

Preserving Water Quality in Building Design



November, 2018

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PURDUE
UNIVERSITY

MICHIGAN STATE
UNIVERSITY

SJSU SAN JOSÉ STATE
UNIVERSITY


MANHATTAN
COLLEGE

 **Tulane**
University

THE UNIVERSITY OF
MEMPHIS

plumb·ing

['pləmiNG]

NOUN

the system of pipes, tanks, fittings, and other apparatus required for the drinking water supply, heating, and sanitation in a building

4000-3000 BCE

Copper water pipes in buildings (India)



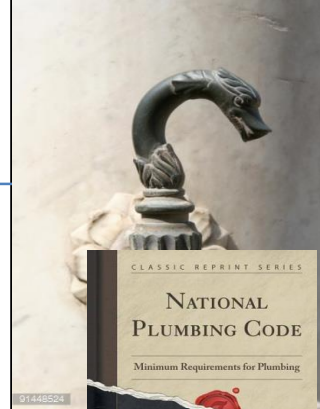
1500 BCE

Rainwater cisterns (Greece)



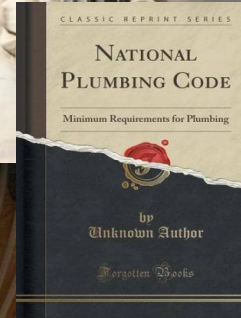
500 BCE- 250 AD

Lead & bronze pipes, marble fixtures, gold & silver fittings (Egypt)



1928

First US plumbing code

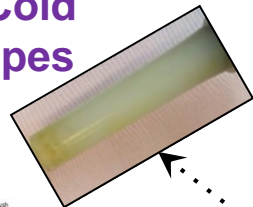


1966

Copper shortage enabled plastics entry



Hot vs. Cold Water Pipes



Metals and Plastics



Fixtures and Aerators



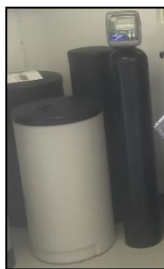
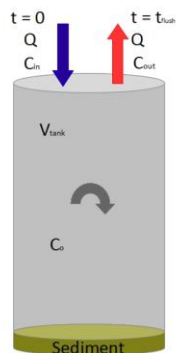
POU Devices



Corrosion Products



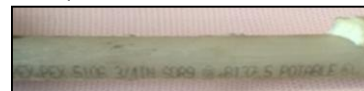
Water Heater



Water Softener

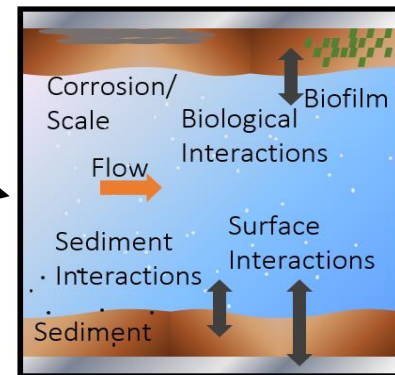


Whole House Filter



Service Lines

Habitat



Building plumbing is complex

Food Prep Facility



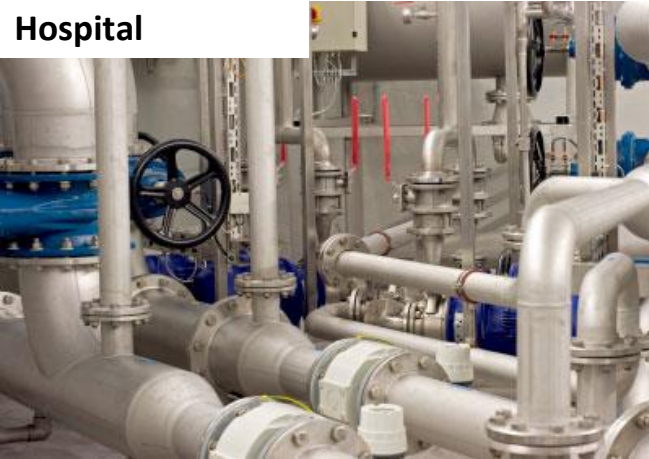
Domestic Hot Water



PEX pipe with copper manifold



Hospital



Cartridge Filters



Copper pipe to cPVC pipe



Some images courtesy of: Gordon & Rosenblatt, LLC

Plumbing, Pathogens, & Disease

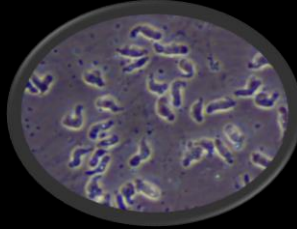
“Pathogens in plumbing are the 1^o source of waterborne disease in developed countries”

Pruden et al. (2013)

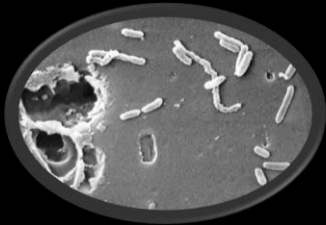
Legionella p.



Naegleria fowleri



P. aeruginosa



**Waterborne diseases in the US
2000-2014**

56% due to drinking water

22% cooling towers

7% hot tubs

44% at hotels and resorts

19% at long-term care facilities

15% percent at hospitals

2nd UW patient with Legionnaire's disease dies

WGN

CNN

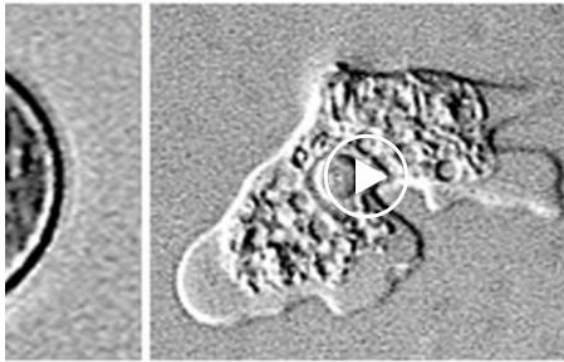
Health » Diet + Fitness | Living Well | Parenting + Family

Live TV • U.S.

4-year-old dies after brain-eating amoeba infection

By John Bonifield, CNN

Updated 10:40 AM ET, Sat September 7, 2013



Travis Pittman, KING 12:22 PM, PDT September 14, 2016

2 dead in Legionnaires' outbreak tied to downtown hotel

Chicago Tribune



Two people have died after contracting

By Mitch Smith
Tribune reporter

AUGUST 28, 2012, 7:17 AM

Two people have died after contracting Legionnaires' disease, a downtown Marriott officials said Monday.

TEXOMA
KTEN North Texas | S.E. Oklahoma

Water faucets at Bonham VA test positive for Legionella

Posted: Dec 04, 2014 7:45 PM EST



BONHAM -- Seven water faucets at two North Texas VA Centers have tested positive for **Legionella**, a bacteria that can lead to Legionnaires' Disease.

The North Texas VA says 205 water samples were taken in November and the positive results were received on Tuesday.

Five of the faucets came from the Bonham VA Medical Center. Two were from the facility in Dallas.

Texoma Headlines

More>>

Bryan County flu shots

VIDEO INCLUDED

Factors that Affect Unhealthy Drinking Water

Sediment (*Solids*)

Temperature

Water Age

Disinfectant Residual

Legionella pneumophila
Gram-negative bacteria
causes “Legionnaires Disease”

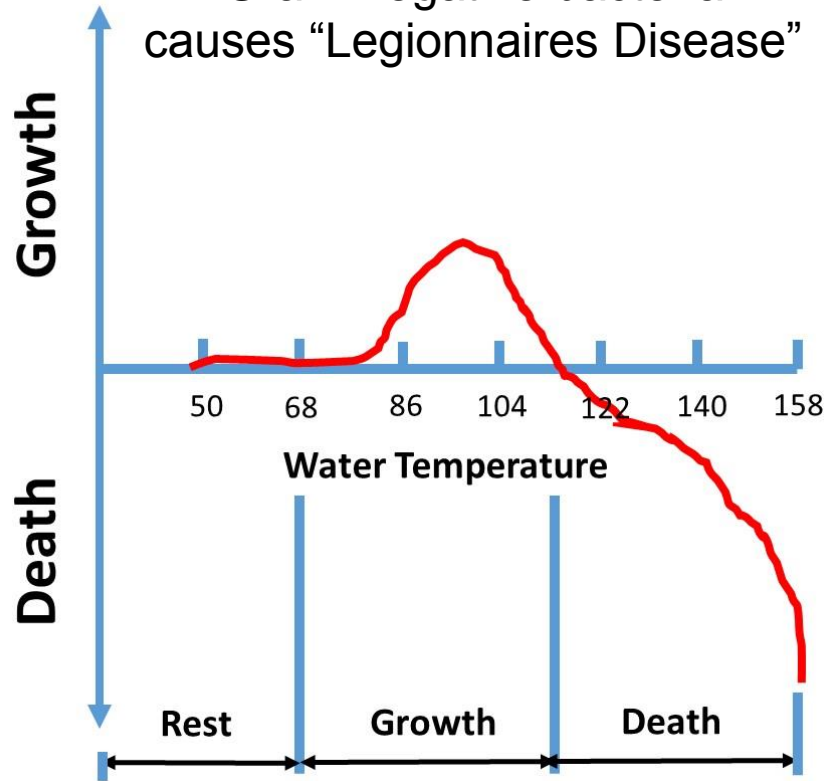


Image: Zeonda AB

Water Temperature

*“... homeowners choose..120°F to
reduce scalding risk or to save energy”
– San Francisco Chronicle*



U.S. DEPARTMENT OF
ENERGY

recommends

120°F unless persons have
suppressed immune system or
chronic disease
Away 3 days+ turn temperature
down or off

Building Water Use has Been Declining

Energy Policy Act of 1992

**Water
Use has
Decreased
From
Lower-Flow
Faucets**

Pre-1994 (4+ gpm)



1994 (2.5 gpm)



2015 (0.5 gpm)



2016? (0.01 gpm)



How old is your water before reaching the faucet?

$$\frac{\text{Volume of water stored in pipes}}{\text{Flowrate of water exiting the Faucet}}$$

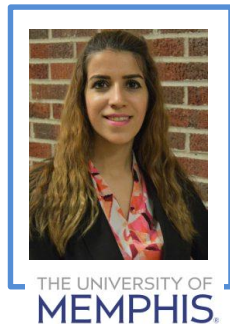


...our water systems are not designed to handle lower use

Leaching can provide organisms food, pH affected
Leaching differs across *and* within pipe brands
No long-term leaching studies
Metal fittings can release heavy metals
Plastics affect lead and copper levels
Compounds causing taste and odors not identified



**Some products are being installed with
little understanding about their
drinking water impacts**



Rebecca Ives, Kyungyeon Ra, Christian Ley, Tolu Odimayomi, Sruthi Dasika, John Mayo, Xianzhen Li, Xiangning Huang, Kara Dean, Ryan Julien, Erica Wang, Miriam Tariq, Emerson Ringger, Bill Schmidt, Kim Petersen, Caitlin Proctor, Mohammad Abouali, Paul Robinson, Jennifer Sturgis



Project Goal and Objectives

To better understand and predict water quality and health risks posed by declining water usage and low flows

1. Improve the public's understanding of decreased flow and establish a range of theoretical premise plumbing flow demands from the scientific literature and expert elicitation with our strategic partners
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 premise plumbing characteristics, operations and maintenance practices that minimize health risks to building inhabitants.

What is the Most Monitored Home in America?



3 Bedroom, 1.5 baths
Renovated 2014
Solar panels
Net-zero waste
Energy efficient appliances
Rainwater catchment
Greywater recycling
Online monitors throughout bldg

ReNEWW House = Retrofit Net Zero Energy, Water, and Waste

ReNEWW Home Preliminary Results

October 2017 to October 2018

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

600+ million online plumbing related measurements

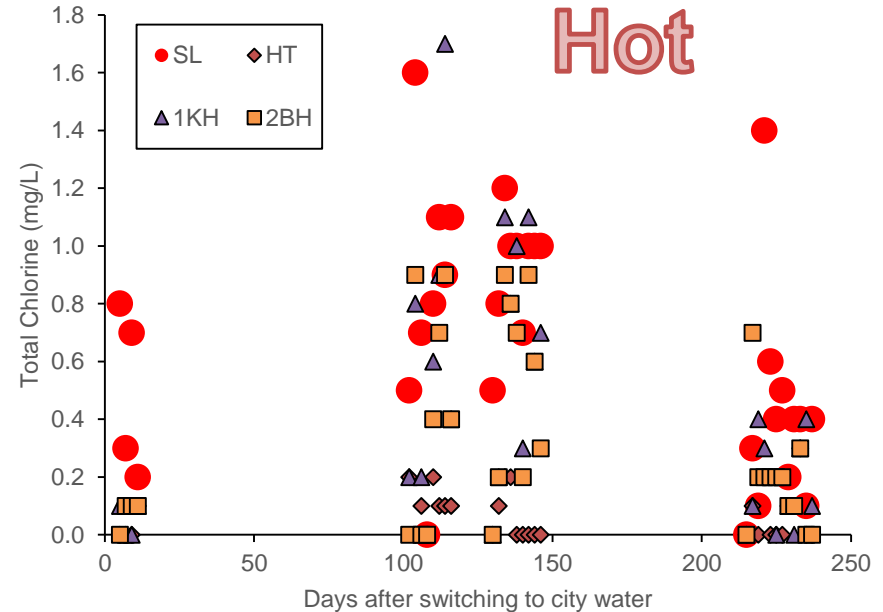
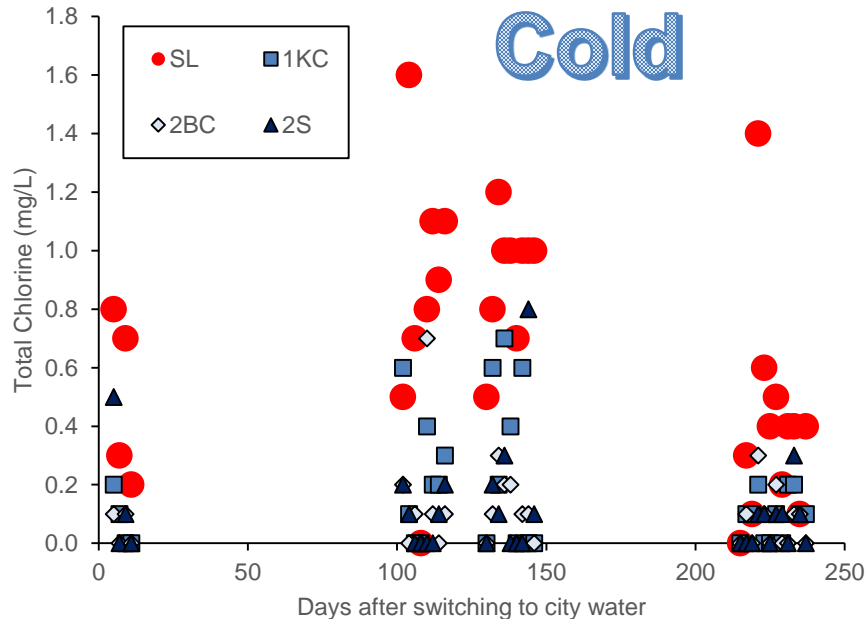
Water in pipes equilibrates to ambient temperature quickly (<4 hours)

Usage events are short; ~70% of events are less than 5 seconds

Snapshot of Preliminary Total Chlorine Results

(Service line = red)

not found in more than 50% of water samples exiting the water heater, at the 1st floor kitchen sink cold, 2nd floor bathroom sink cold, and 2nd floor shower



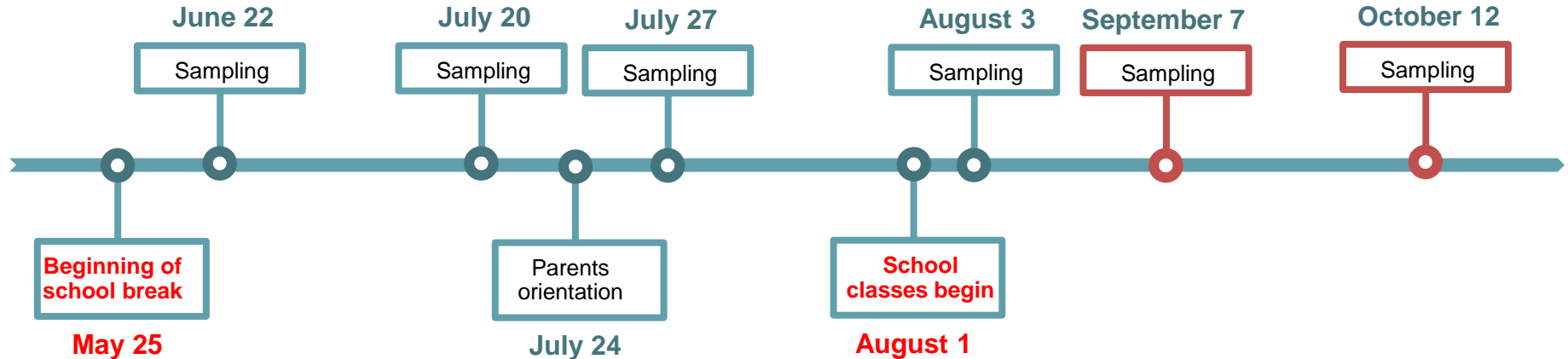
Field Study School



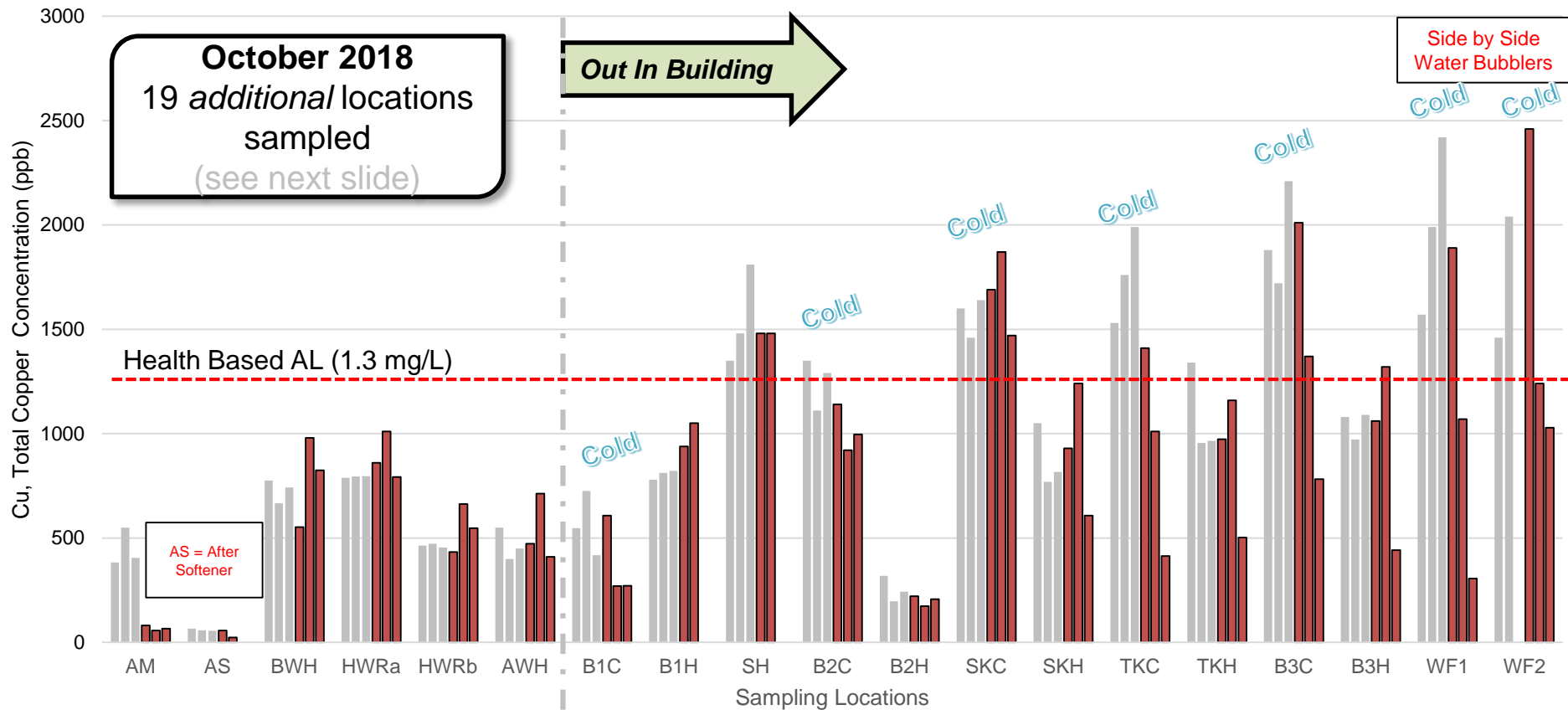
7 year old LEED school receives chloraminated water from a public water system; Copper plumbing, water softener, hot water recirculation system - 4 zones.

Study Goal: Understand how drinking water chemical and microbial parameters change during the **transition from Summer to Fall**

- Service line, staff kitchens, bathrooms, showers, classroom, water bubblers



More than 4,500 tests: Copper drinking water action level was exceeded June 2018 to October 2018



Routine Sampling Locations in October	1 st grab (mg/L)	2 nd grab (mg/L)	Our Experience with Locations
B2C	0.996	1.470	3 of 7 prior samples exceeded the AL
SKC	1.470	0.561	7 of 7 prior samples exceeded the AL
None of our other routine locations exceeded the copper AL during the October sampling event			

of 19 Routine Sampling Locations

In October we added 19 new cold water sampling locations

New Sampling Locations in October	1 st grab (mg/L)	2 nd grab (mg/L)
SRS - shower room right sink	0.123	0.149
SLS - shower room left sink	0.479	0.164
B2CR - bathroom 2 cold right	0.949	1.403
B2CL - bathroom 2 cold left	1.164	1.452
SKD - student kitchen sink D	1.32	0.832
SKF - student kitchen sink F	1.58	0.529
FK - faculty kitchen - A108	0.831	0.120
ARRS - art room right sink - F105	0.424	0.638
WF3 - water fountain 3 - F112 (choral room)	1.773	1.360
WF4 - water fountain 4 - F115W	1.047	0.902
WF5 - water fountain 5 - B103B	0.945	0.374
ABS - auditorium back sink	1.141	1.314
B3LS - bathroom 3 left sink	0.898	0.866
B4 - bathroom 4 - C124G - next to sink 2	1.141	0.868
B5 - bathroom 5 - B103B	0.275	0.216
B6 - bathroom 6 - B124B	1.097	0.819
B7 - bathroom 7 - B112W - staff bathroom	0.649	0.618
B8 - bathroom 8 - C112W - staff bathroom	0.697	0.646
B9 - bathroom 9 - A108M - in office	0.142	0.105

Our Plumbing Testing Facility is Ready: Plumbing, Water Use, and Water Quality Relationships

Full-Scale Testing



Plumbing Testing
Facility @ Purdue



Other Field/Bench- scale tests



Thank You.



Questions: Andrew Whelton, awhelton@purdue.edu

Learn more at www.PlumbingSafety.org

Follow us on Twitter @TheWheltonGroup

Funding: Environmental Protection Agency grant R836890

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