

William J. Rhoads

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<https://www.eawag.ch/de/ueberuns/portraet/organisation/mitarbeitende/profile/william-rhoads/show/>

## EDUCATION AND EXPERIENCE

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- Research Scientist, Eawag**, Department of Environmental Microbiology 5/2020-Present  
Drinking Water Microbiology, Group Leader: Frederik Hammes
- Research Scientist, Virginia Tech**, Civil and environmental Engineering 6/2019-8/2020  
Co-Advisers: Dr. Marc A. Edwards and Dr. Amy Pruden
- Postdoctoral Researcher, Virginia Tech**, Civil and Environmental Engineering 2/2017-5/2019  
Co-Advisers: Dr. Marc A. Edwards and Dr. Amy Pruden
- Ph.D. Virginia Tech**, Civil and Environmental Engineering 2011-2017  
*Growth of Opportunistic Pathogens in Domestic Plumbing: Building Standards, System Operation, and Design*  
Adviser: Dr. Marc A. Edwards GPA: 3.94/4.0  
Co-Adviser: Dr. Amy Pruden  
+ “Preparing the Future Professoriate” Graduate Education Certificate  
+ “Water INTERFace” Graduate Education Certificate
- B.S. Purdue University**, Civil Engineering 2007-2011  
Adviser: Dr. Chad Jafvert  
*Magna Cum Laude* GPA: 3.87/4.0; 3.95/4.0 In-Major  
+ School of Civil Engineering Honors Program

## HONORS AND AWARDS

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- Environmental Science & Technology Early Career Editorial Board 2020  
AEESP CH2M Outstanding Doctoral Dissertation Award 2017  
College of Engineering Outstanding PhD Student 2017  
Virginia Tech *Ut Prosim* Award, University-Wide Outstanding Service Award 2016  
Via Academic Preparation Fellowship 2016  
AWWA Larson Aquatic Research Scholarship 2015  
Civil and Environmental Engineering Research Day Poster Competition, 2<sup>nd</sup> Place 2015  
Water Is Life Award, ACLU of Michigan 2015  
Citizen Scholar Engagement Recognition, Virginia Tech Graduate School 2015  
Edna Bailey Sussman Foundation Summer Research Fellowship 2014  
Travel Grant Winner, VA AWWA Water Jam Conference 2013  
Charles E. Via, Jr Doctoral Fellowship at Virginia Tech 2011

## PUBLICATIONS

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### Peer-Reviewed Journal Articles (\*corresponding author)

1. Gilliland, A.E., K.J. Pieper, S. Straif-Bourgeois, **W.J. Rhoads**, D. Dai, M.A. Edwards, K. Brisolaro, D. Olexia, A. Katner\*. (2021). Evaluation of preparedness and recovery needs of private well users after the Great Louisiana Flood of 2016. *Journal of Public Health Management and Practice*.
2. Pieper, K.J.\*, **W.J. Rhoads**, L. Saucier, A. Katner, J.R. Barrett, M.A. Edwards. (2020). Improving state-level emergency well disinfection strategies in the United States. *Science of the Total Environment*, 720, 137451.
3. Song, Y, A. Pruden, M.A. Edwards, **W.J. Rhoads\***. (2020) "Natural Organic Matter, Orthophosphate, pH, and Growth Phase Can Limit Copper Antimicrobial Efficacy for Legionella in Drinking Water." *Environmental Science & Technology*. doi: 10.1021/acs.est.0c06804
4. Davis, B.C., M.V. Riquelme, G. Ramirez-Toro, C. Bandaragoda, E.D. Garner, **W.J. Rhoads**, P. Vikesland, A. Pruden\* (2020). Demonstrating an Integrated Antibiotic Resistance Gene Surveillance Approach in Puerto Rican Watersheds Post-Hurricane Maria. *Environmental Science & Technology*. doi: 10.1021/acs.est.0c05567
5. **Rhoads, W.J\***, Hammes, F. (2020). Growth of *Legionella* during COVID-19 lockdown stagnation. *Environmental Science: Water Research & Technology*. doi: 10.1039/d0ew00819b
6. **Rhoads, W. J.\***, Keane, T., Spencer, M. S., Pruden, A., & Edwards, M. A. (2020). Did Municipal Water Distribution System Deficiencies Contribute to a Legionnaires' Disease Outbreak in Quincy, IL?. *Environmental Science & Technology Letters*. doi: 10.1021/acs.estlett.0c00637
7. Spencer, M. S., Cullom, A. C., **Rhoads, W. J.**, Pruden, A., Edwards, M.A.\* (2020). Replicable simulation of distal hot water premise plumbing using convectively-mixed pipe reactors. *PLoS One*, 15(9), e0238385.
8. Proctor, C. R., **W.J. Rhoads**, T. Keane, M. Salehi, K. Hamilton, K.J. Pieper, D.M. Cwiertny, M. Prévost, A.J. Whelton\*. (2020). Considerations for large building water quality after extended stagnation. *AWWA Water Science*, 2(4), e1186.
9. **Rhoads, W.J.\***, T.N. Bradley, A. Mantha, L. Buttlng, T. Keane, A. Pruden, M.A. Edwards\*. Residential Water Heater Cleaning and Occurrence of Legionella in Flint, MI. (2020) *Water Research*, doi: 10.1016/j.watres.2019.115439.
10. Mapili, K., K.J. Pieper, D. Dai, A. Pruden, M.A. Edwards, M. Tang, **W.J. Rhoads\***. *Legionella pneumophila* Occurrence in Drinking Water Supplied by Private Wells. (2020). *Letters in Applied Microbiology*, DOI: 10.1111/lam.13273 .
11. Pieper, K.J.\*, **W.J. Rhoads**, L. Saucier, A. Katner, J.R. Barrett, M.A. Edwards. Evaluation of Preparedness and Recovery Needs of Private Well Users After the Great Louisiana Flood of 2016. *Journal of Public Health Management and Practice* (2020) DOI: 10.1097/PHH.1157
12. Dai, D., **W.J. Rhoads**, A. Katner, L. Strom, M.A. Edwards, A. Pruden\*, K.J. Pieper\* (2019). Molecular survey of Legionella and Naegleria fowleri in private well water and premise plumbing following the 2016 Louisiana flood. *Environmental Science: Water Research & Technology*, 5, 1464-1477. DOI: 10.1039/C9EW00109C
13. Garner, E., C. Brown, D.O. Schwake, **W.J. Rhoads**, G. Arango-Argoty, L. Zhang, G. Jospin, D.A. Coil, J.A. Eisen, M.A. Edwards, and A. Pruden. (2019). Comparison of Whole-Genome Sequences of Legionella pneumophila in Tap Water and in Clinical Strains, Flint, Michigan, USA, 2016. *Emerging Infectious Diseases*, 25(11), DOI: 10.3201/eid2511.181032.

14. Dai, D., **W.J. Rhoads**, M.A. Edwards, A. Pruden\* (2018). Shotgun Metagenomics Reveals Taxonomic and Functional Shifts in Hot water Microbiome due to Temperature Setting and Stagnation. *Frontiers in Microbiology*, 9, p. 2695.
15. Ji, P., **W.J. Rhoads**, M.A. Edwards, A. Pruden\* (2018). Effect of Heat Shock on Hot Water Plumbing Microbiota and *Legionella pneumophila* Control. *Microbiome*, 6(1), p. 30.
16. **Rhoads, W.J.**, E. Garner, P. Ji, N. Zhu, J. Parks, O. Schwake, A. Pruden, M.A. Edwards\* (2017). Distribution System Operational Deficiencies Coincide with Reported Legionnaires' Disease Outbreaks in Flint, MI. *Environmental Science & Technology*, 51(20), 11986-11995.
17. **Rhoads, W.J.**\*, A. Pruden, M.A. Edwards. Interactive Effects of Corrosion, Copper, and Chloramine on *Legionella* and *Mycobacteria* in Hot Water Plumbing (2017). *Environmental Science & Technology*, 51(12), DOI:10.1021/acs.est.6b05616.
18. Ji, P., **W.J. Rhoads**, M.A. Edwards, A. Pruden\* (2017). Impact of Water Heater Temperature Setting and Water Use Frequency on the Building Plumbing Microbiome. *International Society of Microbial Ecology*, 11(6), 1318.
19. **Rhoads, W.J.**\*, A. Pruden, M.A. Edwards (2016). Convective Mixing in Distal Pipes Exacerbates *Legionella pneumophila* Growth in Hot Water Plumbing. *Pathogens*, 5(1), DOI:10.3390/pathogens5010029.
20. **Rhoads, W.J.**\*, P. Ji, A. Pruden, M.A. Edwards (2015). Water Heater Temperature Set Point and Water Use Patterns Influence *Legionella pneumophila* and associated microorganisms at the tap. *Microbiome*, 3(1), DOI: 10.1186/s40168-015-0134-1.
21. **Rhoads, W.J.**\*, A. Pruden, M.A. Edwards. Survey of Green Building Water Systems Reveals Elevated Water Age and Microbial Concerns (2015). *Environmental Science: Water Research & Technology*, 2(1), DOI: 10.1039/C5EW00221D
22. **Rhoads, W.J.**, A. Pruden, M.A. Edwards. Anticipating Challenges Associated with In-Building Disinfection for Control of Opportunistic Pathogens in Premise Plumbing (2014). *Water Environment Research*, 86(6), DOI: <https://doi.org/10.2175/106143014X13975035524989>

#### Peer-Reviewed Journal Articles – Accepted or Under Revision

1. Martin, R.L., **W.J. Rhoads**, O. Strom, Y. Song, D. Mena-Aguilar, A. Pruden, M.A. Edwards\*. Copper Pipe, Lack of Corrosion Control and Uncontrolled pH Influenced the Trajectory of the Flint Legionnaires' Disease Outbreak. Under revision at ES&T.
2. Martin R.L., **W.J. Rhoads**, A.R. Pearce, A. Pruden, M.A. Edwards\*. Elucidating the Role of Water Heater System Configuration in Energy Efficiency, Consumer Comfort and Legionella Proliferation. Under revision at Water Research.

#### Invited Feature Articles

1. **Rhoads, W.J.**, A. Pruden, A. Pearce, M.A. Edwards. Anticipating Water Quality and Infrastructure Impacts due to Green Buildings (2015). *Journal American Water Works Association* 107(4), DOI: <http://dx.doi.org/10.5942/jawwa.2015.107.0058> 50-61.

#### Research Project Reports

1. **Rhoads, W.J.**, M. Prevost, K.J. Pieper, T. Keane, A.J. Whelton, F. Rolli, C.R. Proctor, M. Grimard-Conea. (2020). Responding to Water Stagnation in Buildings with Reduced or No Water Use: A framework for building managers. AWWA and IAPMO, Available:

<https://www.awwa.org/Portals/0/AWWA/Government/20201001FrameworkforBuildingManagersFINALDistCopy.pdf>

2. **Rhoads, W.J.**, Spencer, M.S., Edwards, M.A. (2018). Investigating of Continued Legionella pneumophila Positivity at the Illinois Veteran's Home in Quincy, IL: Evaluating the potential for nitrification, chloramine stability, and nontuberculous mycobacteria. Prepared for Governor Rauner's Office.
3. **Rhoads, W.J.**, Spencer, M.S., Edwards, M.A. (2018). Investigating of Continued Legionella pneumophila Positivity at the Illinois Veteran's Home in Quincy, IL. Prepared for Governor Rauner's Office.
4. **Rhoads, W.J.**, T. Keane, M.A. Edwards (2016). Flint, MI Residential Water Heater Sampling Report. Prepared for the State of Michigan.
5. **Rhoads, W.J.**, B. Chambers, A. Pearce, M.A. Edwards, Green Building Design: Water Quality Considerations (2015). Water Research Foundation Project #4383, Denver, CO, 250 pages.
6. Edwards, M. A., A. Pruden, J. Falkinham, III, R. Brazeau, K. Williams, H. Wang, A. Martin and **W.J. Rhoads** (2013). Relationship Between Biodegradable Organic Matter and Pathogen Concentrations in Premise Plumbing. Water Research Foundation, Denver, CO. 111 pages.
7. Pruden, A., M.A. Edwards, J. Falkinham, III, M. Arduino, J. Bird, R. Birdnow, E. Bédard, A. Camper, J. Clancy, E. Hilborn, V. Hill, A. Martin, S. Masters, N.R. Pace, M. Prevost, A. Rosenblatt, **W.J. Rhoads**, J.E. Stout, and Y. Zhang (2013). Research Needs for Opportunistic Pathogens in Premise Plumbing: Methodology, Microbial Ecology, and Epidemiology. Water Research Foundation Project 4379 Final Report. Water Research Foundation. Denver, CO, 188 pages.

### Conference Proceedings

1. **Rhoads, W.J.**, A. Pearce, A. Pruden, M.A. Edwards (2015). The Water Age Problem: Unintended Consequences of Water Conservation. Mascaro Center for Sustainable Innovation Bi-Annual Environmental Sustainability Conference. Pittsburgh, PA. April 21, 2015.
2. Lambrinidou, Y., **W. Rhoads**, S. Roy, E. Heaney, G. Ratajczak, and J. Ratajczak (2014). Ethnography in Engineering Ethics Education: A Pedagogy for Transformational Listening 121<sup>st</sup> American Society for Engineering Education (ASEE) Annual Conference & Exposition, Indianapolis, IN.

### Book Contributions

1. **Rhoads, W.J.**, A. Pruden, A. Pearce, M.A. Edwards. (in press). "Unanticipated Consequences of Water Conservation." in Pearce, A.R., Ahn, Y.H., and HanmiGlobal, Inc. Sustainable Buildings and Infrastructure: Paths to the Future, 2nd ed. Taylor & Francis, Oxford, UK.

### Outreach

1. **Rhoads, W.J.**, R. Martin, S. Roy (2016). We helped uncover a public health crisis in Flint, but learned there are costs to doing good science. The Conversation Online Journal. Available: <http://theconversation.com/we-helped-uncover-a-public-health-crisis-in-flint-but-learned-there-are-costs-to-doing-good-science-54227>

2. Edwards, M.A., **W.J. Rhoads**, A. Pruden, A. Pearce, J.O. Falkinham, III (2014). Green Water Systems and Opportunistic Premise Plumbing Pathogens. Plumbing Engineer. Available: [http://plumbingengineer.com/nov\\_14/edwards\\_feature.php](http://plumbingengineer.com/nov_14/edwards_feature.php)
3. Zhu, N., S. Roy, B. Clark, **W.J. Rhoads**, M.A. Edwards. The Unintended Consequences of Migrating to the Flint River. Available: <http://flintwaterstudy.org/2015/08/the-unintended-consequences-of-migrating-to-flint-river-water/>
4. Edwards, M.A., A. Pruden, S. Roy, **W.J. Rhoads**. Engineers Shall Hold Paramount the Safety, Health and Welfare of the public — but not if it threatens our research funding? Available: <http://flintwaterstudy.org/2016/10/engineers-shall-hold-paramount-the-safety-health-and-welfare-of-the-public-but-not-if-it-threatens-our-research-funding/>

## CONTRIBUTIONS TO SPONSORED RESEARCH PROJECTS

(<sup>^</sup>*Contributed to or led proposal preparation*, \* *indicates funding was awarded*)

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1. **Legionella Control in Buildings\*** 2020-Present  
 Swiss Federal Government  
 PIs: Frederik Hammes, Tim Julian, Franziska Rolli, Daniel Mausezahl, Hans Peter Fuchslin  
 Role: Mentor students, Organize and plan experimental and field work
2. **Responding to Water Stagnation in Buildings with Reduced or No Water Use: A framework for building managers<sup>^\*</sup>** 2020  
 AWWA Water Technical Action Fund, \$20,000  
 Role: Wrote proposal, executed work, managed project to write guidance material related to COVID-19 water stagnation in buildings
3. **Demonstrating the Effectiveness of Flushing for Reducing the Levels of Legionella in Service Lines and Premise Plumbing<sup>^</sup>** Not Awarded: 2019  
 Water Research Foundation, \$287,000  
 PIs: William Rhoads, Marc A Edwards, Amy Pruden  
 Role: Led proposal, coordinated input from CO-PIs
4. **Pre-Proposal: Toolkit for Assessing Household Water Systems as a Source of Sporadic Legionnaires' Disease<sup>^</sup>** Not Awarded: 2018  
 Center for Disease Control, \$450,000  
 PIs: Marc Edwards, William Rhoads, Amy Pruden, Kelsey Pieper  
 Role: Led pre-proposal, coordinated input from CO-PIs
5. **Investigation of Continued *Legionella pneumophila* positivity at the Illinois Veteran's Home in Quincy, IL<sup>^\*</sup> [Renewed <sup>^,\*</sup>]** Awarded 2018  
 State of Illinois, \$128,471, 3 months [Renewal: \$28,763, 3 months; Renewal: \$254,244, 12 months]  
 PIs: Marc Edwards, William Rhoads  
 Role: Designed and wrote scope of work, led sampling campaign and report writing, advised PhD student in executing research
6. **Impact of Hurricane Florence on Well Quality in Communities Surrounding Coal Ash Impoundment in North Carolina<sup>^,\*</sup>** Awarded 2018  
 National Science Foundation (RAPID Response Grant), \$199,609, 1 year  
 PIs: Kelsey Pieper, Adrienne Katner, Kathleen Gray, William Rhoads, Marc Edwards, Andrew George

- Role: Analyzing samples for total coliform and *E. coli* bacteria, coordinating the molecular analysis of samples
7. **Sampling and Monitoring Strategies for Opportunistic Pathogens in Drinking Water Distribution Systems<sup>^</sup>** Not Awarded 2018  
 Water Research Foundation, \$320,000, 3 years  
 PIs: Jennifer Hooper (CDM Smith); Amy Pruden, Emily Garner, William Rhoads (VT); Channah Rock (UA)  
 Role: Co-authored proposal, led literature review, development of hypotheses, and research approach
  8. **Building Infrastructure to Prevent Disasters Like Hurricane Maria<sup>^,\*</sup>** Awarded 2018  
 National Science Foundation Rapid Response Research (RAPID) Grant, \$200,000 (VT: \$36,000); 1 year  
 PI: Christina Bandaragoda (U Washington)  
 Role: Co-PI; Coordinated stakeholders, led sampling campaign, co-advised PhD and MS students in executing research
  9. **Characterizing Potable Water Hazards and Resource Needs in Private Well Communities Impacted by Extreme Flooding Events<sup>^,\*</sup>** Awarded 2017  
 National Science Foundation Rapid Response Research (RAPID) Grant, \$50,000, 1 year  
 PIs: Marc Edwards, Kelsey Pieper, Amy Pruden, William Rhoads  
 Role: Co-authored proposal, led VT-based activities during sampling, coordinated with stakeholders, co-advised MS and undergraduate students in executing research, co-leading peer-reviewed write-up of spatial analysis
  10. **SusChEM GOALI: Harnessing the Antimicrobial Properties of Copper to Control Legionella in Plumbing Systems<sup>^,\*</sup>** Awarded 2017  
 National Science Foundation, \$448,188, 3 years  
 PIs: Marc Edwards, Amy Pruden, Adam Estelle; William Rhoads  
 Role: Gathered preliminary data, led study design and proposal, advised and mentored PhD graduate and undergraduate students to execute experiments
  11. **Advancing Sustainability and Protecting Public Health: Mitigating Unintended Consequences of Water Conservation and Efficiency Practices<sup>^</sup>** Not Awarded 2016  
 Environmental Protection Agency, \$2,000,000  
 PIs: Marc Edwards, Amy Pruden, Annie Pearce (VT), Emily Berglund (NCSU), Heather Cooler, Matthew Herberger (Pacific Institute), Ken Carlson (CSU), Water Research Foundation Program Managers  
 Role: Led literature review and research approach, Coordinated all PIs
  12. **Assessing Risk from and Feasibility of Cleaning Residential Water Heaters<sup>^,\*</sup>**  
 State of Michigan, \$25,000, 6 months Awarded 2016  
 PI: Marc Edwards, Tim Keane  
 Role: Wrote scope of work, planned and executed field sampling, led write-up
  13. **The Great 2016 Louisiana Flood<sup>\*</sup>** Awarded 2016  
 National Science Foundation Rapid Response Research (RAPID) Grant, \$150,919, 1 year  
 PIs: Kelsey Pieper, Marc Edwards  
 Role: Assisted in developing proposal, field sampling protocol, study design, collection and analysis of samples, and provided guidance to the direction of future work
  14. **Synergistic Impacts of Corrosive Water and Interrupted Corrosion Control on Chemical/Microbiological Water Quality: Flint, MI<sup>^,\*</sup>** Awarded 2015

- National Science Foundation Rapid Response Research (RAPID) Grant, \$50,000; 1 year  
 PIs: Marc Edwards, Amy Pruden, Joseph Falkinham, III  
 Role: Helped research and synthesize background information about Flint, MI water quality; assisted in organizing field surveys; performed various lab work; supported efforts led by other students; led write-up of a portion of results for peer-review  
 Renewal 2016
15. **Towards a Sustainable Residential Hot Water Infrastructure: Optimizing Public Health, Water Savings, and Energy Goals \*** Awarded 2013  
 National Science Foundation, \$375,800; 4 years  
 PIs: Marc Edwards, Amy Pruden  
 Role: Designed and constructed experimental apparatus; assisted PhD student that led experiments
16. **Green Building Design: Water Quality Considerations \*** Awarded 2012  
 Water Research Foundation, \$407,710, 3 years  
 PI: Marc Edwards  
 Role: Project management, coordinated activities of stakeholders, executed literature review, field work, and led write-ups for peer-review
17. **Effect of Pipe Materials, Water Flow, and Chemistry on the Building Plumbing Microbiome ^,\*** Awarded 2012  
 Alfred P. Sloan Foundation Microbiology of the Built Environment Program, 2 years  
 PIs: Amy Pruden, Marc Edwards  
 Role: Co-authored proposal, designed, built, and executed experiments, managed undergraduate researchers, led write-ups for peer-review  
 Renewal; 2 years; \$250,000 Renewal 2014
18. **Research Needs for Opportunistic Pathogens in Premise Plumbing Workshop\***  
 Water Research Foundation, 2 years Awarded 2011  
 PIs: Amy Pruden, Marc Edwards, Joseph Falkinham, III  
 Role: Assisted with organization and hosting of workshop to identify key research gaps for premise plumbing pathogens, co-author on final report

## PRESENTATIONS

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### Professional Conference Presentations (Abstract and Extended Abstract Only)

1. **Rhoads, W.J.**, Legionnaires Disease: Considering the Role of Water Utilities. Illinois AWWA Virtual Conference. October 20, 2020.
2. **Rhoads, W.J.**, COVID-19 & Legionnaires Disease: Responsibilities of Water Utilities in Delivering Safe Water. Alliance to Prevent Legionnaires' Disease Virtual Conference. August 20, 2020.
3. **Rhoads, W.J.**, Effects of COVID-19 Lockdowns on Drinking Water Quality. HxEES, Virtual Meeting July 29, 2020.
4. **Rhoads, W.J.**, Flushing to Control Legionella: Limitations and Knowledge Gaps. ACEEE Hot Water Forum. Virtual Meeting, July 18, 2020.
5. **Rhoads, W.J.**, M.S. Spencer, A. Pruden, M.A. Edwards. Lessons Learned on the Aftermath of Severe Legionnaires' Disease Outbreak. ESGLI 2019, Athens, GA, September 12, 2019.

6. **Rhoads, W.J.**, A. Pruden, M.A. Edwards. Unintended Consequences of Water Conservation, Building Design, and Operation for Opportunistic Pathogen Growth. Presented at the 2018 Water Quality and Technology Conference, Toronto, CA, November 14, 2018.
7. **Rhoads, W.J.**; Ji, P.; Pruden, A.; Edwards, M.A. Growth of Opportunistic Pathogens in Domestic Plumbing: Building Standards, System Operation, and Design. Presented at the 2017 Water Quality and Technology Conference, Portland, OR, November 15, 2017.
8. **Rhoads, W.J.**; Garner, E.; Ji, P.; Zhu, N.; Parks, J.; Schwake, D.O.; Pruden, A.; Edwards, M.A. Distribution System Operational Deficiencies Coincide with Reported Legionnaires' Disease Clusters in Flint, MI. Presented at AEESP. Ann Arbor, MI, June 20, 2017.
9. **Rhoads, W.J.**, A. Pruden, M.A. Edwards. Are Green Buildings Going to Make You Blue? Presented at CA/NV AWWA Annual Conference. Sacramento, CA, March 22, 2016
10. **Rhoads, W.J.**, A. Pruden, M.A. Edwards. Emerging Problems with Opportunistic Premise Plumbing Pathogens. Presented at CA/NV AWWA Annual Conference. Sacramento, CA, March 22, 2016.
11. **Rhoads, W.J.**, A. Pruden, M.A. Edwards. Water Quality Considerations in Green Building Design. Presented at Healthy Buildings: America. Boulder, CO, July 22, 2015.
12. **Rhoads, W.J.**, A. Pearce, M.A. Edwards. The Water Age Problem: Unintended Consequences of Water Conservation. Presented at Mascaro Center for Sustainable Innovation Environmental Sustainability Conference. Pittsburgh, PA, April, 2015.
13. **Rhoads, W.J.**, A. Pruden, and M.A. Edwards. Effects of Flow Frequency, Pipe Orientation, and Water Temperature on Growth of Opportunistic Pathogens in a Recirculating Hot Water System. Presented at the Alfred P. Sloan Foundation Microbiology of the Built Environment Annual Conference. Boulder, CO, June, 2014.
14. **Rhoads, W.J.**, A. Pruden, and M.A. Edwards. Building Disinfection Strategies to Control Legionella in Premise Plumbing: Anticipating Concerns with the New ASHRAE Standard. Presented at the American Water Works Association Water Quality Technology Conference. Long Beach California November, 2013.
15. **Rhoads, W.J.** and M. Edwards. Survey of Green Building Water Quality: Identifying Public Health and Aesthetic Concerns, Oral Presentation at AEESP 2013. Golden, CO. July, 2013.
16. **Rhoads, W.J.** and M. Edwards. Potential Implications of Green Building Design and Standard Practices on Water Quality. Oral Presentation at CaNv-AWWA 2013 Inorganic Contaminants Symposium. Sacramento, CA. February, 2013.
17. **Rhoads, W.J.**, A. Pruden, and M. Edwards. Anticipating Challenges Associated with In-Building Disinfection for Control of Opportunistic Pathogens in Premise Plumbing. Oral Presentation and Conference Proceedings. WEF Disinfection and Public Health Conference. Indianapolis, IN. February, 2013
18. **Rhoads, W.J.**, C. Nguyen, C. Elfland, R. Brazeau, A. Pearce, and M. Edwards. Water Quality Issues in Green Buildings. Oral Presentation at AWWA Annual Conference and Exposition. Dallas, TX. June, 2012

#### **Invited Oral Talks (incomplete)**

1. Rhoads, W.J., A. Pruden, M.A. Edwards. Controlling Opportunistic Pathogen Growth in Building Plumbing. Viega, LLC Design Engineers Symposium. October 11, 2019.
2. Rhoads, W.J., A. Pruden, M.A. Edwards. Controlling Opportunistic Pathogen Growth in Building Plumbing. Watts Healthcare Symposium, Boston, MA. October 8, 2019.



3. Rhoads, W.J., A. Pruden, M.A. Edwards. Controlling Opportunistic Pathogen Growth in Building Plumbing. Viega, LLC Design Engineers Symposium. May 17, 2019.
4. Rhoads, W.J., Flint Water Study, M.A. Edwards. The Flint Water Crisis: Communicating with the Public in Emergencies. Oral Presentation at the 2018 Waterborne Pathogen Workshop. Orlando, FL. May 24, 2018.
5. Rhoads, W.J., Flint Water Study, M.A. Edwards. The Flint Water Crisis: Science and the Public. Invited Oral Presentation at the Annual Washington Public Utility Districts Association Conference. Spokane, WA. November 29, 2017.
6. Rhoads, W.J., A. Pruden, M.A. Edwards. Opportunistic Pathogens: Biological Considerations Related to Water Quality at the Tap. Congressional Briefing for Senator Kildee's Office, Washington, D.C. May 3, 2017.
7. Rhoads, W.J., P. Ji, M.A. Edwards, A. Pruden. Water Age, *Legionella*, and NT mycobacteria. Invited Oral Presentation at the American Industrial Hygiene Conference and Exposition. Seattle, WA, June 6, 2017.
8. Rhoads, WJ; Pruden, A; Edwards, MA. Water Quality Considerations In Green Building Design. Presented at ACEE Hot Water Forum, February 27, 2017, Portland, OR.
9. Rhoads, WJ; Pruden, A; Edwards, MA. Potential for flow rate to impact growth of *Legionella* in building plumbing. Presented at ACEE Hot Water Forum, February 27, 2017, Portland, OR.
10. Rhoads, WJ; Garner, E; Zhu, J; Ji, P; Schwake, DO; Parks, J; Pruden, A; Edwards, MA. Legionnaires' disease in Flint, MI: Lessons Learned. Presented at ACEE Hot Water Forum, February 27, 2017, Portland, OR.
11. Rhoads, W.J. on behalf of the Flint Water Study Team. Keynote Address – The Flint Water Crisis Lessons Learned: Communicating Science and Influencing Public Discourse Using Research. Invited Oral Presentation at the Tri-State Water Resource Coalition Building a Secure Water Annual Future Conference. Springfield, MO, October 20, 2016.
12. Rhoads, W.J. on behalf of Flint Water Study Team. Flint Michigan: Lessons Learned. Presented at WEFTEC, New Orleans, September 27, 2016.
13. Rhoads, W.J., A. Pruden, M.A. Edwards. Plenary Talk – Opportunistic Premise Plumbing Pathogens: Grand Public Health Challenge for the 21st Century. Invited Oral Presentation at the 66<sup>th</sup> Annual Environmental Engineering Conference. Lawrence, KS, April 20, 2016.
14. Rhoads, W.J. on behalf of the Flint Water Study Team. Keynote Address – The Flint, MI Water Crisis: Hold Paramount the Safety, Health, and Well-Being of the Public. Invited Oral Presentation at The Virginia Water Conference. Richmond, VA, March 14, 2016.
15. Rhoads W.J., A. Pruden, M.A. Edwards. Challenges associated with pathogen control considerate of the water-energy nexus. Invited Oral Presentation at ACEEE Hot Water Forum, Portland, OR, February 23, 2016.
16. Rhoads, W.J., A. Pearce, A. Pruden, M.A. Edwards. Unintended Consequences: Lessons Learned in Green Buildings. Guest Lecture in BC 5114 Sustainable Infrastructure. September 19, 2015.
17. Rhoads, W.J. and M. Edwards. Survey of Green Building Water Quality: Identifying Public Health and Aesthetic Concerns, Invited Oral Presentation ACEE Hot Water Forum, Atlanta, GA, November 3, 2013.

## Posters

1. Sindelar, M., C. Margot, L. Neu, F. Boni, M. Gatchter, W.J. Rhoads, F. Hammes. Legionella behavior during the COVID-19 lockdown at Eawag. Eawag Annual Research Symposium. Dübendorf, Switzerland (September 20, 2020)
2. Gilliland A, Pieper K, Straif-Bourgeois S, Rhoads WJ, Edwards M, Brisolaro K, Katner A. 2019. Recommendations on improving access to safe water in domestic well-reliant communities after the Great Louisiana Flood of 2016. 12th Health Disparities Conference. New Orleans, LA (April 8-10 2019).
3. Gilliland A, Pieper K, Straif-Bourgeois S, Rhoads WJ, Edwards M, Brisolaro K, Katner A. 2019. Emergency preparedness and recovery lessons after the Great Louisiana Flood of 2016 among domestic well owners. 2019 Louisiana Water Conference. Baton Rouge, LA (April 15-16).
4. Song, Y., A. Pruden, M.A. Edwards, W.J. Rhoads. Copper Speciation, Complexation, and Precipitation in Governing Toxicity Towards Legionella in Hot Water Building Plumbing Systems. Microbiology of the Built Environment Gordon Research Conference. Biddeford, ME. July 15-20, 2018.
5. Keenum, I., T.A. R. Curet, M.C. Medina, E. Garner, G. Ramirez Toro, A. Pruden, K. Pieper, W.J. Rhoads. Pathogen Profiles in Small Community Water Systems following Hurricane Maria. Microbiology of the Built Environment Gordon Research Conference. Biddeford, ME. July 15-20, 2018.
6. Rhoads, W.J., P. Ji, A. Pruden, M.A. Edwards. Effects of flow frequency, pipe orientation, and temperature on *Legionella* growth in recirculating household water heaters. Poster Presentation at the Alfred P. Sloan Foundation Microbiology of the Built Environment Annual Conference. Boulder, CO, July, 2015.
7. Rhoads, W.J., P. Ji, A. Pruden, M.A. Edwards. Effects of flow frequency, pipe orientation, and temperature on *Legionella* growth in recirculating household water heaters. Poster Presentation at AEESP 2015. Haven, CT, June, 2016.
8. Rhoads. W.J., Y. Lambrinidou. Development of a Reader-Centered Educational Brochure on Drinking Water Quality. Poster Presentation at the annual CEE Research Day. Blacksburg, VA, April 24, 2015.

### **Webcasts**

1. Rhoads, W.J., A. Pruden, M.A. Edwards. Water Quality Considerations in Green Building Design. National Institute of Science and Technology, Environmental Protection Agency, and Water Research Foundation sponsored Measurement Science Workshop for Water Use Efficiency and Water Quality in Premise Plumbing Systems. Pre-workshop webinar. July 12, 2018.
2. Rhoads, W.J., A. Pruden, M.A. Edwards. Understanding Water Age & Unintended Consequences of Green Design. Practice Greenhealth Sustainable Operations Series: Achieving Safer Water in Healthcare Facilities Webinar. October 12, 2016.
3. Rhoads, W.J., B. Chambers, A. Pearce, M.A. Edwards. WRF Webcast Green Building Design: Water Quality Considerations. April 23, 2015.
4. Rhoads, W.J. and M.A. Edwards. Survey of Green Building Water Quality: Identifying Public Health and Aesthetic Concerns, Invited Oral Presentation at 2nd Annual Meeting. Canadian Advisory Council on Plumbing. Alberta, CA. August 2013.

5. Wang, H., C. Proctor, W.J. Rhoads, M. Edwards and A. Pruden-Bagchi. State of the Science of Opportunistic Pathogens in Premise Plumbing Webinar for Water Research Foundation subscribers, July 16, 2013.

### **Outreach**

1. Rhoads, W.J. on behalf of the Flint Water Study Team. Science and Engineering: Goals, application, challenges using Flint, MI as a case study. Science, Technology, Engineering, Architecture, and Mathematics (S.T.E.A.M.) Day during the Virginia Tech Science Festival. Roanoke, VA. October 6, 2017.
2. Rhoads, W.J. on behalf of the Flint Water Study Team. The Flint, MI Water Crisis: Lead, Legionella, and Leaks. Montgomery County Rotary Club, Blacksburg, VA, July 27, 2016.
3. Rhoads, W.J., E. Garner on behalf of the Flint Water Study Team. The Flint, MI Water Crisis: Hold Paramount the Safety, Health, and Well-being of the Public. Blacksburg, VA Rotary Club. Blacksburg, VA, April 21, 2016.
4. Edwards, M.A., W.J. Rhoads, A. Mantha, C. Devine, M. Carolan, R. Martin, M. Tang, E. Garner, D.O. Schwake, S. Roy, P. Ji, N. Zhu (2016). Flint Water Study's Journey with Flint Residents: Lead, Legionella, and Leaks. Presented at Virginia Tech. January 28, 2016.

### **In the Press**

1. Tang, M., W.J. Rhoads, O. Strom, M.A. Edwards. Flint Water Press Conference. December 2, 2016. Available: <http://flintwaterstudy.org/2016/12/flint-water-study-press-conference-12-2-2016/> (Accessed 8/2/2017).
2. Pieper, K., T. Bradley, W.J. Rhoads, M.A. Edwards. Flint Water Press Conference. August 11, 2016. Available: <http://flintwaterstudy.org/2016/08/flint-water-press-conference-august-11-2016/> (Accessed 8/2/2017).
3. Edwards, M.A.; S. McElmurry, A. Pruden, D. Reckhow. Updates on Special Flint Sampling: Flushing and Lead, Disinfection By-Products and *Legionella* Sampling. Press Conference, May 31, 2016. Available: <http://flintwaterstudy.org/2016/05/updates-on-special-flint-sampling-flushing-and-lead-disinfection-by-products-and-legionella-sampling-may-31st-2016/> (Accessed 8/2/2017).
4. Roy, S., W.J. Rhoads. News 7 Sunday Morning. Available: [https://archive.org/details/WDBJ\\_20160207\\_130000\\_News\\_7\\_Sunday\\_Morning](https://archive.org/details/WDBJ_20160207_130000_News_7_Sunday_Morning) (Accessed 8/2/2017).

### **Co-authored Presentations (select key note, invited, conference presentations, and posters)**

List not complete

1. Katner A, A. Gilliland, K. Pieper, W.J. Rhoads, D. Dai, S. Straif-Bourgeois, K. Fitzmorris-Brisolara, A. Pruden, M.A. Edwards. Identifying and addressing drinking water challenges in well-reliant communities after natural disasters: Lessons from a Louisiana Flood. The Annual State of the Coast Conference. New Orleans, LA (May 26-28, 2020).
2. Garner, E., M.A. Edwards, A. Pruden, W.J. Rhoads. Whole Genomes Sequencing
3. Dai, D., W.J. Rhoads, A. Pruden, M.A. Edwards. How consumers shape the microbial world in hot water plumbing systems: a metagenomic view. AEESP Bi-Annual Research and Education Conference, "At the Nexus" Yale University, June 13-16, New Haven CT (2017).
4. Ji, P., W.J. Rhoads, A. Pruden, M.A. Edwards. Effect of Temperature, Plumbing Configuration and Water use Frequency on the Premise Plumbing Microbiome. American

- Water Works Association International Symposium on Waterborne Pathogens, April 13-14, Savannah, GA (2015).
5. Edwards, M.A., A. Pruden, J.O. Falkinham III, W.J. Rhoads, S. Masters. Potential and Limitations of Engineered Controls for Opportunistic Premise Plumbing Pathogens. Presented at the AWWA Annual Conference and Exhibition (ACE) 12, June 10-14, Dallas, TX (2012).
  6. Edwards, M.A., A. Pruden, C. Proctor, W.J. Rhoads, K. Williams, A. Martin, A., R. Hupp (Martin), H. Wang. Addressing the waterborne disease challenges of the 21st century with applied biology and chemistry: Opportunistic premise plumbing pathogens. Key Note Address - American Chemical Society National Meeting. San Francisco, CA. Aug 10-14 (2014).
  7. Edwards, M.A., A. Pruden, P. Ji, W.J. Rhoads\*. U.S. Water Use and Opportunistic Premise Plumbing Pathogens (OPPPs): Water Use in the U.S. – Balancing Needs and Conservation. Water Safety in Healthcare Workshop, Veterans Health Administration National Infectious Diseases Service. Cincinnati, OH. June 24 (2014).
  8. Edwards, M.A., A. Pruden, W.J. Rhoads, K. Chittaladakorn. Plumbing at the Nexus of Energy Conservation, Water Conservation and Public Health. Plumbing Industry Leadership Coalition. Washington D.C, April 22 (2014)
  9. Edwards, M.A., A. Pruden, W.J. Rhoads, K. Chittaladakorn. Plumbing at the Nexus of Energy Conservation, Water Conservation and Public Health. Keynote to Plumbing Manufacturers Institute (PMI) National Meeting. Charleston, SC. March 3, (2014).
  10. Pruden, A., W.J. Rhoads, P. Ji, D. Dai, E.D. Garner, M.A. Edwards. Building Plumbing Design Shapes Water Microbiome: An important Source of Indoor Air Microbes, Indoor Air, Ghent, Belgium, July 7, 2016.
  11. Ji, P., W.J. Rhoads, A. Pruden, M.A. Edwards. Beyond Reconnaissance of the Premise Plumbing Microbiome. *Alfred P. Sloan Foundation Annual Conference on the Microbiology of the Built Environment*, July 15-17, Boulder, CO (2015).
  12. Pruden, A., D. Dai, W.J. Rhoads, P. Ji, M.A. Edwards. Metagenomics of Indoor Plumbing. *International IDEXX Forum on Pathogen Risk Management and Control in Building Water Systems*. May 20, Portland, ME (2015).
  13. Pruden, A., M.A. Edwards, W.J. Rhoads, C.R. Proctor, P. Ji, P\*. Limiting Occurrence of Opportunistic Pathogens in Premise Plumbing through Engineering Controls. Presented at the AWWA Annual Conference and Exhibition (ACE) 14, June 8-12, Boston, MA (2014).
  14. Ji, P, W.J. Rhoads, M.A. Edwards, A. Pruden, A. Effect of Temperature on the Building Plumbing Microbiome. 2015 AEESP Research and Education Conference. Boulder, CO, June 13-16, 2015. (Poster)
  15. Carolan, M. E., W.J. Rhoads, M.A. Edwards, A. Pruden, A. “Effects of Flow Rate on Turbidity and Microbial Growth in Premise Plumbing Systems.” Oral presentation. NSF/AAAS Emerging Researchers National Conference in STEM, Washington, District of Columbia, February 2016.
  16. Carolan, M. E., W.J. Rhoads, A. Pearce, A. Pruden, M.A. Edwards. “Drinking Water Quality of a Full-Scale Rainwater Harvesting System.” Poster presentation. Virginia Tech Civil and Environmental Engineering Research Day, Blacksburg, Virginia, April 2016.

## **PROFESSIONAL LEADERSHIP & ENGAGEMENT**

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## **ASHRAE 514 Minimizing Risk of Disease and Injury Associated with Building Water Systems**

Committee Non-voting Member 2019-present

## **AWWA Premise Plumbing Sub-Committee**

Member 2018-present

Leading committee to write building disinfection guidelines

Lead committee to develop recommendations for addressing building stagnation 2020

## **International Association of Plumbing and Mechanical Officials *Legionella* Task Group**

Served on task group to review and develop recommendations for an appendix to the

Universal Plumbing Code regarding *Legionella* growth temperature ranges 2018-2019

2020

## **Student Chapter of the American Water Works Association**

President, co-founder 2013-2014

Vice President 2014-2015

Role: Planned and organized professional development events, obtained funding for travel to VA AWWA Water Jam Conference, organized student “brown bag” lunch seminars

## **Manuscript Reviewer**

*Environmental Science & Technology* (8); *Water Research* (5); *Applied Energy* (1); *Reviews in Environmental Science and Bio/Technology* (1); *PLOS One* (1); *Building and Environment* (1); *BMC Infectious Diseases* (1); *Environmental Science: Water Research & Technology* (1); *water* (1)

## **Conference Proceedings Reviewer**

American Society for Engineering Education (1)

USGBC

## **STUDENT MENTORING**

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### **Undergraduate Students**

Nadine Graf, Environmental Science, ETH Zürich, Anticipated 2021

Maylin Waddell-Horren, Environmental Science, Anticipated 2020

Carol Yang, B.S. Environmental Science (Water Science and Quality), Anticipated 2020

Sophia Lee, B.S. Environmental Science (Water Science and Quality), 2018

Matthew Dowdle, Undergraduate Research, B.S. Civil Engineering, 2018

Mariana Martinez, Research Experience for Undergraduates (REU), B.S. Civil Engineering, Arizona State University, 2017

Margaret Carolan, Research Experience for Undergraduates (REU), Sustainable Water Undergraduate Research (SWUR) Fellowship, B.S. Water Resources, Policy, and Management and Environmental Science, 2018

+Co-authored successful SWUR Fellowship application, \$4,000

+1<sup>st</sup> Place, Oral Presentation, NSF/AAAS ERN Conference in STEM, February 2016

Kimberly Hughes, Undergraduate Research, B.S. Biochemistry and Biology (2016), M.S. Public Health, Virginia Tech, 2017

Daniel Logsdon, Undergraduate Research, B.S. Biological Systems Engineering, Virginia Tech, 2015

Arjan Ahluwalia, Undergraduate Research, B.S. Biology, Virginia Tech, 2015

+ 2<sup>nd</sup> Place, Poster Presentation, Civil and Environmental Engineer Research Day, April 2015

Joshua Caldwell, Research Experience for Undergraduates (REU), B.S. Mechanical Engineering, Georgia Tech, 2015

Kelly Petterson, Undergraduate Honors Research, B.S. Civil Engineering, Virginia Tech, 2013

Rachel Thomas, Undergraduate Research, B.S. Environmental Science, Virginia Tech, 2011

### Graduate Students

*(primary mentor or extended assistance on research project design or analysis)*

Taylor Bradley, M.S. Civil and Environmental Engineering 2018

**Connor Brown**, B.S. Biophysics, 2018, M.S. Biophysics 2019

Topic: Evaluating *L. pneumophila* protein response to environmental stress

**Sarah Busch**, B.S. Civil and Environmental Engineering 2018, M.S. 2019

Topic: Effect of Flow Rate of Growth of Opportunistic Pathogens

+Co-authored successful Virginia Water Resources Research Council Student Research Grant, \$5,000 to fund M.S. lab supplies

+Serving on committee

Benjamin Davis, Ph.D Civil and Environmental Engineering 2021 (anticipated)

**M. Storme Spencer**, MS Civil and Environmental Engineering 2020

Topic: Investigation of Continued Positivity of *L. pneumophila* at Illinois Veteran's Home in Quincy, IL

+Serving on committee

Rebekah Martin, Ph.D Civil and Environmental Engineering 2020

**Yang Song**, Ph.D Civil and Environmental Engineering 2021 (anticipated)

Topic: Effect of Copper Concentration and Speciation on the Growth of *L. pneumophila*

+Serving on committee

Ishi Keenum, Ph.D Civil and Environmental Engineering 2022 (anticipated)

**Anurag Mantha**, Ph.D Civil and Environmental Engineering 2022 (anticipated)

Topic: Evaluating Risk Factors for Residential Colonization of Nontuberculous Mycobacteria

**Kris Mapili**, MS Civil and Environmental Engineering 2018

Topic: Growth of Opportunistic Pathogens in Private Well Water

**Meril Sindelar**, MS Biology 2020

Topic: Effect of Stagnation on Legionella Growth

Alessio Cavallaro, PhD, ETH Zürich Anticipated 2023

Topic: Probiotic control for Legionella

Céline Margot, PhD, ETH Zürich Anticipated 2023

Topic: Stagnation in building water systems

### TEACHING EXPERIENCE

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**Summer Technical Writing Workshop** Summer 2017, 2019

Virginia Tech, Edwards and Pruden Research Groups

Provided instruction and in-class exercises to develop student scientific writing skills via a flipped class format.

**CEE 3104: Introduction to Environmental Engineering Instructor** Spring 2015

Virginia Tech, Via Department of Civil and Environmental Engineering (CEE)

Instructor of record for introductory environmental engineering sophomore/junior level course. This teaching experience is awarded to students in the Via Department of Civil and Environmental Engineering who are committed to becoming faculty members. The students' average evaluation of my performance was 5.5/6.0.

**CEE 3314: Water Resources Laboratory Instructor** Fall 2011

Virginia Tech, Via Department of Civil and Environmental Engineering (CEE)

Instructed students on how to perform laboratory experiments related to material covered during lecture, graded reports, critiqued technical writing skills

**CEE 5984: Surface Water-Groundwater Interactions Teaching Asst.** Fall 2011

Virginia Tech, Via Department of Civil and Environmental Engineering (CEE)

Designed, set up, organized, and helped execute field labs associated with course content, graded homework and exams, provided students with detailed feedback

## **OUTREACH & ENGAGEMENT**

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**Big Brother Big Sisters of Southwest Virginia** August 2016-June 2018

Mentor, support, and learn from a 7<sup>th</sup> grade student, help to set and achieve goals, provide a positive role model

**First Lego League Team "Expert" Mentor** 2017

Help a group of 6<sup>th</sup> grade students interested in science decide on a topic to research, define a problem, and develop a solution to that problem by providing feedback, and asking and answering questions

+ Regional Finalists (2017)

**Graduate-Undergraduate Mentor Program (GUMP)** 2013, 2014

Mentor up to two students each spring semester on decisions regarding continuing their education in graduate school

**Blue Ridge Highlands Regional Science Fair Judge** 2014

Interacted with student and engaged them about science, judged 6<sup>th</sup> grade projects

## **PROFESSIONAL MEMBERSHIP**

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American Water Works Association (AWWA)

American Environmental Engineering and Science Professors (AEESP)

American Society for Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE)

American Society for Plumbing Engineers (ASPE)