Investigating the Connection Between Wildfires and Drinking Water Contamination

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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

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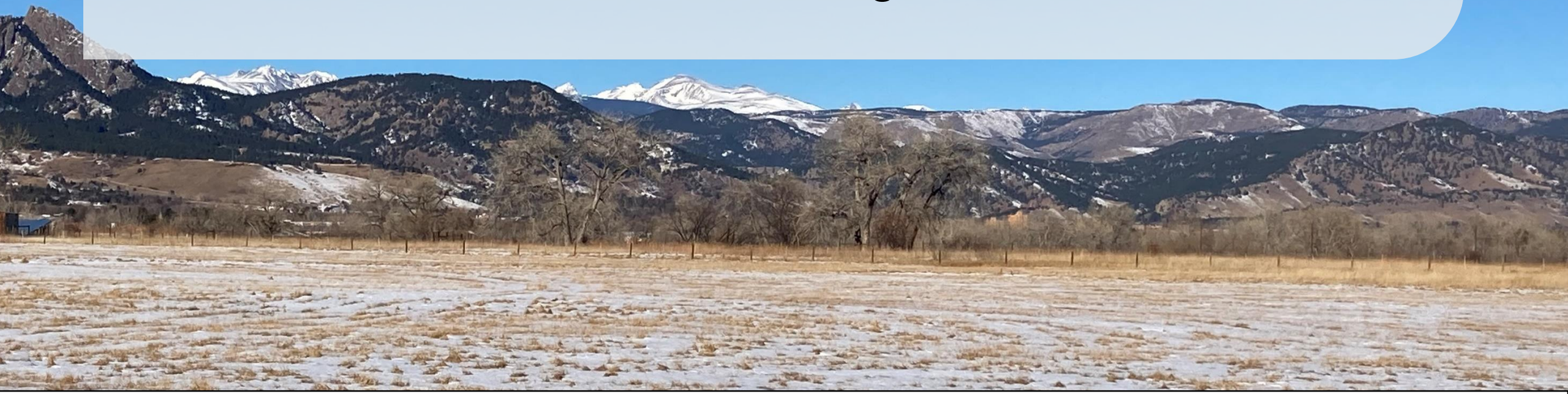
Drinking water for the U.S. population

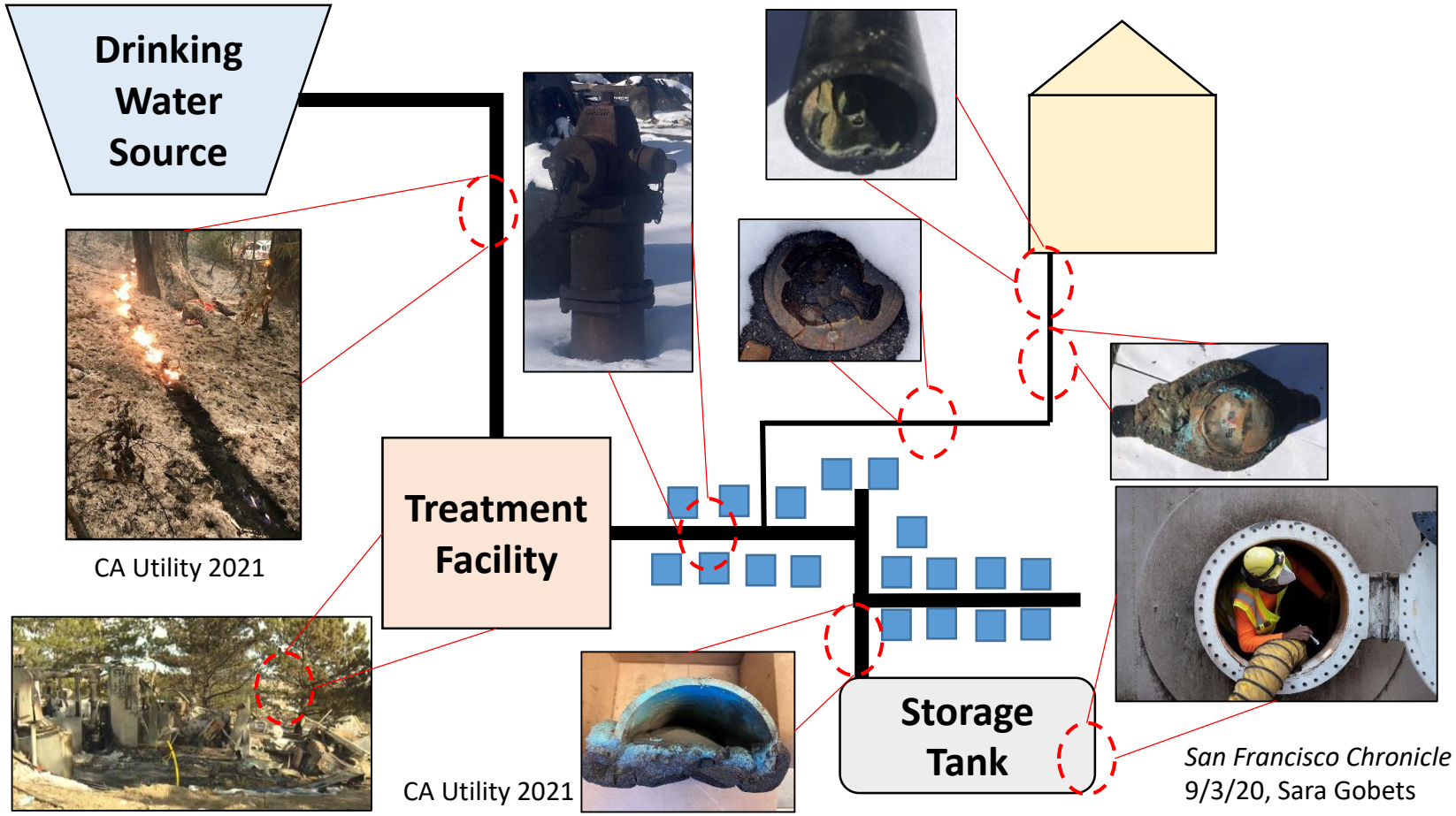
85%: “Regulated” public drinking water systems

15%: Private drinking water well



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

USGS 2009

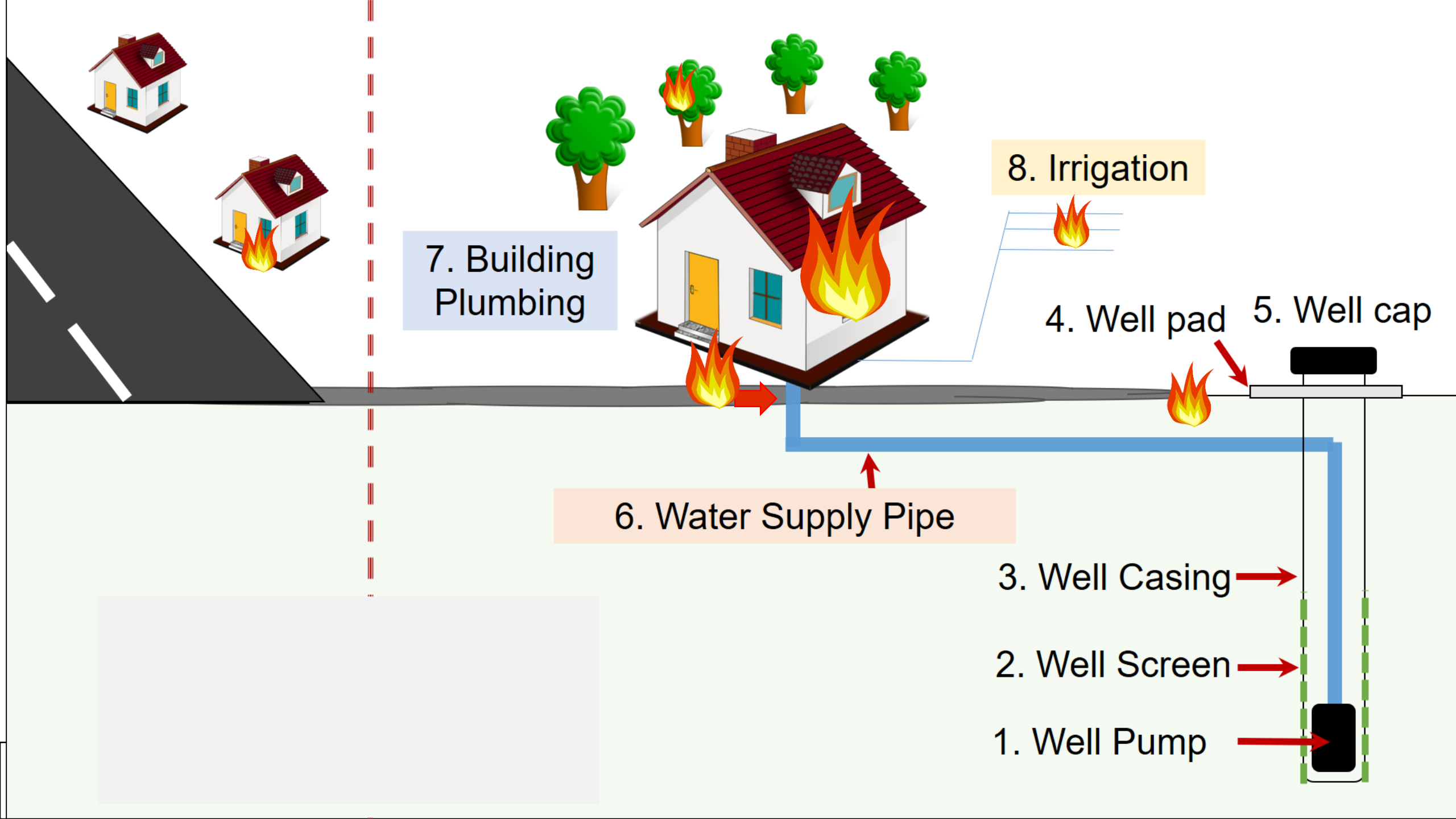


CA Utility 2021

CA Utility 2021

San Francisco Chronicle
9/3/20, Sara Gobets

Fires can physically and chemically damage infrastructure


8. Irrigation
7. Building Plumbing
4. Well pad
5. Well cap
6. Water Supply Pipe
3. Well Casing
2. Well Screen
1. Well Pump

Lessons Learned from the 2017 Tubbs Fire and 2018 Camp Fire

AWWA WATER SCIENCE

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.)

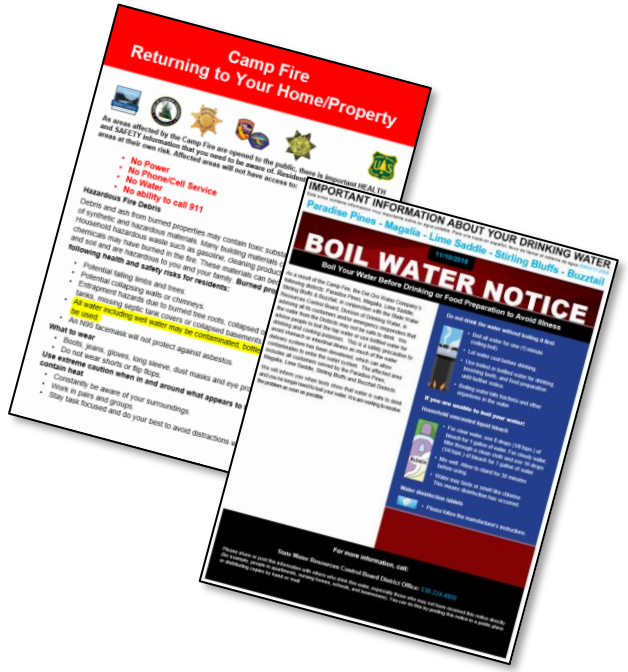
Do Not Use water order should be issued

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





PURDUE UNIVERSITY

MANHATTAN COLLEGE

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

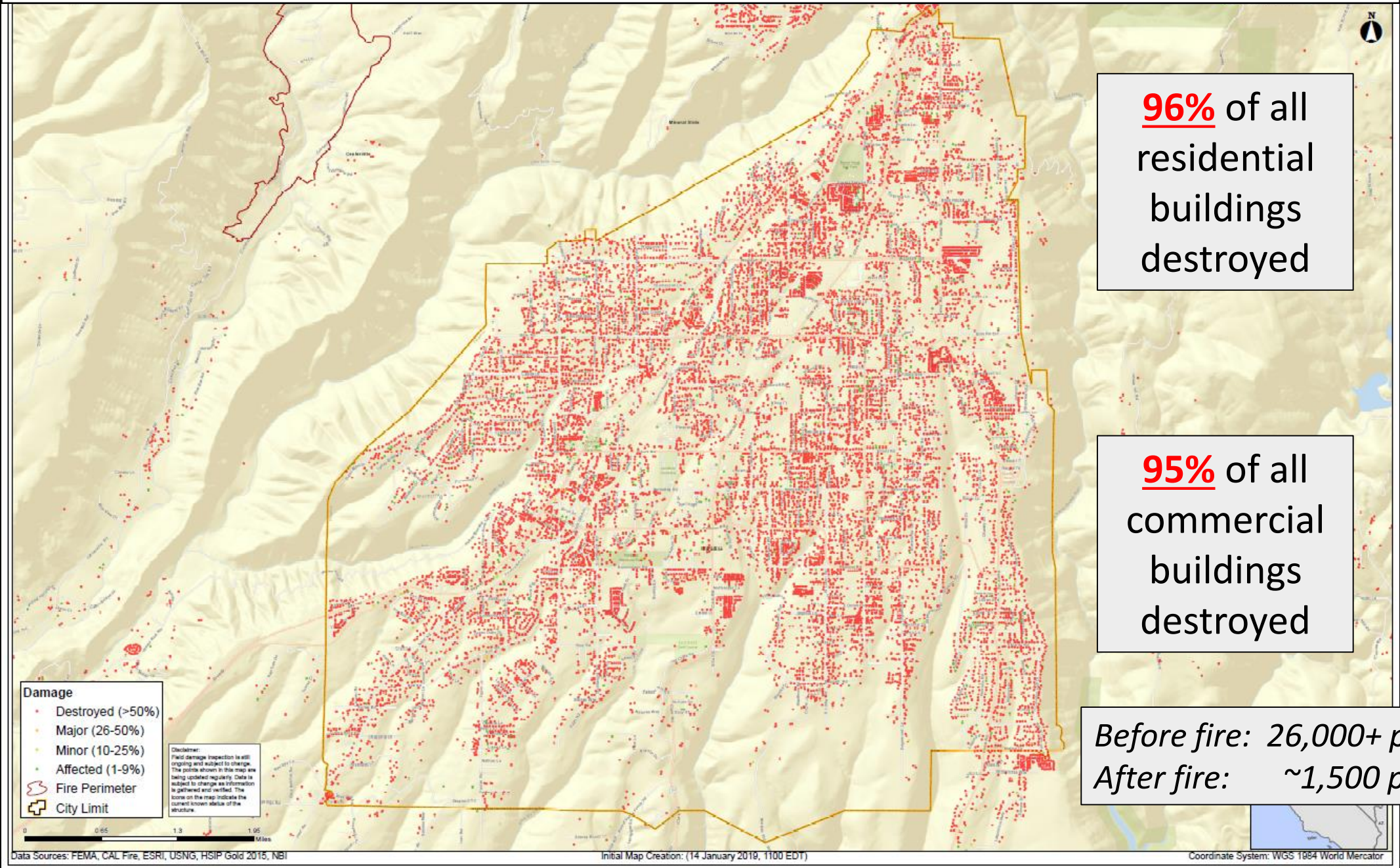
Onsite Visit Response and Recovery Observations Presented to PID February 13, 2019

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

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

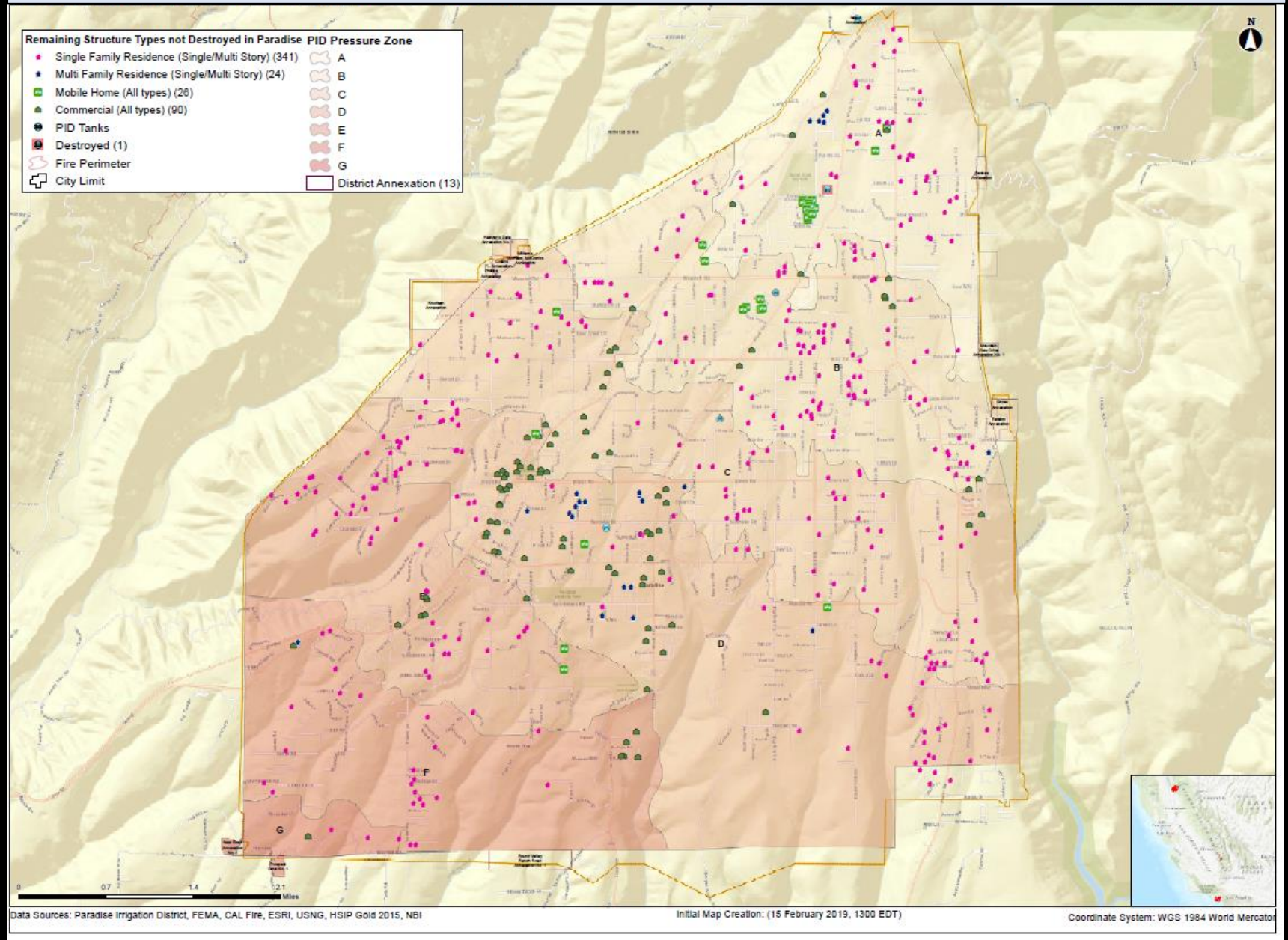
Standing homes were scattered throughout the contaminated water systems: PID Example

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

PID Pressure Zones vs. Standing Structures




11,000+ homes

Water Distribution System Contamination

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

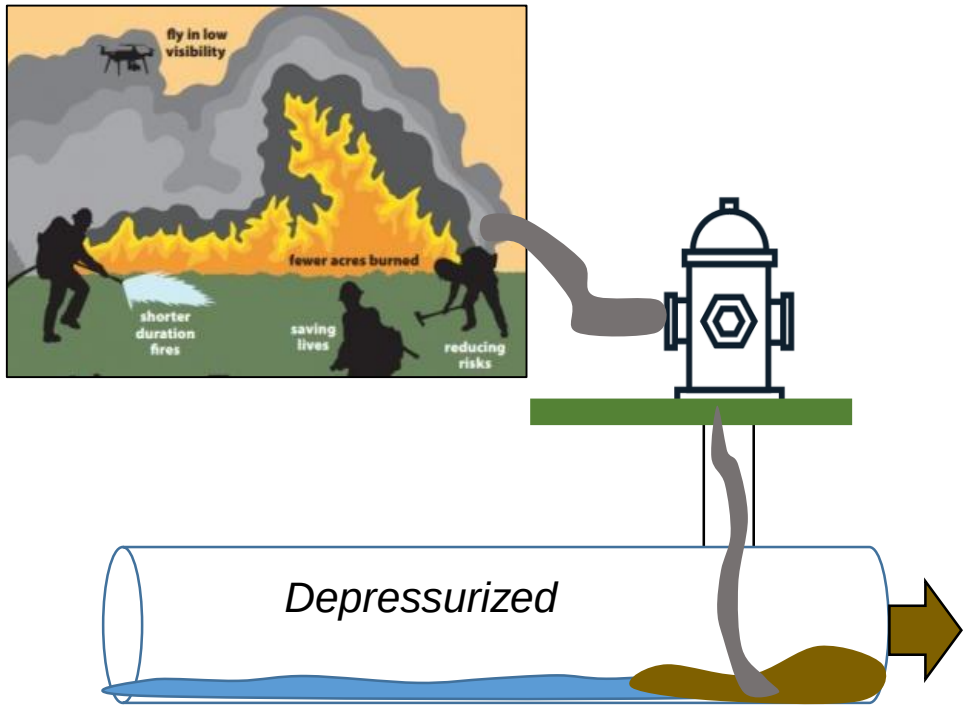
Chemical that Exceeded a Drinking Water Limit	**2018 Camp Fire (8 months after the fire)**				**2017 Tubbs Fire (11 months after the fire)**		
	PID	DOWC	Exceedance		Santa Rosa		
	Max, ppb	Max, ppb	Exceeded Long-Term Limit?	Exceeded ***Short-Term*** Limit?	Max, ppb	Exceeded Long-Term Limit?	Exceeded ***Short-Term*** 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
Tert-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

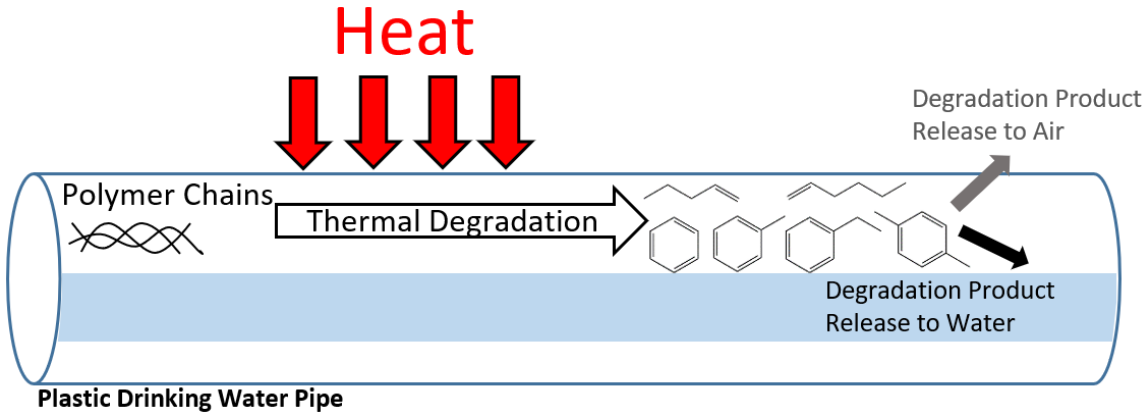
AWWA Water Science, Proctor et al. 2020
https://doi.org/10.1002/aws2.1183

Potential PRIMARY Sources

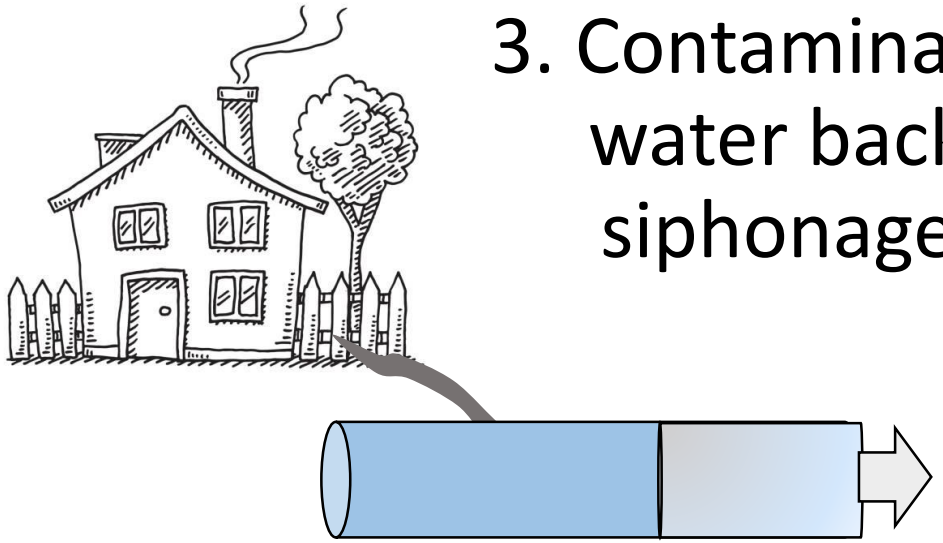
1. Forest biomass or structure combustion



2. Plastic thermal degradation

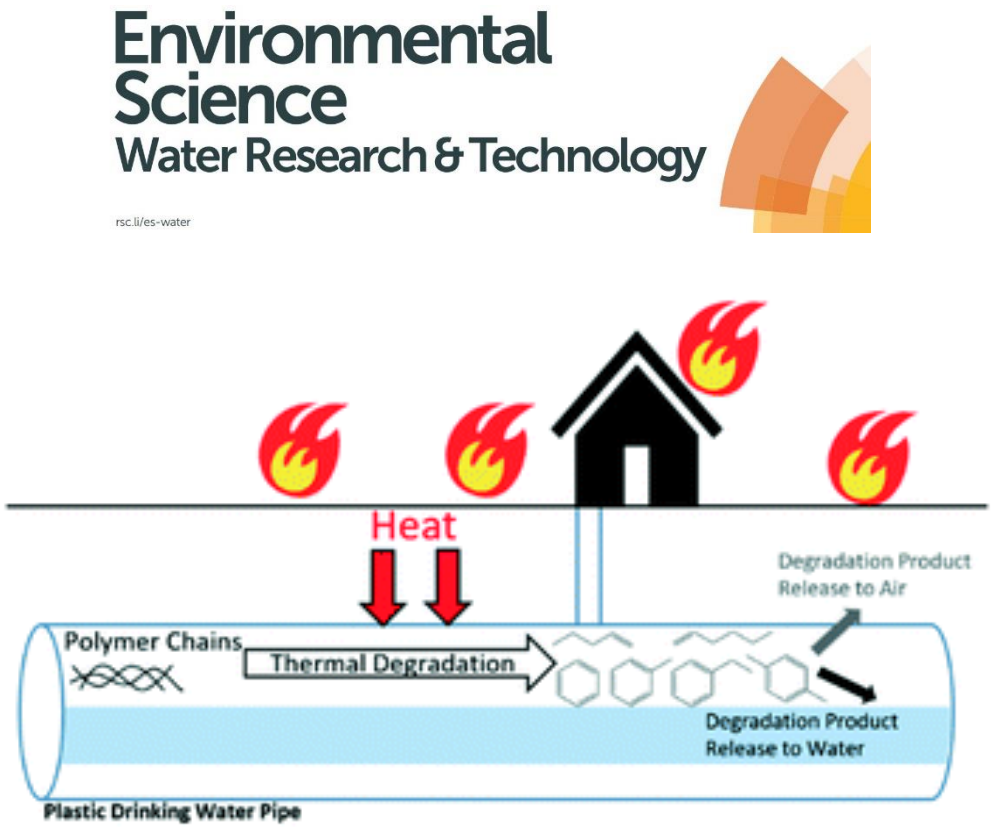


3. Contaminated water back siphonage



Secondary Sources: Infrastructure

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



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

200-400˚C

Material	Confirmation of BTEX Components in Water: B	T	E	X	Number of TICs in extract[a]: Water	*n*-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_2
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*

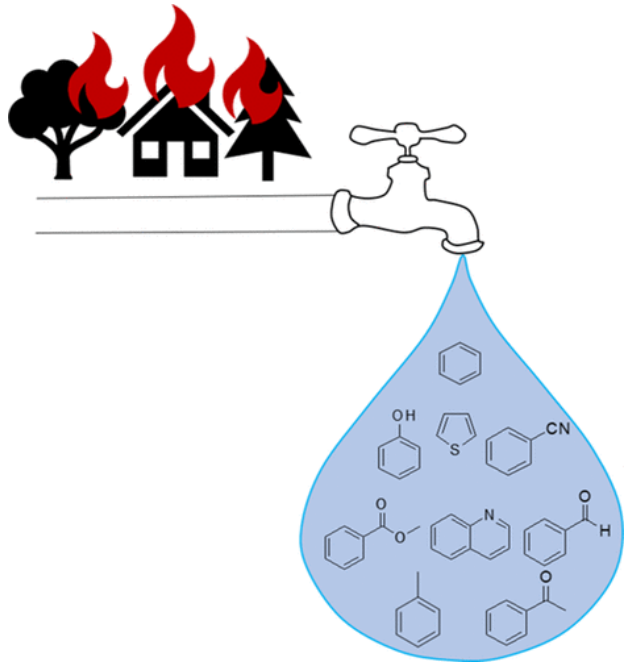
https://doi.org/10.1021/acsestwater.1c00401

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:

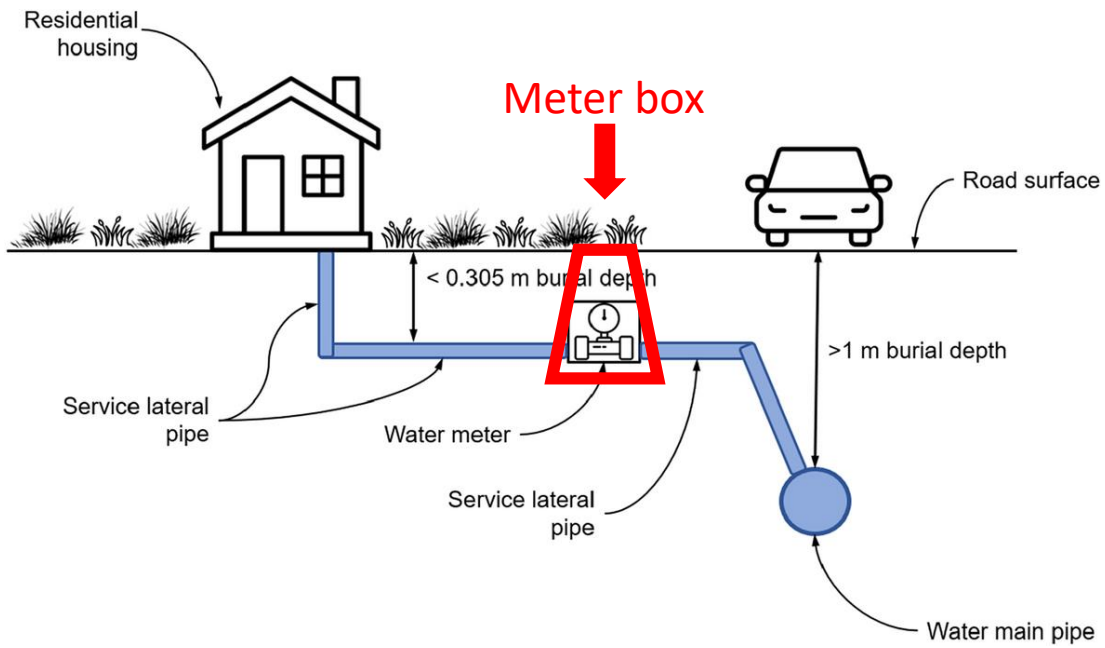
- PVC heating: 32 compounds
- HDPE/PEX heating: 28 compounds
- Service line: 55 compounds associated with uncontrolled burning of biomass and waste materials.



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*

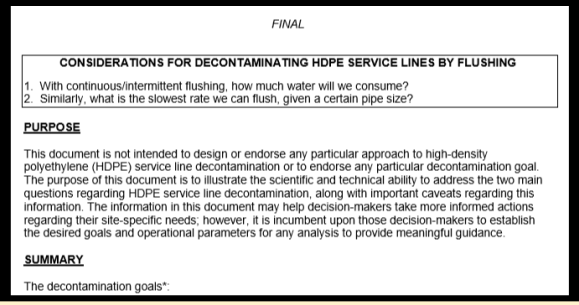
https://doi.org/10.1007/s10694-022-01232-3



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



FINAL

CONSIDERATIONS FOR DECONTAMINATING HDPE SERVICE LINES BY FLUSHING

1. With continuous/intermittent flushing, how much water will we consume?
2. Similarly, what is the slowest rate we can flush, given a certain pipe size?

PURPOSE

This document is not intended to design or endorse any particular approach to high-density polyethylene (HDPE) service line decontamination or to endorse any particular decontamination goal. The purpose of this document is to illustrate the scientific and technical ability to address the two main questions regarding HDPE service line decontamination, along with important caveats regarding this information. The information in this document may help decision-makers take more informed actions regarding their site-specific needs; however, it is incumbent upon those decision-makers to establish the desired goals and operational parameters for any analysis to provide meaningful guidance.

SUMMARY

The decontamination goals*:

Water Distribution System Decontamination

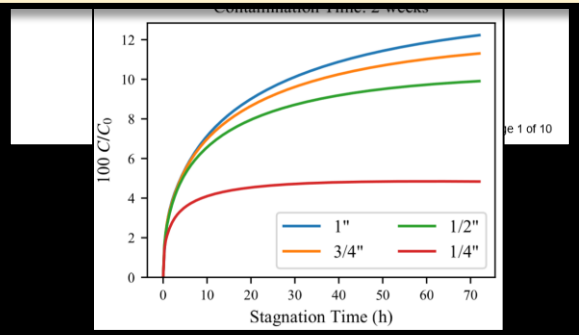
Collaboration between Us & USEPA

Hydraulics

Polymer Science

Environmental Engineering

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



Numerical modeling:

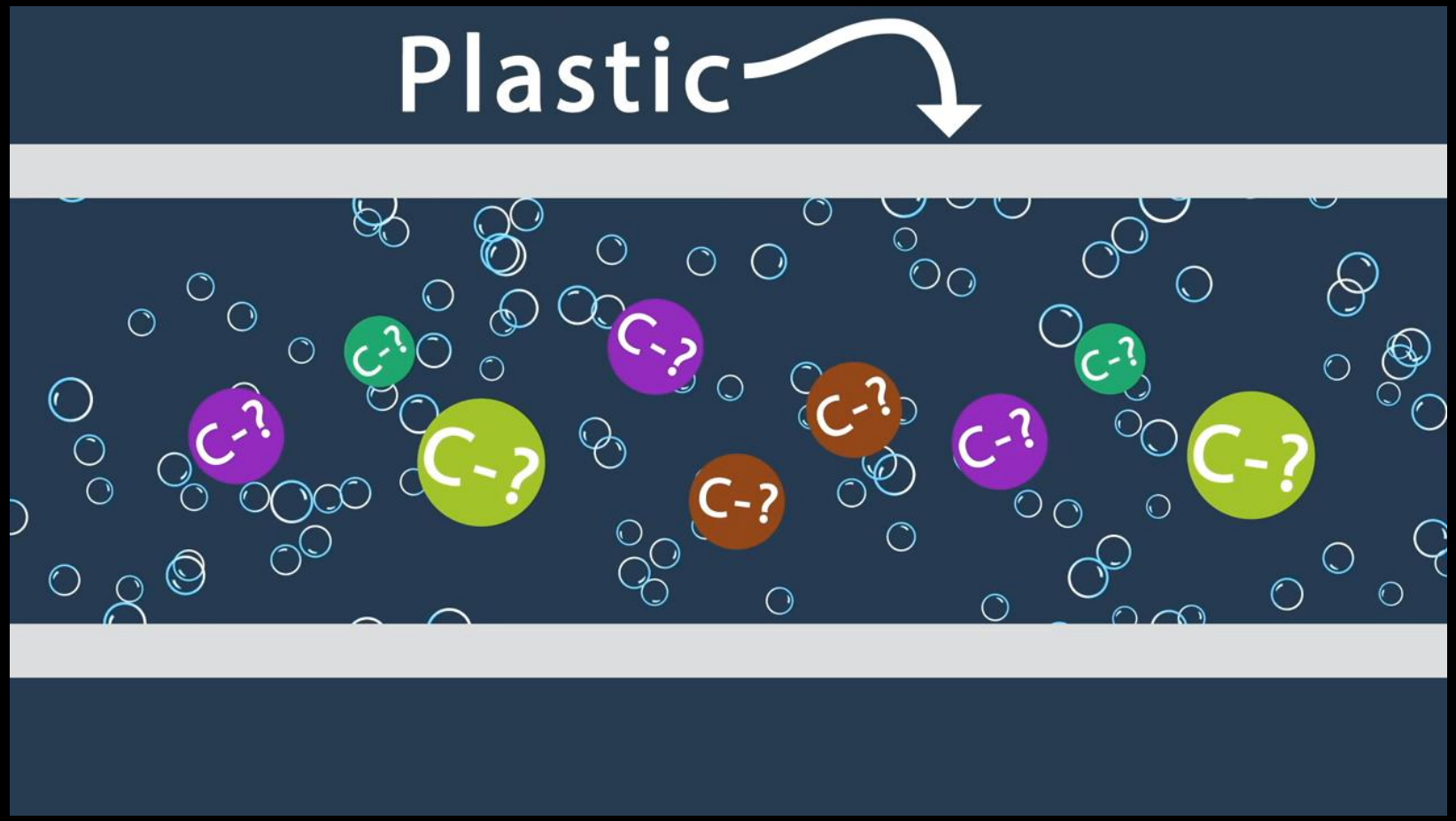
Greater than 286 days vs. less than 64 days of continuous water flushing for 1-inch HDPE service line

(Haupert et al. 2019)

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
DISTRICT BUTTE - GLENN COMMUNITY COLLEGE

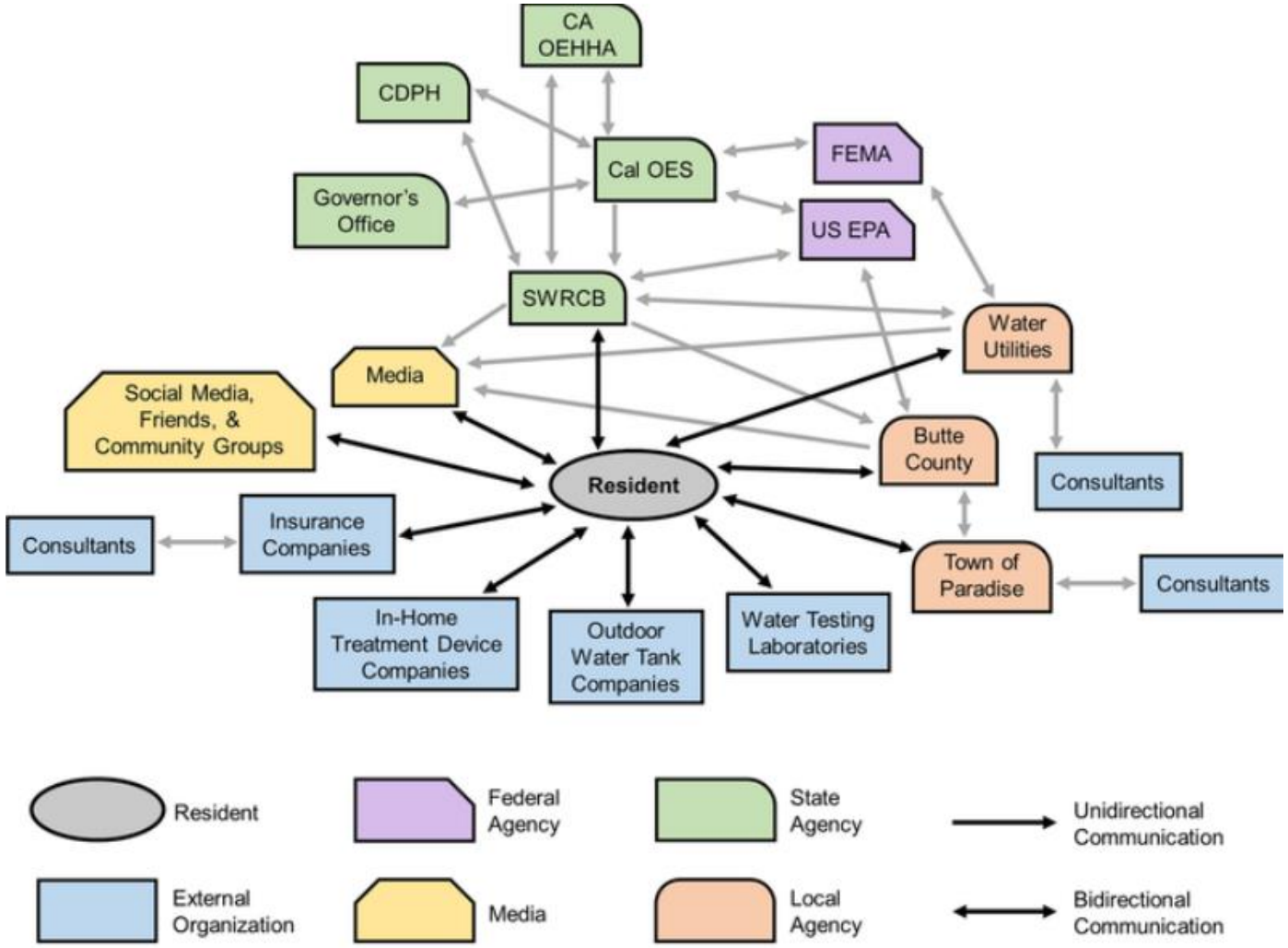
Berkeley
UNIVERSITY OF CALIFORNIA

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

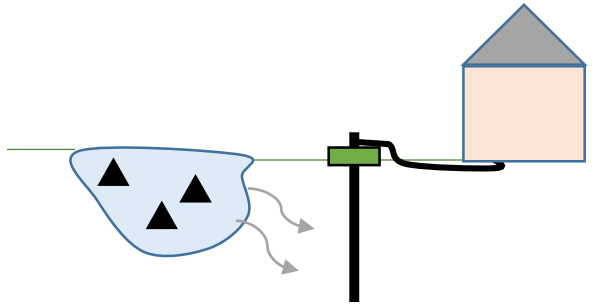
The devices are NOT designed for this. The range of contamination must be known + testing.

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

Camp Fire: ‘Standing Home’ Public Health Issues

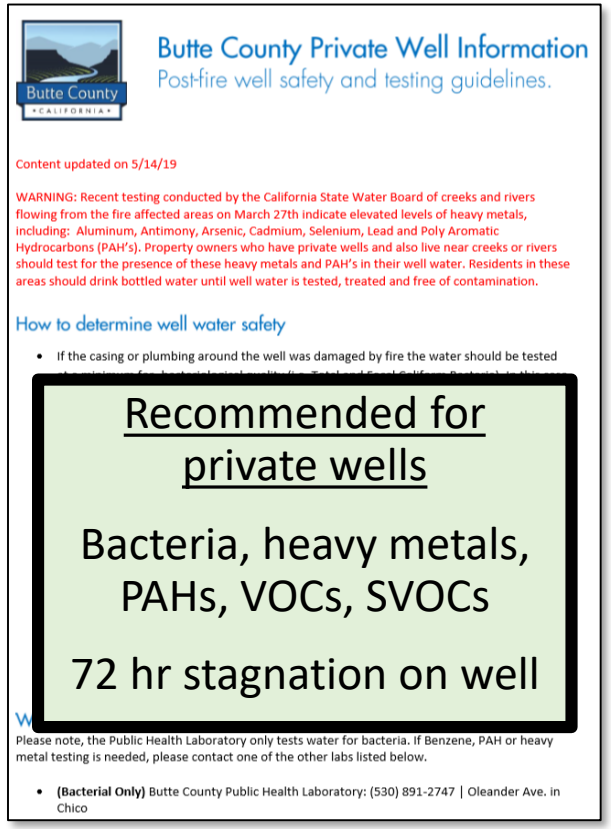
Citizens must be warned and protected from contaminated water

- 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



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

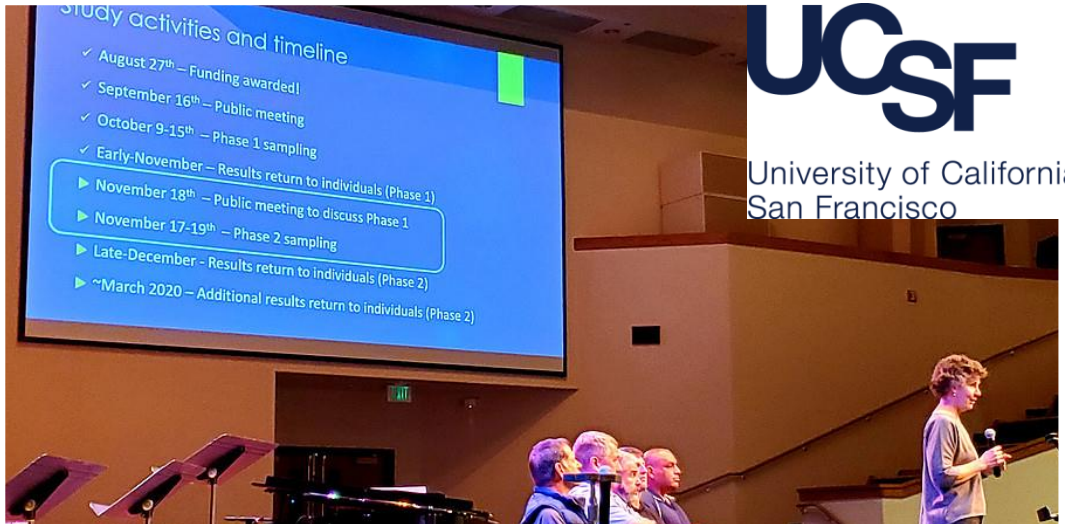
Please note, the Public Health Laboratory only tests water for bacteria. If Benzene, PAH or heavy metal testing is needed, please contact one of the other labs listed below.

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

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



University of California San Francisco

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

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

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_A: 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

University of Colorado Boulder

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

Email: awhelton@purdue.edu
Web: www.PlumbingSafety.org

Funded by: 

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

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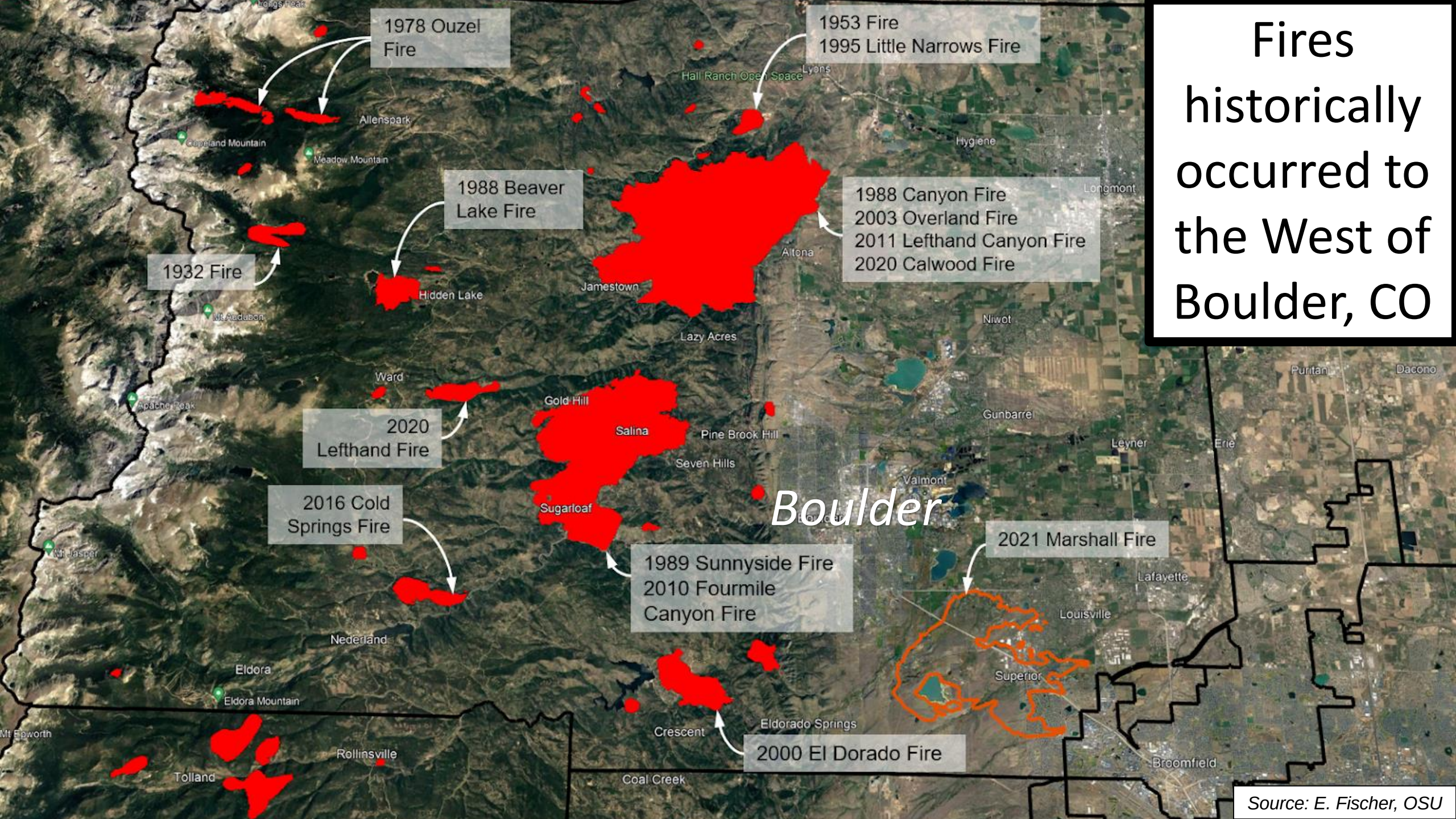
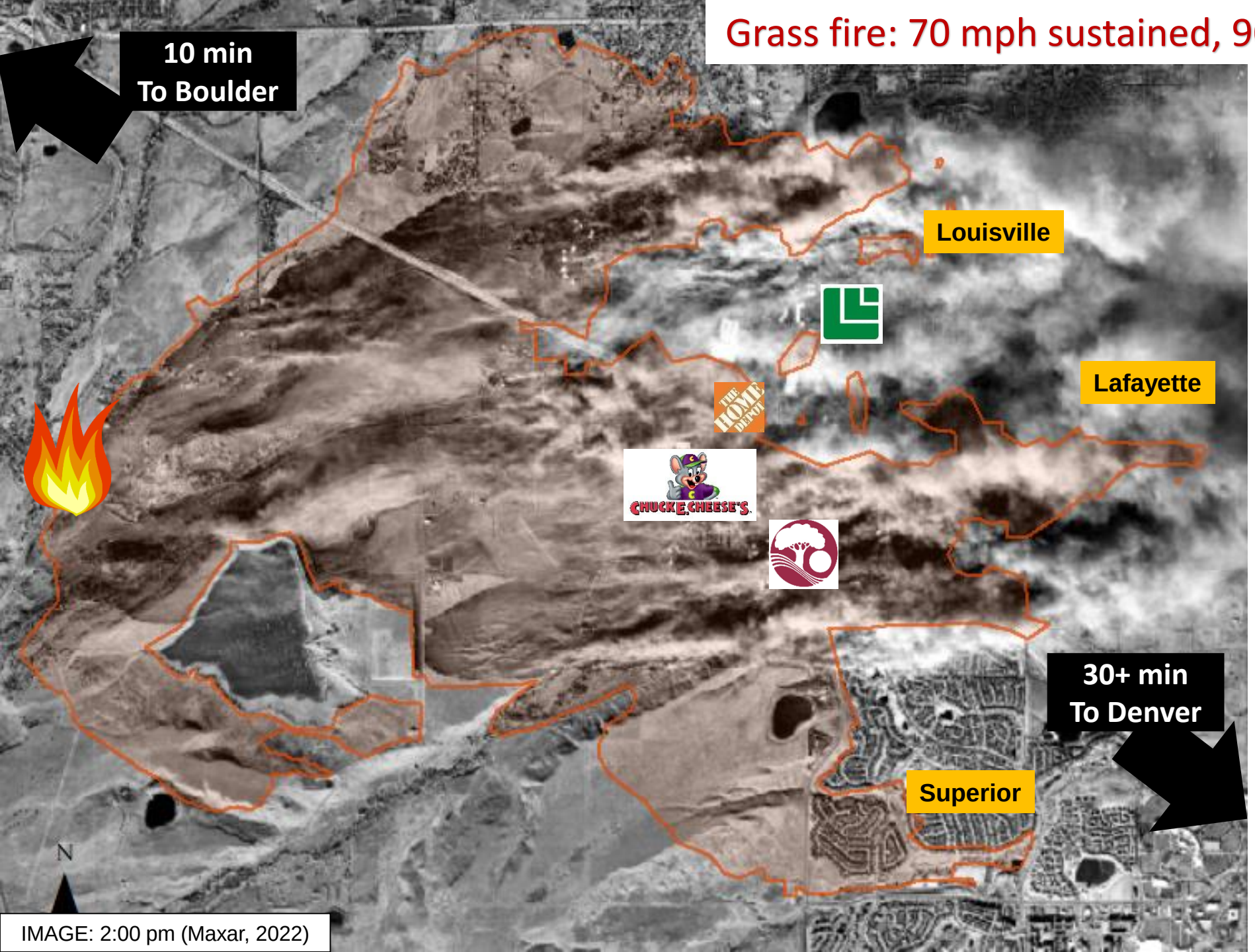
		$$$		
U.S. pop	331,893,745	$62,843	$217,500	32.1%
Boulder Co., CO	**330,758**	**$127,292**	**$592,000**	**62.1%**
Butte Co., CA	208,309	$51,566	$49,000	26.0%


1978 Ouzel Fire
1953 Fire
1995 Little Narrows Fire
1988 Beaver Lake Fire
1988 Canyon Fire
2003 Overland Fire
2011 Lefthand Canyon Fire
2020 Calwood Fire
1932 Fire
2020 Lefthand Fire
2016 Cold Springs Fire
1989 Sunnyside Fire
2010 Fourmile Canyon Fire
2021 Marshall Fire
2000 El Dorado Fire
Boulder
Fires historically occurred to the West of Boulder, CO
Source: E. Fischer, OSU

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



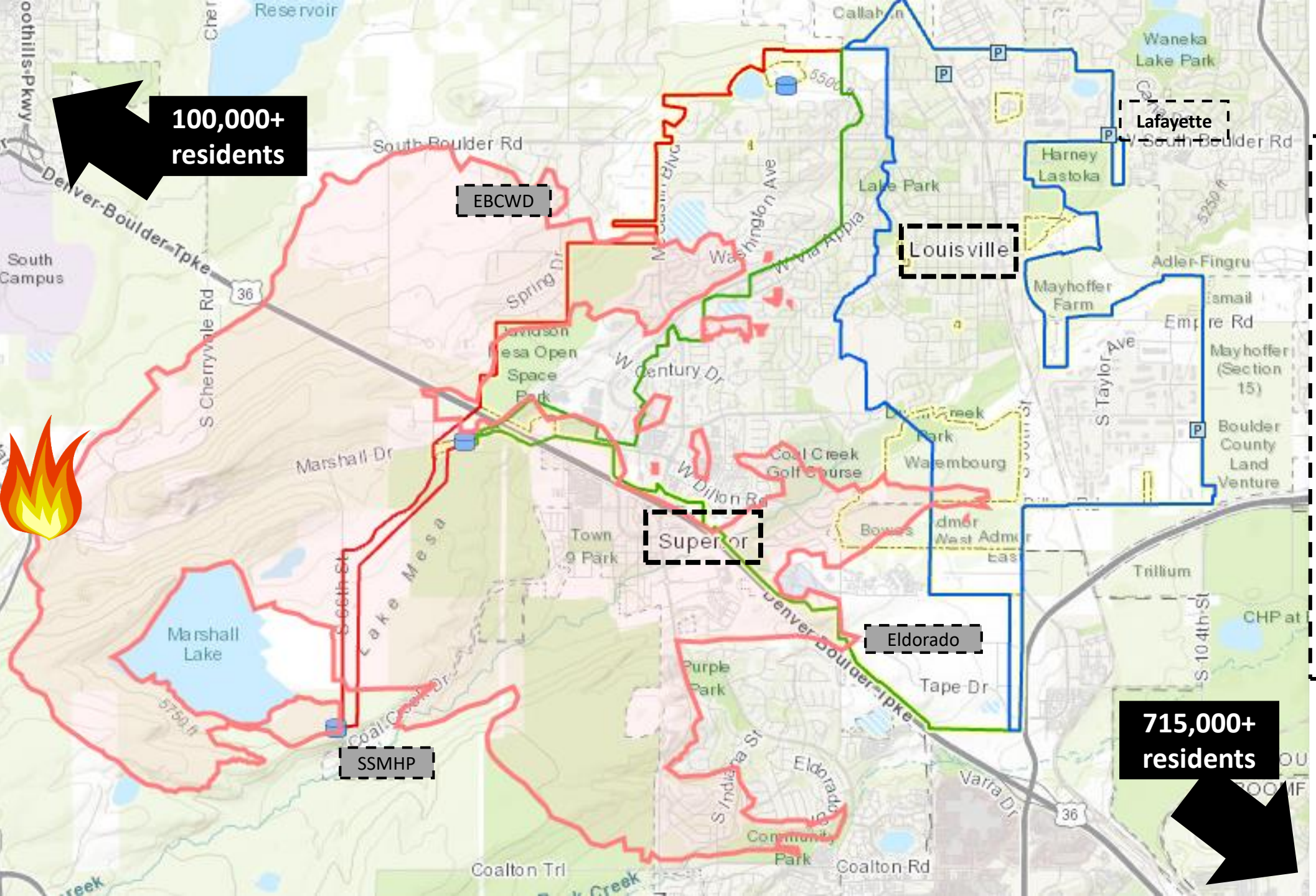
December 30, 2021

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.



6 public water systems were in the burn area

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

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

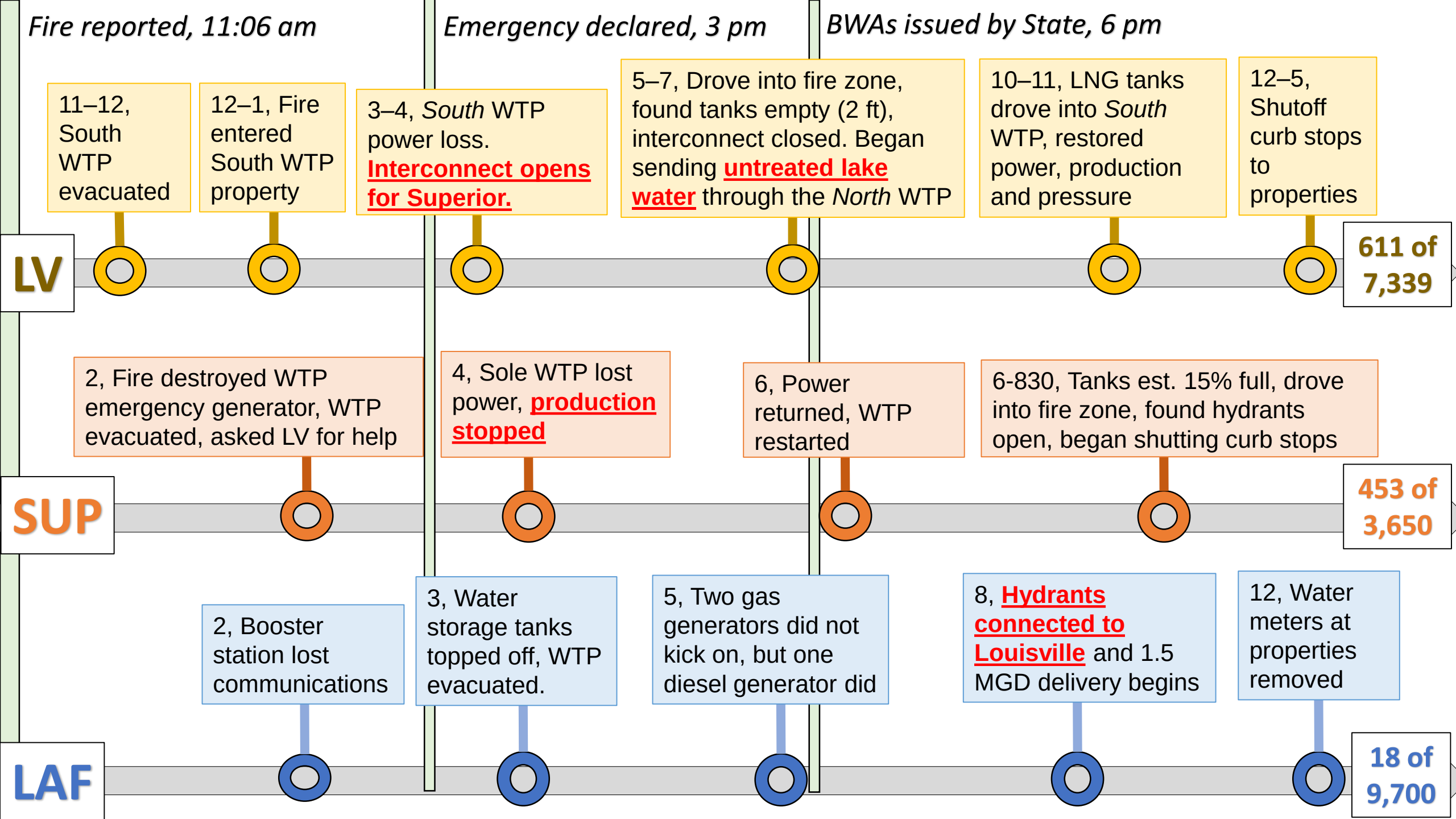
Louisville: VOC and SVOC contamination confirmed (benzene 221 ppb + others), decon underway

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
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
LV
611 of 7,339
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
SUP
453 of 3,650
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
LAF
18 of 9,700

Source: B. Wham, CU Boulder

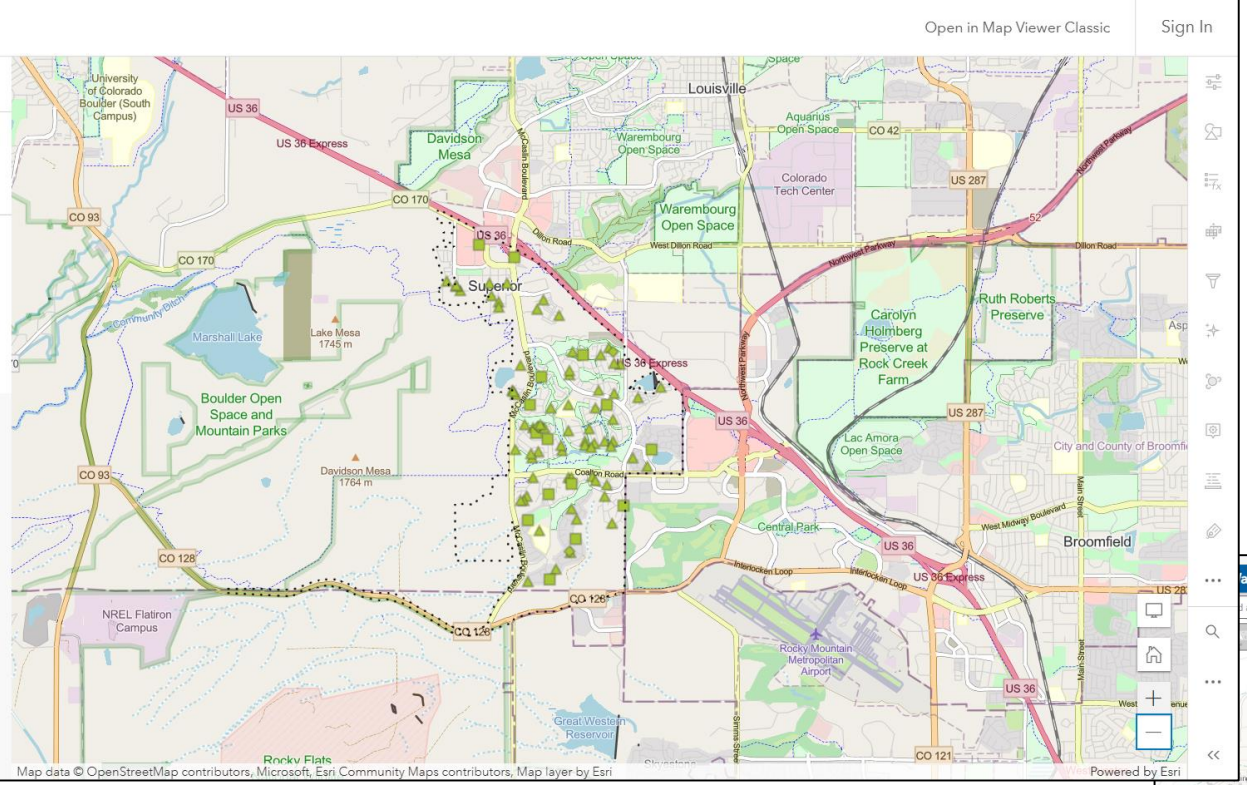
To expedite contamination testing, we reviewed all literature and compiled a "fire package" list of chemicals

Acetonitrile
Acetone
Acrolein
Acrylonitrile
Benzene
Bromochloromethane
Bromodichloromethane
Bromoform
n-Butylbenzene
sec-Butylbenzene
tert-Butylbenzene
Carbon disulfide
Carbon tetrachloride
Chlorobenzene
Chlorodibromomethane
Chloromethane
4-Chlorotoluene
Dibromochloromethane
1,2-Dichlorobenzene
1,4-Dichlorobenzene
1,1-Dichloroethane
1,2-Dichloroethane
1,1-Dichloroethene
cis-1,2-Dichloroethene
trans-1,2-Dichloroethylene
1,2-Dichloropropane
Ethanol
Ethylbenzene
Ethyl-*tert*-butyl ether (ETBE)
Iodomethane
Isopropylbenzene
Methylene chloride
Methyl ethyl ketone (MEK)
Methyl iso butyl ketone (MIBK)
Methyl-*tert*-butyl ether (MTBE)
Naphthalene
Styrene
***tert*-Butyl alcohol (TBA)**
Tetrachloroethylene
Tetrahydrofuran (THF)
Toluene
1,2,3-Trichlorobenzene
1,2,4-Trichlorobenzene
1,1,1-Trichloroethane
1,1,2-Trichloroethane
Trichloroethylene
Trichloromethane
1,2,4-Trimethylbenzene
1,3,5-Trimethylbenzene
Vinyl chloride
ortho-Xylene
meta-Xylene
para-Xylene

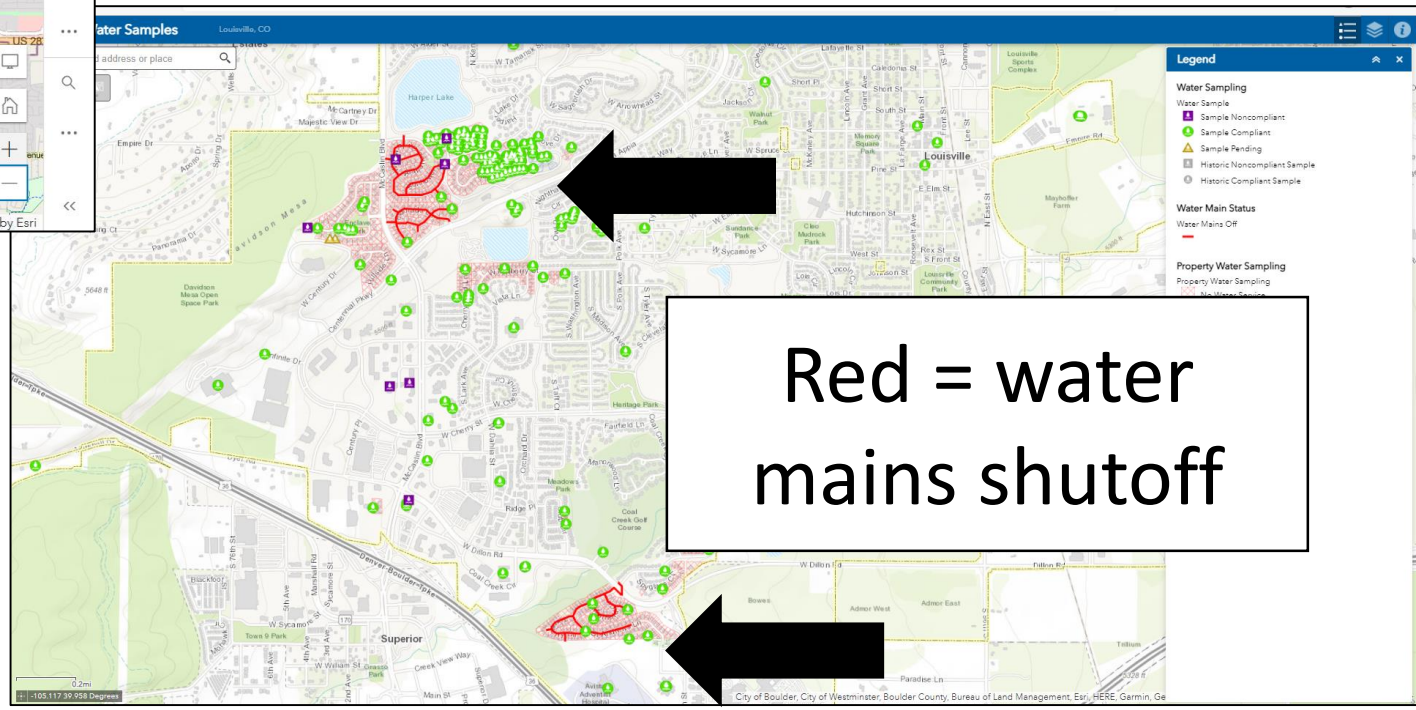
NOTES: In the absence of benzene other chemicals have exceeded health-based limits; RED text indicates the chemical exceeded a short- or long-term health-based limit after a prior fire; SVOCs can also be present.

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

<u>Helpful neighbors:</u>
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.



Red = water mains shutoff

Each utility moved at a different pace with different challenges

1st focus: Bacteria and chlorine

Next: Fire caused VOCs

And then (some): Fire caused SVOCs

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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?
Benzene	**221**	**Y**	
Toluene	511		**Y**
Ethylbenzene	160		**Y**
Xylenes	5		
Styrene	**1,900**	**Y**	**Y**
Naphthalene	11		**Y**
Acrolein	24		**Y**

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.

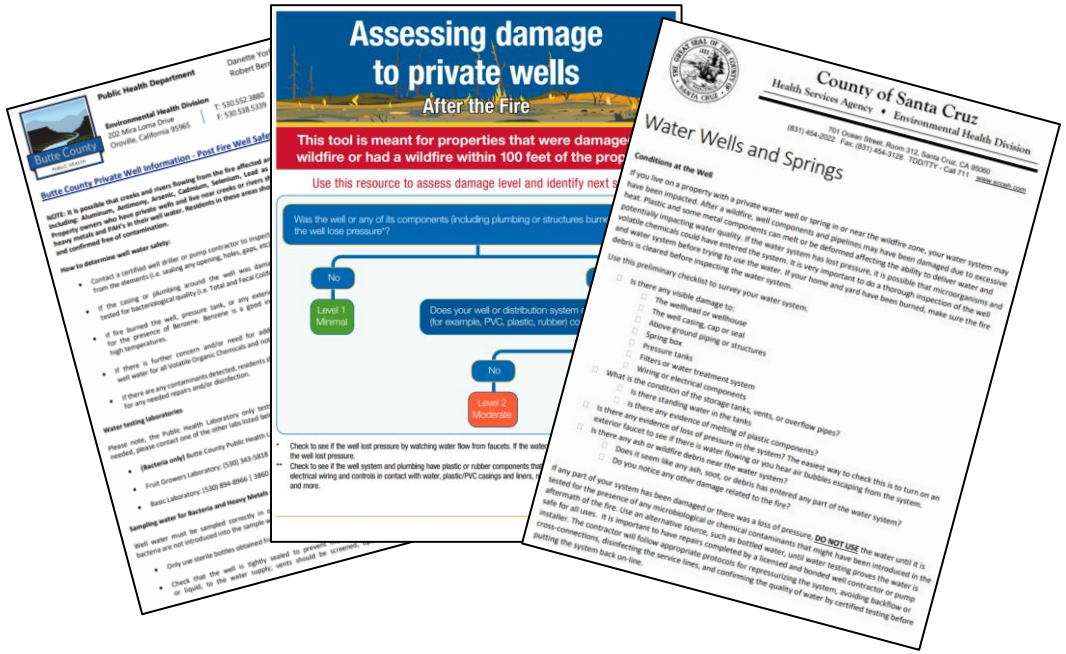
Food science literature: Caused by phenols, *o*-cresol, *p*-cresol, *m*-cresol, guaiacol

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, NO_3^-; BTEX; local contaminants

WaDOH (WA): Coliform bacteria

SCCHD (CA): Coliform bacteria, turbidity, pH, conductivity, color, NO_3^-; VOCs, SVOCs

OHA (OR): Coliform bacteria, As, Pb, 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-*n*-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	-

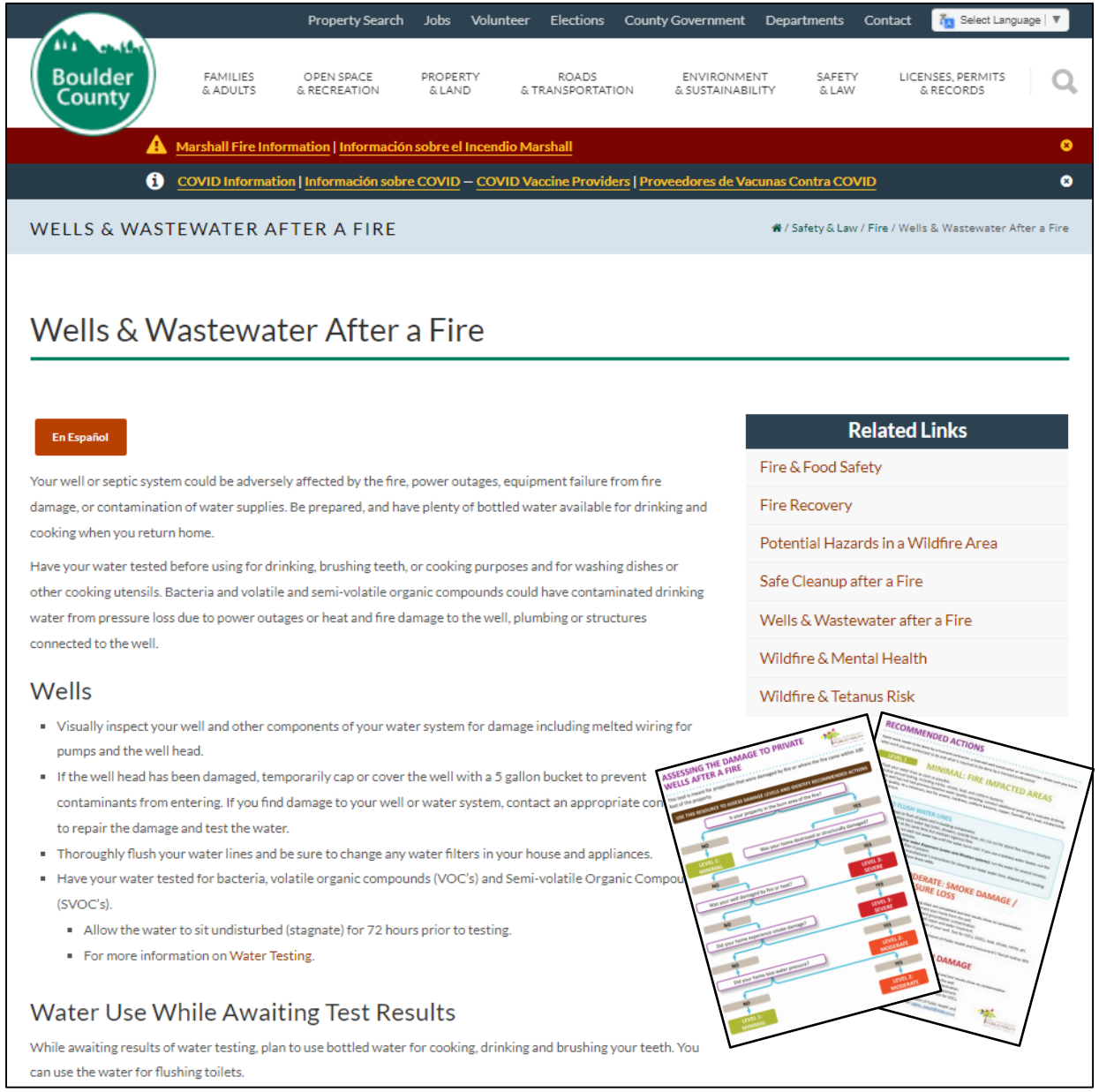
Inorganics

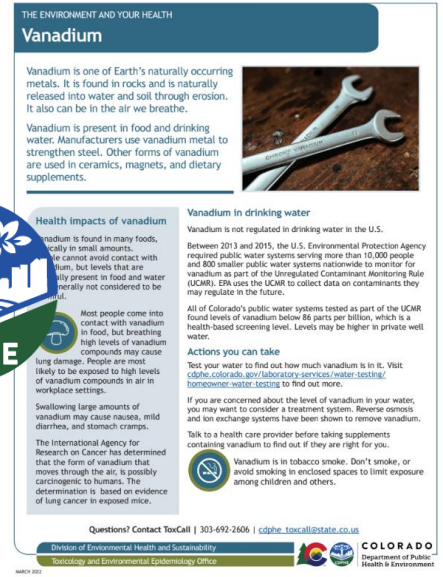
Data Description	Min	Max	Mean ± Stdev
Wells & Cisterns – Marshall Fire (14)	12.4	105	42 ± 26
Faucet – Marshall Fire (8)	4.2	89.3	34.8 ± 25.1
PWS UCMR3 – Colorado (108)	0.9	1,700	20.3 ± 54.1
PWS UCMR3 – Marshall Fire area (108)	1.6	131	25.8 ± 23.7

USEPA Li Screening Level: 10 ppb

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

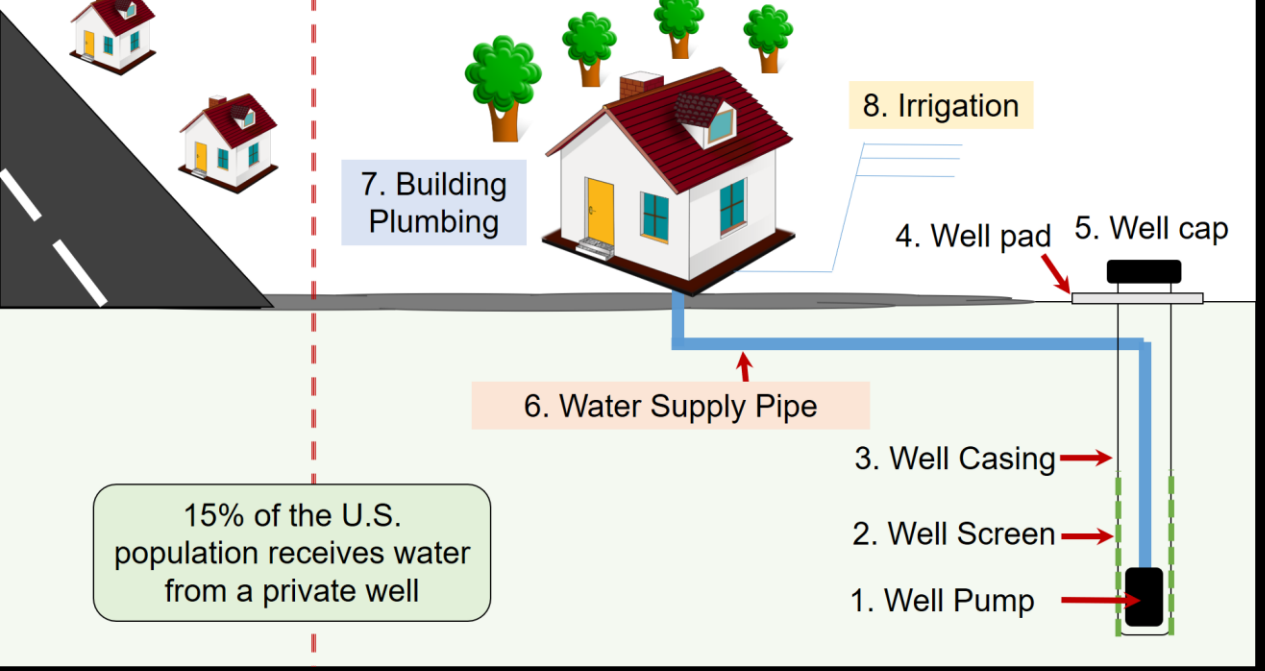
USEPA V Screening Level: 86 ppb

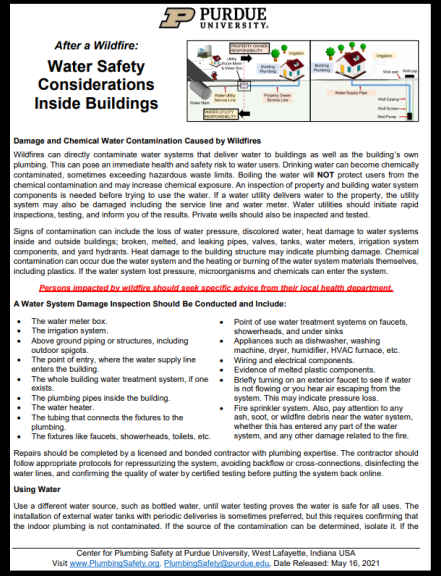




CDPHE

1. Assessing well damage
2. Permit requirements for well repair
3. Water testing
4. CDPHE Factsheets: Lithium and vanadium
5. Testing laboratories for VOCs, SVOC, and heavy metals
6. Home water filtration systems
7. Resources for well owners
8. Resources for onsite wastewater treatment system owners





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 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 sinks
- 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 repressurizing 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

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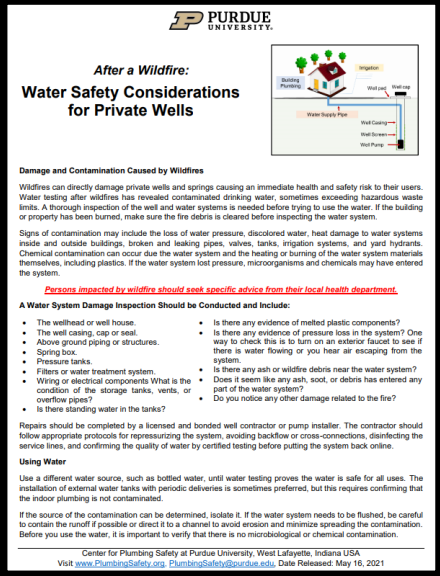
Visit www.PlumbingSafety.org, PlumbingSafety@purdue.edu, Date Released: May 16, 2021



After a Wildfire:

Water Safety Considerations for Private Wells

Damage and Contamination Caused by Wildfires

Wildfires can directly damage 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 cleared 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 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 standing water in the tanks?
- 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 repressurizing 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

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.

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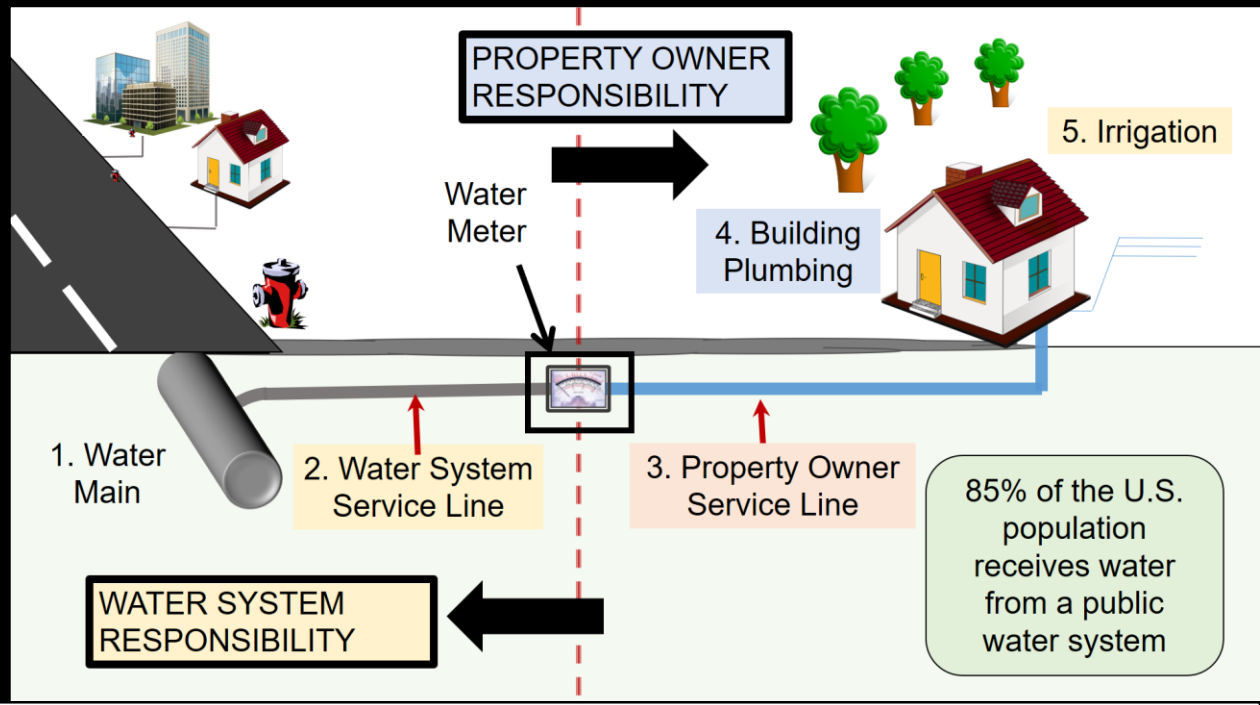
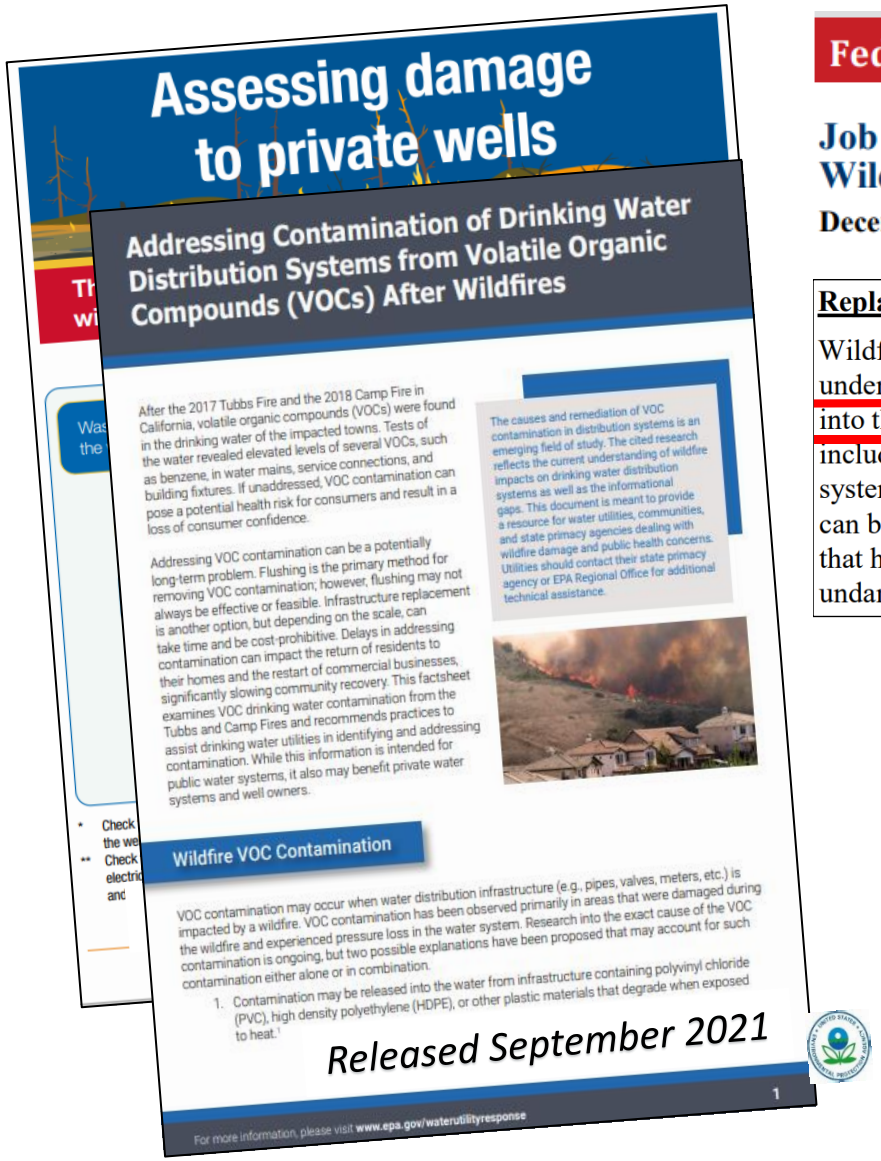
We created two 1 page inspection and water testing guidance sheets for private wells and building water systems

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

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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

What to do now?

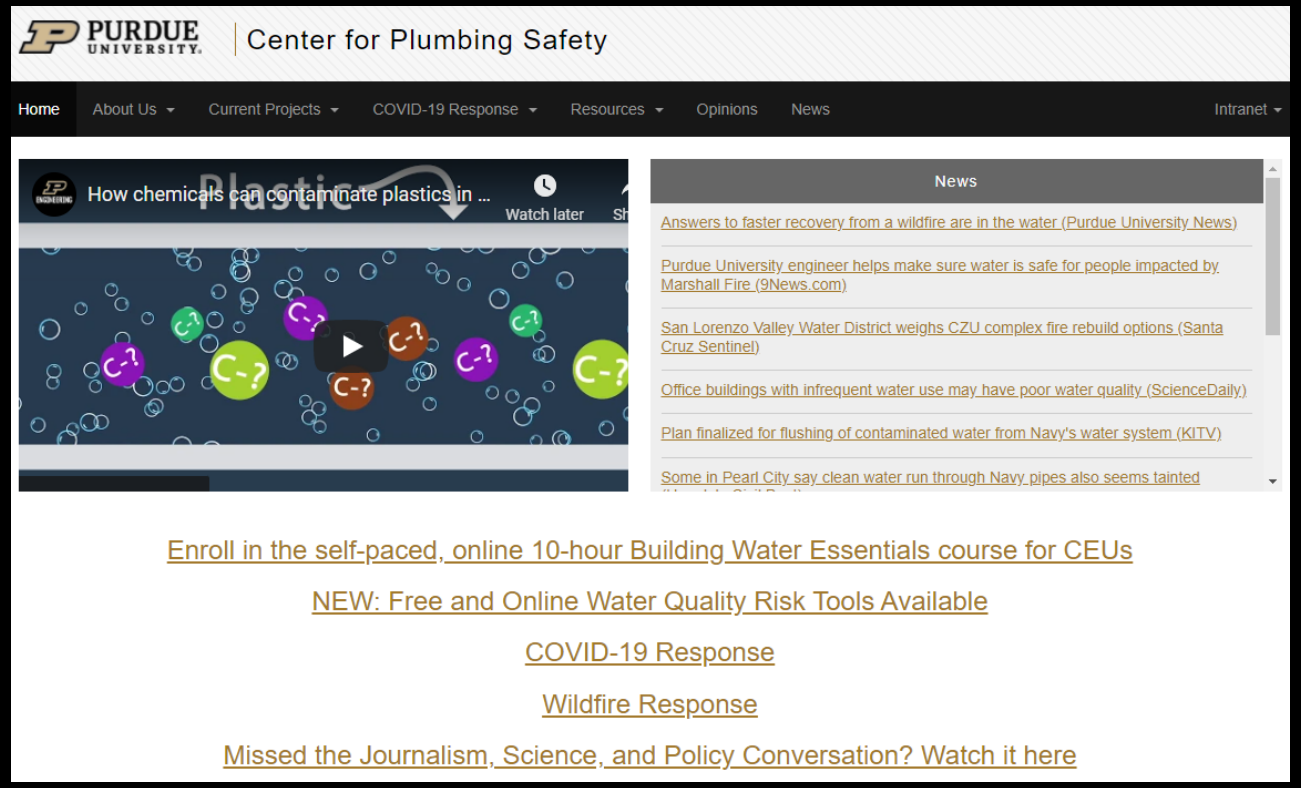
1. Monitor the system during fire
2. Keep power, water pressure, don't depressurize
3. Keep heat away from plastic assets (meter boxes, exposed piping, etc.)
4. Isolate leaks during fire to lessen pressure loss and contamination spread
5. Issue Do Not Use Orders to protect the population from exposure
6. Chemically test the water distribution system extensively after every 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, etc.)
3. Bury assets at least 2 ft below the ground , maybe more
4. Signup for WARN to get rapid access to surge people and equipment

Thank you. Questions?

Andrew Whelton, Ph.D. awhelton@purdue.edu



Funded by:

US EPA R836890

Paradise Rotary Foundation

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Purdue University

More Wildfire Lessons Coming Soon to:
www.PlumbingSafety.org

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