

Water Quality Considerations In Green Building Design

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Water
Research
FoundationSM



Water
INTERFace
IGEP at VT

Outline

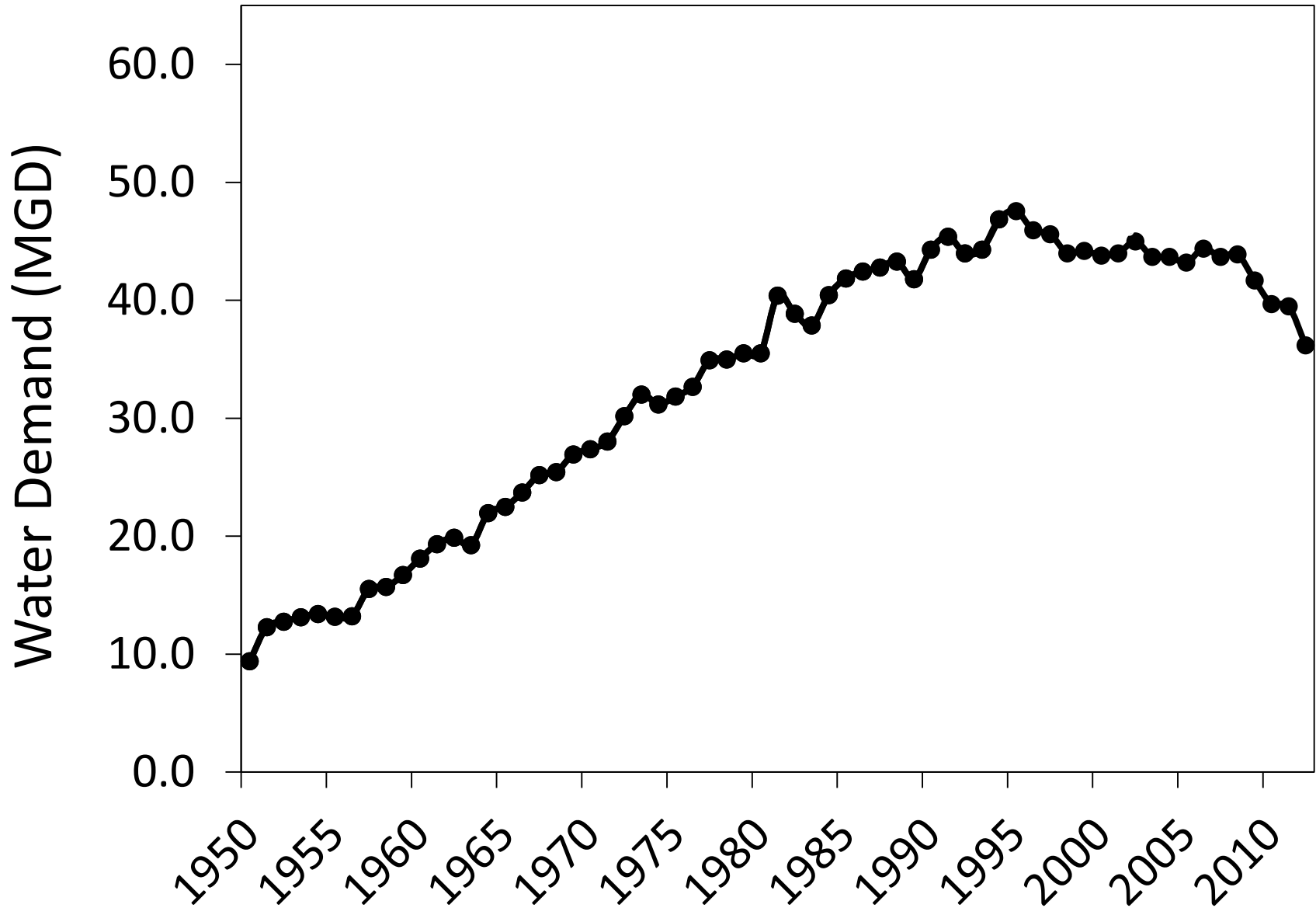
- **Define and describe water age**
- Summarize expected changes in water quality due to high water age
- Current solutions
- Future solutions

Water Age: The amount of time that passes from when water enters a system to the time it is used

Total Water Age =
Distribution System Water Age +
Premise Plumbing System Water Age

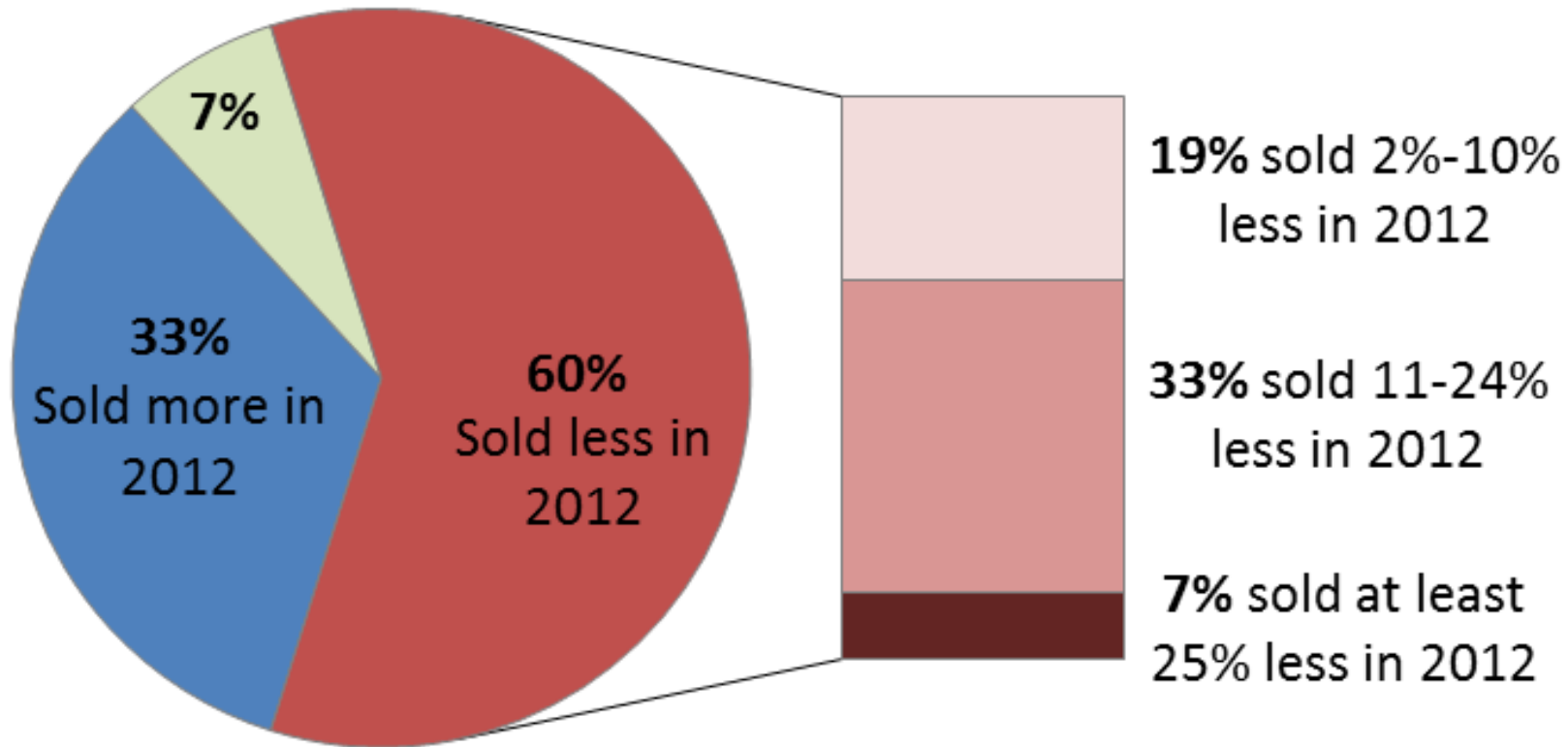
Water age increases as water use decreases

Water Demand – Newport News Waterworks



Data: Brian Ramaley and Newport News, VA Waterworks

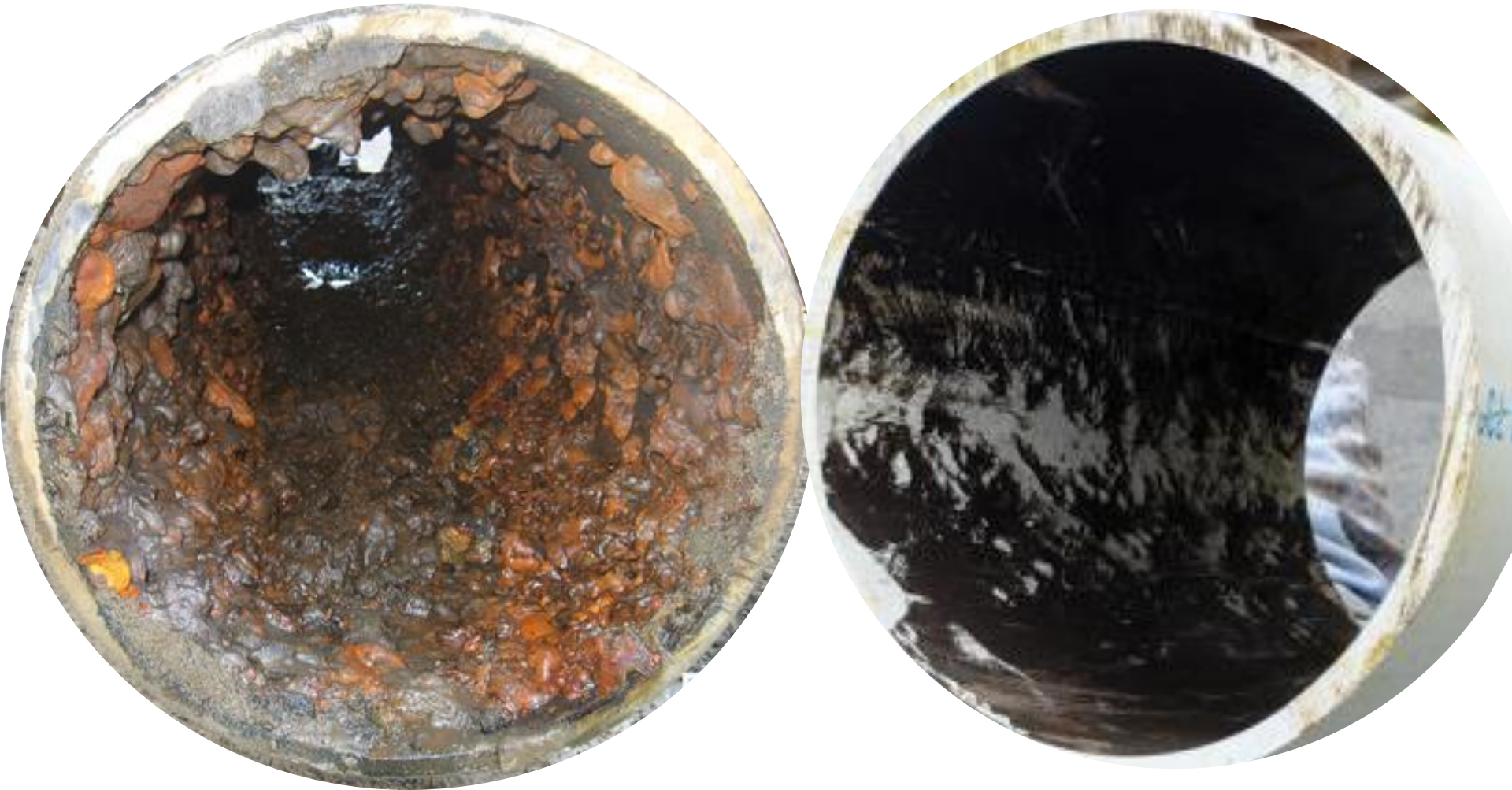
Nationwide Reduction in Water Use



Nationwide survey of 129 utilities water sales in 2006 vs 2012
The number of accounts increased in 81% of utilities sampled.

Water age can be increased
across entire water distribution
system due to cumulative
savings of all buildings

Water Main Pipes



Premise Plumbing Water Age

Building Type	Average potable water use (gal/ft ² /month)
Conventional Lab	63
Green Lab	26
	} 3X
Conventional Classroom	10
Green Classroom	2
	} 5X

Energy conservation impacts water age



Fundamental Changes in Green Building Water Systems

- New sources of water
 - Different physical, chemical, microbiological properties
- On-site water treatment
 - Increased maintenance, chances for failure



The Triple Conservation Conundrum

- Older water age coming into buildings
- Older water age within buildings
- Complicate existing norms with new water sources and treatment

Outline

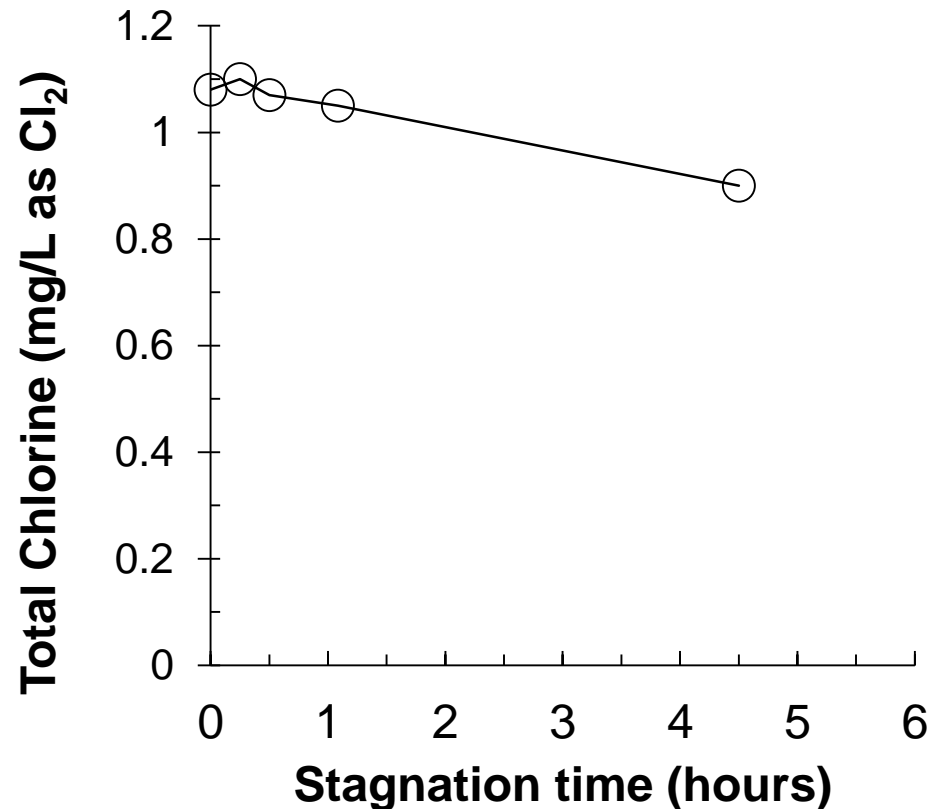
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Problems Associated with Higher Water Age

- **Lower or No Chlorine Residuals**
- **More Problems with Copper and Lead Corrosion**
- Microbial Regrowth
 - Taste and Odor
 - Opportunistic Pathogen Growth

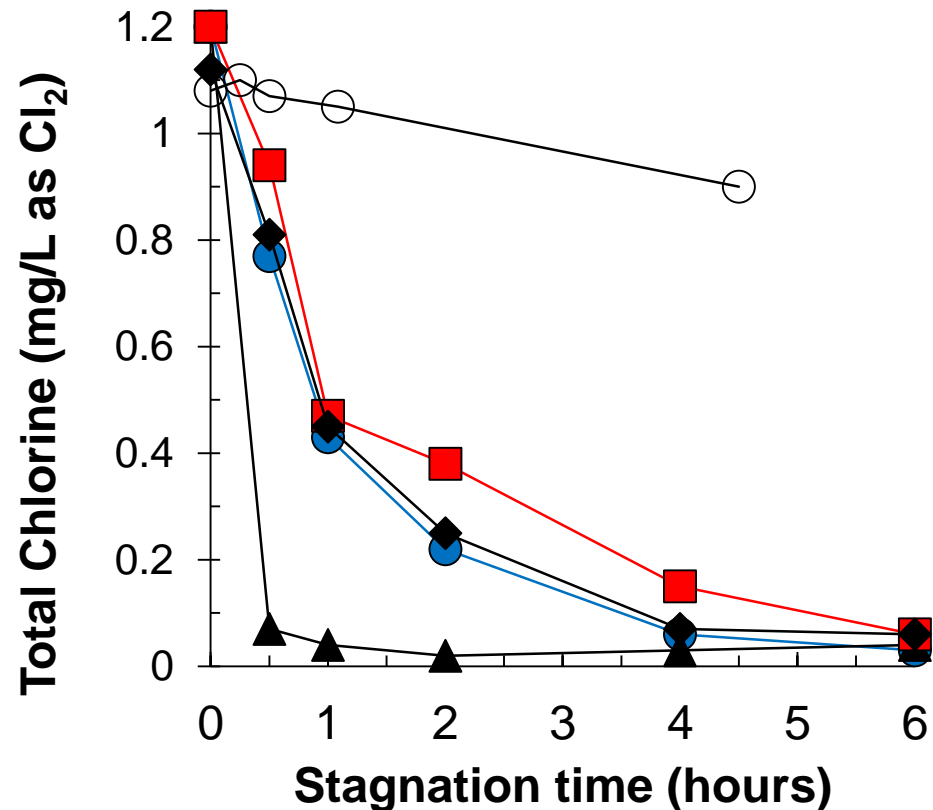
Rapid disinfectant residual decay

- LEED Gold Building
 - 6500 ft²
 - Out patient hospital
 - Using 10X less water than comparable commercial buildings
 - ~8 day water age



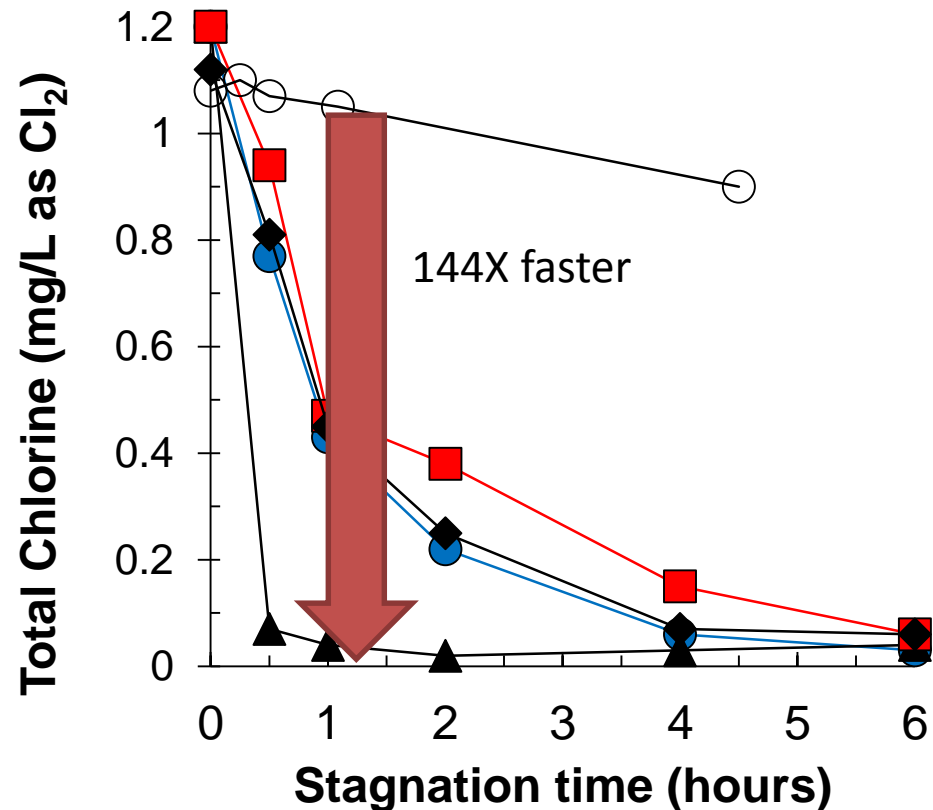
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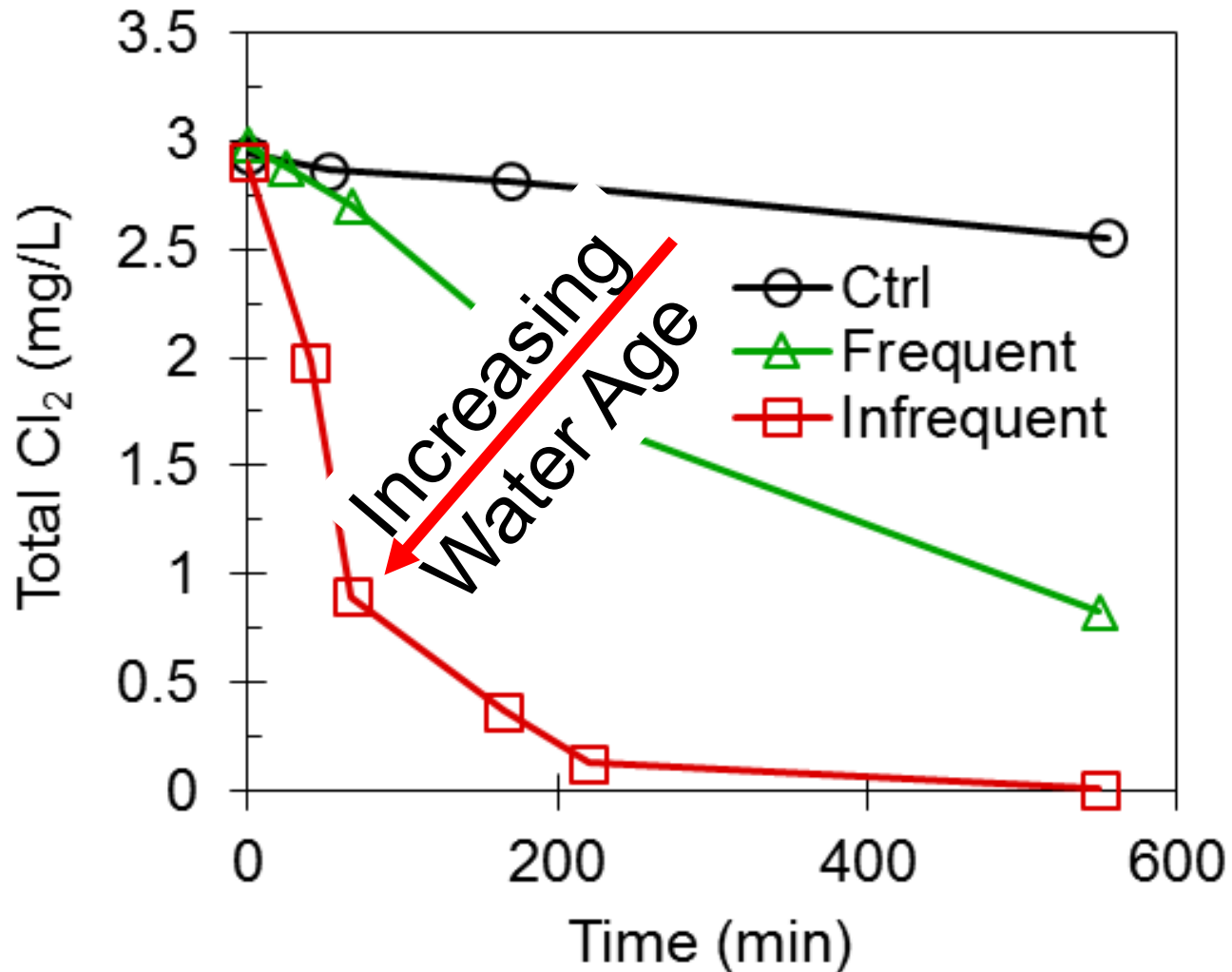


Rapid disinfectant residual decay

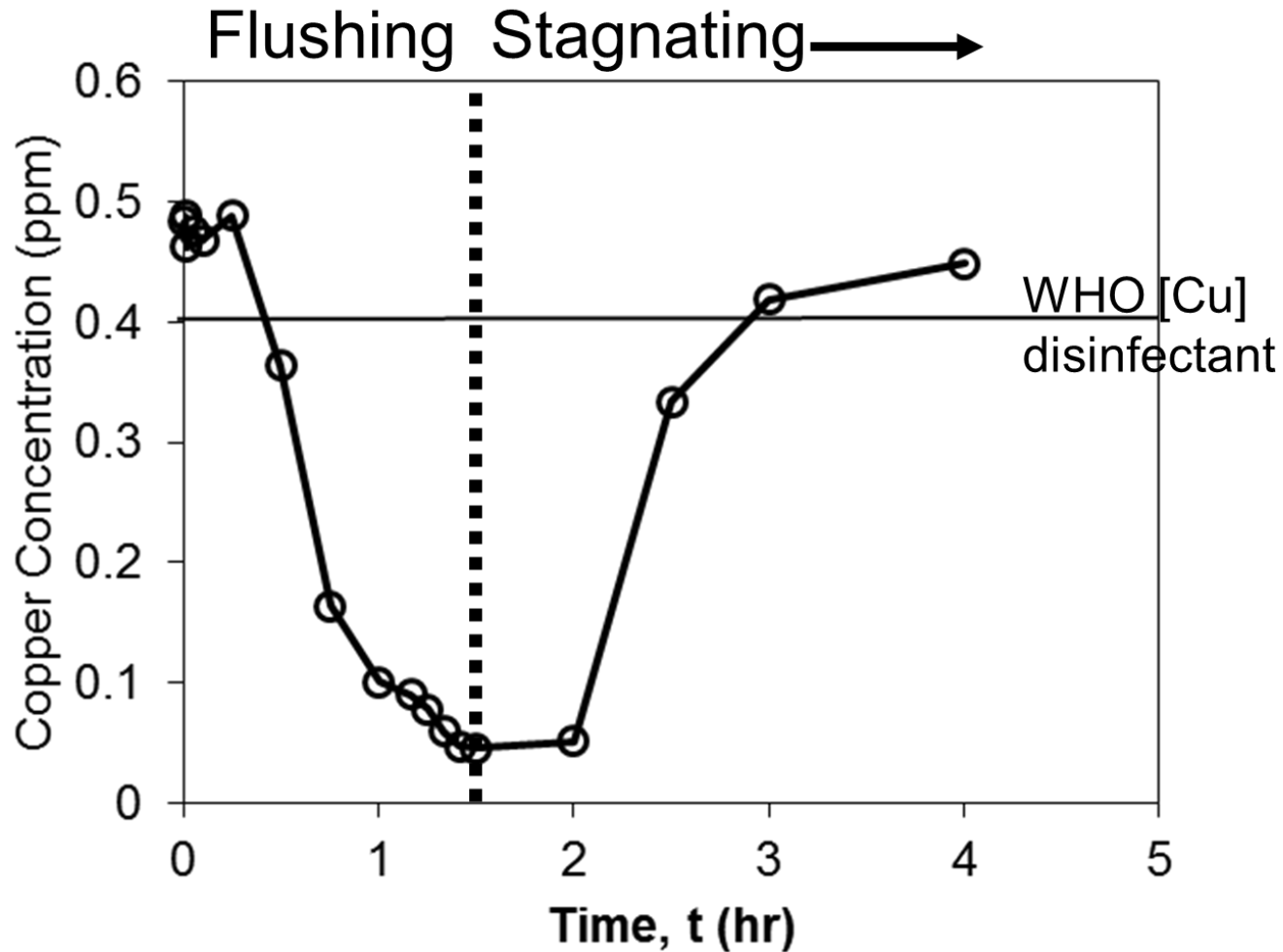
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Rapid disinfectant residual decay



Less effective corrosion control



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 - **Opportunistic Pathogen Growth**

Growth of Opportunistic Pathogens

- Primary cause of waterborne disease in US



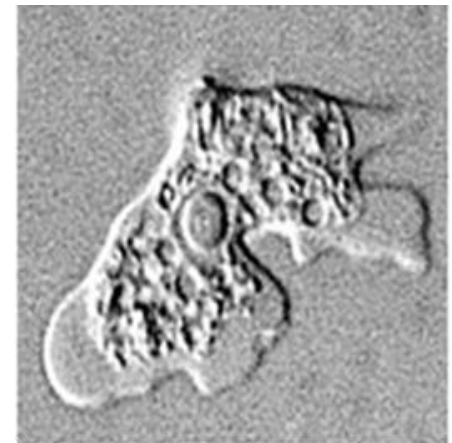
Legionella pneumophila



Mycobacterium avium



Pseudomonas aeruginosa



Naegleria fowleri

- 8K-18K cases/yr
- \$430M/yr
- Cause of all 31 reported respiratory waterborne disease outbreaks 2007-10

- 100 cases/ 10^5 people >60yrs
- \$425M/yr
- Only recently linked to drinking water

- 11,000 HAIs from 1992-93
- No required reporting

- “Brain eating amoeba” – 2 recent high profile cases linked to drinking water

Why OP problems are expected to be worse in domestic plumbing

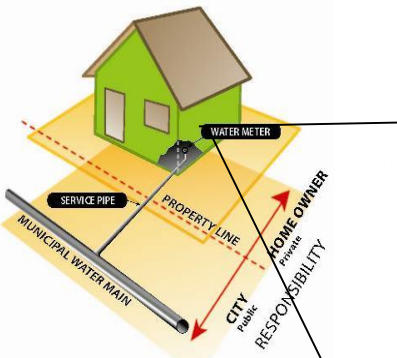


Image: Randi Brazeau, Sheldon Masters

Domestic Plumbing

- High water age
- Low residual
- Warm Temp
- Variable material
- Variable flow
- SA:V ratio

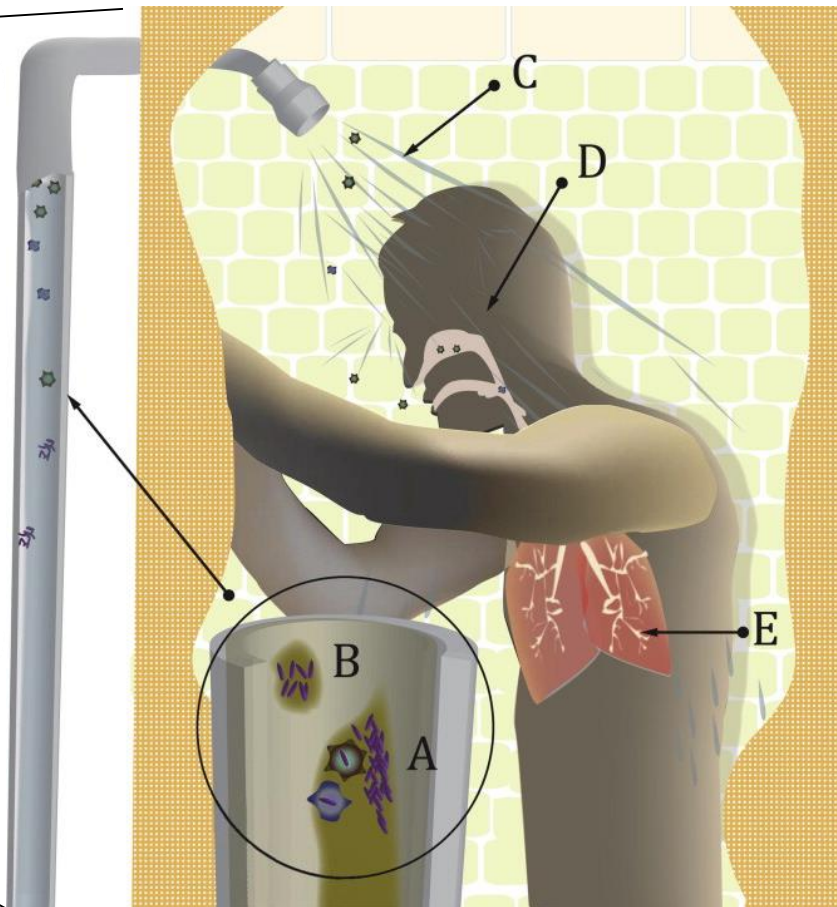
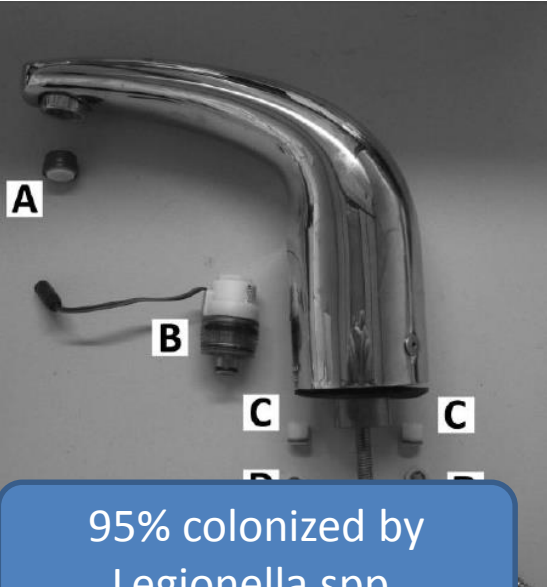


Image: Schoen, M. & Ashbolt, N. *Water Research*. 2011

Buildings with high water age are more likely to be colonized with opportunistic pathogens

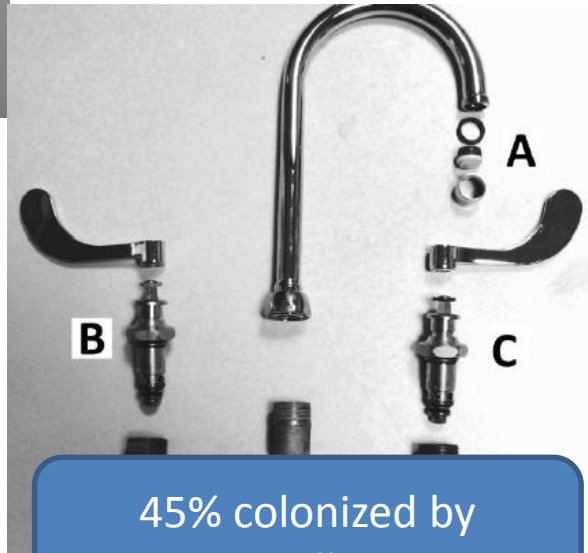
Building	Water Age	Cause of Water Age	Pathogens detected?
LEED office	8 days	Large # of infrequently used fixtures	Yes
Net-zero office	2-6 months	Rainwater cistern	Yes
Net-zero energy house	2.5 days	Solar water heater	Yes
Conventional House	<1 day	NA	No

Opportunistic Pathogen Growth



95% colonized by
Legionella spp.

Sydnor et al. 2012



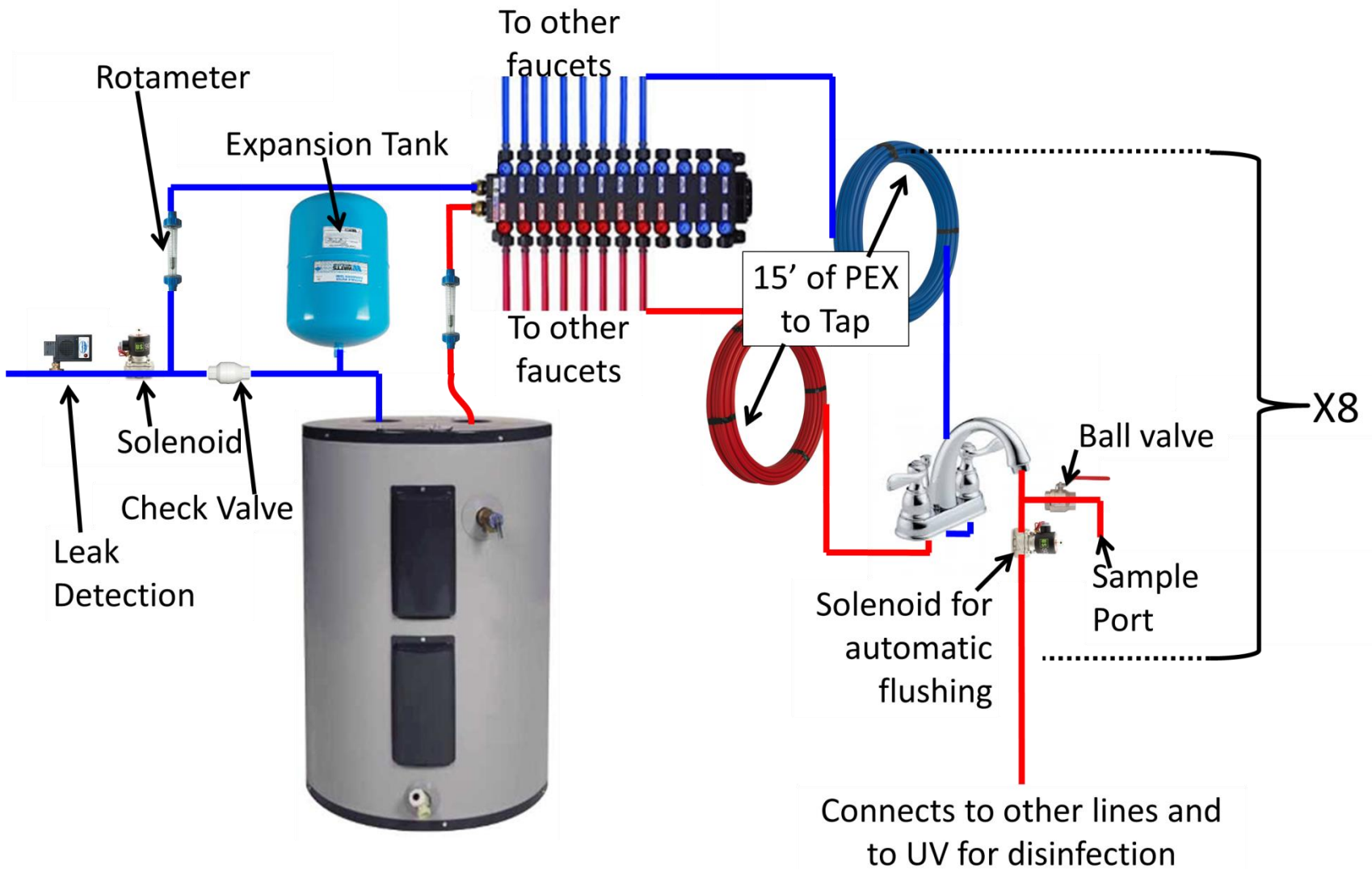
45% colonized by
Legionella spp.

Cause?

- Materials
- Mixing volume
- Flow rates

Devices were removed and replaced with conventional devices....

On-going Experiments at VT



Outline

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- **Current solutions**
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Current Solutions

- Replace green tech with convectional tech
 - Downside: Life cycle, capital costs
- Adjust temperature
 - Scalding, energy efficiency
- Optimize plumbing design?
- In-building treatment

Limitations to in-building disinfection

- Need residual (ozone and UV not likely effective unless at end of tap)
- Maintenance required
- Dosing disinfectants triggers EPA utility monitoring and reporting??
- Efficacies unproven and microbe resistance possible over time
- Disinfectants are corrosive and may impact plumbing

Current Solutions...cont'd

For on-grid buildings with municipal water...

- Flush water to reduce water age

For off-grid buildings...

- No current recommendations based on research
- No resources for home/building owners to get help

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Future Solutions

- Assess extent of issues
- Encourage water quality consideration in green building certification, codes, and standards
- Optimize flushing protocols
- Decentralized water heating strategies?
- Investigate alternative treatment methods for off-grid buildings

Thank You!

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Project 4383: Green Building Design
Water Quality Considerations

Microbiology of the
Built Environment



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 Water
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IGEP at VT

Edwards' Research Group



Collaborator:



Annie Pearce