Working Toward Safer Drinking Water at Home, Work, and School

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Core Team

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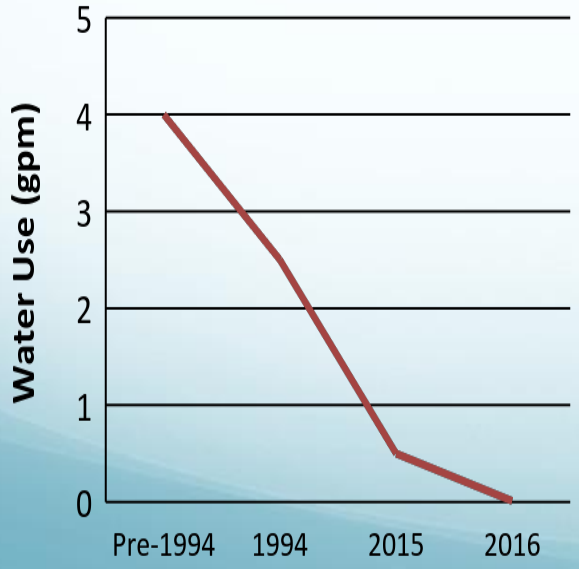
MICHIGAN STATE UNIVERSITY

Our Project Goal

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



Prepared by Andrew Whelton (Purdue)

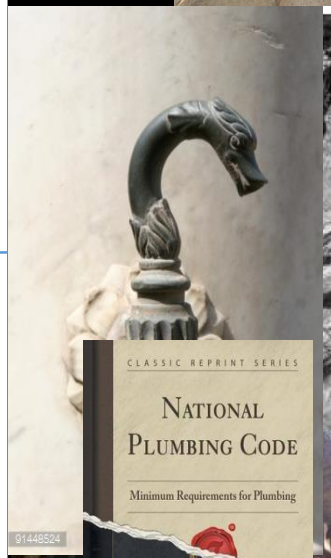
plumb·ing

[ˈpləmiNG] ***NOUN***

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

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

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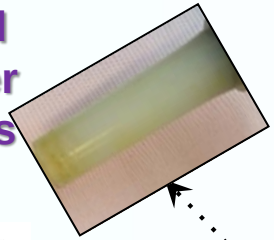
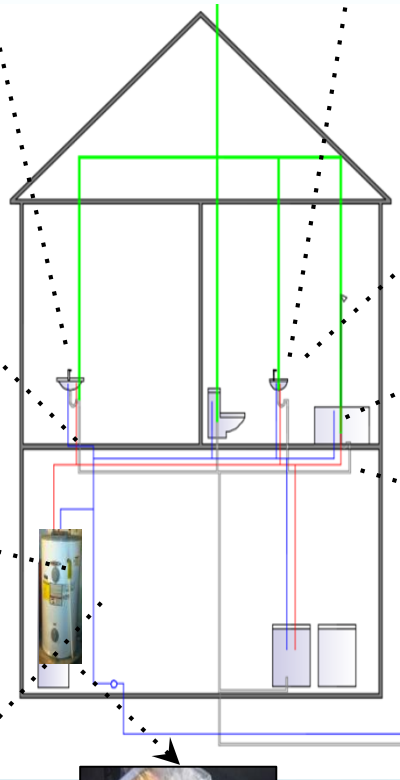
Fixtures and Aerators

Metals and Plastics

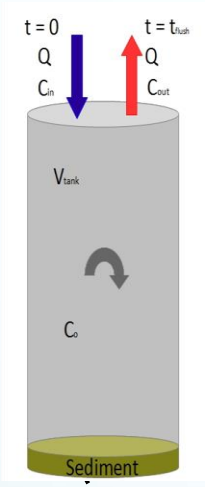
Hot vs. Cold Water Pipes

POU Devices

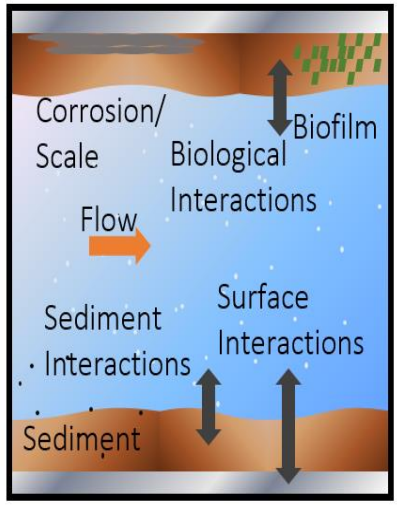




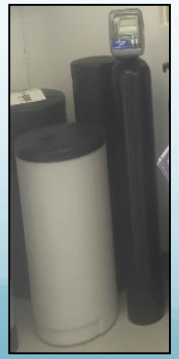
Corrosion Products



Water Heater



Habitat



Water Softener

Whole House Filter

Service Lines

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Building Water Use has Been Declining

Water Use 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)

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Safe Water at the Tap

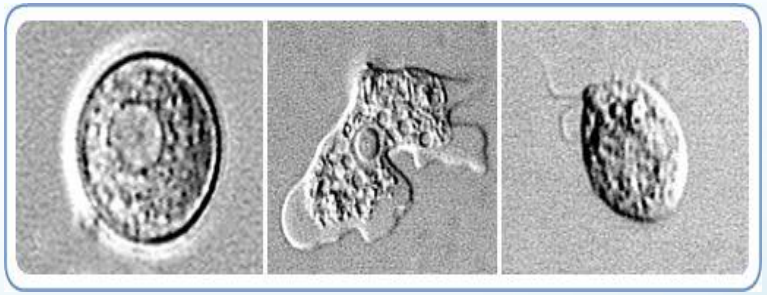
- While the SDWA addresses national water quality, it will be the collective efforts of the water utilities, building/ housing and plumbing professionals that achieve safe water for consumers at the tap.
- Where ever there is water there are microbes and the distribution system and premise plumbing are no exceptions.
- There is a great need to manage the microbial biofilm for pathogens that cause disease via the plumbing system.

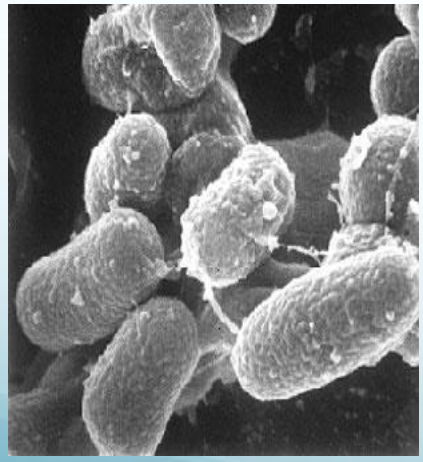
Opportunistic pathogens are those naturally occurring microbes that opportunistically - can cause disease in humans especially those who are immunocompromised

Legionella pneumophila

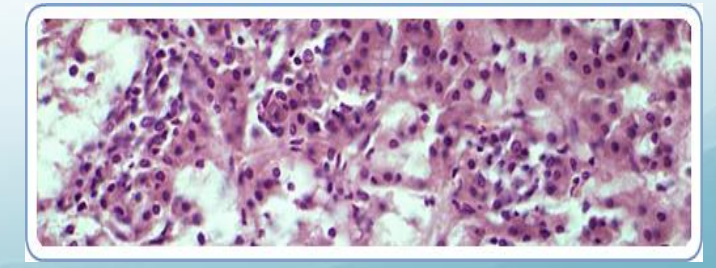
Pseudomonas aeruginosa

Naegleria fowleri





Acanthamoeba

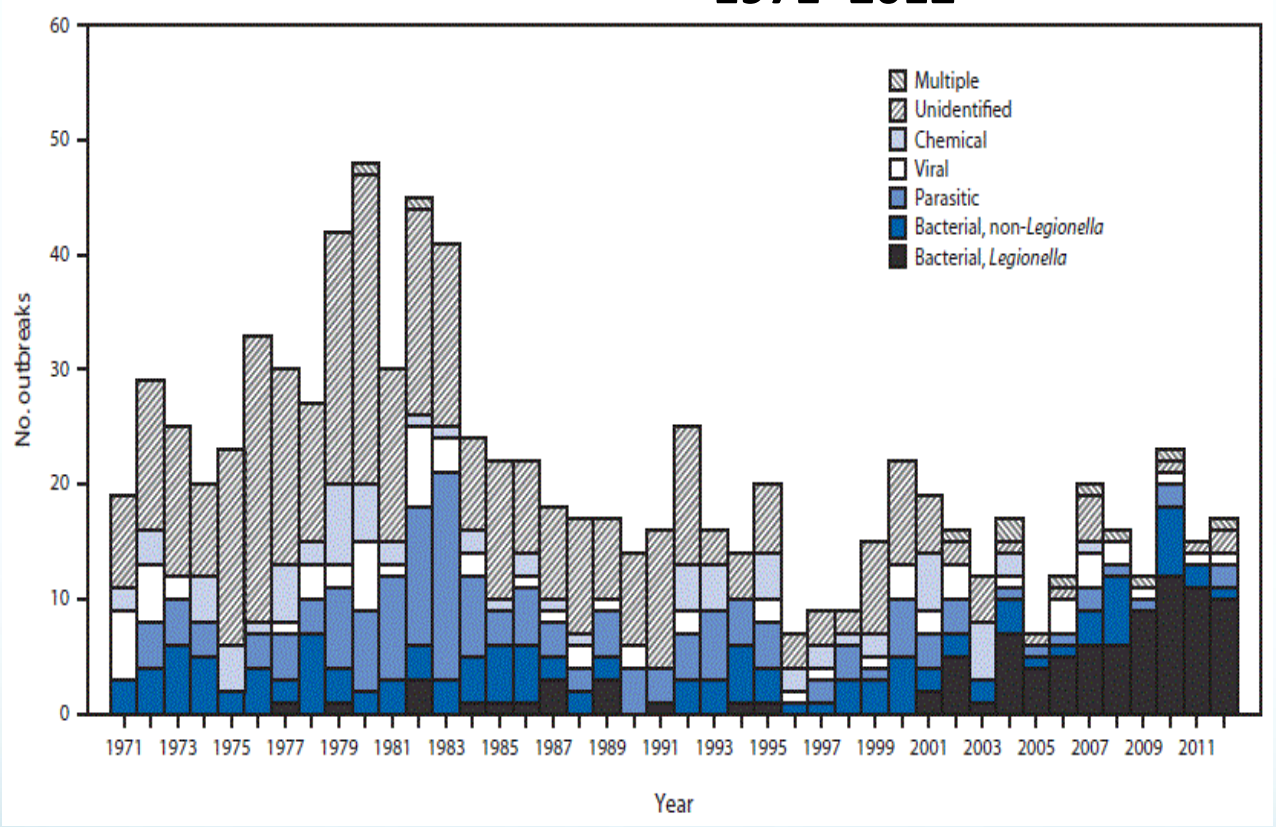


Mycobacterium avium complex (MAC)

Source: CDC

Opportunistic pathogens are now the primary source of waterborne disease outbreak in U.S.

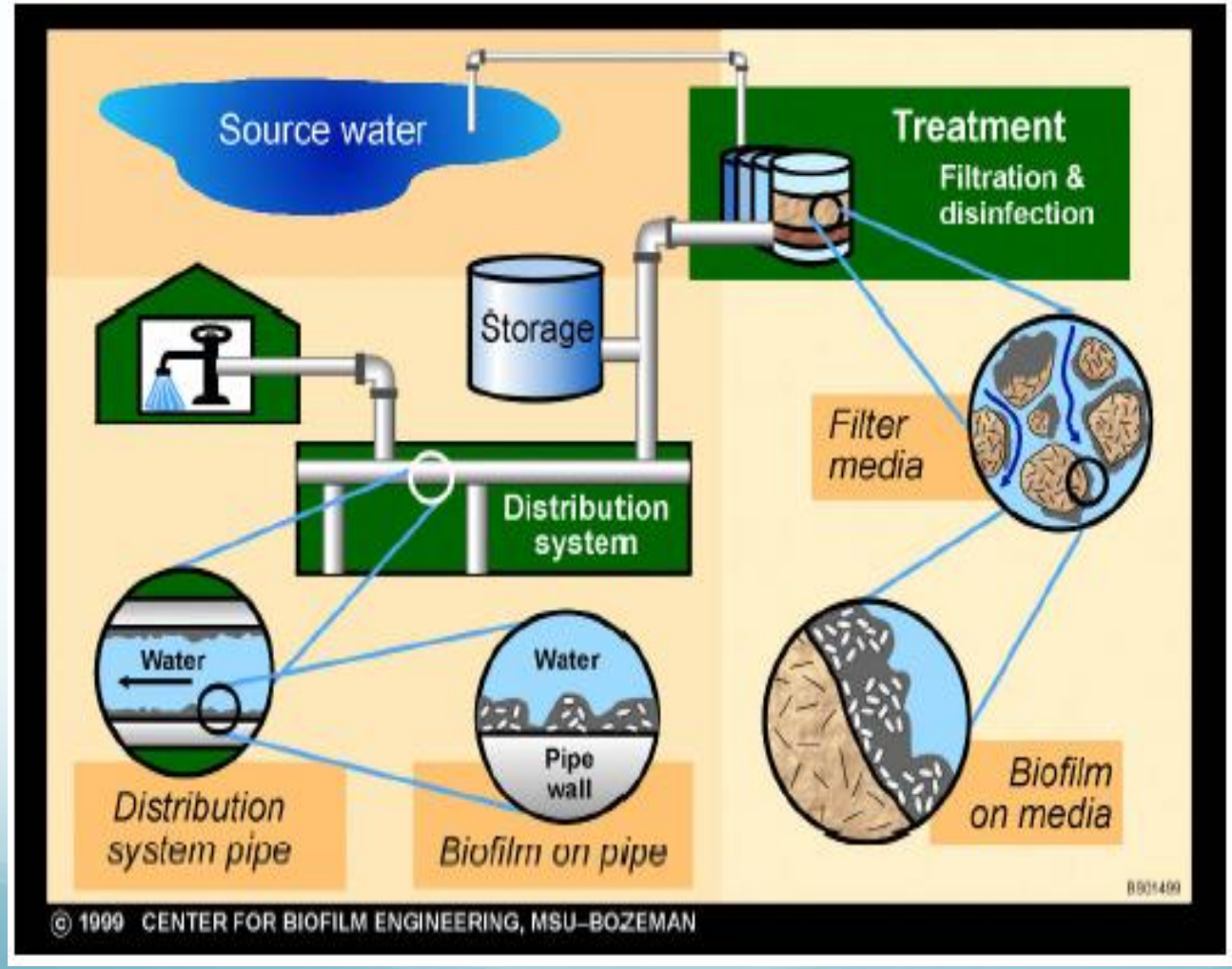
Etiology of 885 drinking water–associated outbreaks, by year — U.S. 1971–2012



Source: CDC

- **2011–2012**, 32 drinking water–associated outbreaks were reported 431 cases of illness, 102 hospitalizations, and 14 deaths
- ***Legionella*** was responsible for **66% of outbreaks** and **26% of illnesses**
- Most commonly identified deficiencies leading to drinking water–associated outbreaks were ***Legionella*** **in building plumbing systems (66%)** and **untreated groundwater (13%)**

Biofilms are common in all pipes



Source: Dr. Joan Rose http://www.nature.com/nature/journal/v523/n7562/fig_tab/nature14660_SV1.html

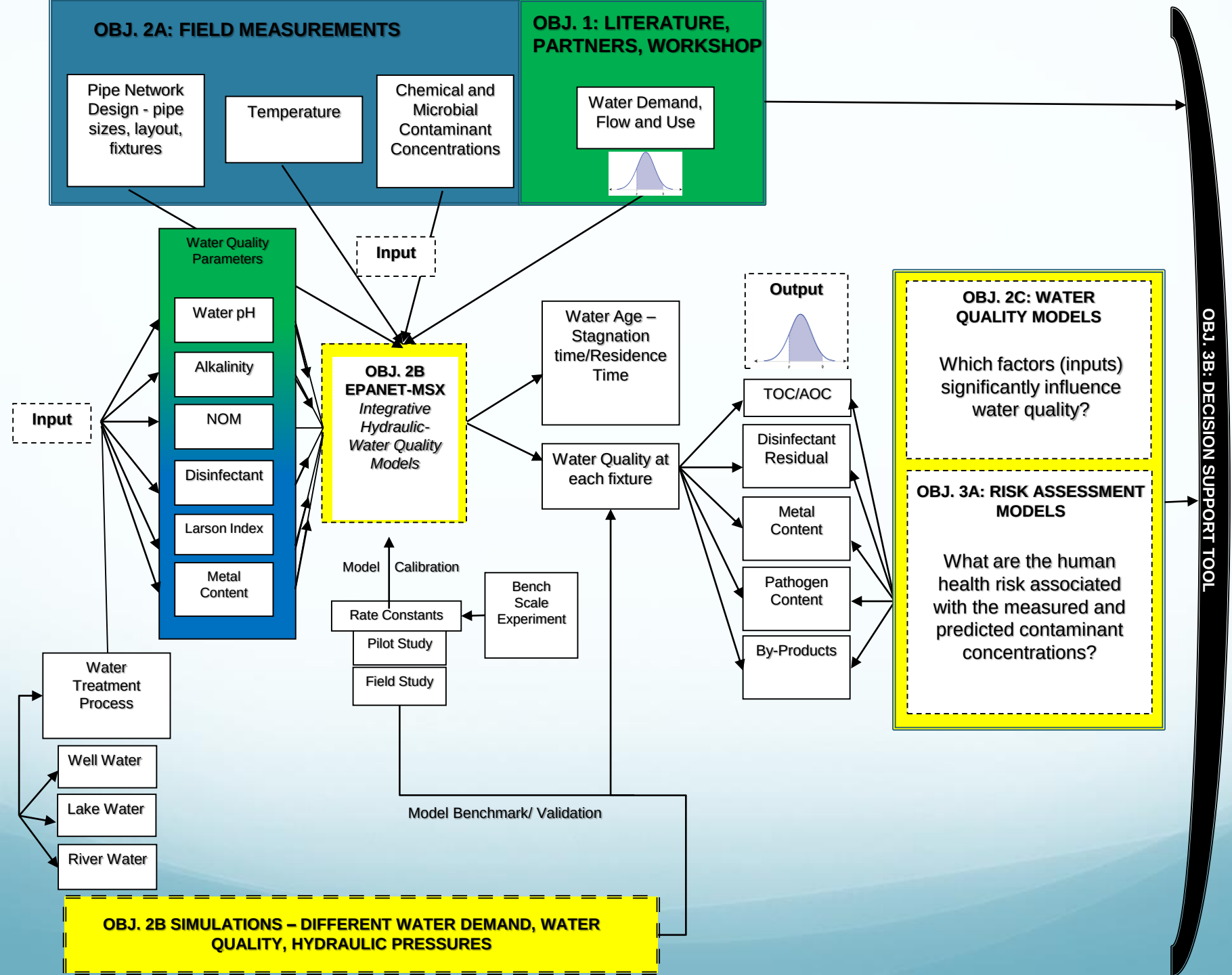
Source: The Biofilms Hypertextbook; http://biofilmbook.hypertextbookshop.com/public_version/contents/chapters/chapter001/section001/green/page001.html

Project Objectives

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.


OBJ. 2A: FIELD MEASUREMENTS
Pipe Network Design - pipe sizes, layout, fixtures
Temperature
Chemical and Microbial Contaminant Concentrations
OBJ. 1: LITERATURE, PARTNERS, WORKSHOP
Water Demand, Flow and Use
Water Quality Parameters
Water pH
Alkalinity
NOM
Disinfectant
Larson Index
Metal Content
Input
Input
OBJ. 2B EPANET-MSX Integrative Hydraulic-Water Quality Models
Water Age – Stagnation time/Residence Time
Water Quality at each fixture
Output
TOC/AOC
Disinfectant Residual
Metal Content
Pathogen Content
By-Products
OBJ. 2C: WATER QUALITY MODELS
Which factors (inputs) significantly influence water quality?
OBJ. 3A: RISK ASSESSMENT MODELS
What are the human health risk associated with the measured and predicted contaminant concentrations?
OBJ. 3B: DECISION SUPPORT TOOL
Model
Calibration
Rate Constants
Bench Scale Experiment
Pilot Study
Field Study
Water Treatment Process
Well Water
Lake Water
River Water
Model Benchmark/ Validation
OBJ. 2B SIMULATIONS – DIFFERENT WATER DEMAND, WATER QUALITY, HYDRAULIC PRESSURES

Full-Scale Buildings

ReNEWW House, Indiana

Efroymson Center, Indiana

Avon Middle School, Indiana

MSU Chemistry Building, Michigan

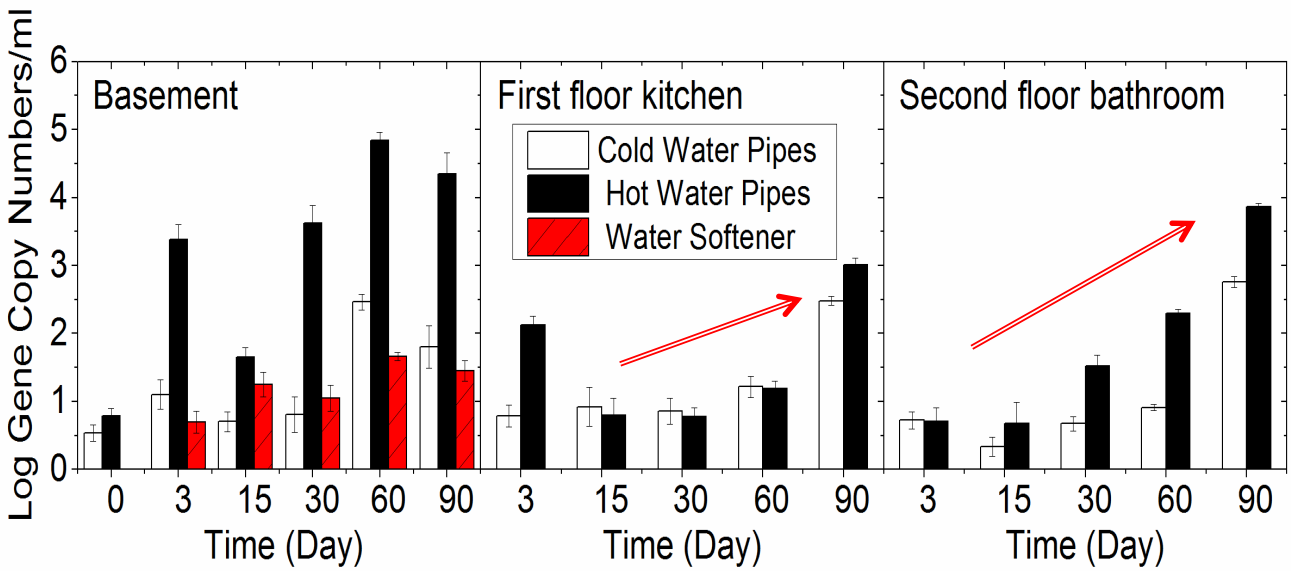
Legacy renovated office building, 16 floors, Michigan

December Water Use, Month 3				
Water Sampling Location	Total Volume of Water Used, m^3	Number of Events	Average Stagnation Time, hr	Maximum Stagnation Time, hr
Service Line	5.2	3535	0.1	72
Basement-Cold	0.4	60	0.5	72
Basement-Hot	0.04	21	0.7	72
1st Floor-Cold	0.3	619	0.6	72
1st Floor-Hot	0.2	389	0.9	72
2nd Floor-Cold	0.1	145	2.0	72
2nd Floor-Hot	1.0	825	0.5	72

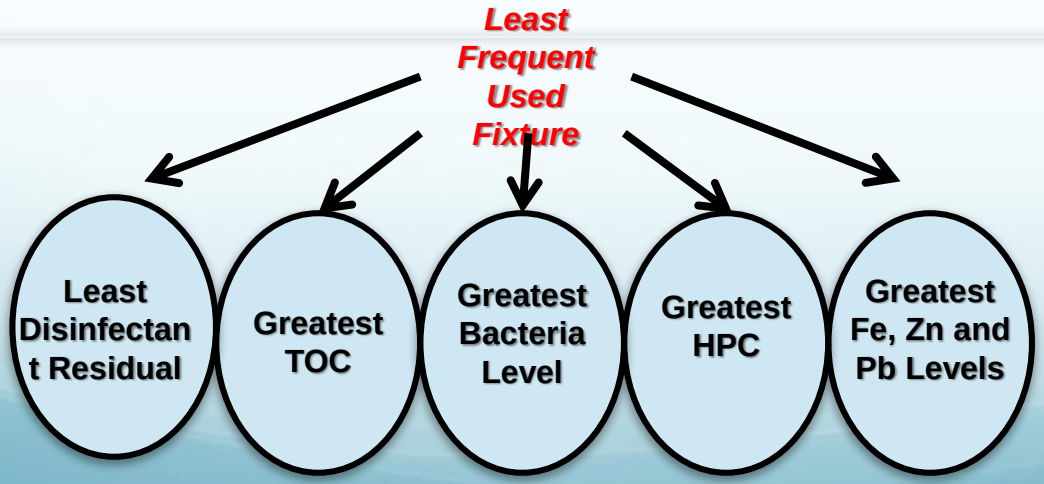
Early Results: We monitored water use at 4 locations in a new green building during a 3 month period (Oct to Dec)

Salehi et al. 2018.

During the same period, bacteria levels increased with time and bacteria were more numerous in hot water vs. cold water

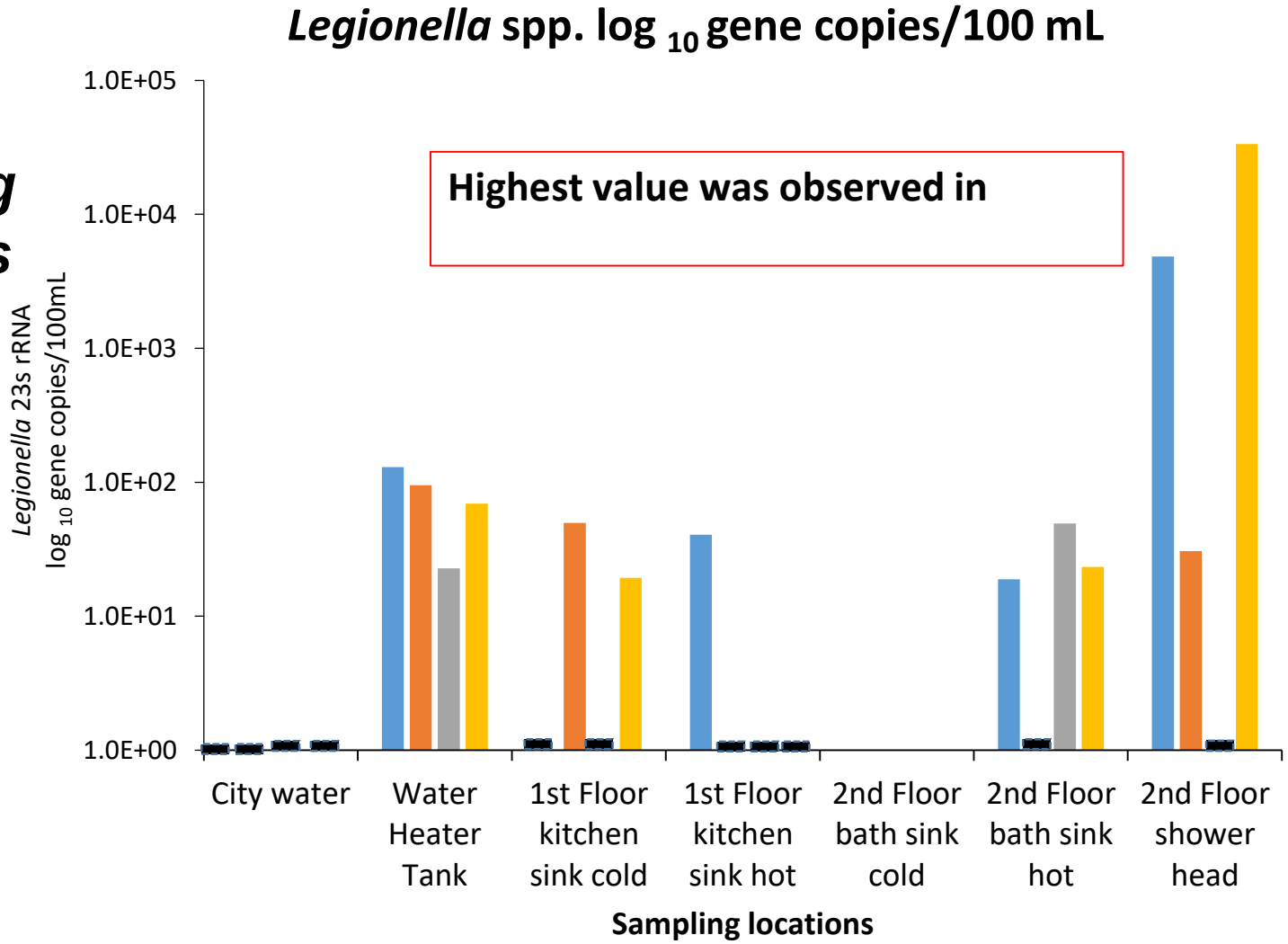


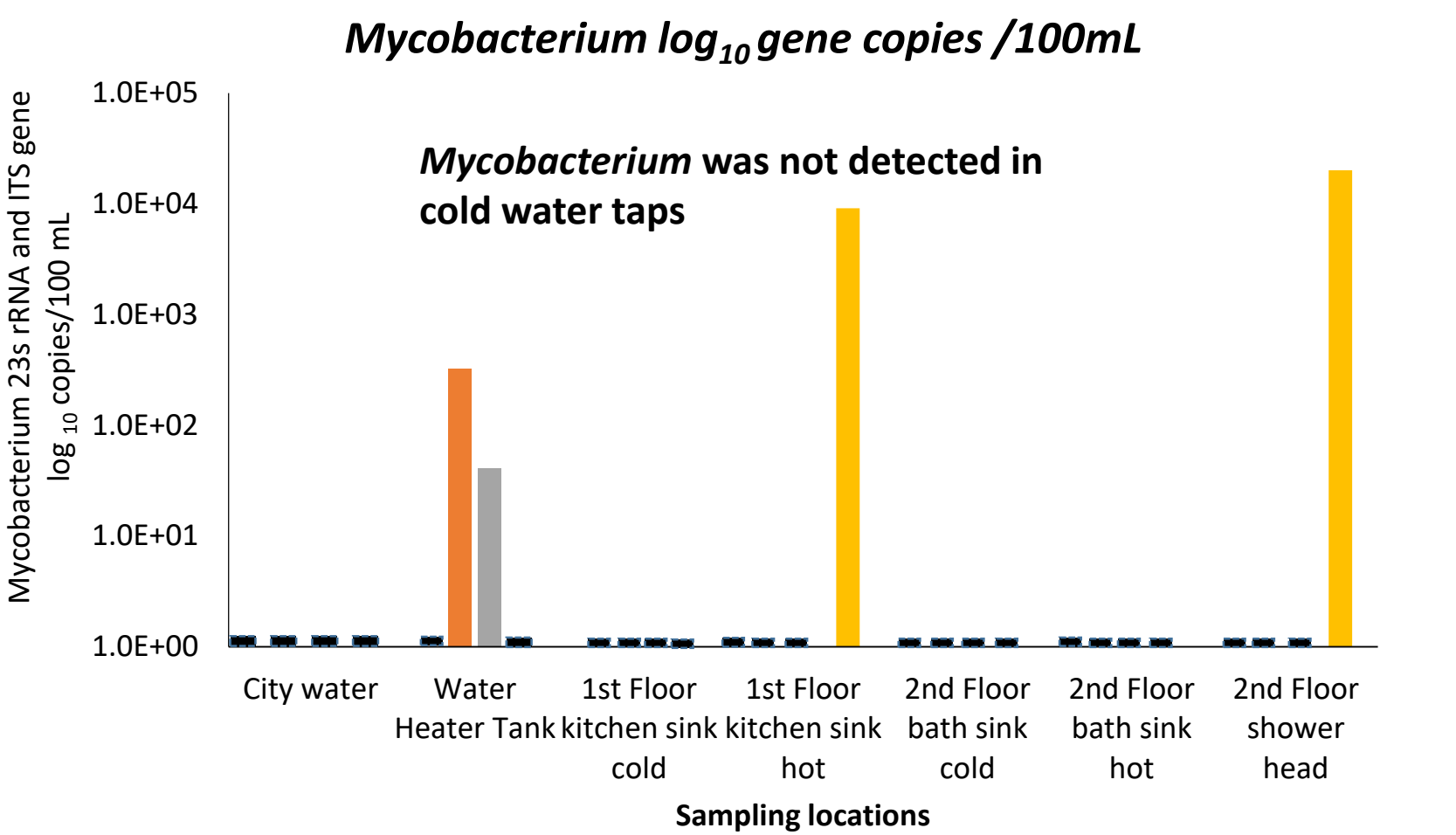
Both HPC levels & Gene Copy Numbers Increased at 1st & 2nd Floor



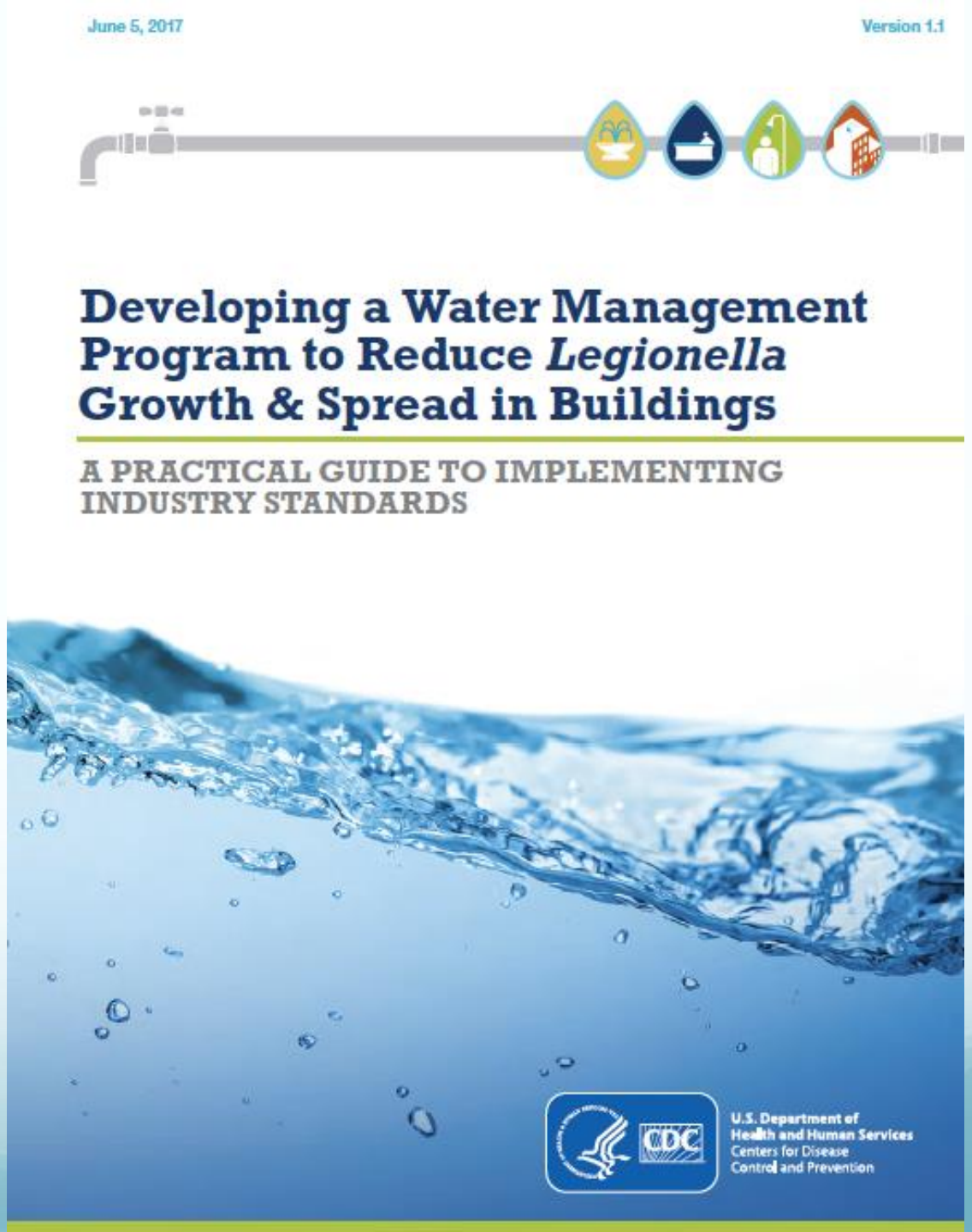
Salehi et al. 2018.

We're currently sampling the same building for pathogens




Mycobacterium log10 gene copies /100mL
Mycobacterium was not detected in cold water taps
Mycobacterium 23s rRNA and ITS gene log 10 copies/100 mL
1.0E+05
1.0E+04
1.0E+03
1.0E+02
1.0E+01
1.0E+00
City water
Water Heater Tank
1st Floor kitchen sink cold
1st Floor kitchen sink hot
2nd Floor bath sink cold
2nd Floor bath sink hot
2nd Floor shower head
Sampling locations
10/10/2017
10/12/2017
10/14/2017
10/16/2017
Indicates Values are below limit of detection of qPCR assay

CDC *Legionella* Toolkit
- Provide guidance for developing, implementing and evaluating a *Legionella* water management program for your building



Top 10 Tips for Your Safety

1. Clean your aerators
2. Do not drink water from a shower
3. Do not drink hot water from a fixture
4. Water heater should be at least 120°F
5. Drain, flush-out your water heater
6. Flush unused faucets before use (i.e., guest bath, vacation)
7. Hotels, motels, hospitals? Flush taps before use
8. Determine what type of drinking water pipes are in your building
9. Do you have a lead pipe? Need a water filter
10. When told to flush for a certain time period ask how that time period was determined

Learn more at www.PlumbingSafety.org

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Thank You!

Acknowledgement:

Funding agency: US EPA