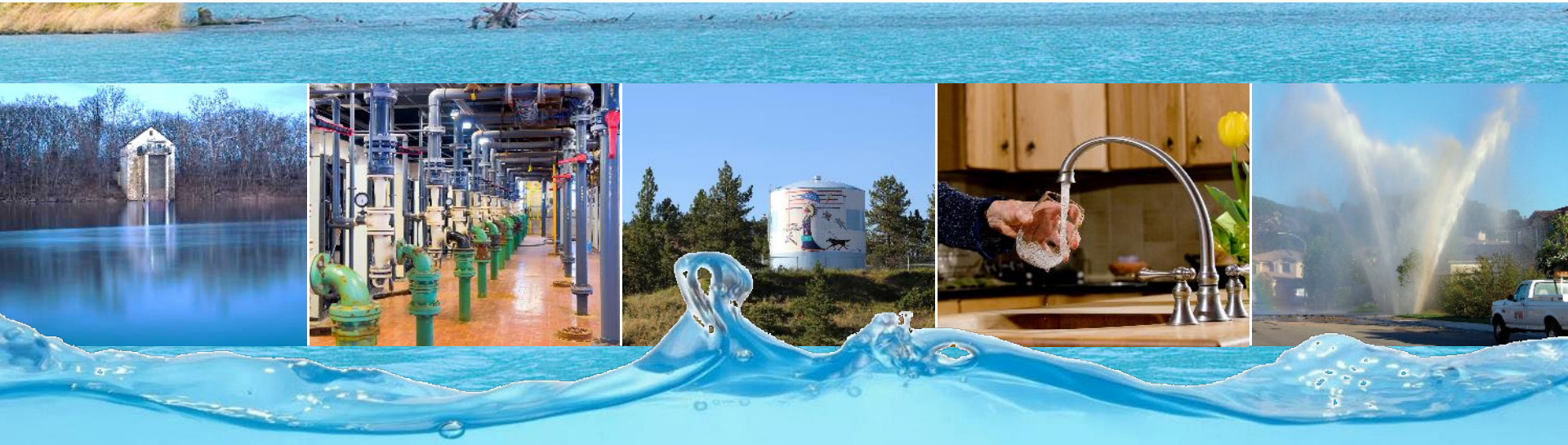
EPA

Office of Research and Development

SAFE AND SUSTAINABLE WATER RESOURCES RESEARCH PROGRAM



SSWR BoSC Meeting – May 26, 2021

Research Area 7: Drinking Water/Distribution Systems

Hale Thurston, RA Coordinator

Background

- Water systems face increasingly greater challenges for delivering adequate supplies of safe drinking water.
- Legacy issues—such as aging infrastructure, lead service lines, disinfectant residual, and disinfection byproducts—threaten water safety and availability.
- Emerging issues—such as the treatment of algal toxins and PFAS—are also high priorities.

Innovative, cost-effective approaches are needed to optimize the efficacy and efficiency of water treatment and distribution, especially for small systems that often face greater technical, financial, and operational challenges to comply with new and existing standards.

Water Treatment and Infrastructure

Research Area 7 Drinking Water/Distribution Systems

Provide essential results and tools to our customers for managing existing and future drinking water needs. Specifically, it focuses on areas of recent concern that require novel solutions.

Research Area 8 Per- and Polyfluoroalkyl Substances (PFAS)

Robust analytical methods for analyzing PFAS in water, solids, and tissue samples, and a centralized website for treatment and pretreatment recommendations for wastewater and reuse.

Research Area 9 Wastewater/Water Reuse

Guidance on new and existing treatment technologies and analytical methods for emerging contaminants and contaminant risks.

Research Area 10 Integrated Stormwater Management

Integrated aspects of green/gray infrastructure and stormwater flow control to help states, municipalities, and utilities reduce the number of combined sewer overflows.

Research Area 11 Technical Support

Provide a means for rapid response to specific, unplanned program office, state, tribe, and community research needs concerning high-priority issues.

Drinking Water/Distribution Systems

This research area is providing essential results and tools to the program offices, primarily OW's Office of Ground Water and Drinking Water (OGWDW), states, tribes, and communities to manage existing and future drinking water needs.

- **Agency Driver:** Safe Drinking Water Act
- **Focus:** Areas of recent concern that require novel solutions.
  - Lead/copper
  - Emerging contaminants
  - Small systems
  - Distribution systems/premise plumbing

Research Outputs Overview

Output 7.1: Resources and tools for characterizing and mitigating lead in drinking water distribution systems and premise plumbing

Output 7.2: Best practices, tools, and information for assessing and controlling pathogens and biostability in drinking water systems, managing disinfectant residuals, and minimizing disinfection byproducts

Output 7.3: Analytical methods, occurrence, health effects, and treatment assessments to aid regulatory decision making

Output 7.4: Resources and tools toward a systems approach for maintaining drinking water infrastructure performance and integrity

Research Products Overview

Products from this work will help provide stakeholders with appropriate and cost-effective treatment of increasingly limited and degraded drinking source waters that reliably and consistently meets EPA, state, and Tribal health-protective standards.

Balancing disinfection, disinfection byproduct formation, and toxicity against microbial risk; and controlling opportunistic pathogens in premise plumbing.

Prioritizing contaminants of emerging concern, such as algal toxins, based on occurrence and toxicity and investigating treatment processes to remove them to determined safe levels.

Addressing legacy issues, such as removing leaded materials in distribution systems, and identifying cost-effective infrastructure improvements.

Research Output 7.1

Resources and Tools for Characterizing and Mitigating Lead in Drinking Water Distribution Systems and Premise Plumbing

Lead: Darren Lytle

SSWR 7.1.1: Treatment Strategies for Reducing Lead and Copper in Drinking Water

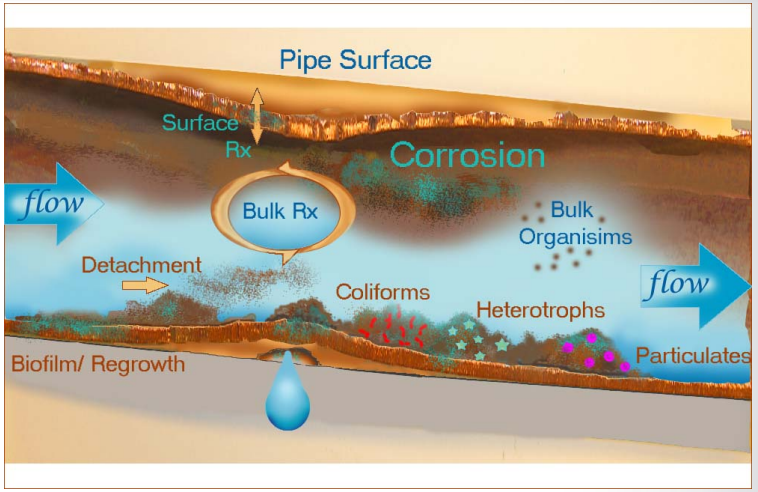
Problem: Lead and copper levels in drinking water remains a public health concern. Events in Flint, MI, and Newark, NJ, reinforced the need to reexamine treatment strategies to reduce lead in drinking water. The anticipated revised LCR is expected to require water systems to review current treatment practices.

Action: This product will improve and develop strategies to reduce lead and copper in consumer's tap water and, as a result, reduce human exposure to the metals.

Results:

- The Impact of Water pH and Orthophosphate on Corrosion of New Copper Surfaces Using Quartz Crystal Microbalance with Dissipation
- POU water filters effectively reduce lead in drinking water: a demonstration field study in flint, Michigan.
- Sequential Drinking Water Sampling as a Tool for Evaluating Lead in Flint, Michigan.
- Lead Corrosion Scale Formation and Structure on Lead Pipe and Lead-Tin Solder: A Conceptual Model

Impact: Improved and new treatment strategies can be directly used by states, consultants, and water systems to reduce lead and copper levels at consumer's taps.



Product POC: Darren Lytle (CESER)

Internal Partners: OGWDW, EPA Regions

External Collaborators: ASDWA, cities, consultants, states

SSWR 7.1.2: Lead Exposure Assessment and Modelling Considerations and Tools

Problem: Widely used lead monitoring methods in water do not capture exposure or the amount of lead consumed. Such information is necessary to predict reductions in BLLs (health benefits) of corrosion control treatment. Furthermore, lead transport models could be applied to help inform on the selection of strategies for assessment sampling.

Action: Explore sampling methodologies and modeling approaches to inform on strategies to capture lead exposure from drinking water.

Results:

- Variability and Sampling of Lead (Pb) in Drinking Water: Assessing Potential Human Exposure Depends on the Sampling Protocol.
- A Framework for Modeling Lead in Premise Plumbing Systems using EPANET.
- Modeled Impacts of Drinking Water Pb Reduction Scenarios on Children's Exposures and Blood Lead Levels.

Impact: Improved predictive models such as those with regulatory needs in conjunction with health exposure studies (e.g., IEUBK and AALM models). This product will also assist other health modeling efforts that attempt to extrapolate existing lead sampling data into datasets that may have greater predictive characteristic to represent true exposure numbers.

Product POC: Jonathan Burkhardt (CESER)

Internal Partners: OGWDW, EPA Regions

External Collaborators: cities, consultants, states, building engineers

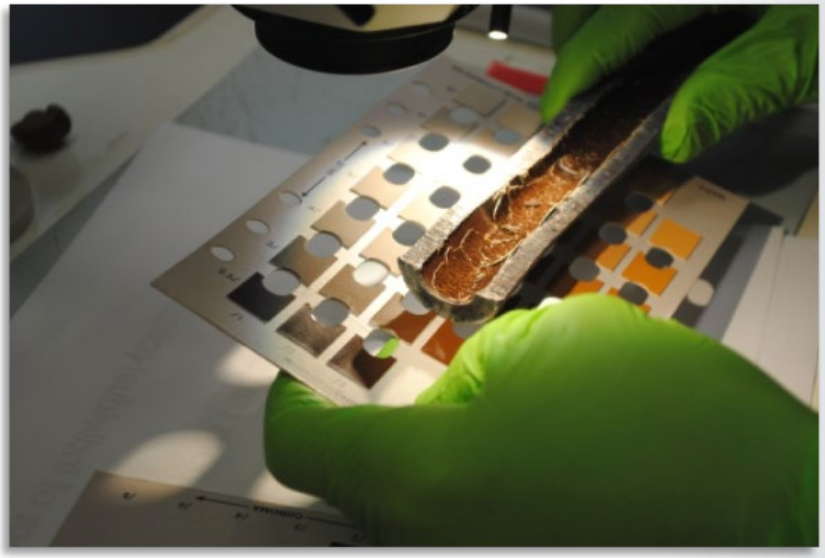
SSWR 7.1.3: Lead and Copper Source Characterization and Assessment Strategies

Problem: The release of lead and copper from drinking water materials is largely related to the nature of materials including corrosion by-products, deposits and biofilm on material surfaces. The understanding of the make-up of these surfaces and how they relate to water quality and metal release are not well understood.

Action: Characterize the speciation of lead and copper on the surfaces of distribution system and premise plumbing devices, pipes, storage materials, and other solids to ascertain lead release mechanisms and corrosion control effectiveness. Will also consider the effects of biofilms on the corrosion of premise plumbing and how the resulting corrosion impacts biofilms.

Results: Pipe scale analyses for solving lead problems in communities (technical support). Outputs describing approaches to lead pipe scale analyses and best practices.

Impact: Improved understanding of the nature of pipe scales will help water systems improve corrosion control approaches and avoid unintended consequences of source water and treatment change related to lead and copper release.



Product POC: Mike DeSantis (CESER)

Internal Partners: OGWDW, EPA Regions

External Collaborators: ASDWA, cities, consultants, states

SSWR 7.1.4: Lead and Copper Sampling and Monitoring Tools

Problem: There is a need to identify the appropriate method(s) to sample for lead and copper in water to achieve the desired objective. Furthermore, alternative Pb monitoring tools that can provide rapid and accurate measurements are needed.

Action: Develop novel tap sampling methods to meet various sampling goals and compare them against more common methods. Sampling methods to assess treatment effectiveness, and broader distribution system monitoring strategies to identify unintended consequences of corrosion control will also be examined.

Results:

- The impact of sampling approach and daily water usage on lead levels measured at the tap.
- Field analyzers for lead quantification in drinking water samples.
- Development of a Lead Assessment and Exposure Device (Patent).

Impact: The information will inform or be directly used by states, consultants, and water systems to link desired lead and copper questions with the proper water sampling approach.

Product POC:
Simoni Triantafyllidou (CESER)

Internal Partners: OGWDW, EPA Regions

External Collaborators: ASDWA, cities, consultants, states

SSWR 7.1.5: Sampling for Lead Service Line Identification and Exposure Assessment

Problem: There is a need to identify the make-up of service material in cases where it is unknown. This knowledge will help water systems build lead service line inventories, prioritize lead service line removals and reduce lead exposure from drinking water.

Action: This product evaluates various methods to determine the presence of leaded materials within premise plumbing, particularly lead service lines, but considers all lead sources. This can be done in numerous ways from innovative tap sampling methods, novel sensors and visual inspection to remote sensing.

Results:

- Lead Service Line Identification: A Review of Strategies and Approaches
- A Water Sampling Device for Assessing the Presence of LSLs: Demonstration
- Field Comparison of Water Sampling Approaches for Lead Assessment

Impact: This Product aims to advance knowledge on existing tools for lead service line identification and lead exposure assessment, but also aims to develop new such tools.

Product POC:
Simoni Triantafyllidou (CESER)

Internal Partners: OGWDW, EPA Regions

External Collaborators: ASDWA, cities, consultants, states

Research Output 7.2

Best Practices, Tools, and Information for Assessing and Controlling Pathogens and Biostability in Drinking Water Systems, Managing Disinfectant Residuals, and Minimizing Disinfection Byproducts

Lead: Eric Villegas

SSWR 7.2.1: Understanding the Occurrence, Prevalence, and Control of *Legionella* Throughout the Drinking Water System

Problem: *Legionella* is the leading cause of infectious disease outbreaks from drinking water and the incidence continues to rise.

Action:

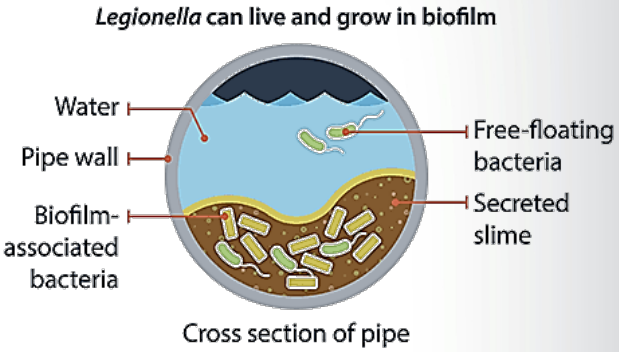
- Evaluate the interplay between water quality parameters, microbial communities, engineering/plumbing designs, and *Legionella* in distribution and premise plumbing systems
- Use next-gen technology to understand *Legionella* in DWS
- Identify treatment technologies, pipe materials and, engineering designs that minimize risks associated with *Legionella*
- Develop tools to improve water management practices/treatment options and mitigation strategies to control *Legionella*

Results:

- New and refined tools developed to monitor *Legionella* and other opportunistic premise plumbing pathogens (OPPPs) in distribution systems
- Key research collected for improved management plans to control *Legionella*
- Pipe materials and disinfectant residuals play an important role on *Legionella* and biofilm growth in distribution system and storage tanks
- Nano-based particles and UV-based disinfectants are effective on *Legionella*

Impact:

Improved better management practices (building and utilities) aimed at reducing risks associated with *Legionella* and OPPPs.



Product POC:
Laura Boczek (CESER) and Jingrang Lu (CEMM)

Internal Partners: OGWDW, Regions

External Collaborators:
Water utilities, AWWA

SSWR 7.2.2: Disinfection Byproducts in Drinking Water Systems

Problem: More effective management of disinfectant residual and disinfection byproducts (DBPs) in distribution and premise plumbing systems while effectively reducing OPPPs are needed.

Action:

- Use of bench scale and computer-simulated approaches to determine effective disinfectant concentrations to treat OPPPs and minimize DBPs.
- Understand the relationships between health risks associated with DBPs, disinfectant residuals, pathogen occurrences and corrosion control of public distribution systems and in-home premise plumbing.

Results:

- Disinfectant demand in building plumbing systems evaluated.
- Penetration efficacies of disinfectants on biofilms evaluated.
- Optimal conditions to reduce DBPs and pipe corrosion in DS evaluated.
- Sensor technology developed to monitor inorganic contaminants (e.g., bromide and iodide) in water.

Impact: Provide tools for effective disinfectant residuals to control pathogen occurrences while minimizing DBPs in the distribution systems. Understand the overall relationships between pathogen occurrences and DBPs as it relates to OPPPs in DS and human health.

Product POCs: David Wahman and Darren Lytle (CESER)

Internal Partners: OW, OGWDW, Regions

External Collaborators: Local area hospitals and utilities, AWWA, Cincinnati Water Works

Rules: Disinfectants and DBPs Rules (DBPRs)

SSWR 7.2.3: Exposure and Human Health Effects from Drinking Water Pathogens Found in Distribution Systems

Problem: Human health effects of OPPPs, especially those causing gastrointestinal and respiratory diseases are still not well understood.

Action:

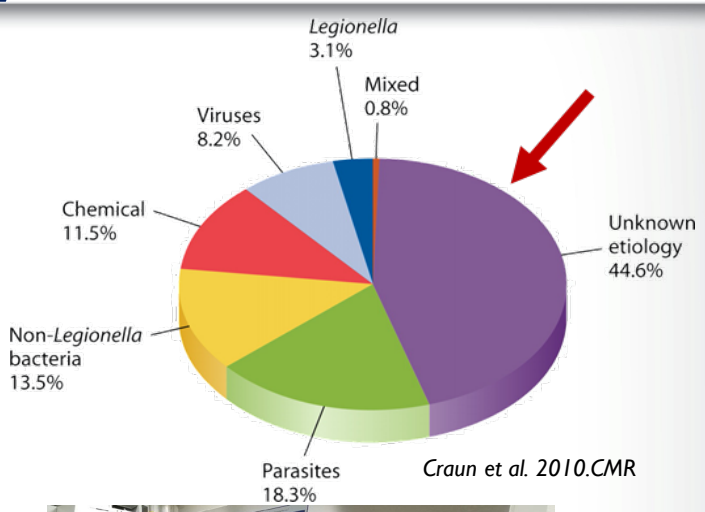
- Understand prevalence/incidences of OPPPs-associated disease burden in endemic regions, especially in underserved communities with inadequately treated water.
- Determine occurrences and human health effects of OPPPs in the system (e.g., storage tanks, cisterns, and POU devices) in emergency/non-emergency scenarios.
- Establish dose response models for various OPPPs found in DS.

Result:

- Established the Aerosol Exposure Chamber facility to develop a dose-response model for inhaled *Legionella* (on-going).
- A salivary antibody immunoassay to measure human exposure to waterborne pathogens established. *Legionella* specific assays currently being evaluated (on-going).
- Occurrence of waterborne pathogens in rural communities receiving inadequately treated water in Puerto Rico initiated (on-going).

Impact:

New tools/surveillance approaches to monitor OPPPs and their disease burden in communities; and improved quantitative microbial risk assessment models to assist in establishing more effective BMPs that reduce health risks posed by *Legionella* and other OPPPs.



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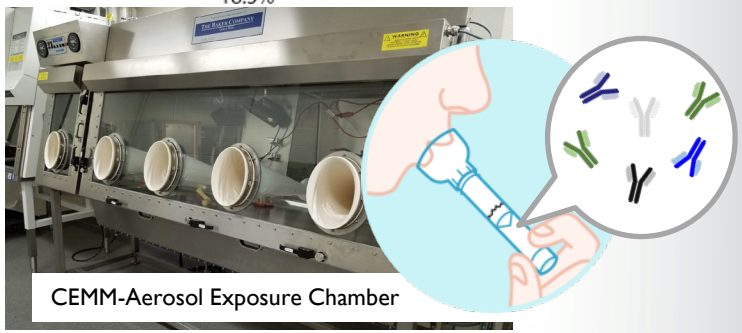


Product POC: Shannon Griffin (CPHEA)

Internal Partners: OGWDW, Region 2/6

External Collaborators: AWWA, APHA

Research Output 7.3

Analytical Methods, Occurrence, Health Effects, and Treatment Assessments to Aid Regulatory Decision Making

Lead: Jane Ellen Simmons

SSWR 7.3.1: Predictive Computational Tools to Group Chemicals, Determine Joint Toxicity and Components Driving Risk and Improve Estimation

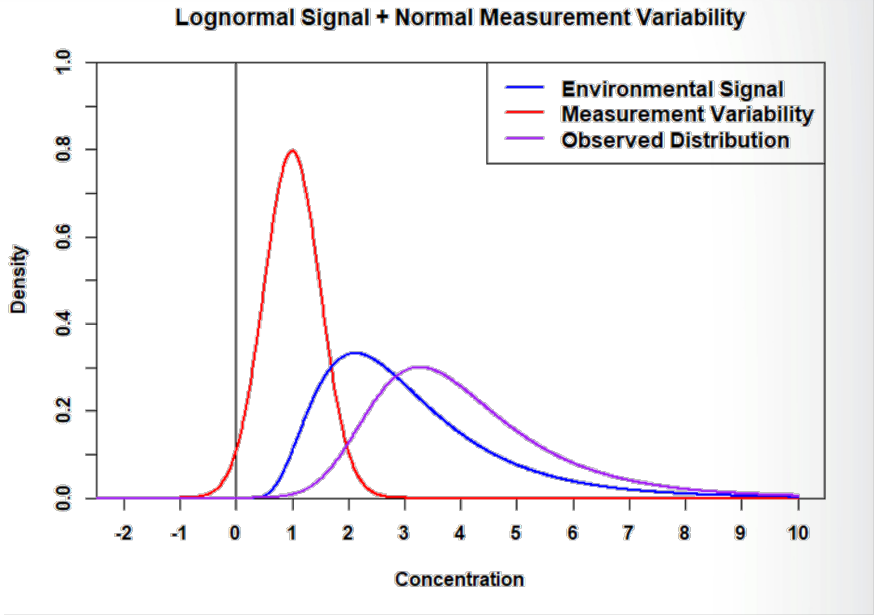
Problem: Program offices, states, and communities need improved computational methods to inform future DBP, Contaminant Candidate List, and Unregulated Contaminant Monitoring Rule decisions.

Action: Develop methods and models for robust estimation and prediction of contaminant occurrence, toxicity, and risk.

Results:

- Increased understanding of the impact of key statistical analysis decisions.
- Best practices to guide use of improved methods and models.
- Predictive models of combined exposure and cumulative toxicity.
- Determination of effect drivers.

Impact: Reduced bias and improved precision in estimation and model predictions; effect driver identification, fit-for-purpose grouping methodology, predicting toxicity of chemical mixtures/groups.



Product POCs: B.J. George and Jane Ellen Simmons (CPHEA)

Internal Partners: OST and OGWDW

Rules/Other: CCL, UCMR monitoring. DBP Rules, Chemical Contaminant Rules, Risk Assessment Methods

SSWR 7.3.2 Decreasing Uncertainty in Regulatory Decision Making

Problem: Lack of knowledge on unregulated emerging chemical and microbial contaminants increases uncertainty in regulatory decision making.

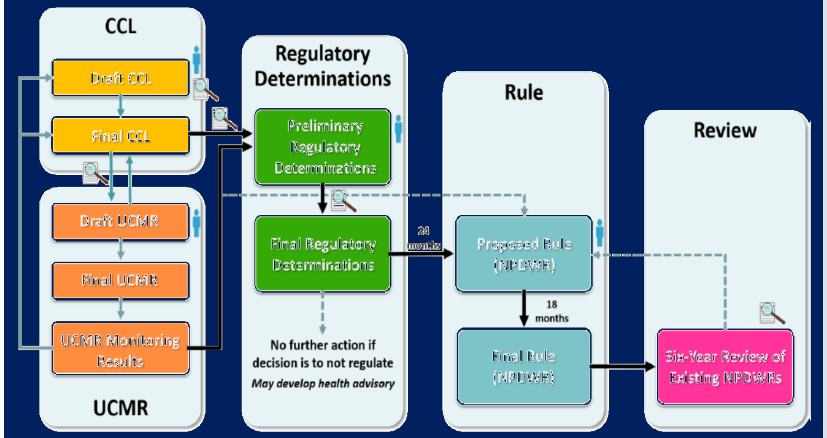
Action: Develop updated information on integrated dosimetry models of multi-route and multi-contaminant exposures, the evaluation of the importance of metabolism and the impact of susceptibility factors on dosimetry and toxicity, and quantitative methods for CCL priority pathogens.

Results:

- Improved understanding of the need to consider multi-route (oral, dermal, inhalation) and multi-contaminant exposures.
- Improved understanding of how xenobiotic metabolism and susceptibility factors impact toxicity and dosimetry.
- Development and use of experimental methods to evaluate key developmental endpoints observed in epidemiologic studies.
- Improved assessment methods for detection and quantification of priority pathogens including those on CCL and those that may be considered for future UCMR monitoring.

Impact: This product will provide OW with updated information to fill research gaps that impede/prevent regulatory determination.

SDWA – Process for Developing Drinking Water Standards



Product POC: Hodon Ryu (CESER)

Internal partners: OGWDW, OST

External collaborators: CDC

Rules/Other: CCL development, UCMR monitoring

SSWR 7.3.3 Filling Key Knowledge Gaps to Support and Enhance Regulatory Decisions for Chemical and Microbial Contaminants: 1. Chemicals

Problem: Critical data gaps increase uncertainty in regulatory decision-making and prioritization of contaminants either regulated or potentially regulated under the SDWA.

Action: Provide methods and models linking occurrence and effects information to aid OW, regional partners, and states in meeting EPA regulatory responsibilities under the CCL, UCMR, and 6-Year Regulatory Review mandates of the SDWA Amendments.

Results:

- Toxicokinetic and toxicodynamic data to inform identification of key DBPs and adverse outcome pathways contributing to DBP-associated bladder cancer.
- New data and analyses that will improve our understanding of the impact of alternative treatments on health endpoints.
- Assessments of dermal impacts of water contaminants.
- Measurement methods for priority CCL and CEC contaminants.
- Evaluation of point-of-use filters for contaminant sampling.
- Occurrence data for the prioritization of chemical contaminants for future CCLs.

Impact: This product will provide OW with updated information to fill research gaps that impede/prevent regulatory determinations.

Balancing and Minimizing Chemical Risks

Product POCs: Rex Pegram (CCTE), Maura Donohue (CESER)

Internal Partners: OGWDW, OST

External collaborators: Water Utilities

Rules/Other: CCL, UCMR, DBP Six-Year Regulatory Review

SSWR 7.3.3 Filling Key Knowledge Gaps to Support and Enhance Regulatory Decisions for Chemical and Microbial Contaminants: 11. Microbial

Problem: Critical data gaps increase uncertainty in regulatory decision-making and prioritization of contaminants either regulated or potentially regulated under the SDWA.

Action: This product will provide methods and models linking occurrence and effects information to aid OW, regional partners and states in meeting EPA regulatory responsibilities under the CCL, UCMR, and 6-Year Regulatory Review mandates of the SDWA Amendments.

Results:

- Validate analytical methods for CCL microbes for the next round of UCMR5/6 sampling- microbial.
- Method Comparison (culture and molecular) -*Legionella* and NTM.-UCMR.
- Examine Haloacetic acids (HAAs) and trihalomethanes (THMs) occurrence/toxicity with CCL microbes- SDWA and DBP rules.

Impact: Provide OW with updated information: filling data gaps that impede/prevent regulatory determination; and/or help strengthen or amend current rules.

Balancing and Minimizing Chemical Risks

Product POCs: Maura Donohue (CESER) and Rex Pegram (CCTE)

Internal Partners: OGWDW, OST

Rules/Other: CCL, UCMR

SSWR 7.3.4: Innovative Approaches for Evaluating Exposure to and Toxicity from Chemical Mixtures

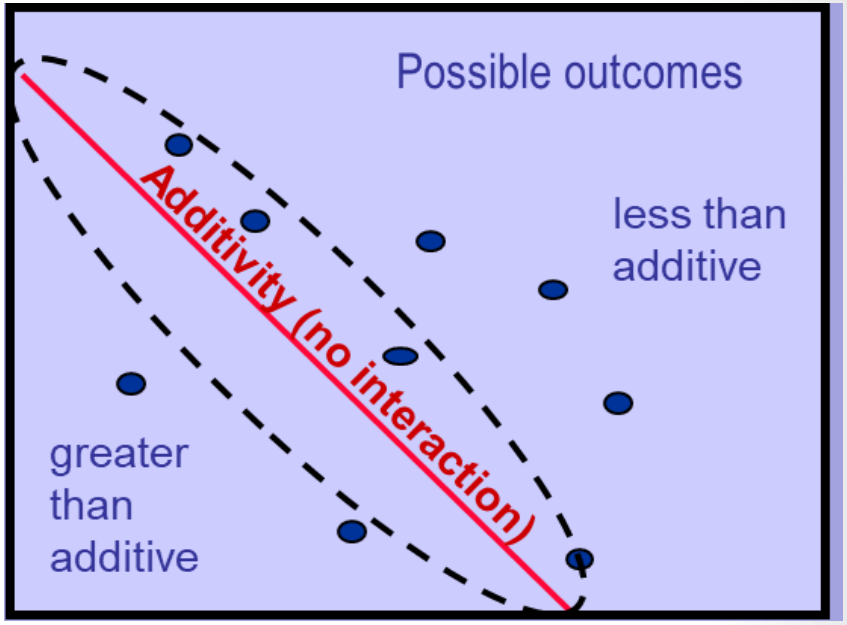
Problem: Program offices, states, and communities need improved exposure methods and computational toxicological methods for chemical mixtures to inform regulatory decisions.

Action: Development, application, evaluation of innovative tools to evaluate exposure to and toxicity from exposure to chemical mixtures.

Results:

- Characterization of the ability of gene-expression biomarkers to distinguish different mixtures.
- Evaluation of the consistency of the in vivo toxicity of trihalomethane mixtures to proportional response addition predictions.
- Consideration of the utility of these two approaches for different mixtures.

Impact: New tools for determining risk posed by chemical mixtures.



Product POCs: Jane Ellen Simmons (CPHEA) and Adam Biales (CCTE)

Internal Partners: OGWDW

External Collaborators: Consultants

Rules/Other: DBP Rules, CCL, Chemical Contaminant Rules, Risk Assessment Methods

Research Output 7.4

Resources and Tools Toward a Systems Approach for Maintaining Drinking Water Infrastructure Performance and Integrity

Lead: Regan Murray

SSWR 7.4.1: Water Infrastructure and Water Quality Models to Improve Water System Performance and Estimate Exposure to Contaminants

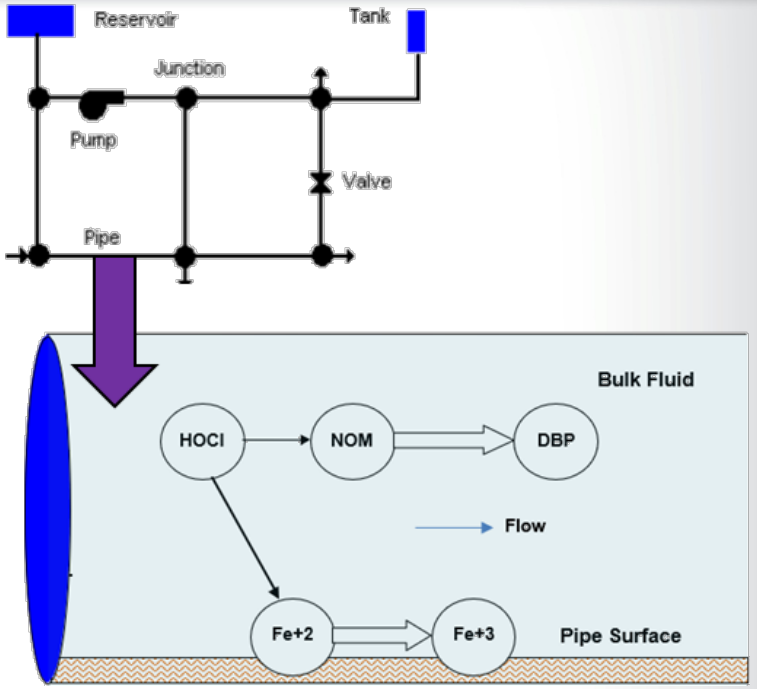
Problem: Improved water quality and hydraulic models are needed to support decision making at the community, state and regional level related to drinking water infrastructure and quality.

Action: The water quality component of the EPANET software will be updated to improve the ability of users to model complex reactions in drinking water and premise plumbing systems (e.g., DBPs). Experimental studies will be conducted to validate pressure and dispersion models contained within EPANET.

Results:

- Improved multi-species water quality model for EPANET software with updated user interface, examples, and manual
- Development of 1D and 2D dispersion models for laminar flow regimes and studies to determine dispersion coefficients
- Experimental studies to validate pressure dependent demand models in EPANET

Impact: Updated systems analysis models, tools and information will be used by drinking water systems around the world to solve complex infrastructure and water quality issues.



Product POC: Feng Shang (CESER)

Internal Partners: OGWDW

External Collaborators: Argonne National Laboratories

SSWR 7.4.2: Treatment Technologies to Meet the Needs of Small Systems

Problem: Small water systems have unique challenges including limited staffing, lack of specialized technical expertise, and fewer financial resources.

Action: Treatment technologies will be developed, modified and optimized to achieve the desired removal of regulated contaminants (e.g., nitrates) and contaminants of concern (e.g., manganese) in innovative and cost-effective ways. The technologies will be evaluated at the pilot scale and in full scale demonstrations in partnership with communities, EPA Regions, and states and territories, such as Iowa, Ohio, and Puerto Rico.

Results:

- Pilot-scale biological treatment studies for ammonia removal
- Nitrate removal through anaerobic biological denitrification pilot
- Bench-scale evaluation of the reduction of nitrate by sulfur
- Demonstration of cost-effective technologies in Puerto Rico

Impact: This work will develop approaches that can be used sustainability by small systems nationwide.

Product POC: Dan Williams (CESER)

Internal Partners: Regions 2 and 5

External Collaborators: City of London, OH; state of Ohio; Puerto Rico

SSWR 7.4.3: Water Distribution System Integrity and Performance Research

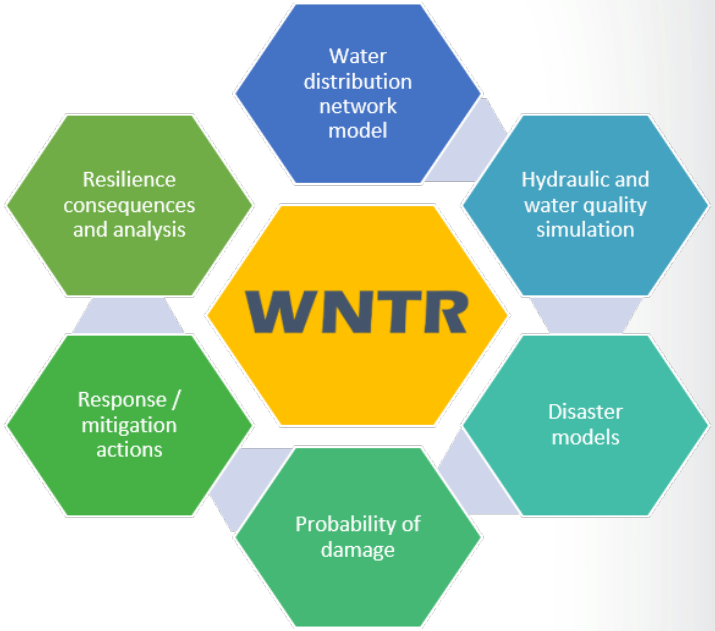
Problem: Faced with the challenges of aging infrastructure, natural disasters, environmental emergencies, and changes in water use, communities need tools to help prioritize infrastructure repairs.

Action: This product will develop an EPA website summarizing our applied science to improve drinking water infrastructure integrity, resilience, and performance, highlighting ORD research, tools, and data resources. In addition, case study publications will demonstrate the use of EPA tools to solve infrastructure problems.

Results:

- Case study application of the Water Network Tool for Resilience (WNTR) for City of Pittsburgh
- Case study application of security tools with DC WASA
- EPA water system integrity and resilience website

Impact: Information, data, and tools will be readily accessible to communities, states, and Regions.



Product POC: Robert Janke (CESER)

Internal Partners: OGWDW, R3

External Collaborators: Argonne National Laboratories, Sandia National Laboratories

Questions?

Charge Question 1

The SSWR research program is implementing drinking water and distribution system research focused on lead/copper control, management of disinfection by-products (DBPs), and opportunistic pathogens. These issues are especially challenging for small systems and some environmental justice communities.

What suggestion(s)/recommendation(s) does the Subcommittee have on ORD's implementation of its drinking-water and distribution research, and in particular on how these research activities can be comprehensively integrated to ensure safe disinfectant levels, while minimizing or eliminating exposure to lead, opportunistic pathogens, and DBPs in small treatment and distribution systems and in disadvantaged communities?