New Developments in Building Water Safety

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www.PlumbingSafety.org

PMI Annual Meeting
November 2021
A special thanks to the many people who made this possible
The Center for Plumbing Safety at Purdue

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✓ Online short-course
✓ Plumbing education videos
✓ Flushing plans
✓ Plumbing explainers
✓ List of projects
✓ Scientific opinions
✓ Resources ➔ presentations
✓ Scientific reports
✓ External plumbing docs
✓ YouTube Channel

10 hr, 1 CEU, Self-paced, Online Building Water Essentials Short-Course:
https://engineering.purdue.edu/online/certifications/building-water-essentials

www.PlumbingSafety.org
Building water system public health risks

Exposure Routes of Concern: Ingestion, Dermal, Inhalation

Routine Operations
Disinfectant residual may not be replenished

Heavy metals can leach (Cu, Mn, Ni, Pb, Zn..)

Organics can leach/form (VOCs, SVOCs, DBPs)

Scale can destabilize and suspend

Harmful organisms can grow (e.g., L. pneumophila, MAC, P. aeruginosa …)

Accident and Post-Disasters
Pressure loss, backflow, chemical spill, hurricane, flooding, wildfire, intentional attack, and more
Right Sizing Tomorrow's Water Systems for Efficiency, Sustainability, & Public Health

Completed: 2017-2021
Andrew Whelton, Jade Mitchell, Joan Rose, Juneseok Lee, Pouyan Nejadhashemi, Erin Dreelin, Tiong Gim Aw, Amisha Shah, Matt Syal, Maryam Salehi

Funded by:
1. **Improve the public’s understanding of decreased flow** and establish a range of theoretical plumbing flow demands

2. **Elucidate the factors and their interactions that affect drinking water quality** through fate and transport simulation models for residential and commercial buildings

3. **Create a risk-based decision support tool** to help guide decision makers through the identification of plumbing characteristics, operations and maintenance practices that minimize health risks to building inhabitants.
<table>
<thead>
<tr>
<th><strong>Some highlights</strong></th>
<th><strong>Education</strong></th>
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<tbody>
<tr>
<td></td>
<td>&gt;100 presentations to share knowledge</td>
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<td>100,000(s)+ people reached</td>
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<td>Assisted all major sectors (plumbing, construction, public health, policy)</td>
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<td>Commercial and residential building sectors helped</td>
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<td><strong>Engagement</strong></td>
<td>Direct support to building owners, designers, manufacturers, and consultants</td>
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<td>Supported US government agencies identify research priorities</td>
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<td>Helped develop and shape industry best practices</td>
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<td>Provided scientific opinions to agencies</td>
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<td>Direct support to communities following water contamination disasters</td>
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<td>LCR Federal Register comment</td>
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<td>Developed and provided example flushing plans</td>
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<td><strong>Discovery</strong></td>
<td>Peer-review: 22 Published + 8 in Review + &gt;10 in Development</td>
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<td>Industry innovation research priority identification</td>
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<td>Discovered chemical and microbiological water safety issues in buildings</td>
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<td>Explored fundamental processes that control building water safety</td>
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<td>Identified and tested building water system mitigation methods</td>
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<td>Created a 1st of its kind Plumbing Decision Support Tool (DST)</td>
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Thermocouples throughout piping, 1x /sec
Indoor air temperature, 1x /sec
Flowrates at every fixture, 1x /sec
Energy use per device, 1x /sec

www.ReNEWWHouse.com

The Most Monitored Home in America
West Lafayette, Indiana
Less than 100 yards from Purdue
3 Bedroom, 1.5 baths
Water saving fixtures
Trunk-and-Branch design
PEX piping
Renovated in 2014

October 2017-October 2018
30,000+ individual water quality measurements completed - does not include flow monitoring, pressure monitoring, or qPCR

2.64 billion online plumbing related measurements
Online and FREE Building Water Quality Tools Now Available

Usefulness
Multiple contaminants: *Legionella spp.*, HPC, Cl₂, Cu, Fe, Pb, NO₃⁻, TTHM

Compare exposure scenarios
Examine design impacts
Examine water use impacts
Disasters Expose a Critical Lack of Plumbing Knowledge:
Federal, State, County agencies, and in Households

What’s Needed
Basic understanding of plumbing design, use, materials, and aging
What products are in plumbing
How to use damaged plumbing post-disaster
How to test plumbing post-disaster
How to clean plumbing post-disaster

https://doi.org/10.1007/s11069-021-04714-9
16+ years ago with the US Army I was working on contamination/decontamination issues associated with water infrastructure systems.

LESSONS LEARNED
from drinking water disaster and terrorism exercises

Journal AWWA
Whelton et al. 2006.
98 (8), 63-73.
COVID-19 Pandemic Response

March to June 2020, more than 45+ guidance documents telling building owners what they could do to prevent and deal with stagnation situations.

Many differed quite dramatically. Some lacked key info (safety, devices, sensitive population, etc.).
YES!

Building Water Use Changed During the Pandemic

Implications of Social Distancing Policies on Drinking Water Infrastructure: An Overview of the Challenges to and Responses of U.S. Utilities during the COVID-19 Pandemic


- 28 water utilities contacted
- 43% increased RESIDENTIAL demand
- 46% decreased COMMERCIAL demand
- 21% decreased INDUSTRIAL demand

Sometimes the increase in RESIDENTIAL demand offset the decrease in COMMERCIAL demand

https://doi.org/10.1021/acsestwater.0c00229
Shutdowns and Consequences - Extreme Plumbing Stagnation and Recommissioning

1. Support to the plumbing and public health sectors on building water safety guidance and decisions, **ongoing**
2. Building water safety review due to prolonged stagnation with experts from 7 private and public sector organizations, **complete**
3. Field testing to determine how impacted building water safety is in actual large buildings, **complete**
4. Bench-/pilot-scale testing to determine how to fully recover contaminated building water system devices and equipment, **ongoing**
5. Help transform public awareness, **complete**
2020: State-of-the-knowledge review about water safety impacts of prolonged stagnation

Collaborative effort
Caitlin R. Proctor, Ph.D., Purdue University
William Rhoads, Ph.D., Virginia Tech
Tim Keane, Legionella Risk Management, Inc.
Maryam Salehi, Ph.D., University of Memphis
Kerry Hamilton, Ph.D., Arizona State University
Kelsey J. Pieper, Ph.D., Northeastern University
David R. Cwiertny, Ph.D., University of Iowa
Michele Prévost, Ph.D., Polytechnique Montreal
Andrew J. Whelton, Ph.D., Purdue University

Considerations for Large Building Water Quality after Extended Stagnation

Download FREE here: https://doi.org/10.1002/aws2.1186
Initiating a Transformative Building Water System Research Collaborative in Response to the COVID-19 Pandemic

U.S. National Science Foundation EAGER Award 2039498

Click Here

Building Water SLAM
Stagnation, Legionella, And Metals
July 7-9, 2021

A virtual conference to explore results from studies of building water quality that took place during the COVID-19 pandemic and reflect on the state of the science after an exciting year.

Wednesday, July 7 11 – 13h EST → Science during the pandemic
Thursday, July 8 11 – 13h EST → A broader view of the science
Friday, July 9 10 – 12h EST → Reflection on a year of policy

A conversation with three leaders of journalism and water policy moderated by Professor Andrew Whelton and Carolin Proctor.

Register here for free: https://tinyurl.com/BldgSLAMReg
Questions? Email Carolin-Proctor@Purdue.edu

US National Science Foundation: www.nsf.gov
Some of our COVID-19 response efforts

11 buildings across 4 studies
All free chlorine disinfectant
3-5 months of low/no water use
Some served by the same utility
Some have recirculation loops, in-building storage, showers
All had indoor copper pipe
Up to 400 water outlets/building
Not all had as-built drawings

1. Elementary school, Indiana (Ra et al.)
2. Large residential building, Indiana (Angert et al., led by Proctor, Ph.D.)
3. Institutional buildings, Indiana (Ra et al.)
4. Elem/mid/high school, Ohio (Ley et al.)
Some of Our Discoveries

Water management programs basically nonexistent at daycares, schools, colleges, and universities

Metal (Cu, Pb, Ni, Zn) health-based limit exceedances. Don’t just look at water fountains.

*Legionella pneumophila* detected in 3 of 4 studies

- 2 buildings where flushing applied, no legionella detected after flushing, 2 weeks later low levels (<10 MPN/100 mL)
- Highest levels found in cold water *not* hot water. Water fountain hot spots.

Super chlorination levels throughout building differed (est. 160-340 mg/L+ for 3 hours). Likely due to ineffective mixing, reactions, and/or decay

Much more found…..
Infrastructure Contamination and Decontamination

Science, Technology, Policy and Impact

Heat and Fire Damage to Plastic Infrastructure Materials

Recognize Limitations
Better Inspect/Test
Better Defend
We created two 1 page inspection and water testing guidance sheets for private wells and building water systems.

Access here ➔ [Click]
Assessing damage to private wells

After the Fire

This tool is meant for properties that were damaged by wildfire or had a wildfire within 100 feet of the property.

Use this resource to assess damage level and identify next steps.

Was the well or any of its components (including plumbing or structures burned or did the well lose pressure)?

- Yes

Level 1 Minimal

Does your well or distribution system contain synthetic (for example, PVC, plastic, rubber) components?

- Yes

Level 2 Moderate

- Yes or Unsure

Level 3 Severe

- No

Level 1 Minimal

Released January 2021

Addressing Contamination of Drinking Water Distribution Systems from Volatile Organic Compounds (VOCs) After Wildfires

After the 2017 Tubbs Fire and the 2018 Camp Fire in California, volatile organic compounds (VOCs) were found in the drinking water of the impacted towns. Test results revealed elevated levels of several VOCs, such as benzene, in water mains, service connections, and building fixtures. If unaddressed, VOC contamination can pose a potential health risk for consumers and result in a loss of consumer confidence.

Addressing VOC contamination can be a potentially long-term problem. Filtration is the primary method for removing VOC contamination; however, flushing may not always be effective or feasible. Infrastructure replacement is another option, but depending on the scale, it can take time and be cost-prohibitive. Delays in addressing contamination can impact the return of residents to their homes and the restart of commercial businesses, significantly slowing community recovery. This fact sheet examines VOC drinking water contamination from the Tubbs and Camp Fires and recommends practices to assist drinking water utilities in identifying and addressing contamination. This information is intended for public water systems; it also may benefit private water systems and well owners.

Wildfire VOC Contamination

VOC contamination may occur when water distribution infrastructure (e.g., pipes, valves, meters, etc.) is impacted by a wildfire. VOC contamination has been observed primarily in areas that were damaged during the wildfire and experienced pressure loss in the water system. Research into the exact cause of the VOC contamination is ongoing, but two possible explanations have been proposed that may account for such contamination either alone or in combination:

1. Contamination may be released into the water from infrastructure containing polyvinyl chloride (PVC), high-density polyethylene (HDPE), or other plastic materials that degrade when exposed to heat.

Released September 2021

For more information, please visit www.epa.gov/waterdisasterresponse
The Role of Water Softeners

Reservoir of *Legionella spp.* growth and chloramine breakdown to NH$_3$ (Ra et al. 2019)

↑pH, ↓ disinfectant residual, ↑ THMs (Richard et al. 2021)

NEW: Plumbing Testing Facility

1,000 sqft, Online water quality and flow monitoring
Auto flushing, POE/POU treatment and wall storage
Municipal source, Expansion primed

1,000 mg/L TOC 1st flush

1,000 sqft
Technology of The Future

Voice activated fixtures
Artificially Intelligent systems
IWQ sensors
Refreshing fixtures
Communicative appliances
Integrated home intelligence
Greywater to landscaping
And more...
The Healthy Plumbing Consortium

Mission: To advance health and quality of life by innovating new and existing technologies and providing transformative education.

1. Technological and operational approaches for maximizing building water health
2. Smart technology for improved building water health
3. Education of systems and technology

...Interested? Contact Me.
Building Water Essentials
10 Hour, Online Short-Course

Public health, code officials, manufacturers, architects, engineers

Input from practicing engineers, scientists, utilities and public health officials.

A training tool, an encyclopedia, and an extensive FAQ, designed to be immediately applicable in the field.

8 modules do not have to be taken in sequence.

If interested e-mail EngrOnline@purdue.edu
Info and registration: https://cutt.ly/Sg4RXJv
PurdueX: Massive Open Online Course (MOOC)

Plastics in Infrastructure and the Environment

Summers 2020, 2021, 2022
Online 8 week course
6-8 hours/week
FREE

Learning Objectives

- Explain the properties of polymer materials.
- Recognize the performance differences between polymeric materials.
- Describe the advantages and disadvantages of polymers for engineering applications.

PROFESSOR PROCTOR LAB GROUP

Working to manipulate microbial aquatic systems by taking advantage of ecological principles of selection within biofilms.

- Biofilms
- Bacteria and microbiomes
- Opportunistic pathogens
- Drinking water quality
- Public health and policy

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Thank you. Questions?

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COVID-19 Response

Wildfire Response

Enroll in the self-paced, online 10-hour Building Water Essentials course for CEUs

Missed the Journalism, Science, and Policy Conversation? Watch it here

www.PlumbingSafety.org

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