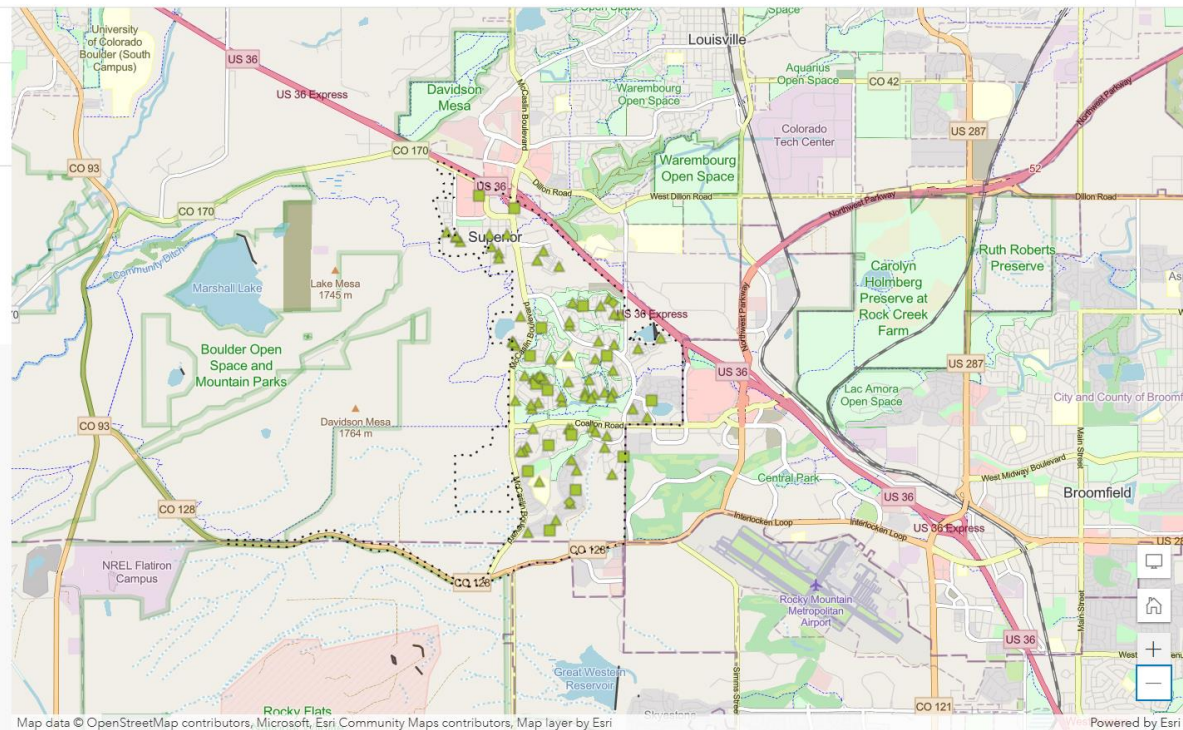




Internal leadership,  
exceptional staff, and  
requests for aide  
helped utilities  
stabilize

Helpful neighbors:  
Boulder, Ft. Collins,  
Erie, Westminster,  
South Adams County,  
Broomfield,  
Longmont, more...





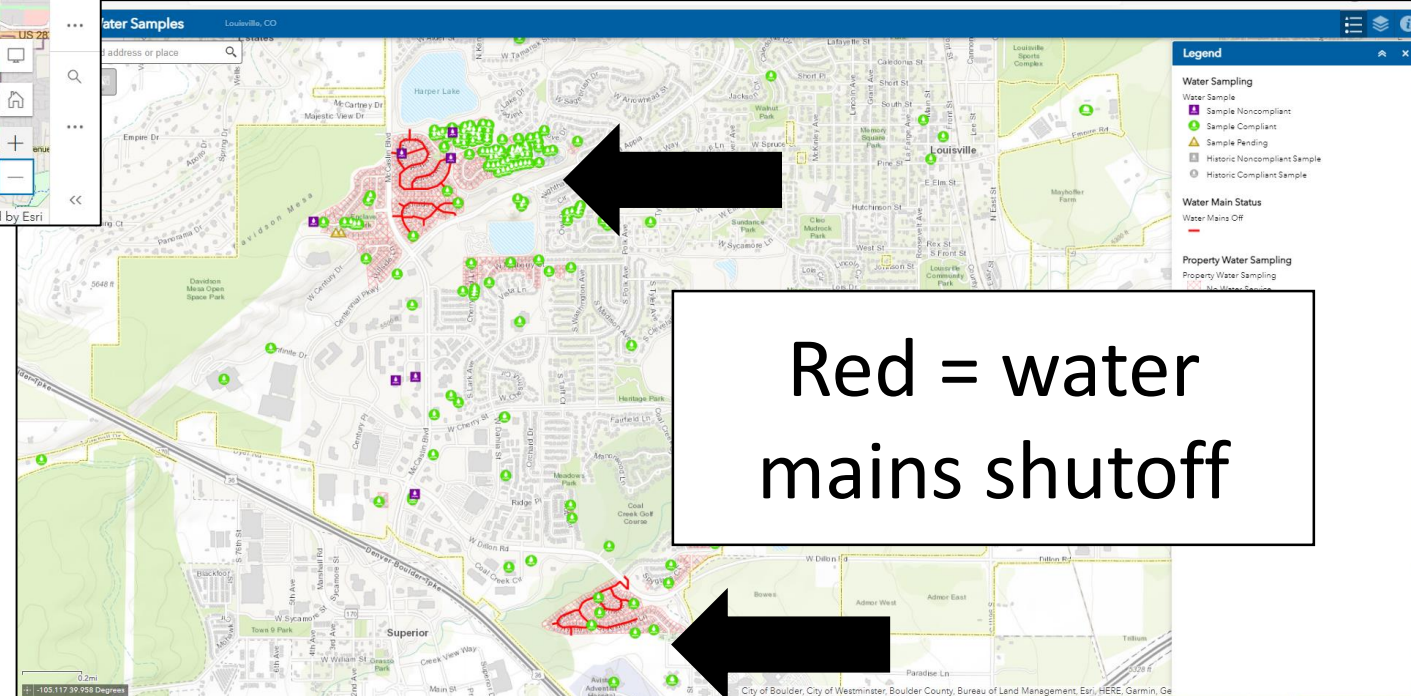
*Technology was critical to Louisville and Superior in finding valves, isolating systems, flushing, and identifying sampling locations to restore pressure.*

Each utility moved at a different pace with different challenges

1<sup>st</sup> focus: Bacteria and chlorine

Next: Fire caused VOCs

And then (some): Fire caused SVOCs



Red = water mains shutoff

# In Louisville, CO, chemical contamination was found above short-term drinking water exposure limits in isolated, shutoff sections

*Sample → Flush → Sample → Stagnate 72 hr → Sample → Repeat*

Chemical	Max	>Limit?	Odor?
<b>Benzene</b>	<b>221</b>	<b>Y</b>	
Toluene	511		<b>Y</b>
Ethylbenzene	160		<b>Y</b>
Xylenes	5		
<b>Styrene</b>	<b>1,900</b>	<b>Y</b>	<b>Y</b>
Naphthalene	11		<b>Y</b>
Acrolein	24		<b>Y</b>

*3 EPA Methods (524.2, 524.4, and 8260C)  
and >4 laboratories used*

*Locations with VOC exceedances were not  
returned to service until results were below  
health limits*

*Majority of samples had no detections*

*SVOCs were found too*

Others: 1,1-DCP, 1,2,4-TMB, 1,2-Dichloroethane, 4-Chlorotoluene, Acetone, Acetonitrile, Acrylonitrile, DEHP, Carbon disulfide, Chlorobenzene, Chloromethane, IPB, MEK, MTBE, N-Butylbenzene, N-Propylbenzene

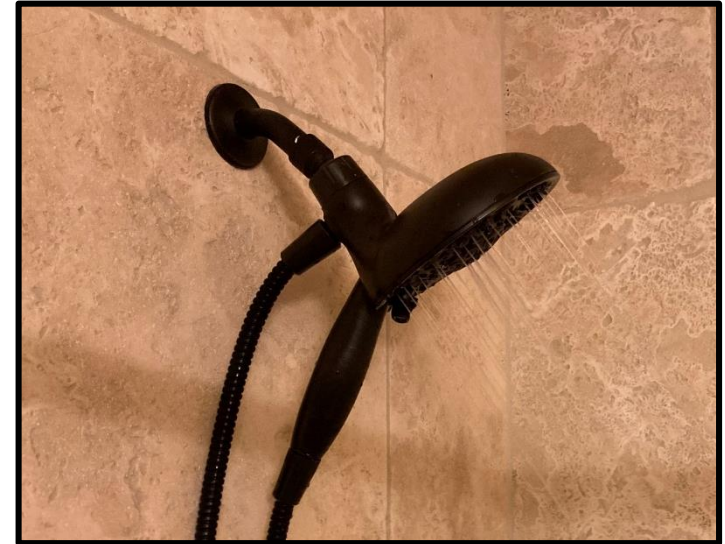


# Smoky, Ash Tray, Camp Fire Flavored Water

Superior received 300+ complaints in a day

Community concerns:

- ✓ Present at 1 household and not the neighbors
- ✓ Present in hot water only, not cold water
- ✓ Water heaters were contaminated
- ✓ The depressurized system sucked in chemicals
- ✓ Contamination was trapped in parts of the system



Smoke flavor after '03, '13, '16 wildfires assumed to be caused by drinking water source ash contamination.

Food science literature: Caused by phenols, *o*-cresol, *p*-cresol, *m*-cresol, guaiacol

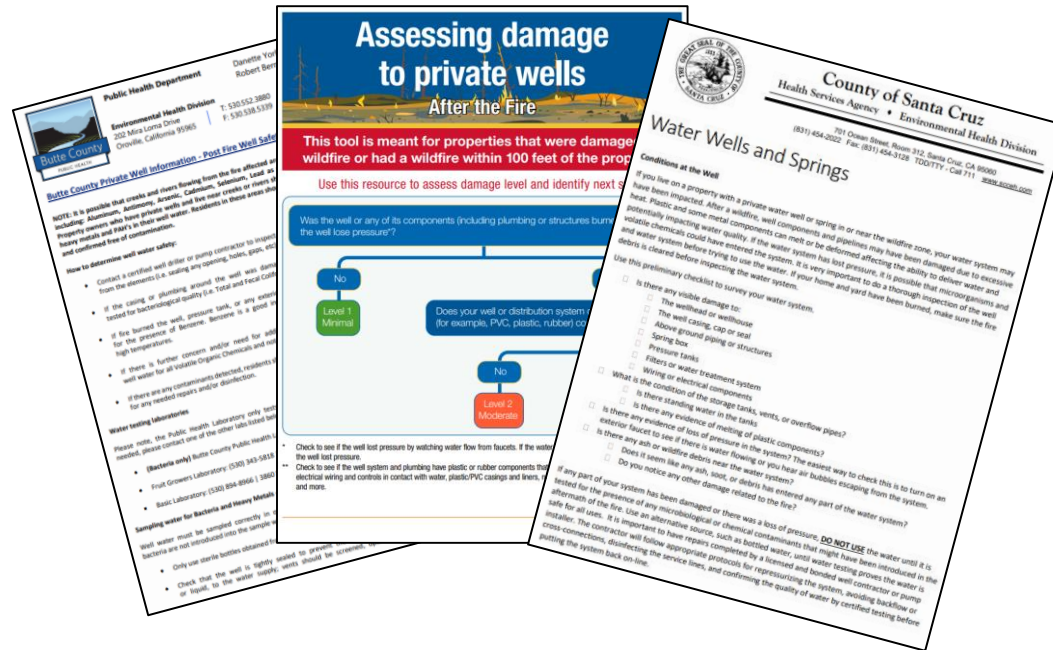
CSU Dr. Omur-Ozbek confirmed the flavor was originating from the source water (lake)  
–*and*– in the treatment plant –*and*– in the water distribution system

CU Boulder Dr. Thurman, Dr. Ferrer, and Corona identified and attributed a tricarboxylic benzoic acid and a dicarboxylic benzoic acid as the “smoky flavor” agents at ppb (Ferrer et al. 2021)

They stated chemicals identified were not known to be a health risk at levels found



# For drinking water wells damaged by fire, there's no consistency on “what” chemicals to test for



**BCHD (CA):** Bacteria, Al, As, Cd, Pb, Sb, Se, PAH's

**CDC:** Bacteria,  $\text{NO}_3^-$ ; BTEX; local contaminants

**WaDOH (WA):** Coliform bacteria

**SCCHD (CA):** Coliform bacteria, turbidity, pH, conductivity, color,  $\text{NO}_3^-$ ; VOCs, SVOCs

**OHA (OR):** Coliform bacteria, As, Pb,  $\text{NO}_3^-$ ; BTEX







# No VOCs Found, but SVOCs

Contaminant	W7 (surface)	W7 (3-4 ft)	W13	W5
Azobenzene	-	-	-	0.3
2-Nitrophenol	0.15	0.11	-	-
1,2,3-Trichlorobenzene	0.14	0.16	-	-
Naphthalene	0.15	0.19	-	-
2-Methylnaphthalene	0.10	0.08	-	-
1-Methylnaphthalene	0.16	0.18	-	-
2-Nitroaniline	-	0.10	-	-
Acenaphthylene	0.19	0.23	-	-
1,2-Dinitrobenzene	0.14	0.11	-	-
Fluorene	0.10	0.13	-	-
4-Nitroaniline	0.10	-	-	-
Phenanthrene	0.14	0.25	-	-
Di- <i>n</i> -butylphthalate	5.9	0.48	-	-
Fluoranthene	0.13	1.0	0.19	-
Pyrene	0.14	0.19	-	-
Bis(2-ethylhexyl)adipate	9.3	4.9	-	-
Chrysene	0.12	0.12	-	-
Bis(2-ethylhexyl)phthalate	3.6	3.0	-	-
Anthracene	-	-	0.11	-

# Inorganics

Data Description	Min	Max	Mean $\pm$ Stdev
Wells & Cisterns – Marshall Fire (14)	12.4	105	42 $\pm$ 26
Faucet – Marshall Fire (8)	4.2	89.3	34.8 $\pm$ 25.1
PWS UCMR3 – Colorado (108)	0.9	1,700	20.3 $\pm$ 54.1
PWS UCMR3 – Marshall Fire area (108)	1.6	131	25.8 $\pm$ 23.7

USEPA Li Screening Level: 10 ppb

Data Description	Min	Max	Mean $\pm$ Stdev
Wells & Cisterns – Marshall Fire (14)	9.3	243	69.4 $\pm$ 73
Faucet – Marshall Fire (8)	15.5	86.5	59.3 $\pm$ 30.4
PWS UCMR5 – ongoing	tbd	tbd	tbd

USEPA V Screening Level: 86 ppb

Property Search
Jobs
Volunteer
Elections
County Government
Departments
Contact
Select Language

FAMILIES & ADULTS
OPEN SPACE & RECREATION
PROPERTY & LAND
ROADS & TRANSPORTATION
ENVIRONMENT & SUSTAINABILITY
SAFETY & LAW
LICENSES, PERMITS & RECORDS

Marshall Fire Information | Información sobre el Incendio Marshall

COVID Information | Información sobre COVID — COVID Vaccine Providers | Proveedores de Vacunas Contra COVID

WELLS & WASTEWATER AFTER A FIRE
/ Safety & Law / Fire / Wells & Wastewater After a Fire

# Wells & Wastewater After a Fire

En Español

Your well or septic system could be adversely affected by the fire, power outages, equipment failure from fire damage, or contamination of water supplies. Be prepared, and have plenty of bottled water available for drinking and cooking when you return home.

Have your water tested before using for drinking, brushing teeth, or cooking purposes and for washing dishes or other cooking utensils. Bacteria and volatile and semi-volatile organic compounds could have contaminated drinking water from pressure loss due to power outages or heat and fire damage to the well, plumbing or structures connected to the well.

## Wells

- Visually inspect your well and other components of your water system for damage including melted wiring for pumps and the well head.
- If the well head has been damaged, temporarily cap or cover the well with a 5 gallon bucket to prevent contaminants from entering. If you find damage to your well or water system, contact an appropriate contractor to repair the damage and test the water.
- Thoroughly flush your water lines and be sure to change any water filters in your house and appliances.
- Have your water tested for bacteria, volatile organic compounds (VOC's) and Semi-volatile Organic Compounds (SVOC's).
  - Allow the water to sit undisturbed (stagnate) for 72 hours prior to testing.
  - For more information on [Water Testing](#).

## Water Use While Awaiting Test Results

While awaiting results of water testing, plan to use bottled water for cooking, drinking and brushing your teeth. You can use the water for flushing toilets.

Related Links

- Fire & Food Safety
- Fire Recovery
- Potential Hazards in a Wildfire Area
- Safe Cleanup after a Fire
- Wells & Wastewater after a Fire
- Wildfire & Mental Health
- Wildfire & Tetanus Risk

THE ENVIRONMENT AND YOUR HEALTH
Lithium in drinking water

Lithium is one of Earth's naturally occurring metals. It is found throughout the environment.

Lithium occurs naturally in some ground and surface water used for drinking. Lithium in our diet comes mostly from the foods we eat such as grains and vegetables. Manufacturers use lithium in batteries, renewable energy systems, medicine, and more.

Benefits and risks

Research suggests lithium has positive effects on the human brain, but too much lithium can cause health impacts.

Some people take lithium to treat conditions such as bipolar illness or major depression.

People who take lithium as a medication typically have their blood levels checked routinely to ensure the level of lithium isn't toxic.

Symptoms of too much lithium include nausea, diarrhea, dizziness, muscle weakness, fatigue, and neurological effects.

Too much lithium over longer time periods can cause thyroid or kidney problems.

Lithium in drinking water: Rules and guidelines

Lithium is not regulated in drinking water in the U.S.

Starting in January 2023, public water systems serving more than 3,300 people and 800 smaller public water systems nationwide will be required to monitor for lithium as part of the Environmental Protection Agency's (EPA) Unregulated Contaminant Monitoring Rule (UCMR). EPA uses the UCMR to collect data on contaminants in drinking water that have health-based standards. This data may lead to future regulations.

The EPA has a Health-Based Screening Level for lithium in drinking water of 10 parts per billion. This health-based guideline could change as we learn more about the potential health impacts of lithium.

Actions you can take

Test your water to find out how much lithium is in it. Visit [cdphe.colorado.gov/laboratory-services/water-testing/homeowner-water-testing](https://cdphe.colorado.gov/laboratory-services/water-testing/homeowner-water-testing) to find out more.

If you are concerned about the level of lithium in your water, you may want to consider a treatment system. Reverse osmosis and ion exchange are effective at removing lithium from drinking water.

If you have symptoms of too much lithium, talk to a health care provider.

If you take lithium as medication, do not stop taking it without talking to a health care provider.

Questions? Contact ToxCall

303-692-2606 | [cdphe\\_toxcall@state.co.us](mailto:cdphe_toxcall@state.co.us)

Division of Environmental Health and Sustainability

Toxicology and Environmental Epidemiology Office

THE ENVIRONMENT AND YOUR HEALTH
Vanadium

Vanadium is one of Earth's naturally occurring metals. It is found in rocks and is naturally released into water and soil through erosion. It also can be in the air we breathe.

Vanadium is present in food and drinking water. Manufacturers use vanadium metal to strengthen steel. Other forms of vanadium are used in ceramics, magnets, and dietary supplements.

Health impacts of vanadium

Vanadium is found in many foods, locally in small amounts. People cannot avoid contact with vanadium, but levels that are only present in food and water are generally not considered to be harmful.

Most people come into contact with vanadium in food, but breathing high levels of vanadium compounds may cause lung damage. People are most likely to be exposed to high levels of vanadium compounds in air in workplace settings.

Swallowing large amounts of vanadium may cause nausea, mild diarrhea, and stomach cramps.

The International Agency for Research on Cancer has determined that the form of vanadium that moves through the air, is possibly carcinogenic to humans. The determination is based on evidence of lung cancer in exposed mice.

Vanadium in drinking water

Vanadium is not regulated in drinking water in the U.S.

Between 2013 and 2015, the U.S. Environmental Protection Agency required public water systems serving more than 10,000 people and 800 smaller public water systems nationwide to monitor for vanadium as part of the Unregulated Contaminant Monitoring Rule (UCMR). EPA uses the UCMR to collect data on contaminants they may regulate in the future.

All of Colorado's public water systems tested as part of the UCMR found levels of vanadium below 86 parts per billion, which is a health-based screening level. Levels may be higher in private well water.

Actions you can take

Test your water to find out how much vanadium is in it. Visit [cdphe.colorado.gov/laboratory-services/water-testing/homeowner-water-testing](https://cdphe.colorado.gov/laboratory-services/water-testing/homeowner-water-testing) to find out more.

If you are concerned about the level of vanadium in your water, you may want to consider a treatment system. Reverse osmosis and ion exchange systems have been shown to remove vanadium.

Talk to a health care provider before taking supplements containing vanadium to find out if they are right for you.

Vanadium is in tobacco smoke. Don't smoke, or avoid smoking in enclosed spaces to limit exposure among children and others.

Questions? Contact ToxCall

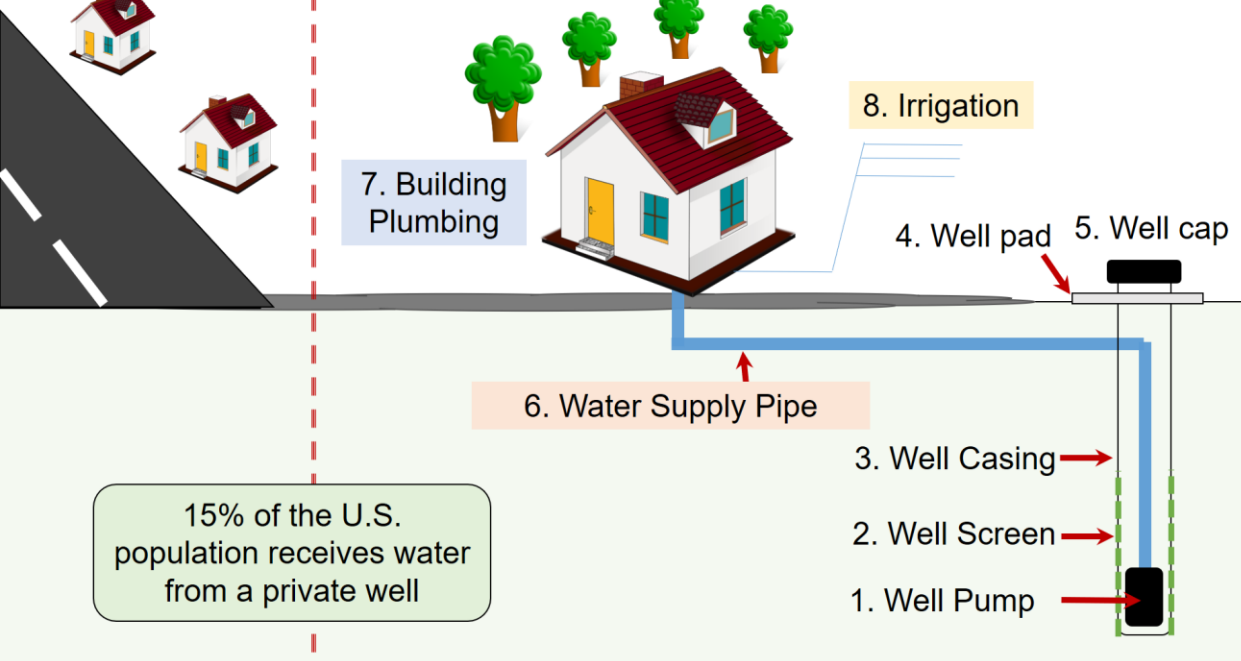
303-692-2606 | [cdphe\\_toxcall@state.co.us](mailto:cdphe_toxcall@state.co.us)

Division of Environmental Health and Sustainability

Toxicology and Environmental Epidemiology Office

- Assessing well damage
- Permit requirements for well repair
- Water testing
- CDPHE Factsheets: Lithium and vanadium
- Testing laboratories for VOCs, SVOC, and heavy metals
- Home water filtration systems
- Resources for well owners
- Resources for onsite wastewater treatment system owners





**PURDUE UNIVERSITY**

**After a Wildfire: Water Safety Considerations Inside Buildings**

**Damage and Chemical Water Contamination Caused by Wildfires**

Wildfires can directly contaminate water systems that deliver water to buildings as well as the building's own plumbing. This can pose an immediate health and safety risk to water users. Drinking water can become chemically contaminated, sometimes exceeding hazardous waste limits. Boiling the water will NOT protect users from the chemical contamination and may increase chemical exposure. An inspection of property and building water system components is needed before trying to use the water. If a water utility delivers water to the property, the utility system may also be damaged including the service line and water meter. Water utilities should initiate rapid inspections, testing, and inform you of the results. Private wells should also be inspected and tested.

Signs of contamination can include the loss of water pressure, discolored water, heat damage to water systems inside and outside buildings, broken, melted, and leaking pipes, valves, tanks, water meters, irrigation system components, and yard hydrants. Heat damage to the building structure may indicate plumbing damage. Chemical contamination can occur due to the water system and the heating or burning of the water system materials themselves, including plastics. If the water system lost pressure, microorganisms and chemicals can enter the system.

Persons impacted by wildfire should seek specific advice from their local health department.

**A Water System Damage Inspection Should Be Conducted and Include:**

- The water meter box.
- The irrigation system.
- Above ground piping or structures, including outdoor spigots.
- The point of entry, where the water supply line enters the building.
- The whole building water treatment system, if one exists.
- The plumbing pipes inside the building.
- The water heater.
- The tubing that connects the fixtures to the plumbing.
- The fixtures like faucets, showerheads, toilets, etc.
- Point of use water treatment systems on faucets, showerheads, and under tanks.
- Appliances such as dishwasher, washing machine, dryer, humidifier, HVAC furnace, etc.
- Wiring and electrical components.
- Evidence of melted plastic components.
- Briefly turning on an exterior faucet to see if water is not flowing or you hear air escaping from the system. This may indicate pressure loss.
- Fire sprinkler system. Also, pay attention to any ash, soot, or wildfire debris near the water system, whether this has entered any part of the water system, and any other damage related to the fire.

Repairs should be completed by a licensed and bonded contractor with plumbing expertise. The contractor should follow appropriate protocols for representing the system, avoiding backflow or cross-connections, disinfecting the water lines, and confirming the quality of water by certified testing before putting the system back online.

**Using Water**

Use a different water source, such as bottled water, until water testing proves the water is safe for all uses. The installation of external water tanks with periodic deliveries is sometimes preferred, but this requires confirming that the indoor plumbing is not contaminated. If the source of the contamination can be determined, isolate it. If the water system needs to be flushed, be careful to contain the runoff if possible or direct it to a channel to avoid erosion and minimize spreading the contamination. Before you use the water, it is important to verify that there is no microbiological or chemical contamination.

Center for Plumbing Safety at Purdue University, West Lafayette, Indiana USA  
Visit [www.PlumbingSafety.org](http://www.PlumbingSafety.org), [PlumbingSafety@purdue.edu](mailto:PlumbingSafety@purdue.edu), Date Released: May 16, 2021

**PURDUE UNIVERSITY**

**After a Wildfire: Water Safety Considerations for Private Wells**

**Damage and Contamination Caused by Wildfires**

Wildfires can directly contaminate private wells and springs causing an immediate health and safety risk to their users. Water testing after wildfires has revealed contaminated drinking water, sometimes exceeding hazardous waste limits. A thorough inspection of the well and water systems is needed before trying to use the water. If the building or property has been burned, make sure the fire debris is cleaned before inspecting the water system.

Signs of contamination may include the loss of water pressure, discolored water, heat damage to water systems inside and outside buildings, broken and leaking pipes, valves, tanks, irrigation systems, and yard hydrants. Chemical contamination can occur due to the water system and the heating or burning of the water system materials themselves, including plastics. If the water system lost pressure, microorganisms and chemicals may have entered the system.

Persons impacted by wildfire should seek specific advice from their local health department.

**A Water System Damage Inspection Should Be Conducted and Include:**

- The wellhead or well house.
- The well casing, cap or seal.
- Above ground piping or structures.
- Spring box.
- Pressure tanks.
- Filters or water treatment system.
- Wiring or electrical components. What is the condition of the storage tanks, vents, or overflow pipes?
- Is there any evidence of melted plastic components?
- Is there any evidence of pressure loss in the system? One way to check this is to turn on an exterior faucet to see if there is water flowing or you hear air escaping from the system.
- Is there any ash or wildfire debris near the water system?
- Does it seem like any ash, soot, or debris has entered any part of the water system?
- Do you notice any other damage related to the fire?

Repairs should be completed by a licensed and bonded well contractor or pump installer. The contractor should follow appropriate protocols for representing the system, avoiding backflow or cross-connections, disinfecting the service lines, and confirming the quality of water by certified testing before putting the system back online.

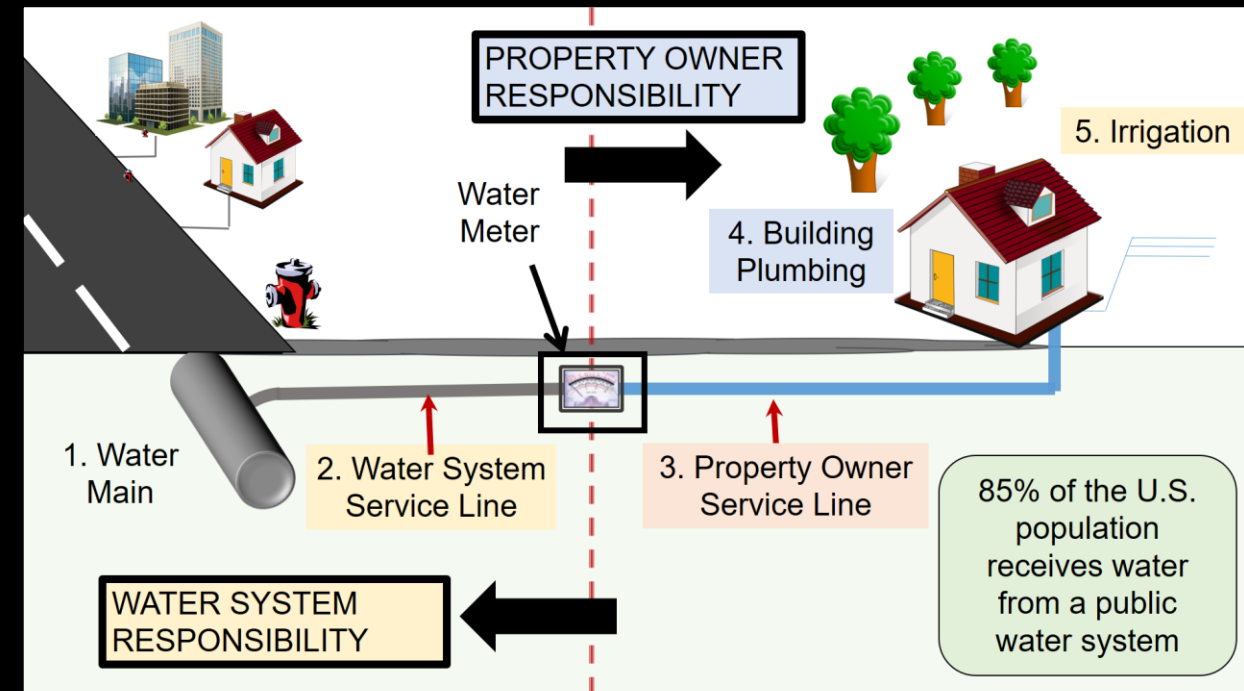
**Using Water**

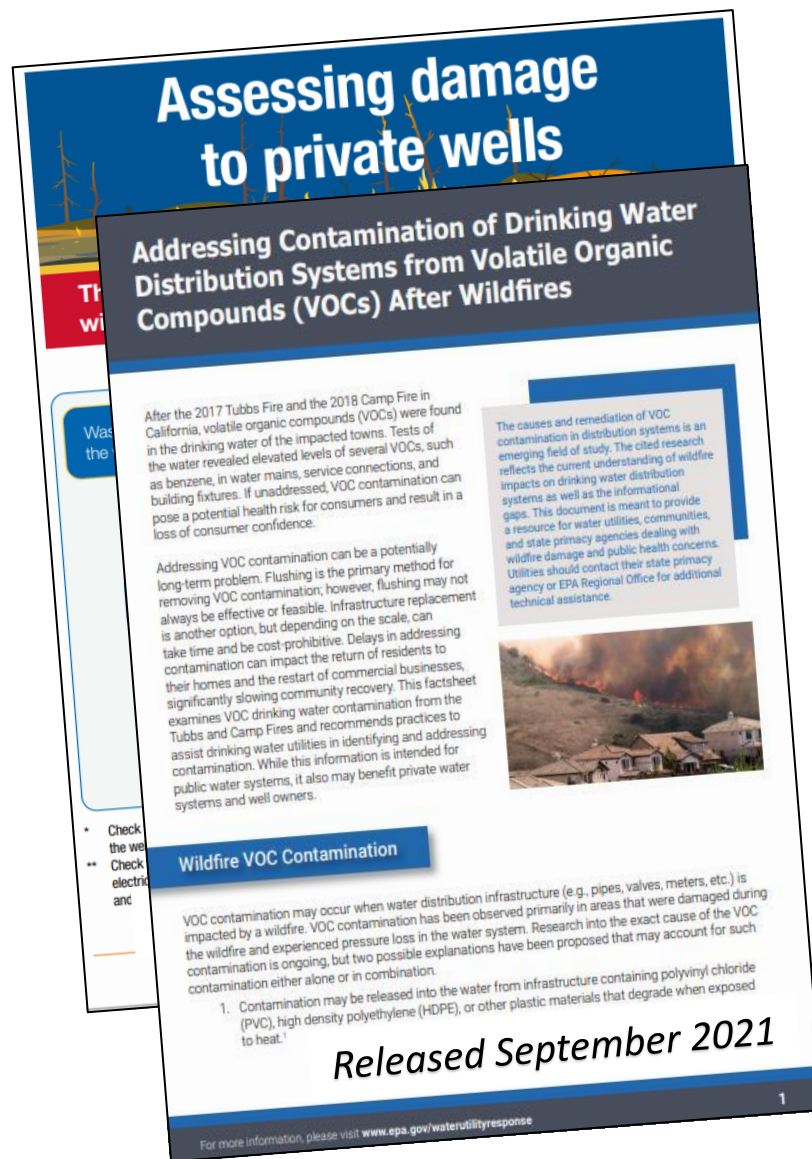
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Visit [www.PlumbingSafety.org](http://www.PlumbingSafety.org), [PlumbingSafety@purdue.edu](mailto:PlumbingSafety@purdue.edu), Date Released: May 16, 2021

We created two 1 page inspection and water testing guidance sheets for private wells and building water systems

Access here → [\[Click\]](#)





## Federal Insurance and Mitigation

### Job Aid for Disaster Recovery Reform Act, Section 1205 Additional Activities for Wildfire and Wind Implementation under Hazard Mitigation Assistance Programs

December 3, 2019

#### Replacing water systems that have been burned and have caused contamination

Wildfires generate intense heat that can adversely impact water system components both on the surface and underground. If intense heat modifies the chemical properties of water system components, chemicals might leach into the water, causing contamination. Infrastructure retrofits that reduce future risk to existing utility systems, including water systems, are eligible for HMA funding. The mitigation measures that are applied to the utility system can be multi-hazard to address more than just the hazard that caused the damage. Because HMA grants can be used to address undamaged portions of a utility system, they can be used to mitigate system components that have not been damaged but have properties like other systems that have sustained damage as well as undamaged portions of systems that have been partially damaged.



FEMA

# ...Government Policies





## **WaterRF Project 5106: Post-Wildfire Water Distribution System Water Quality Impacts and Potential Responses**



## **NSF RAPID 2214580: Drinking Water System Contamination Response and Recovery Following the 2021 Colorado Wildfires**



## In Conclusion: What Do We Know?

1. Chemical drinking water contamination occurs due to fire posing an immediate health risk due to water users (inhalation, dermal, ingestion).
2. Chemicals enter water systems by multiple pathways: Depressurization vs. direct thermal damage
3. Sources are varied: Plastics vs. structures vs. vegetation
4. Nonroutine water sampling and testing methods must be applied
5. Finding and removing contamination takes weeks to months
6. Responding agency staff may not understand how to advise on this testing and recovery problem
7. Major differences in finding contamination in neighboring wells and homes
8. Bacteria has not been found post-fire....but health departments test for it



## How Can We Work to Keep Drinking Water Safe?

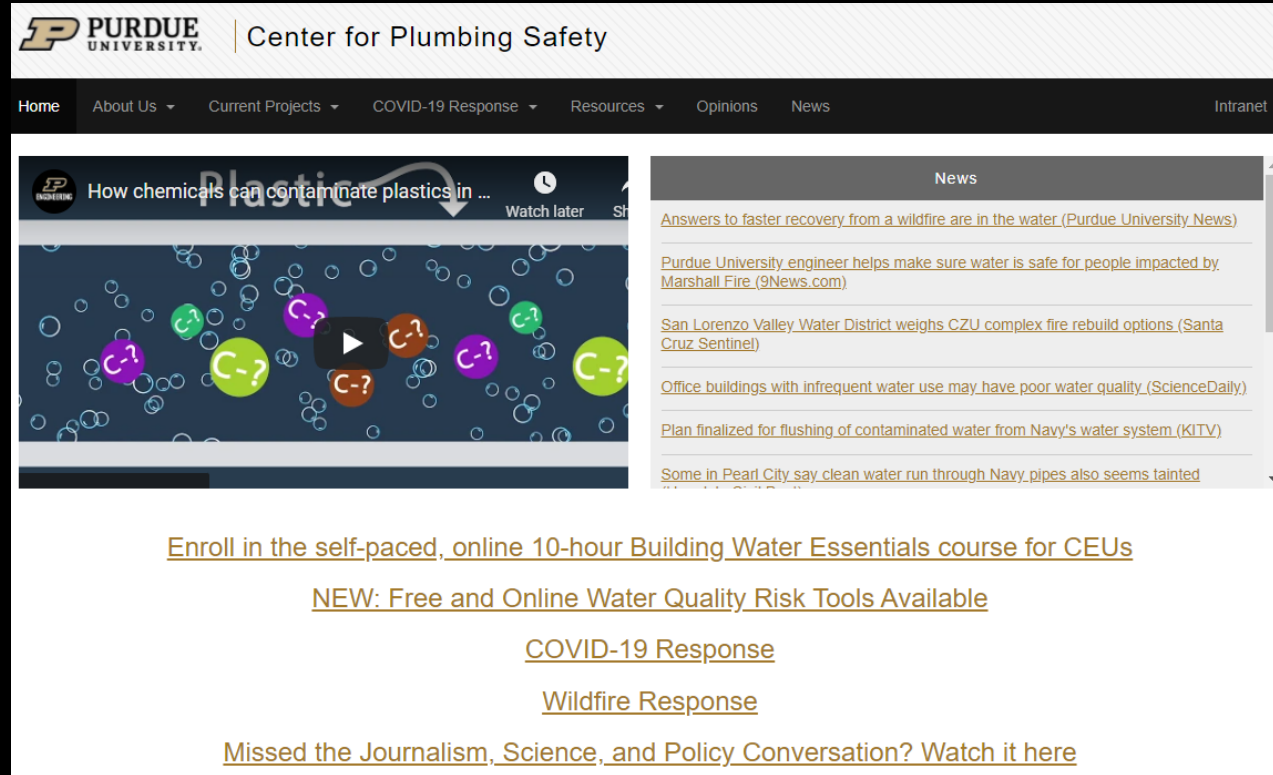
1. Keep power, water pressure.... don't depressurize
2. Keep heat away from plastic assets (meter boxes, exposed piping, pump houses, buildings, etc.)
3. Isolate leaks during fire to lessen pressure loss and contamination spread
4. Issue Do Not Use Orders to protect the population from exposure until tests
5. Chemically test the water distribution system extensively after fire
6. Inspect and chemically test private wells/plumbing after fire

## To make systems more resilient...

1. Use backflow prevention devices in new builds and retrofits
2. Reduce vegetation near assets (meter boxes, exposed pipes, structures, etc.)
3. Bury assets at least 2 ft below the ground , maybe more
4. Public Water Systems: Signup for XXWARN to get rapid access to surge people and equipment

# Thank you. Questions?

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US EPA R836890

Paradise Rotary Foundation

Water Research Foundation

NSF RAPID 2214580

Purdue University

More Wildfire Lessons Coming Soon to:

[www.PlumbingSafety.org](http://www.PlumbingSafety.org)



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