# COVID-19 Crisis' Impact on Plumbing Systems

**Andrew J. Whelton, Ph.D.**

Civil, Environmental, and Ecological Engineering

1. **Impact on municipal water supplies and vacant buildings**
2. **Overview best flushing practices prior to occupancy**
3. **Testing requirements**

*Download free plumbing related COVID resources at* **www.PlumbingSafety.org**

U.S. National Science Foundation RAPID Award 2027049

# 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 8 private and public sector organizations, ***ongoing***
3. Field testing to determine how impacted building water safety is in actual large buildings, ***ongoing***
4. Lab testing to determine how to fully recover contaminated building water system devices and equipment, ***planned***
5. Help transform public awareness, ***ongoing***

Helping

IAPMO

American Water Works Association

astho™

NRDC

Washington State Department of Health

ASDWA

Ohio Environmental Protection Agency

ASPE American Society of Plumbing Engineers

NEHA

SLOAN

Whirlpool Corporation

SAFE WATER ENGINEERING

*Commercial district*

Street

Fire Hydrant

**PROPERTY OWNER RESPONSIBILITY**

*Single vs. Multiple tenants*

**BUILDING PLUMBING**

**Water meter**

Corporation Stop

Water Main (metal or plastic)

**WATER UTILITY RESPONSIBILITY**

**Utility Service Line (metal or plastic)**

**Property Service Line (metal or plastic)**

***[sometimes other water sources]***

# Commercial plumbing can be very complex

Water source

Service line

Safety devices including valves

Water treatment devices

Water service and distribution piping and faucet connectors

Hot water heating, recirculation system

Fixture and fixture fittings

Pumps, tanks

Point-of-use devices

**Table 1.** Types of building plumbing components

| Components | Description |
|---|---|
| Water source | Municipal water, onsite well, treated surface water, rainwater. |
| Service line | Pipe system that carries water from the source to the building water system. Service line materials are variable and may or may not be the same as indoor pipes. |
| Safety devices including valves | Pressure relief valve, pressure reduction value, isolation valve, mixing valve, thermostatic mixing valves, backflow prevention device, water hammer arrestors. Materials can include aluminum, brass, copper, lead, plastic, and stainless steel. |
| Water treatment devices | Filter, strainer, water softener, chemical addition equipment for disinfection and corrosion control. |
| Water service and distribution piping and faucet connectors | Various material types have been used to include acrylonitrile butadiene styrene (ABS), brass, cast iron (CI), chlorinated polyvinyl chloride (CPVC), copper, crosslinked polyethylene (PEX), ductile iron (DI), high density polyethylene (HDPE), lead, lead lined steel, multilayer pipes, polyethylene raised temperature (PERT), polypropylene (PP), unplasticized polyvinyl chloride (uPVC), polyvinylidene fluoride (PVDF), black steel, stainless steel. |
| Hot water recirculation system | Hot water is pumped through primary and secondary water heater loops, which serve different building zones to reduce delivery time of hot water. These have to be hydraulically balanced. Equipment includes master mixing valves, local mixing valves, flow balancing valves, pressure reducing valves,hot water return pumps and water heaters. Multiple temperature loops may exist. Operation of pumps may be intermittent in some systems. |
| Fixtures and fixture fittings | Aerator, air washers, atomizers, bathtub, bidet, decorative fountains, dishwasher, drinking fountain, eyewash stations, manual faucet, electronic faucet, faucet flow restrictors, hoses, point of use mixing valves, hot tubs, humidifiers, ice machines, misters, shower head, shower wand, sink, tub spout, toilet, urinal, washbasin |
| Pumps | Pumps are often used for pressure boosting within the building (i.e., for multi-story buildings) where water pressure entering the building is not adequate for water use at distal locations. Pumps are also used for hot water recirculation systems. |
| Tanks | Standard water heater, pressure tanks, on-demand water heater, hydropneumatic tanks, cold water supply storage tank. Water heaters can contain Mg or Al sacrificial anodes and plastic dip tubes. |
| Point-of-use devices | On-faucet treatment system, under sink treatment system. |

https://doi.org/10.31219/osf.io/qvj3b

# Stagnation *noun*

stag·na·tion | \ stag-ˈnā-shən

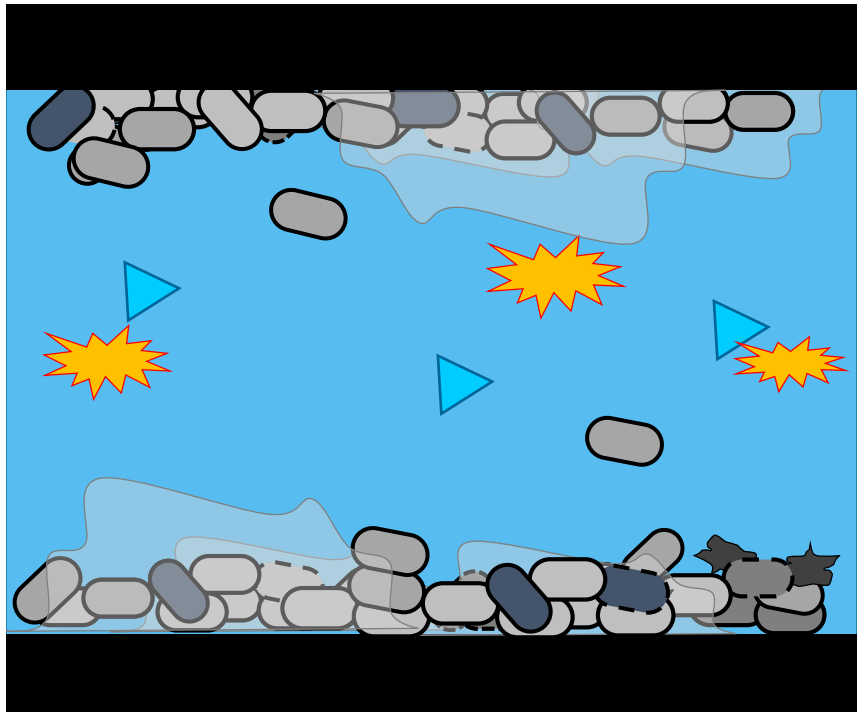
a state or condition marked by lack of flow, movement

When water does not flow well; areas of stagnant water encourage biofilm growth and reduce temperature and level of disinfectant

# Stagnation causes water to get older

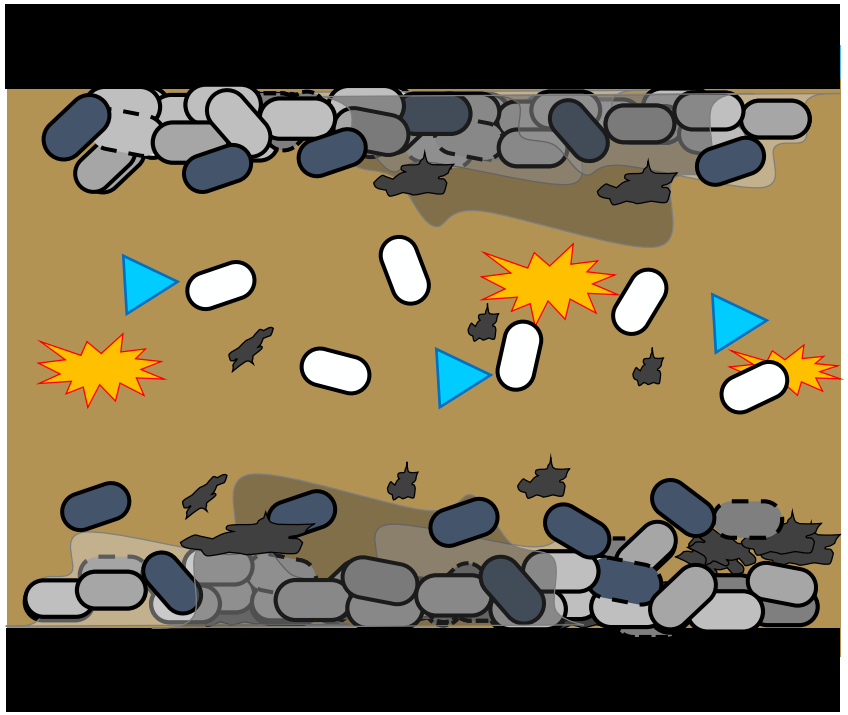
**Normal water use** refreshes:

- disinfectant residual &
- corrosion control



**Old water** (not refreshed):

- bacterial growth &
- corrosion not controlled



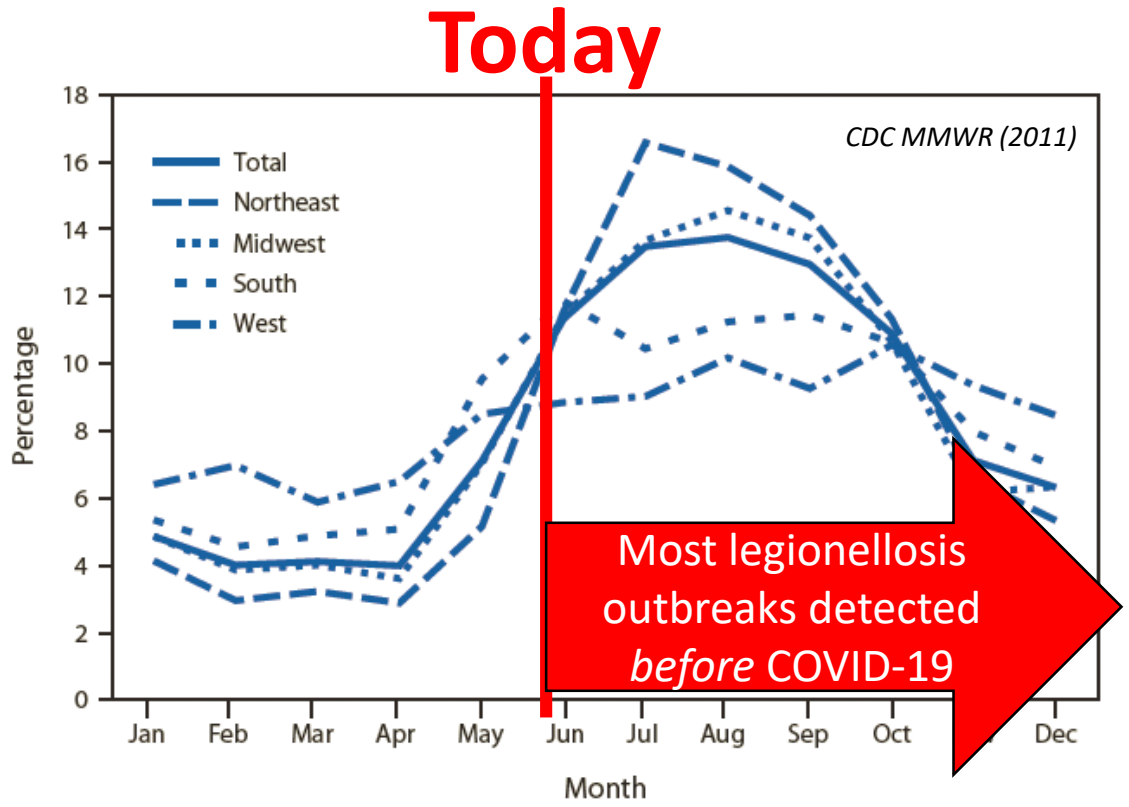
**Disinfectant** in water – used to reduce microbial growth in water, typically chlorine

**Corrosion control** – used to reduce metals leaching, stabilizes pH and may add chemicals

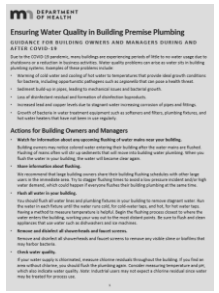
*Slide from our Dr. Caitlin Proctor YouTube Video*

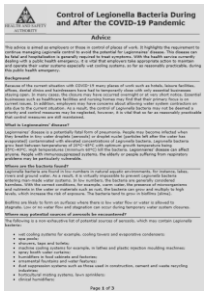
# *Prior* to the pandemic, stagnation posed health **risks**

- **Copper** can leach
  - Nausea, vomiting, diarrhea, abdominal cramps
- **Lead** can leach
  - Nausea, vomiting, diarrhea, abdominal cramps, longer-term developmental issues with children
- **Scale** can be suspended
- **Harmful organisms** (e.g., *Legionella pneumophila* and other opportunistic pathogens) can grow - better
  - Many organisms cause respiratory illness, and other infections can occur

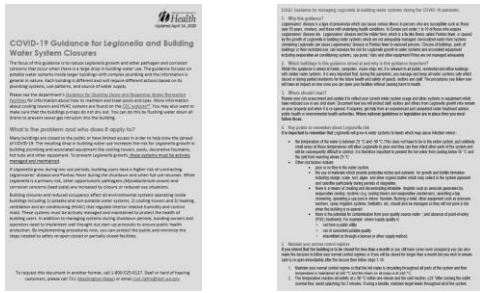



*Exposure Routes of Concern: Ingestion, Dermal, Inhalation*


Ensuring Water Quality in Building Premise Plumbing

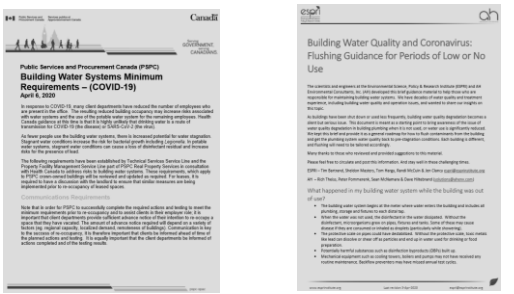

Control of Legionella Bacteria During and After the COVID-19 Pandemic

Advice

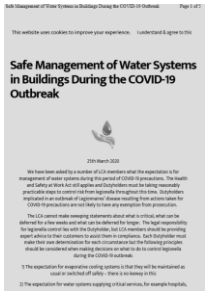

COVID-19 Guidance for Legionella and Building Water System Closures




Public Health England


Public Services and Procurement Canada (PSPC)
Building Water Systems Minimum Requirements – (COVID-19)

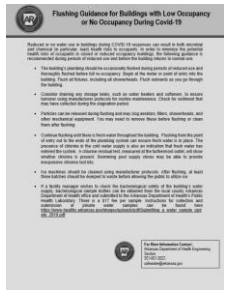


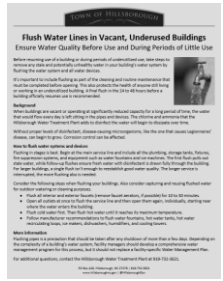

Building Water Quality and Coronavirus: Flushing Guidance for Periods of Low or No Use

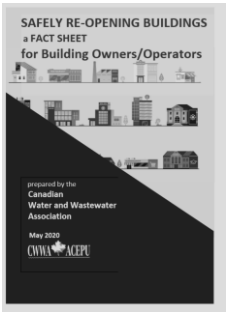

Safe Management of Water Systems in Buildings During the COVID-19 Outbreak

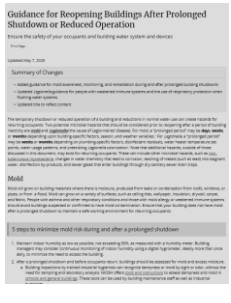

Ohio Department of Health

Guidance for Premise Plumbing Water Service Restoration


Flushing Guidance for Buildings with Low Occupancy or No Occupancy During Covid-19


Flush Water Lines in Vacant, Underused Buildings
Ensure Water Quality Before Use and During Periods of Little Use

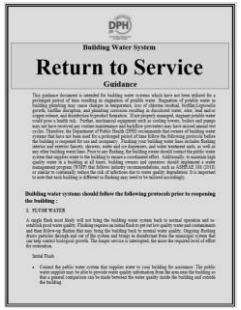

SAFELY RE-OPENING BUILDINGS
a FACT SHEET
for Building Owners/Operators
prepared by the Canadian Water and Wastewater Association
May 2020
CWWA ACEPU


Guidance for Reopening Buildings After Prolonged Shutdown or Reduced Operation

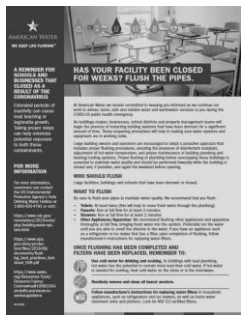
Summary of Changes

Mold

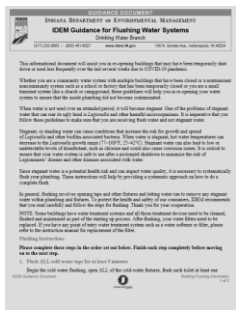
5 steps to minimize mold risk during and after a prolonged shutdown

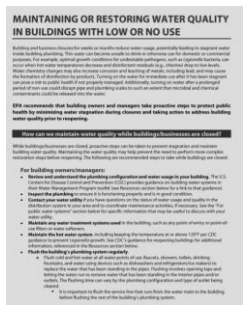

Building Water System
Return to Service
Guidance

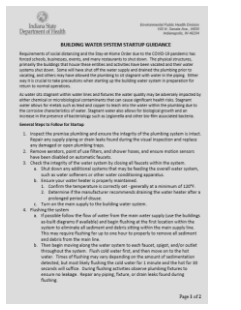

BUILDING PERFORMANCE
ENSURING THE SAFETY OF YOUR BUILDING WATER SYSTEM POST COVID 19 LOCKDOWN

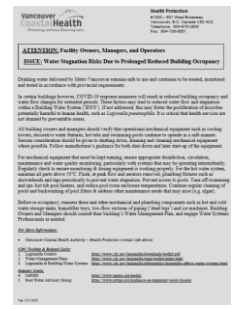

HAS YOUR FACILITY BEEN CLOSED FOR WEEKS? FLUSH THE PIPES.

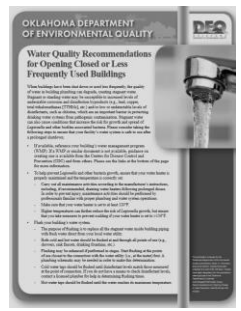

Public Health
Water Quality and Your Business: Tips for Re-opening After Closure


INDIANA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT
IDEM Guidance for Flushing Water Systems
Drinking Water Branch


MAINTAINING OR RESTORING WATER QUALITY IN BUILDINGS WITH LOW OR NO USE


Indiana State Department of Health
BUILDING WATER SYSTEM STARTUP GUIDANCE

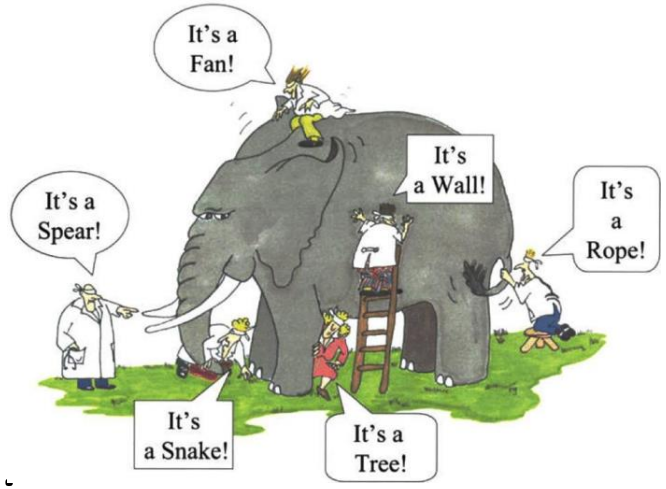

Vancouver Coastal Health
ATTENTION: Facility Owners, Managers, and Operators
RE: Water Stagnation Risks Due to Prolonged Reduced Building Occupancy


OKLAHOMA DEPARTMENT OF ENVIRONMENTAL QUALITY
Water Quality Recommendations for Opening Closed or Less Frequently Used Buildings

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

Many differ quite dramatically. Some lack key info (safety, devices, sensitive population, etc.).

# Why are they so different?




- Different perspectives - *sides of the elephant*
- Different starting information about water safety
- Different starting information about building plumbing
- Guidance targeted for different readers
- Deliberately step-by-step documents vs. general advice
- Some are derivatives of others, & others… & others!
- Some have been revised (version 3 since March 2020)
- Media, water utilities, & associations making even brief(er) messages

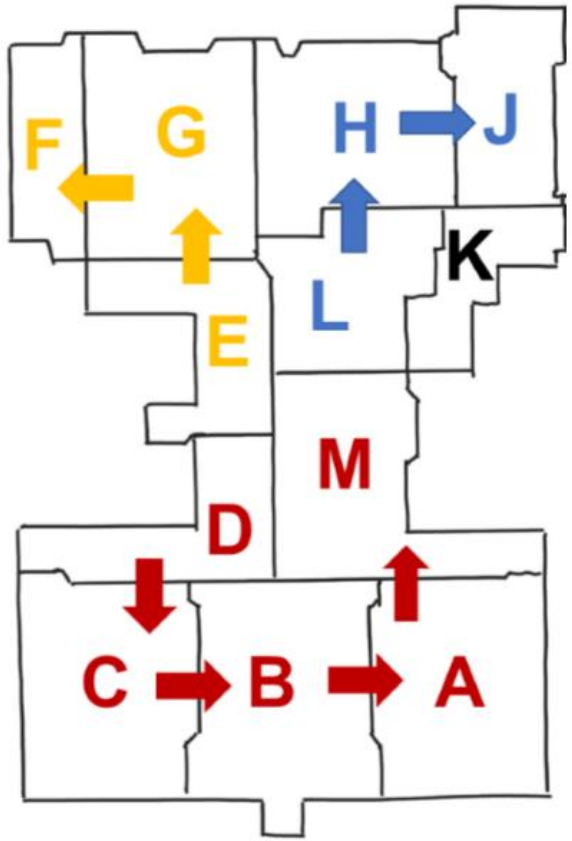
***Awareness vs. Informational vs. Warnings vs. Actions***

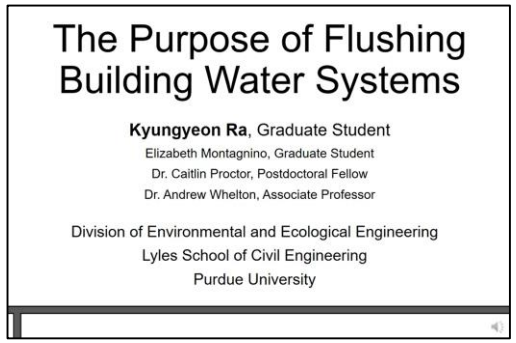
# How could we *minimize* water quality problems?

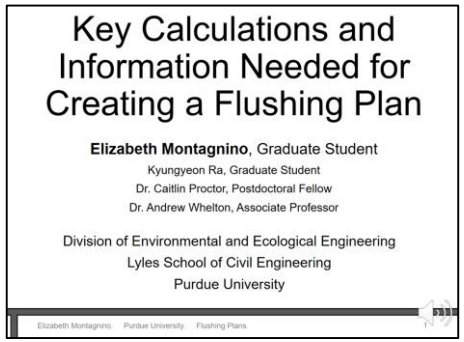
## Keep the water moving! ≠ stagnation

- Source water must be fresh (utility, onsite well, Source may need to flush!)
- Clean devices and equipment
- Flushing – Keep water fresh
- Water heater and recirculation loops – Keep hot water hot, Keep cold water cold

## *Flushing Plans*

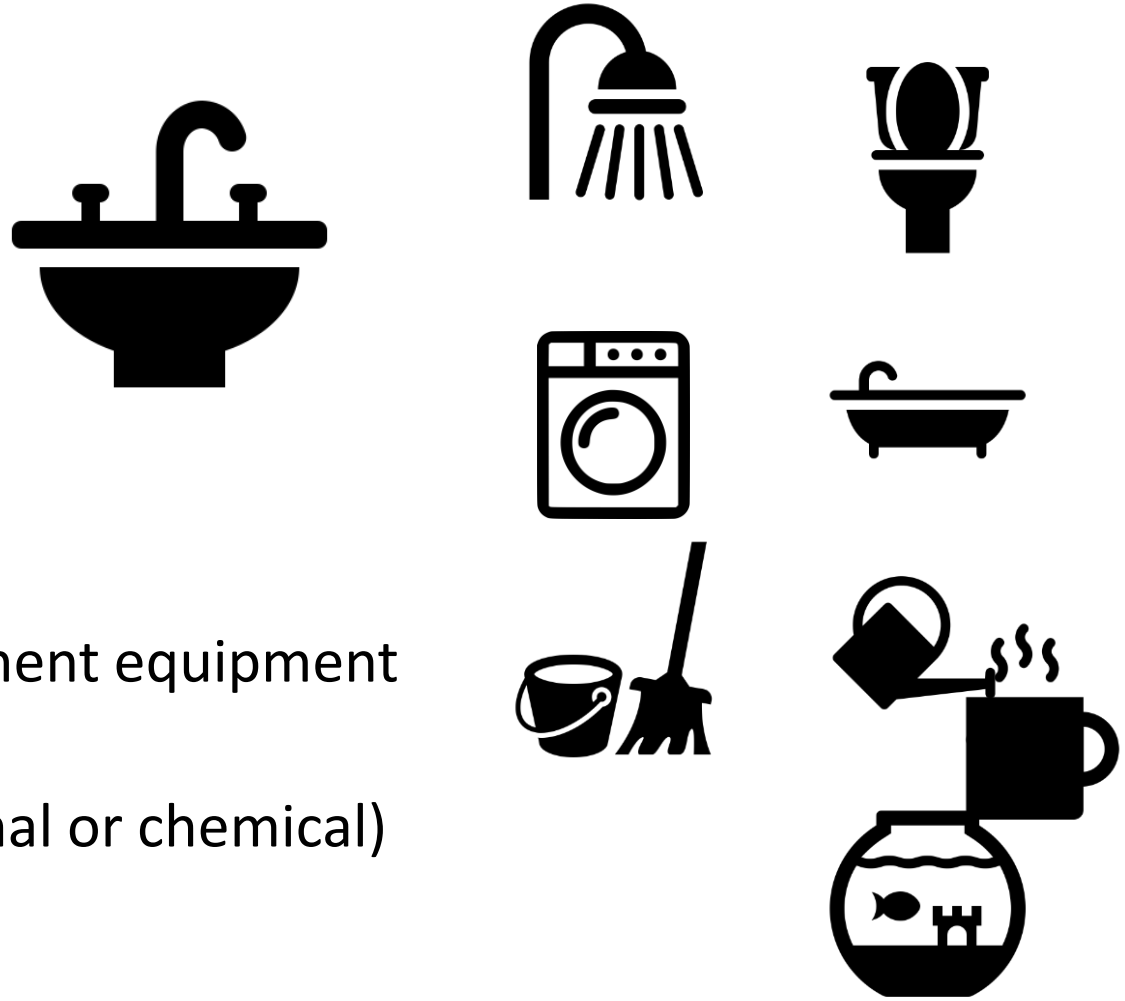


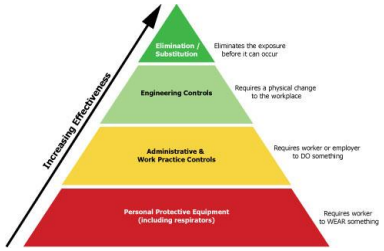



# What actions can be taken to *deal with* water quality deterioration?

- Recommissioning plumbing
  - System integrity checks
  - Flushing (and cleaning)
  - Shock disinfection
  - Testing
- Professional help might be needed
  - Address complex mechanical and treatment equipment
  - Develop effective flushing plans
  - Perform shock disinfection safely (thermal or chemical)
  - Perform accurate testing



# Flushing and More Intensive System Cleaning Can Make People Sick




## Engineering Controls

- Fill sink and floor drains traps with water
- Maintain pressure when flushing
- During flushing (especially initial), many methods to reduce exposure: Cover toilets, showerheads, faucets, reduce splashing, use hoses
- Flooding, cross-connections, dealing with waste

## Administrative and Work Practice Controls

- Temporarily forbidding use of high-risk exposure items (showers, hot tubs, decorative fountains)
- Temporarily closing facilities to concentrate use

## Personal Protective Equipment (PPE)

- Protect against scalding
- Protect against chemical exposure
- OSHA and other agencies recommend respirators *if* Legionella is *suspected or possible*

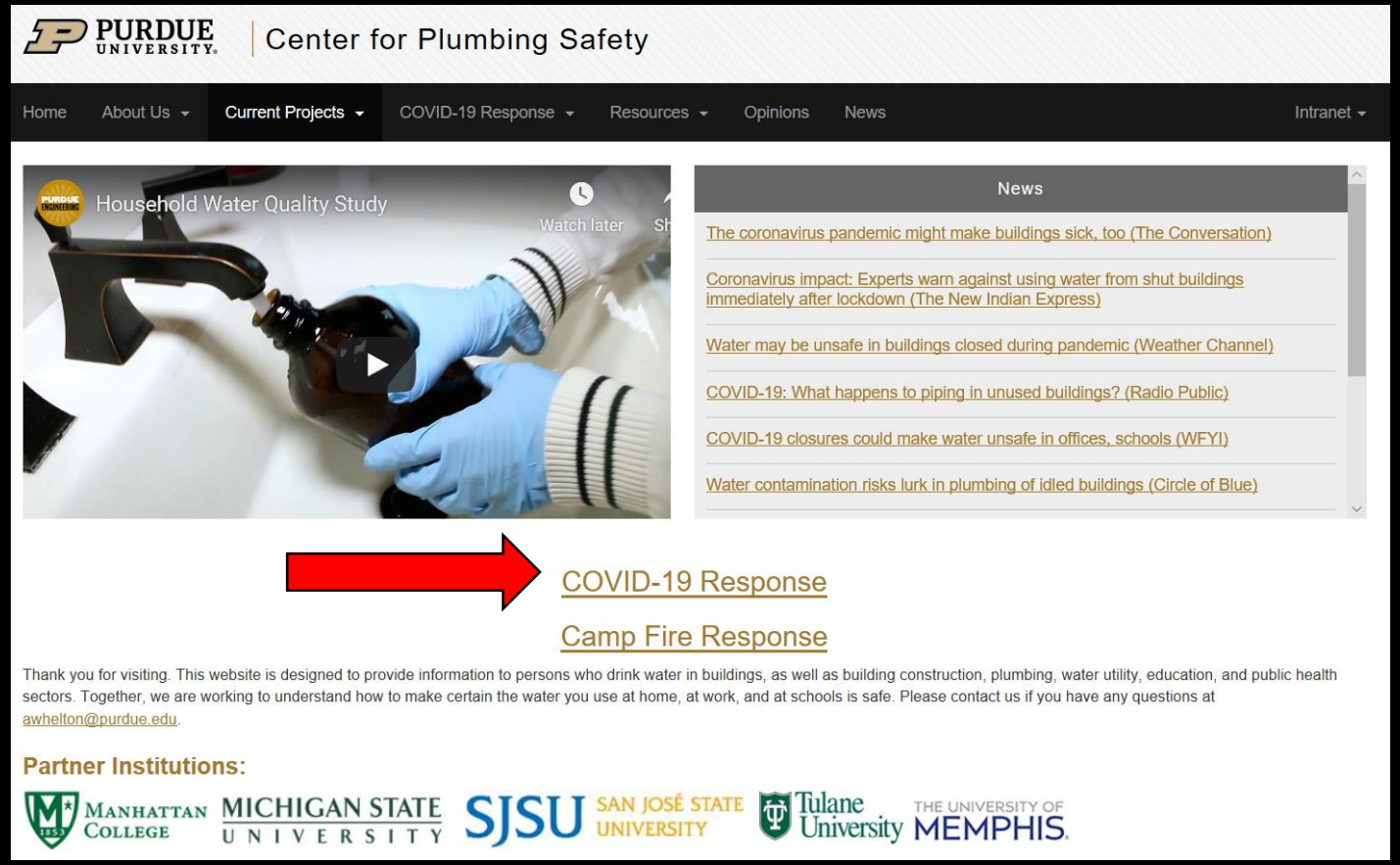
OSHA

N95 respirators, but recommends voluntary use of N100 “if *Legionella* contamination is possible”.

AIHA®
*Protecting Worker Health*

P100 HEPA filter respirators when sampling building water and *Legionella* may be present

# *Thank you…* www.PlumbingSafety.org




*Access to world-class expertise, capabilities, and education in and outside Purdue*

## A Resource for All

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

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# Extra Slides

# What do I test for?

## BASIC PARAMETERS

Cold water = disinfectant level & temperature

Hot water = temperature


For others, you need a plan about what you will do if you test: Lead, copper, legionella, and more

**Section 3.185 Table 6:** European Union Action Levels for *Legionella* in Potable Hot and Cold Water Systems

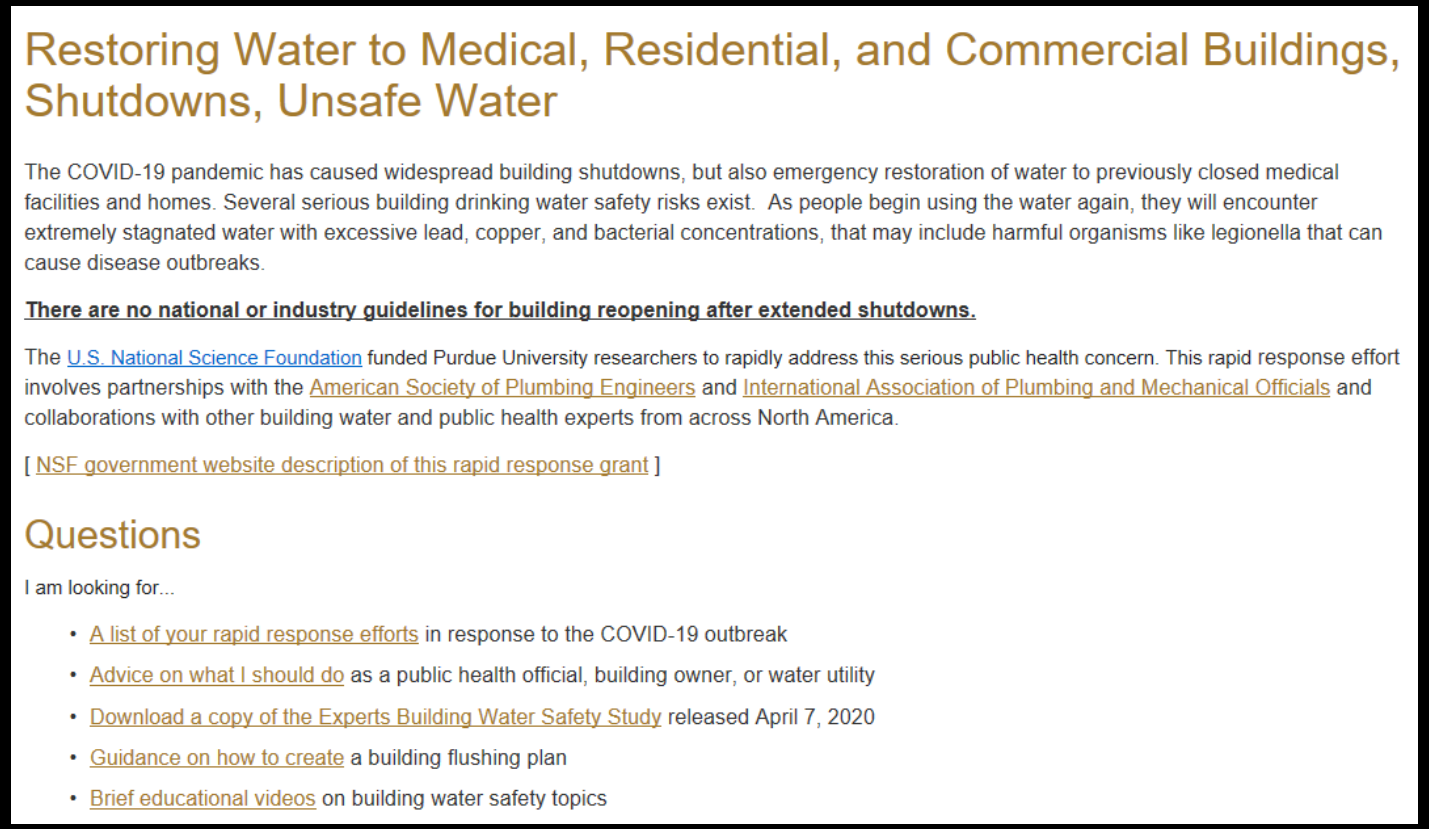
| ***Legionella* CFU/Liter** | **Action Required** |
|---|---|
| Not Detected | Acceptable – continue monitoring |
| < 100 to 1,000 | Refer to responsible person and assure water quality values are within target |
| > 1,000 to < 10,000 | i) Resample if small percentage (10-20%) are positive; review control measures<br>ii) If >20% positive may indicate low level colonization, disinfection of system, and risk assessment to determine additional actions |
| ≥ 10,000 | Resample, immediate review of control measures, disinfection of whole system |

Source: EU (2017).

The EU guidelines emphasize the goal to achieve no cultural *Legionella*, but acknowledge that occasional detection (<20%) of low levels of *Legionella* (< 1,000 CFU/L) may be acceptable provided that other water quality values (e.g., temperature, disinfectant) and operational parameters are within the water management plan guidelines. Intermediate levels (> 1,000 to < 10,000 CFU/L) and high levels (≥ 10,000 CFU/L) trigger a series of actions including resampling, remedial measures such as disinfection, and overall review of the water management plan program.

*Washington State Department of Health Guidance*

# COVID Specific Building Water Safety Support Resources



## Restoring Water to Medical, Residential, and Commercial Buildings, Shutdowns, Unsafe Water

The COVID-19 pandemic has caused widespread building shutdowns, but also emergency restoration of water to previously closed medical facilities and homes. Several serious building drinking water safety risks exist. As people begin using the water again, they will encounter extremely stagnated water with excessive lead, copper, and bacterial concentrations, that may include harmful organisms like legionella that can cause disease outbreaks.

**There are no national or industry guidelines for building reopening after extended shutdowns.**

The U.S. National Science Foundation funded Purdue University researchers to rapidly address this serious public health concern. This rapid response effort involves partnerships with the American Society of Plumbing Engineers and International Association of Plumbing and Mechanical Officials and collaborations with other building water and public health experts from across North America.

[ NSF government website description of this rapid response grant ]

### Questions

I am looking for...

- A list of your rapid response efforts in response to the COVID-19 outbreak
- Advice on what I should do as a public health official, building owner, or water utility
- Download a copy of the Experts Building Water Safety Study released April 7, 2020
- Guidance on how to create a building flushing plan
- Brief educational videos on building water safety topics

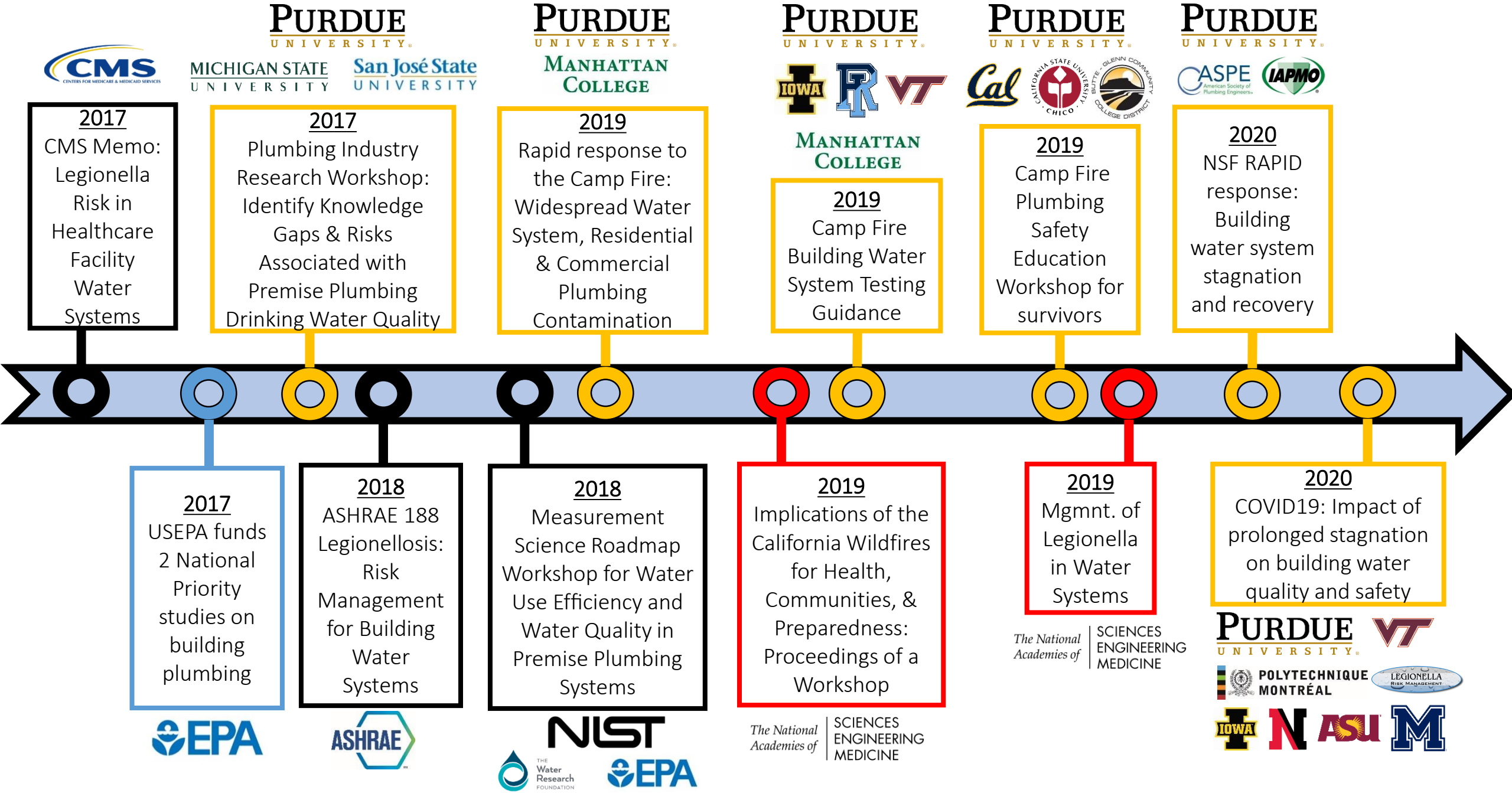
- ✓ Advice for building owners, health officials and utilities
- ✓ Building water safety education videos
- ✓ Guidance on how to create flushing plan
- ✓ Access to the Building Water Safety Study
- ✓ Guidance on building water safety from multiple nations and U.S. states


Onsite Education & Plumbing Safety YouTube Channel

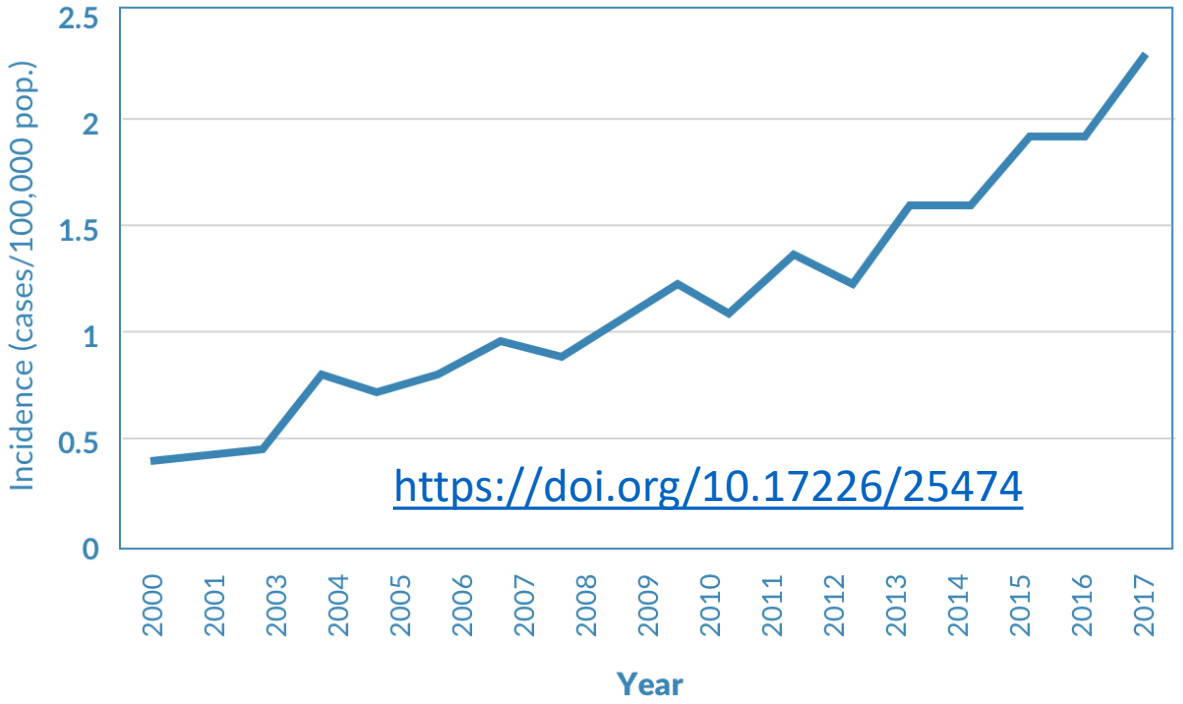
Nearby Innovation Partner with Full-Scale Testing Facility

Plumbing Testing Facility at Purdue

Onsite Testing and Technical Support


2017
CMS Memo: Legionella Risk in Healthcare Facility Water Systems
2017
Plumbing Industry Research Workshop: Identify Knowledge Gaps & Risks Associated with Premise Plumbing Drinking Water Quality
2019
Rapid response to the Camp Fire: Widespread Water System, Residential & Commercial Plumbing Contamination
2019
Camp Fire Building Water System Testing Guidance
2019
Camp Fire Plumbing Safety Education Workshop for survivors
2020
NSF RAPID response: Building water system stagnation and recovery
2017
USEPA funds 2 National Priority studies on building plumbing
2018
ASHRAE 188 Legionellosis: Risk Management for Building Water Systems
2018
Measurement Science Roadmap Workshop for Water Use Efficiency and Water Quality in Premise Plumbing Systems
2019
Implications of the California Wildfires for Health, Communities, & Preparedness: Proceedings of a Workshop
2019
Mgmt. of Legionella in Water Systems
2020
COVID19: Impact of prolonged stagnation on building water quality and safety


- ✓ Drinking water systems that support biofilm growth to include cooling towers, hot tubs, fountains, and building plumbing systems and their outlets like faucets and showerheads.
- ✓ Warm temperatures + **stagnant water** + and no chemical disinfectant
- ✓ Exposure route: *Inhalation* of contaminated aerosols



# Precautions Are Needed for COVID-19 Patients with Coinfection of Common Respiratory Pathogens

24 Pages • Posted: 12 Mar 2020

Quansheng Xing
Qingdao University - Qingdao Women and Children's Hospital

Guo-ju Li
Qingdao University - Qingdao Women and Children's Hospital

More...

[2020 Preprint]

THE LANCET

http://dx.doi.org/10.2139/ssrn.3550013

"The most common respiratory pathogens detected in Qingdao COVID-19 patients were influenza virus A (60.00%) and influenza virus B (53.30%), followed by *mycoplasma pneumoniae* (23.30%) and ***legionella pneumophila* (20.00%).**"

# Documents to consider to DEVELOP guidance

** Guidance evaluation tool: Virginia Tech, Polytechnique Montreal, Purdue University, Northeastern University*

**2020** Peer-reviewed report: Prolonged stagnation *[All contaminants]* https://www.doi.org/10.31219/osf.io/qvj3b

**2020** COVID-19 Building Water System Guidance Evaluation Tool *[All contaminants]* https://engineering.purdue.edu/PlumbingSafety/covid19/Guidance-Evaluation-Tool.pdf

**2019** NASEM 2019 Management of Legionella in Water Systems *[Legionella specific]* https://www.nationalacademies.org/our-work/management-of-legionella-in-water-systems

**2018** ASHRAE 188 Legionellosis: Risk Management for Building Water Systems *[Legionella specific]* https://www.ashrae.org/File%20Library/Technical%20Resources/Bookstore/86611_188-2018preview.pdf

**2017** CDC Water Management Plan Toolkit *[Legionella specific]* https://www.cdc.gov/legionella/downloads/toolkit.pdf

# Building water safety review due to prolonged stagnation with experts from 7 private and public sector organizations

## 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

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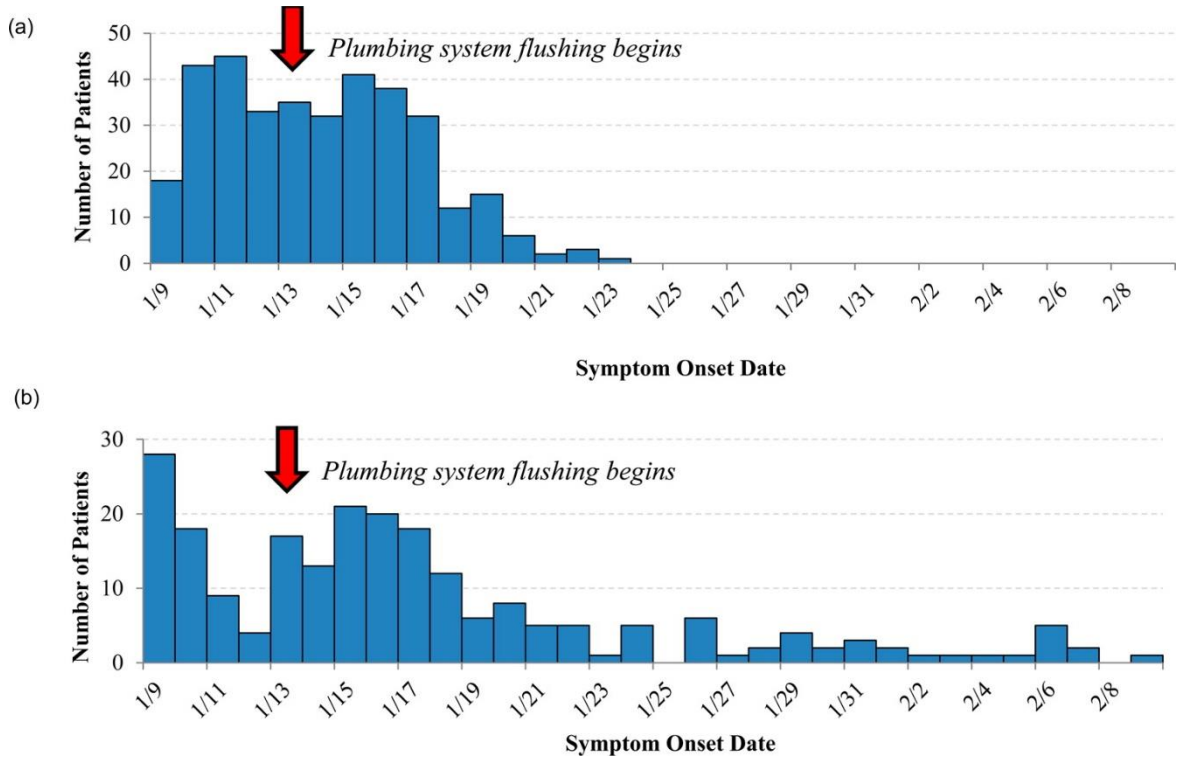
# A look back: Residential building water system flushing guidance made people sick

https://doi.org/10.1021/es5040969




2014 WV chemical spill – illnesses caused by flushing guidance

2015 Purdue critical review of past residential flushing guidance shows the absence of a scientific foundation

2017 Purdue water heater flushing study

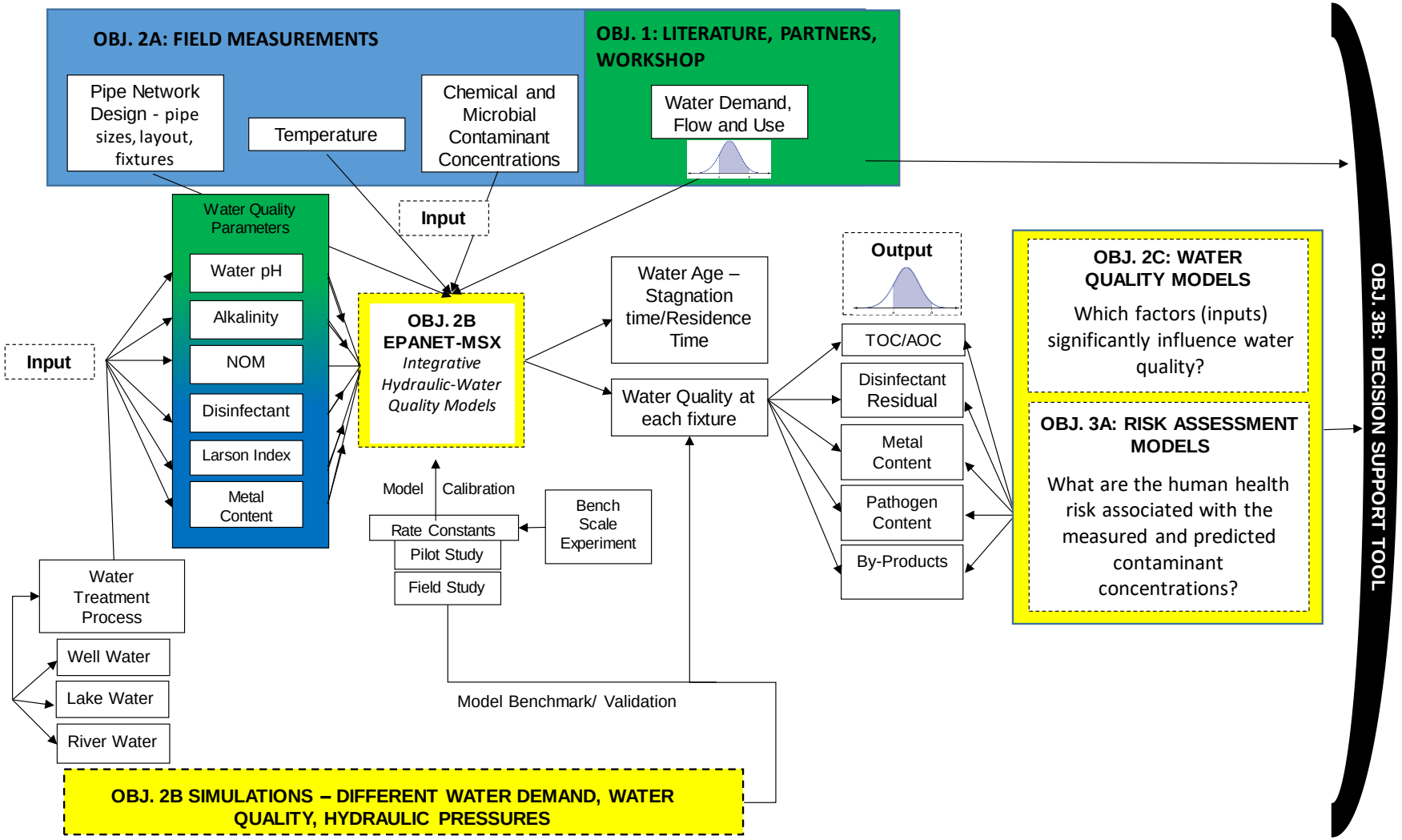
2018 MetroCOG, CEC LLC, and Purdue provide foundational flushing guidance

2018 USEPA flushing study shows weeks to months needed to decon some plastic plumbing pipes

2019 Camp Fire: USEPA and Purdue estimate months needed to decon HDPE plastic plumbing pipes

# The FUTURE? Predict water quality at the tap

## Ongoing Residential Home Study

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