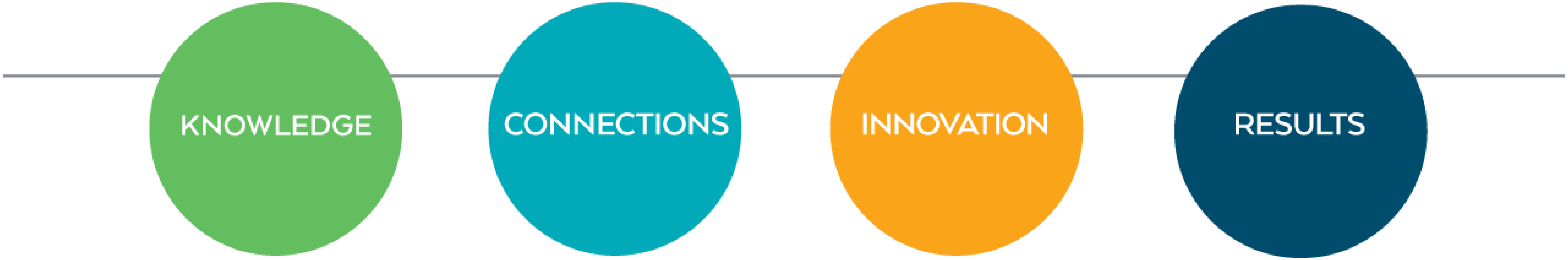
WateReuse Florida Membership Meeting

advancing the science of water®

What does The Water Research Foundation do?

Identify, prioritize and fund research for the water sector.

Accelerate the adoption of new technologies in the water sector.



Convene experts and sector representatives to identify and collaborate on priority water research.

Educate decision-makers on the science of water.

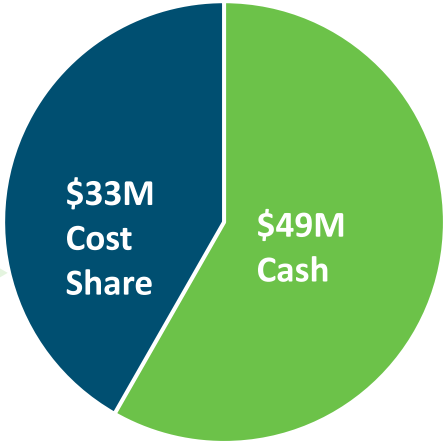
advancing the science of water

Funded Research

$82M

Contractually Funded Research

Managed by 54 Staff



Research Portfolio

- **1** Federal Contracts
- **3** Private Grants
- **6** Federal/State Grants
- **72** Co-funded Projects

151 Co-funders

264 Active Projects

Subscribers

- **1030** UTILITIES
- **79** CONSULTANTS
- **57** MANUFACTURERS

Research & Innovation Programs

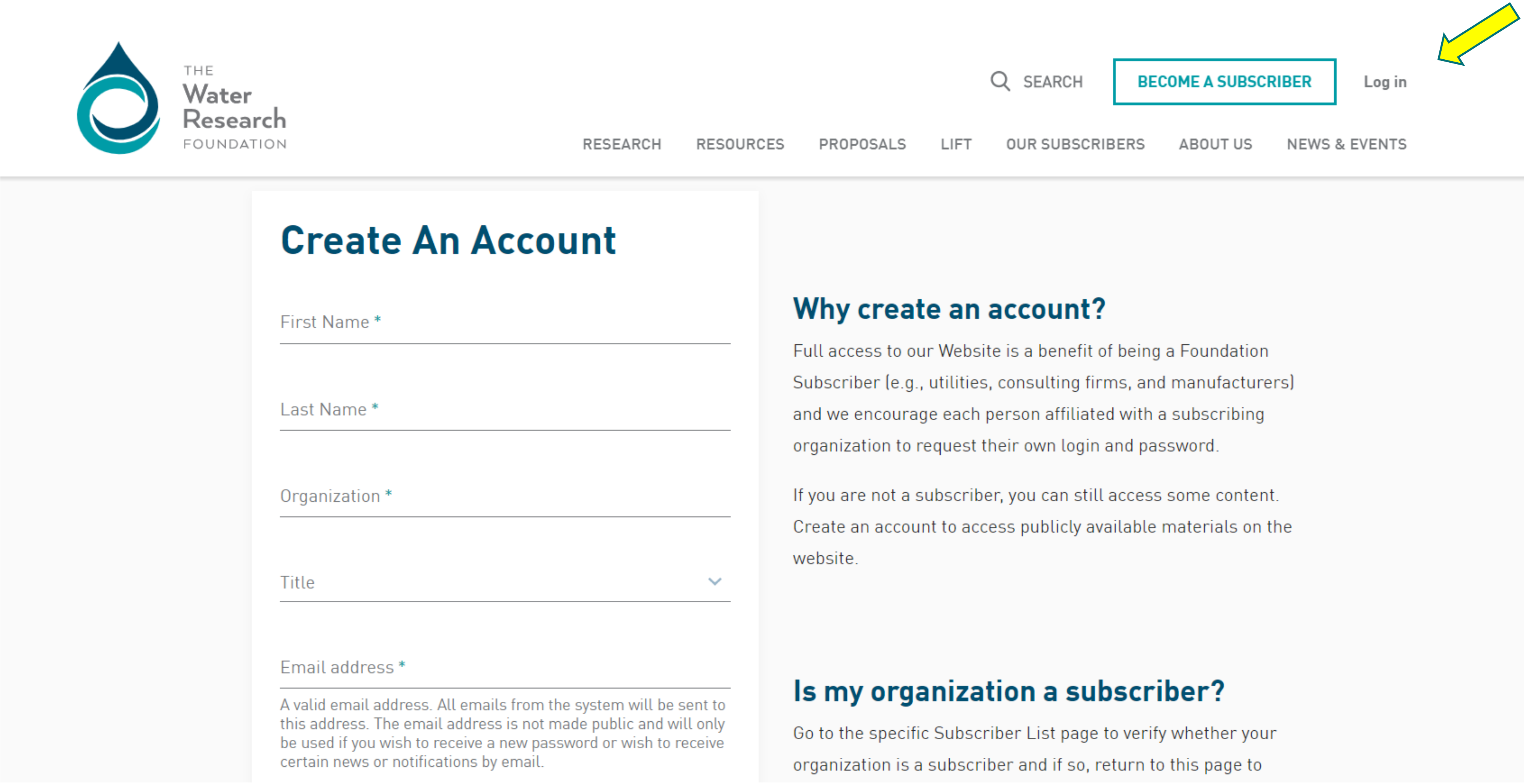
- Research Priority
- Tailored Collaboration
- Emerging Opportunities
- Grants/Awards *Paul L. Busch Award*
- Facilitated Research
- Unsolicited Research

$.84 OF EVERY DOLLAR supports program services

* As of October 18, 2021

Account Access

www.waterrf.org



Agenda

1:00	WateReuse Florida Board Meeting
1:45	Kerry Kates and Mike Sweeney – Welcome and Introductions
1:50	Overview of WRF's Reuse Research Efforts – Julie Minton, WRF Research Unit Leader
2:10	Water Quality Monitoring for Potable Reuse – Erin Partlan, WRF Innovation Program Manager
2:30	Water Reuse in Agriculture and Irrigation – Anne Thebo, Pacific Institute
2:50	Break
3:00	UV and UV/AOP for Water Reuse – Alice Fulmer, WRF Regional Liaison
3:20	Biologically Active Filtration for Potable Water Reuse – Gaya Ram Mohan, Gwinnett County Department of Water Resources
3:40	Discussion of WRF Reuse Research Needs and Opportunities for Engagement - Lyndsey Bloxom, WRF Research Program Manager
4:00	PFAS Treatment and Management Strategies – Alice Fulmer, WRF Regional Liaison
4:30	Adjourn

WRF Reuse Team Introductions

Julie Minton
Research Unit Lead

Lyndsey Bloxom
Research Program Manager

Water Quality Monitoring for Potable Reuse

Erin Partlan, Ph.D.

Innovation Program Manager

Water Research Foundation

Water Reuse in Agriculture and Irrigation

Anne Thebo, Ph.D.

Senior Researcher

Pacific Institute

UV and UV/AOP for Water Reuse

Alice Fulmer, Regional Liaison

WateReuse Florida Membership Meeting

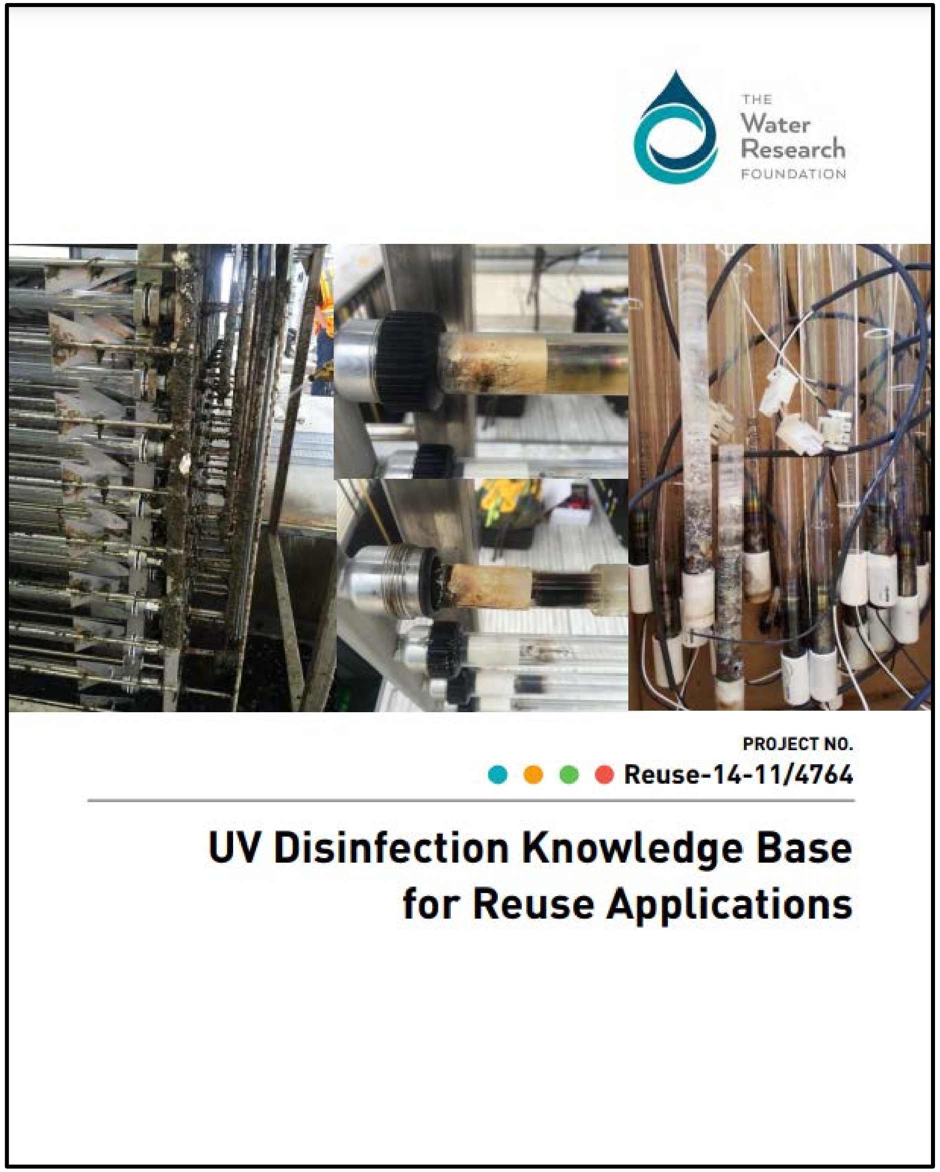
3/31/22

Value of UV to Water Reuse

- Ultraviolet (UV) light used for reuse water disinfection for almost 30 years
- Potable and non-potable reuse applications
- Robust disinfection of all known pathogens, including virus and protozoa
  - *Giardia*, *Cryptosporidium*, Enteric virus
- Destruction of NDMA by UV photolysis
- Destruction of contaminants such as 1,4-dioxane by advanced oxidation (AOP, e.g., UV with H2O2)

UV Knowledge Base

- Published 10/23/20
- Carollo Engineers, Inc.
- Principal Investigator: Harold Wright
- Co-Principal Investigator: Andrew Salveson
- Project Team: Traci Brooks, Mark Heath, Ed Wicklein



Background

- National Water Research Institute (NWRI) and WRF published the Ultraviolet Disinfection Guidelines for Drinking Water and Water Reuse in 2000
  - NWRI updated in 2012
- Audit of a UV system used for potable reuse in 2012 revealed issues:
  - Excessive lamp aging and fouling, UV dose monitoring not using UV intensity sensors, bypass of untreated effluent past the UV reactors, and operation with failed lamps
- Questions:
  - How is UV disinfection working with water reuse?
  - What are the issues and what recommendations can be made to improve the application of the technology?

Objectives and Approach

- Benchmarking the performance of UV systems
- Developing recommendations for UV implementation
- Developing troubleshooting tools that utilities can use to quantify and optimize UV system operation
- Conducted UV system performance audits at 16 participating UV facilities
- Used UV dose models based on Computational Fluid Dynamics (CFD) to evaluate the impact of hydraulics and lamp failure on UV dose delivery and high-level disinfection
- Used Supervisory Control and Data Acquisition (SCADA) from UV facilities to evaluate the efficiency of UV dose monitoring and control

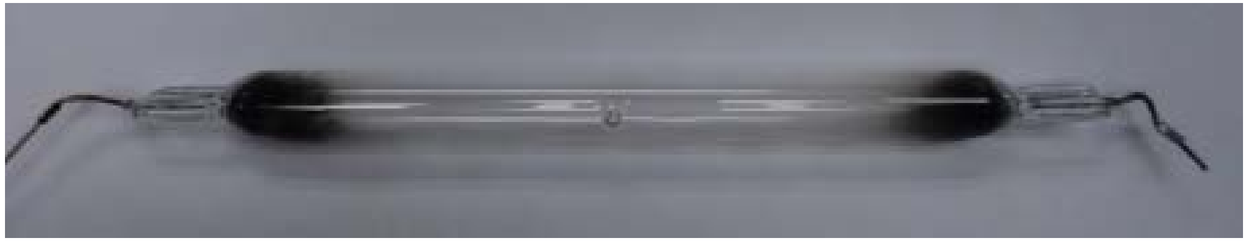
Participants

- Hillsborough County, FL
- Pinellas County, FL
- City of Grants Pass, OR
- Clark County Water Reclamation District, NV
- Olivenhain Municipal Water District, CA
- City of Yuma, AZ
- City of Santa Rosa, CA
- Victor Valley Wastewater Reclamation Authority, CA
- EPCOR Water Services, Edmonton, CAN
- Pierce County Public Works and Utilities, WA
- City of Petaluma, CA
- Xylem, WEDECO
- Calgon Carbon
- Aquionics/Berson

UV System Audits

- Visual inspection
- Evaluation of lamp aging and sleeve fouling using a custom optics bench
- Evaluation of indicator microbe UV dose response using a collimated beam apparatus and indicator microbe inactivation by the UV reactor
- Evaluation of the UV dose monitoring algorithm and instrument accuracy
- Review of operating costs and maintenance activities

Visual Inspections



Issues included:

- Algae and biofilm buildup on the channel walls and reactor components
- Water in the quartz sleeves housing the lamps which led to corroded lamp connections and internal sleeve fouling
- Darkening of the lamp envelope near the electrodes with lamp aging
- Sleeve fouling (22-99%)
- Misaligned modules and wipers
- Damaged and worn wiper mechanisms

Sensors

- Accuracy of duty UV intensity sensors and online UVT monitors was measured by comparison to a reference UV intensity sensor and a calibrated portable UVT monitor
- Data showed that UV intensity sensors can provide an accurate input to the UV dose algorithm and that reference UV sensor checks are useful for identifying failed UV sensors
- Differences between online and bench UVT measurements were within ± 2% per cm with seven of the 16 UV audits and within ±5% per cm with 11 of the 16 UV audits

Maintenance

- UV systems are often described as having low maintenance requirements
- Plant staff at many of the facilities reported that UV system maintenance was greater than expected
- Maintenance includes replacing UV lamps at the end of lamp life, failed lamps, ballasts, wipers and seals, cleaning banks using acid baths, and draining and removing biofilm was the channel walls

Evaluation of SCADA Data

- Indicated that facilities do not record all the information needed to evaluate UV system performance
- SCADA should collect information on channel flows, UVTs, bank ballast power settings, bank lamp hours, bank UV intensity sensor readings, UV dose delivery, and any other information that impacts UV dose delivery such as water level
- UV sensor signals showed short- and long-term trends
- Short-term trends often correlated with UVT
- Can use SCADA calculations to provide confidence that the UV system is operating as intended as well as identify issues that should be addressed

Tools for UV System Trouble Shooting

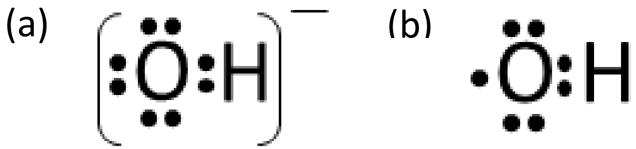
1. Use of CFD-based UV dose models quantify the effects of RED bias and lamp failure and optimize UV system hydraulics
2. An optics bench that can be used to quantify lamp aging and fouling
3. Calculations that use UV sensor readings to quantify lamp aging and fouling
4. Collimated beam apparatus that can be used to identify the UV dose required to meet permit levels
5. A high-volume microbial assay that evaluates how well a UV system is achieving indicator microbe inactivation
6. Validation data analysis and spot check bioassays that can be used to confirm poliovirus inactivation for high level disinfection
7. Use of reference UV intensity sensors and portable online UVT monitors to confirm the accuracy of duty UV intensity sensors and online UVT monitors
8. Analytical methods for evaluating the UV dose algorithm used by the UV system that can also be used to analyze SCADA data to identify trends and issues

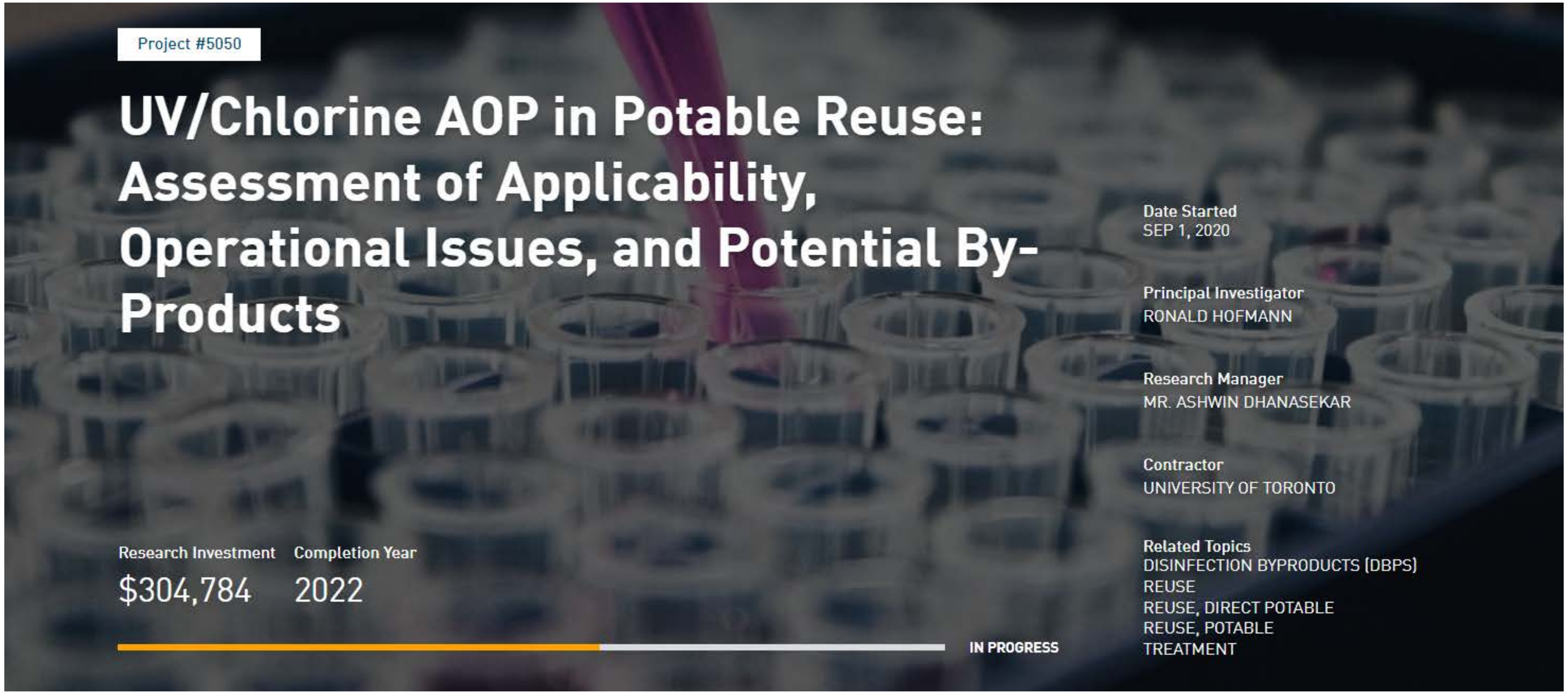
Conclusions and Recommendations

- UV dose-response of indicator microbes measured with the UV audits show that permit levels for the UV system effluents were met at UV doses well below the design UV doses
- Several recommendations for UV systems used for non-potable reuse are identified in the report related to:
  - UV dose monitoring approaches, addressing lamp failures, verifying the accuracy of UVT monitors and UV intensity sensors, conducting spot check bioassays, and others
- Recommends that NWRI UV Guidelines be updated to address issues identified and provide consistency with UVDGM and other resources

UV Advanced Oxidation Process (UV-AOP)

- Taste and odor control, destruction of regulated contaminants and CECs, reuse
- UV-AOP can earn 6-long inactivation credit for virus, *Cryptosporidium* and *Giarda*
- UV-H_2O_2 / UV-O_3 / UV-Cl_2
- Recent analysis indicated that 76% of active-design and under-construction UV-AOP projects were pursuing UV-Cl_2 versus UV-hydrogen peroxide (H_2O_2; Festger et al. 2021)
- UV-Cl_2 differences from UV-H_2O_2 AOP include:
  - Different optimum water quality conditions
  - Different efficiencies when using low-pressure high-output (LPHO) and medium-pressure (MP) UV lamps
  - Potential formation of by-products





- Draft report under review (DBP studies delayed due to COVID)
- Co-Principal Investigators:
  - Erin Mackey, Brown and Caldwell
  - Ron Hofmann, University of Toronto
- Partner: California State Water Resources Control Board

Objectives

- To consolidate information about the state of the art of UV/Cl-AOP in a single reference applicable to utilities, non-expert consultants, and regulators
- Report on the basic science of UV/Cl-AOP, as well as highlight practical issues related to its implementation and operation
- Compare and contrast UV/Cl-AOP to alternative AOPs in the context of both RO- and ozone/biofiltration-based reuse treatment trains
- Highlight current knowledge about by-product formation, and conduct experiments to fill DBP data gaps and to explore critical areas of unknowns (e.g., unregulated DBPs, and overall toxicity assessment)

Participants

- Calgon Carbon
- City of Cornwall (ON)
- Hampton Roads Sanitation District (VA)
- Los Angeles Department of Water and Power (CA)
- Orange County Water District (CA)
- Peel Region (ON)
- City of Roseville (CA)
- San Diego Public Utilities Department (CA)
- Southern Water (UK)
- Trojan Technologies
- Water Replenishment District of Southern California (CA)
- Region of Waterloo (ON)
- Xylem

Deliverables

- Guidance Manual
- Literature Review
- $UV\text{-}Cl_2$ and $UV\text{-}H_2O_2$ web-based application tool
  - Will allow a non-expert stakeholder to explore the effect of water quality parameters on the relative performance of UV-Cl vs. $UV\text{-}H_2O_2$ AOP, assuming an ideal UV dose distribution
- Two $UV\text{-}Cl_2$ case studies

Key Considerations and Take Aways

Topic	Key Considerations	Recommendations
pH	Net availability of •OH (and other radicals) at lower pH than at higher pH	Use low pH for LPHO + chlorine applications
Alkalinity	Alkalinity > 20 mg/L as $CaCO_3$ can impact scavenging	If alkalinity is high, consider upstream reduction strategies to further reduce alkalinity
Bromide	High levels can result in DBP formation	Carefully review water quality and potential for bromide in the source water, including possibility of infiltration. Include bromide removal as needed in upstream process, or mitigation efforts.
Ammonia and nitrate	Will combine with free chlorine to form chloramines	Consider dose location and chlorine demand tests as needed

Topic	Key Considerations	Recommendations
Nitrite	>1 mg/L as N has significant effect on UV-H_2O_2	Consider in chlorine vs peroxide decision
Organic matter	May be present in non-RO applications	Bench scale testing to determine impact of scavenging on UV and oxidant dose
Monitoring	Complicated and robust	Work with utility, design engineer, and regulator to determine the appropriate monitoring and control strategies at the facility.
Monitoring HRT	Dynamic chemistry complicates monitoring	Designer should attempt to match HRT of the monitor sample line and travel time to the reactor to predict changes in chemistry (free chlorine and effects on UVT)
Lamp and Oxidant Type	Chlorine absorbs UV light better than peroxide at any wavelength and could suggest better efficiency with MP lamps.	Consider target parameters in selection of MP vs LPHO lamp. Consider bench and pilot scale testing of MP + chlorine applications

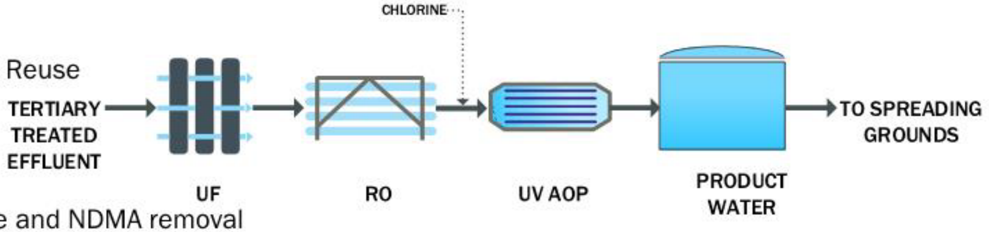
Topic	Key Considerations	Recommendations
Operating costs	UV-H_2O_2 generally incur higher operating costs than UV-Cl_2	Consider quenching requirements for the application, which has a significant impact on operating costs.
Chemical costs	Sodium hypochlorite chemical costs are higher than peroxide	The designer should consider water quality and chlorine dose required to achieve desired free chlorine residual to determine the point at which hydrogen peroxide may be more cost effective
Testing requirements	Bench and pilot scale testing may not inform process unit scaling	Bench scale testing may help inform which oxidant to use for design but more research should be done to better understand how to scale up for full scale
Startup testing requirements	Should validate intended operational strategy and control	Be prepared with reference checklist and important considerations. Recognize that dynamic chemistry may affect results

Case Study: Water Replenishment District of Southern California – Albert Robles Center

WRD ARC is one of the first applications of UV/Cl_2 for advanced treatment in the U.S. The WRD ARC Facility produces 14.9 MG of advanced treated water daily.

Application

Indirect Potable Reuse



Goals

- 1,4-Dioxane and NDMA removal
- 6-log virus, *Cryptosporidium*, and *Giardia* inactivation

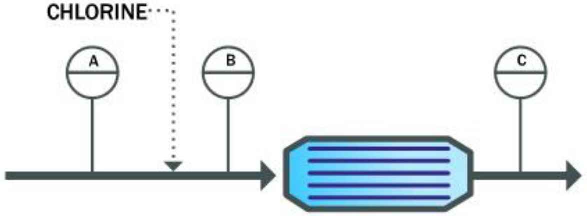
WRD ARC UV AOP Design	
Criteria	Value
UV AOP Influent pH	6.0
Number of UV Trains	2
Capacity per UV Train	7.45 MGD
Reactors per Train	6
Lamps per Train	432
Power Draw per Lamp	0.24 kW
Lamp Type	LPHO
Design UVT	96%
Free Chlorine Concentration	1.5 mg/L
1,4-Dioxane Reduction	0.5 log
NDMA Reduction	1.67 log

Operation

Design: Monitor free chlorine and dose-pace chlorine to feed 1.5 mg/L free chlorine to UV system

Current: Operate to threshold UV and chlorine dose. EED leads to adjustment of delivered power-based flow rate

Monitoring Strategy



Point A: UVT, ammonia/ monochloramine, pH, flow

Point B: free chlorine, total chlorine

Point C: UVT, free chlorine

Maintenance

- Chlorine analyzers serviced twice daily
- Online monitor calibration checks

Lessons Learned

- Chemical and UV dose thresholds can result in over-dosing and more frequent manual adjustment. WRD is working with regulators to upgrading the control strategy to a UV power and free-chlorine pacing strategy based on a target contaminant treatment objective
- Match analyzer sample line and process line hydraulic retention time for accurate chlorine measurement
- Use UV-resistant piping upstream and downstream of the UV reactor where UV light can penetrate.

Facility Permit:

NPDES for spreading
DDW for drinking water

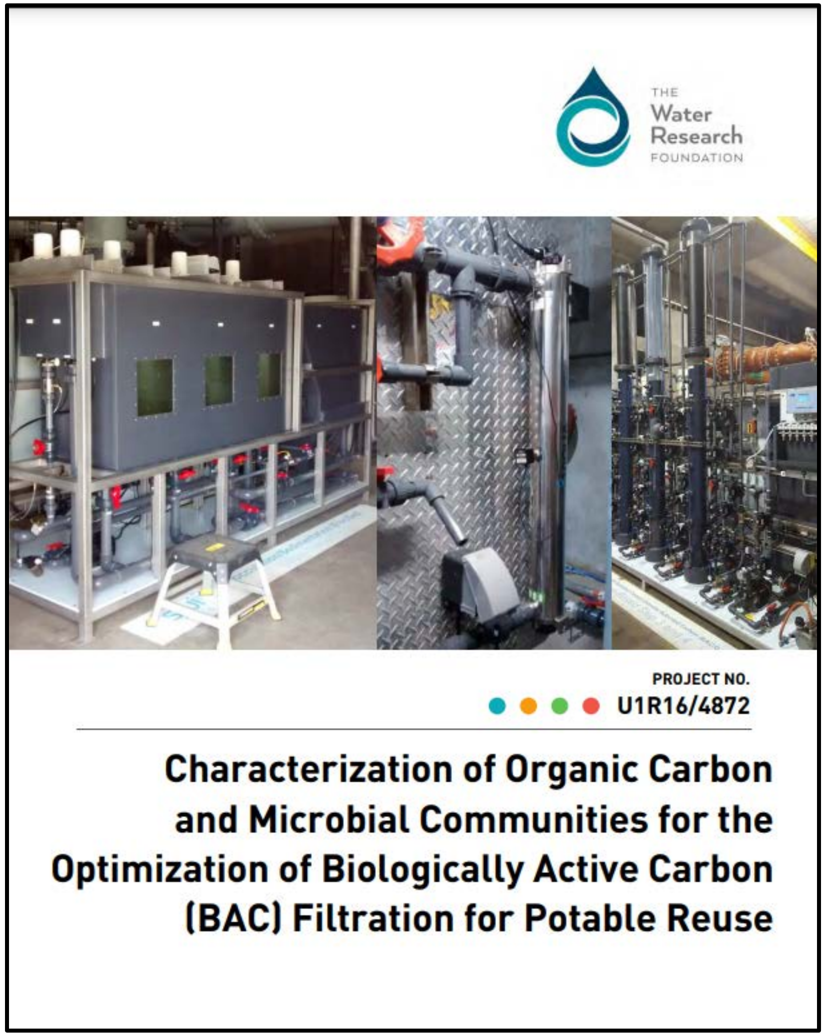
Regulatory Requirements

- 15-minute variance on reporting parameters
- <0.1 mg/L total chlorine in discharge for NPDES
- DDW does not currently allow dose pacing for chlorine

CCPs (Operation and Reporting): pH, EED, free chlorine, UVT

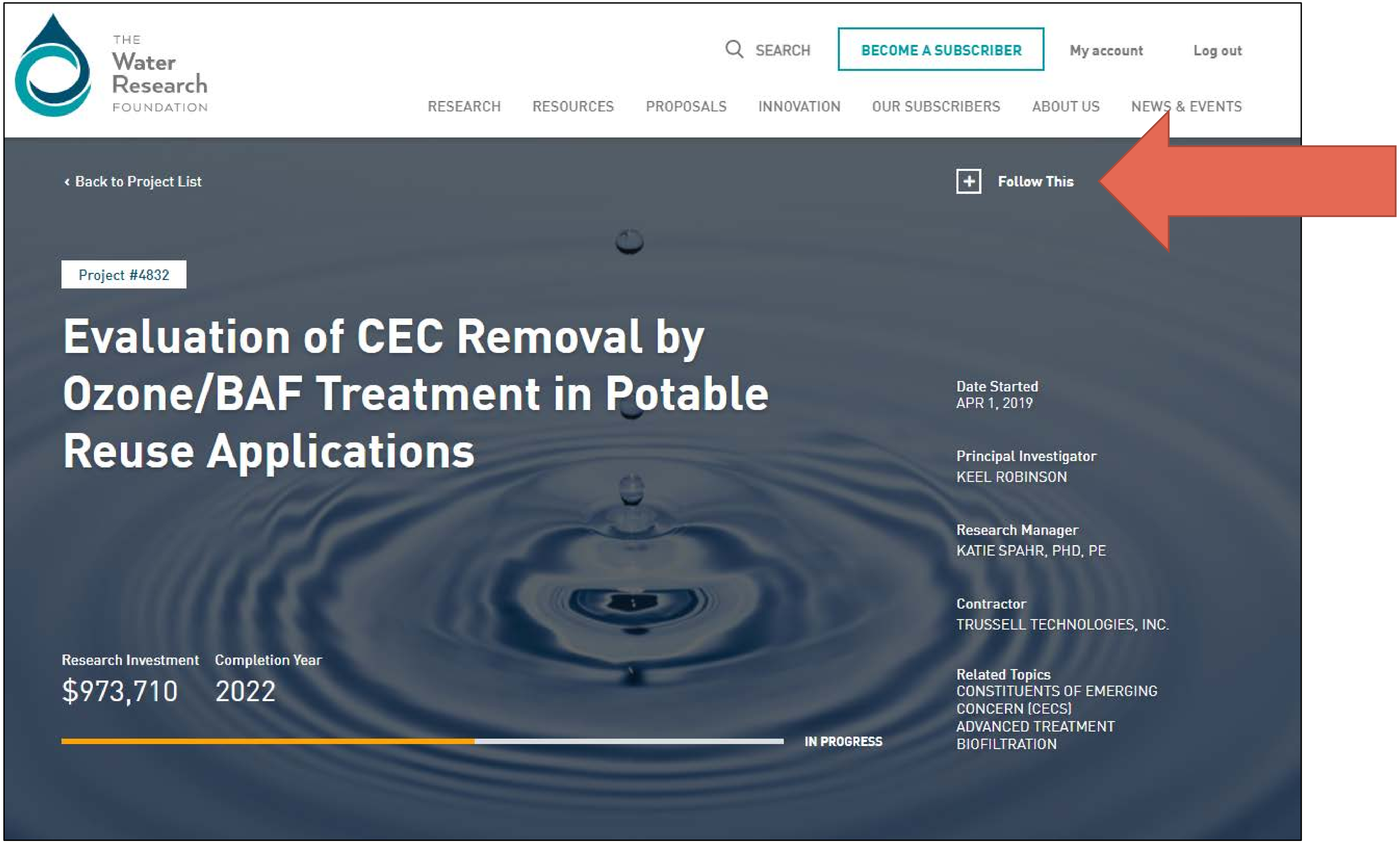
Biologically Active Filtration for Potable Water Reuse

- Published 6/12/2020
- Principal Investigators:
  - Amy Pruden, Peter Vikesland, Marc Edwards, Kang Xia, Virginia Tech
- Collaborators:
  - Charles Bott, Chris Wilson, HRSD
  - Larry Schimmoller, Jacobs
- Evaluated the performance of HRSD’s SWIFT for removal of pathogens, nutrients, organic pollutants, and CECs
- Applied biomolecular analysis and shotgun metagenomic sequencing to profile BAC microbial communities
- Indicates that O3/BAC is promising for fit-for-purpose advanced water treatment



Optimization of Ozone/BAC for Potable Reuse

- Published 2/9/22
- Zia Bukhari, Sunayna Dasgupta, and Ruth Marfil-Vega, American Water
- Vijay Sundaram, Stantec
- Co-Sponsors:
  - Stantec
  - American Water
- Compared full-scale BAC and RO by measuring TOC, DOC, AOC, UV, fluorescence excitation emission matrix [FEEM], ammonia, nitrate, nitrite, ortho-phosphate, chlorite, chlorate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Project #4832
Evaluation of CEC Removal by Ozone/BAF Treatment in Potable Reuse Applications
Date Started
APR 1, 2019
Principal Investigator
KEEL ROBINSON
Research Manager
KATIE SPAHR, PHD, PE
Contractor
TRUSSELL TECHNOLOGIES, INC.
Related Topics
CONSTITUENTS OF EMERGING CONCERN (CECS)
ADVANCED TREATMENT
BIOFILTRATION
Research Investment
$973,710
Completion Year
2022
IN PROGRESS

Evaluation of CEC Removal by Ozone/BAF Treatment in Potable Reuse Applications (4832)

- **PI:** Keel Robinson (Trussell)
- **Project Team:**

  AECOM, Stantec, Technical University of Munich, Data Instincts

Project Tasks

Task 1: Prioritized Literature Review on Ozone/BAF

Task 2: Develop Health-based Water Quality Goals for Ozone/BAF

Task 3: Synthesis of Results and Additional Testing

Task 4: Develop and Design Operational Guidelines

Task 5: Develop Public Outreach Documents

WRF Research Program Manager: Katie Spahr

Ozone-BAC in Potable Reuse Application at Gwinnett County, GA

Gayathri Ram Mohan, Ph.D., P.E.

Senior Research Scientist

Gwinnett County Department of Water Resources

PFAS Treatment and Management Strategies

Alice Fulmer, Regional Liaison

WateReuse Florida Membership Meeting

3/31/22

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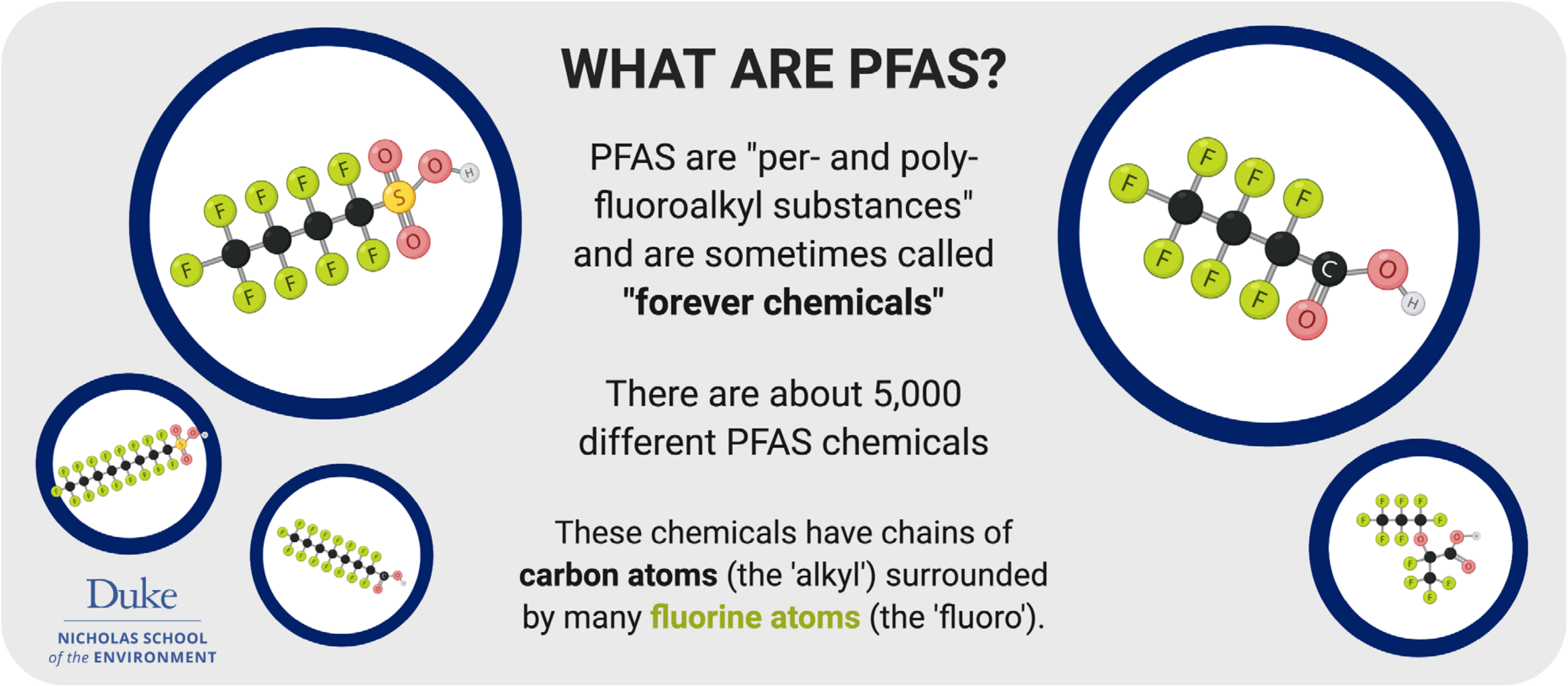
The Daily Show with Trevor Noah, March 5, 2020



[What-are-PFAS-general-2.png (2978×1418) (duke.edu)](https://nicholas.duke.edu)

PFAS Family of Chemicals

TERMS

PFC = Perfluorinated Compound

PFAS = Perfluoroalkyl or Polyfluoralkyl Substance

PFOA = Perfluorooctanoic Acid
$C_8HF_{15}O_2$

PFOS = Perfluorooctane Sulfonate
$C_8HF_{17}O_3S$

GenX = $C_6H_4F_{11}NO_3$

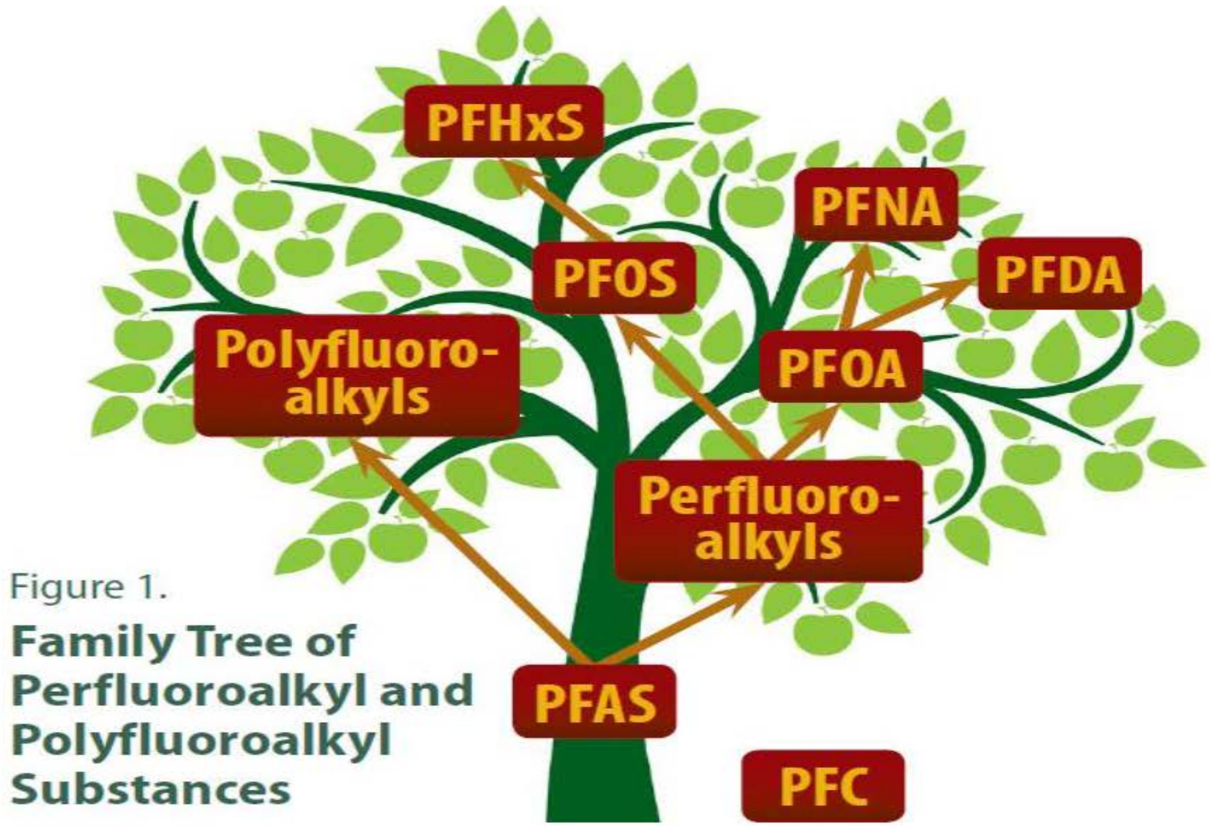
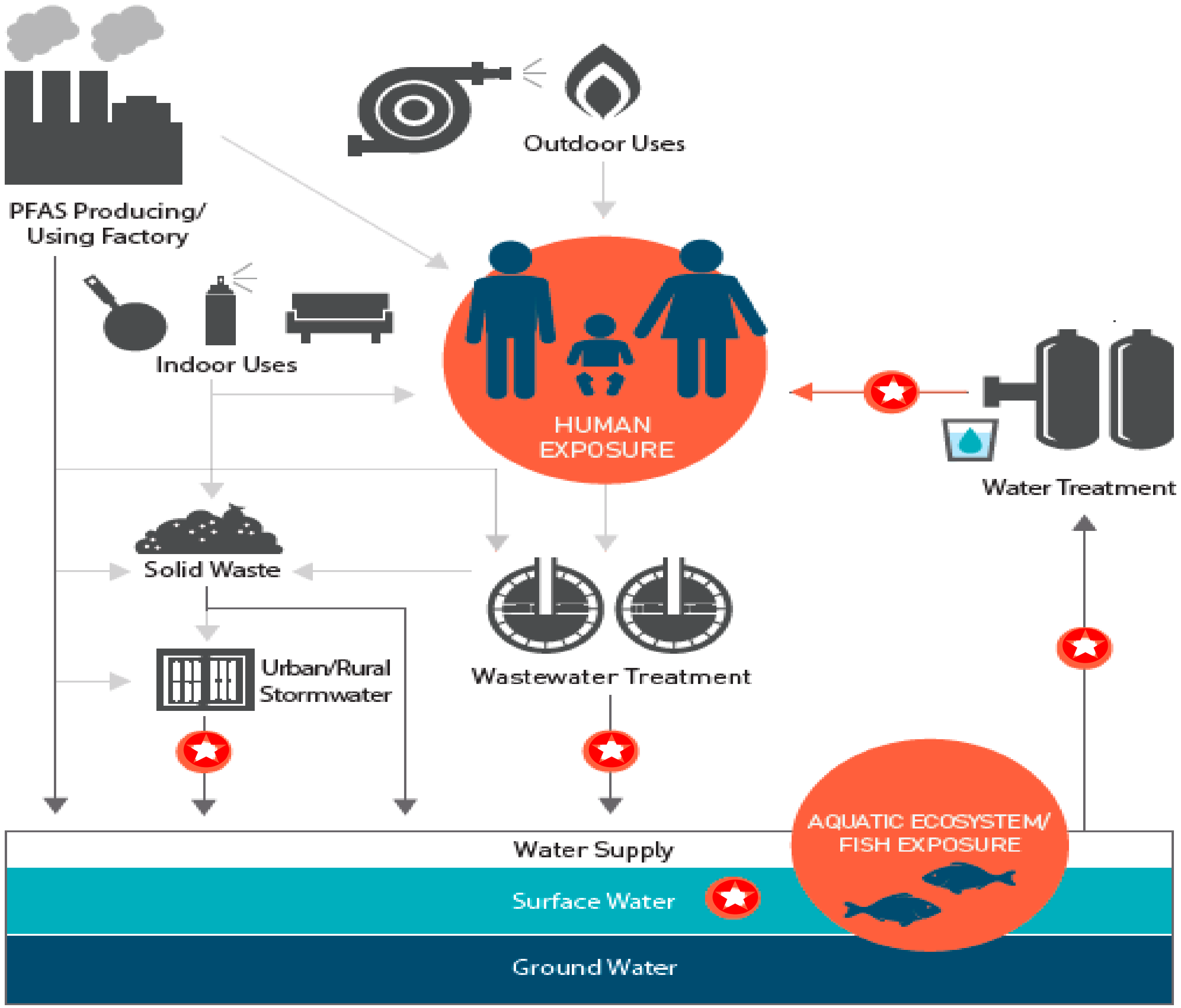


Figure 1.
Family Tree of Perfluoroalkyl and Polyfluoroalkyl Substances

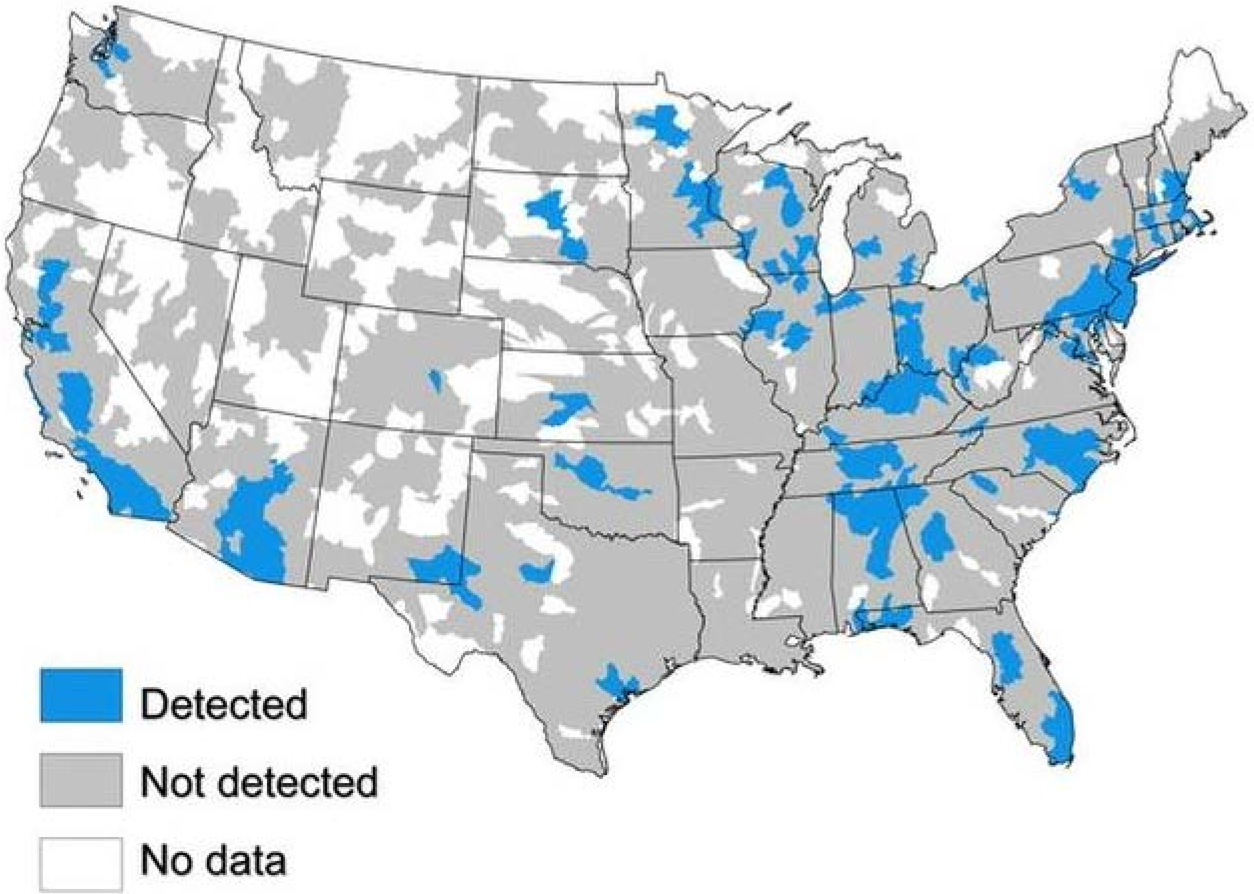
Source: https://www.atsdr.cdc.gov/docs/17_278160-A_PFAS-FamilyTree-508.pdf


PFAS Uses
Fire fighting foams
Fast food packaging
SHAMPOO
Personal care products
Paints
Photographic processes
Stain resistant products
Mist suppressant in metal plating industry
Aviation hydraulic fluids
Floor polishes
Non-stick cookware
Mining and oil well surfactants
Pesticides and herbicides

Human Exposure to PFAS



PFAS Occurrence

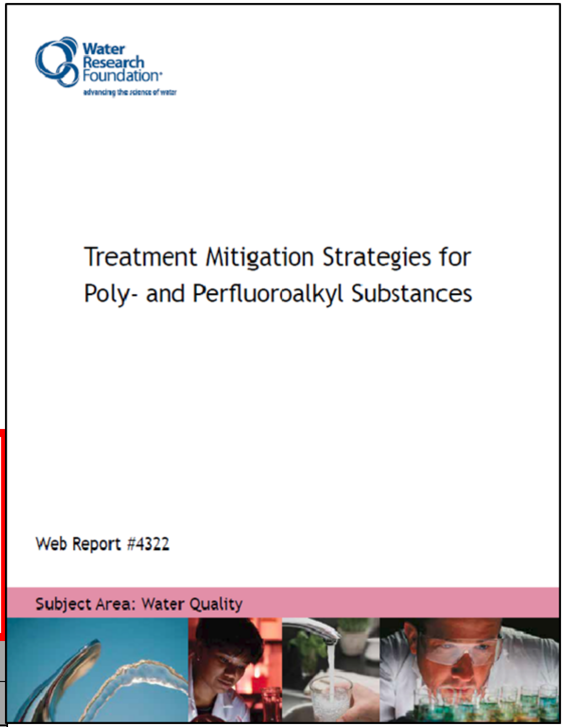


Source: Hu XC et al., Environmental Science & Technology Letters

PFAS Removal Summary

Removal <10%	Removal 10-90%	Removal > 90%

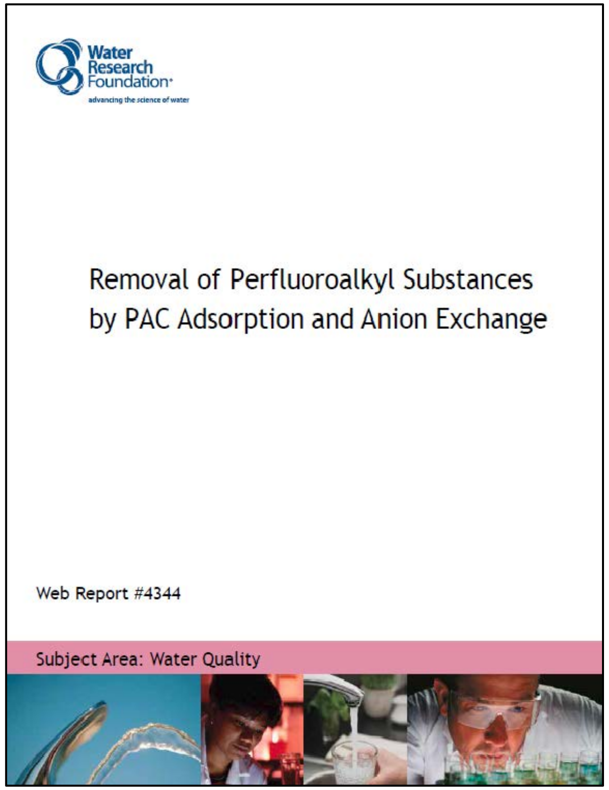
Compound	M.W. (g/mol)	AER	COAG/DAF	COAG/ FLOC/SED/ G- or M-FIL	AIX	GAC	NF	RO	MnO_4, O_3, ClO_2, Cl_2, CLM, UV, UV-AOP
PFBA	214	assumed	assumed						
PFPeA	264								
PFHxA	314								
PFHpA	364								
PFOA	414								
PFNA	464		unknown		assumed	assumed			
PFDA	514		unknown		assumed	assumed			
PFBS	300								
PFHxS	400								
PFOS	500								
FOSA	499	unknown	unknown		unknown	assumed	unknown	assumed	unknown
N-MeFOSAA	571	assumed	unknown		assumed	assumed	assumed		unknown
N-EtFOSAA	585		unknown		assumed	assumed	assumed		unknown[a]

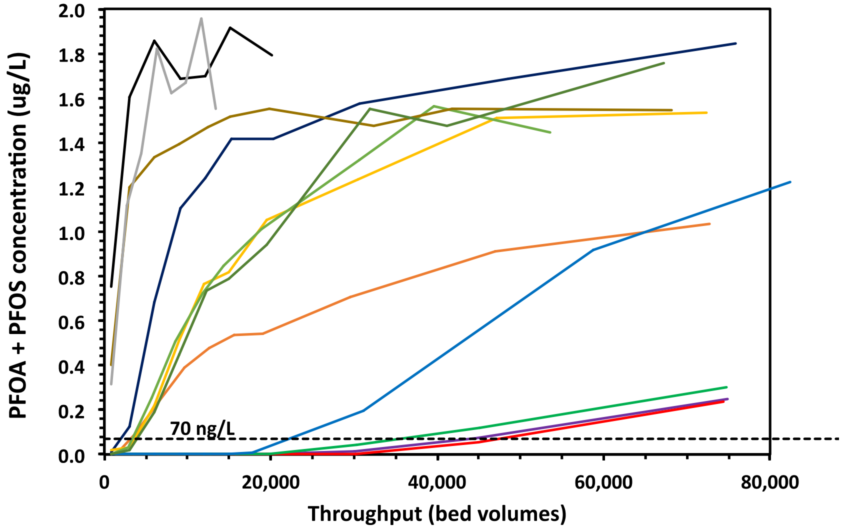


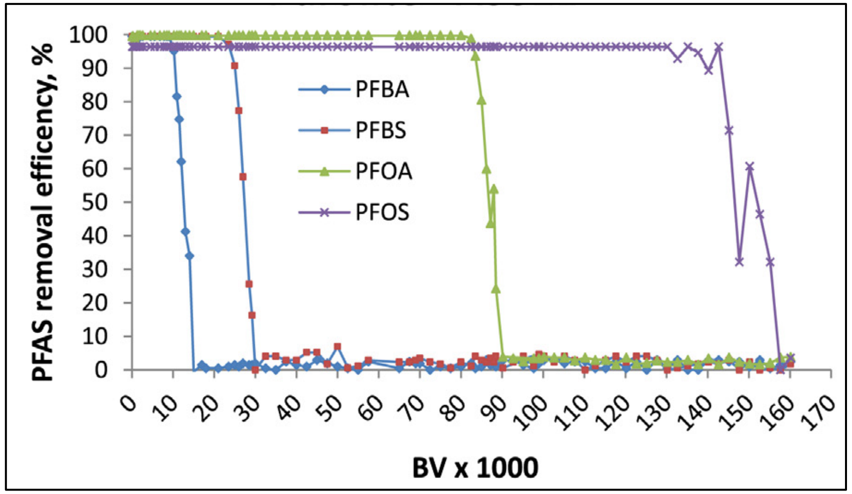
Source – WRF Project 4322 Final Report, full-scale removal testing at WTPs

Adsorption – GAC, PAC and AIX

- GAC/AIX media selection important
- Residuals require disposal or further treatment
- IX regeneration options require consideration
- GAC followed by IX may have advantages



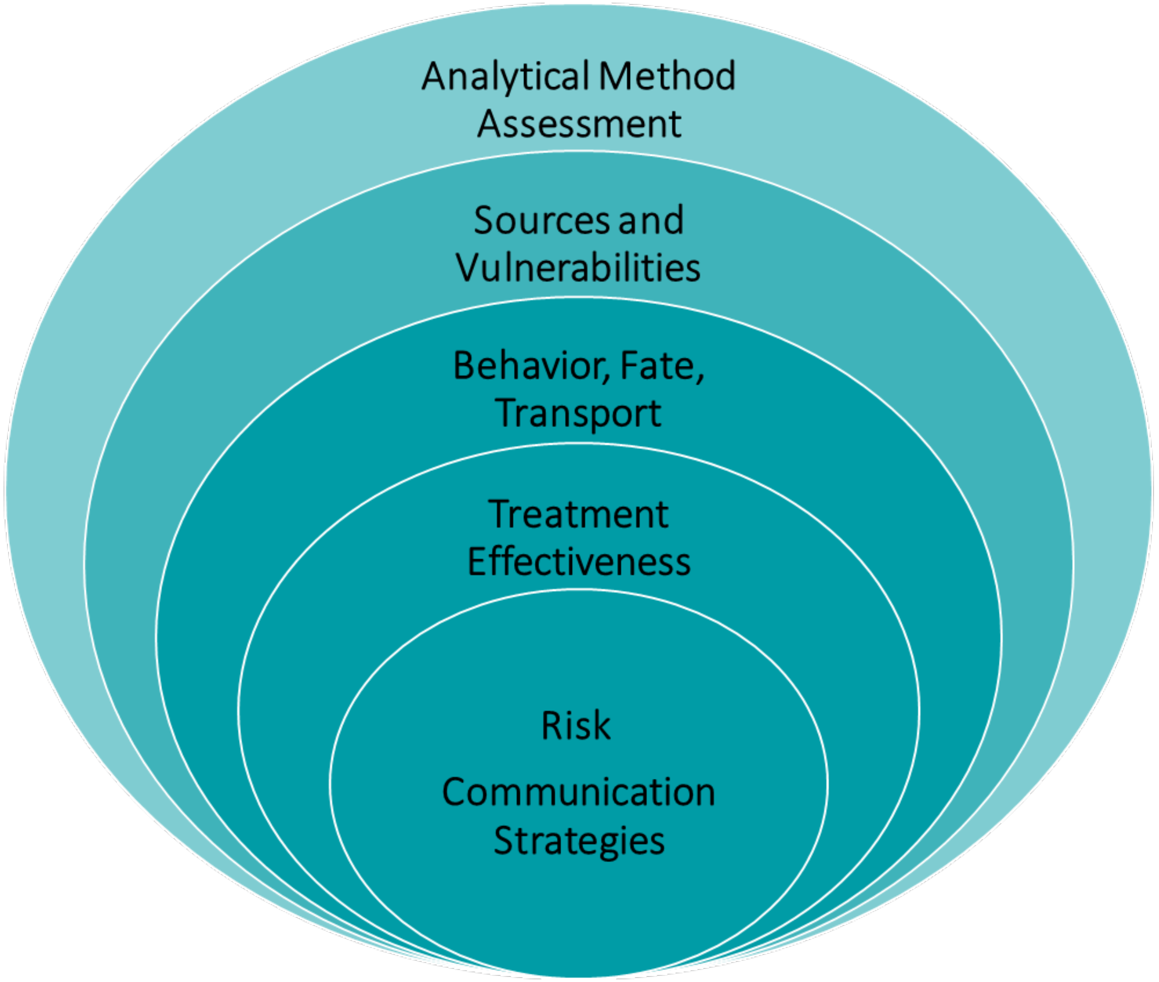




[Zaggia et al. (2016) Water Research]

2018-2021 WRF PFAS Research Area (RPP)

Management, analysis, removal, fate and transport of per- and polyfluoroalkyl substances (PFAS) in water



WRF PFAS Research: Treatment

- Concept Development of Chemical Treatment Strategy for PFOS-Contaminated Water (4877, completed)
- Investigation of Treatment Alternatives for Short-Chain Per- Polyfluoroalkyl Substances (4913, in progress)
- Evaluation and Life Cycle Comparison of Ex-Situ Treatment Technologies for Per-and Polyfluoroalkyl Substances (PFASs) in Groundwater (Funding from Dept. of Defense) (5011 in progress)
- Microwave Regeneration of PFAS-Exhausted Granular Activated Carbons (5103, in progress)
- Understanding Pyrolysis for PFAS Removal (5107, in progress)
- Evaluation of Bench-Scale Methods to Predict Drinking Water PFAS Removal Performance of Ion Exchange and Novel Adsorbents at Pilot- and Full-Scale (5153, in progress)

WRF PFAS Research: Behavior, Fate, Transport

- Formation of Nitrosamines and Perfluoroalkyl Acids During Ozonation in Water Reuse Applications (1693, completed)
- Determining the Role of Organic Matter Quality on PFAS Leaching from Sewage Sludge and Biosolids (NSF Project) (5002, in progress)
- Occurrence of PFAS Compounds in US Wastewater Treatment Plants (5031, in progress)
- Assessing Poly- and Perfluoroalkyl Substance Release from Finished Biosolids (5042, completed)
- Studying the Fate of PFAS through Sewage Sludge Incinerators (5111, in progress)

WRF PFAS Research:

Analytical Methods

Application of Novel Method to Estimate Total PFAS Content in Water (5102, in progress)

Management Strategies

Investigation of Alternative Management Strategies to Prevent PFAS from Entering Drinking Water Supplies and Wastewater (5082, in progress)

Risk Communication

PFAS One Water Risk Communication Messaging for Water Sector Professionals (5124, in progress)

Two Projects

Funded around same time, complementary

- Project 4913 - Investigation of Treatment Alternatives for Short-Chain PFAS
  - PI – Detlef Knappe (NCSU)
  - Co-PIs – Chris Bellona (CSM), Eric Dickenson (SNWA), Erik Rosenfeldt (Hazen and Sawyer), Charles Schaefer (CDM Smith), Brian Steglitz (City of Ann Arbor), and Lauren Weinrich (American Water)
- DOD Grant - Evaluation & Life Cycle Comparison of Ex-Situ Treatment Technologies for PFASs in Groundwater
  - $990K
  - PI – Kenan Ozekin (outreach & project management)
  - Co-PIs - Chris Bellona (CSM), Detlef Knappe (NCSU), Sherri Cook (CU-Boulder), Charles Schaefer (CDM Smith), and Christopher Higgins (CSM)
- Both scheduled for completion in 2022

RPP

Objectives:

- Investigate short-chain PFAS removal in a wide range of background water matrices (groundwater, surface water, treated wastewater) at multiple scales (bench, pilot, full) by existing and emerging treatment processes
- Develop guidance manual and decision support tool to select treatment processes and bench-scale testing of media for short-chain PFAS removal

Experimental Testing Protocol

Treatability Plan for GAC/IX Treatments

RSSCTs will evaluate the impact of the following factors on PFAS removal:

- Effect of influent PFAS concentration on removal capacity and site competition
- Effect of DOM on PFAS removal capacity
- Effect of ionic strength on PFAS removal capacity
- Effect of non-fluorinated organic compounds on PFAS removal capacity
- Effect of co-contaminants and other constituents on PFAS removal capacity

Matrix effects

Adsorbent selection

- Effect of GAC/IX type on PFAS removal capacity

Design parameters

- Effect of empty bed contact time (EBCT) on PFAS removal capacity

- Membrane processes including NF, RO and SPAC/MF
- Electrochemical treatment of residuals

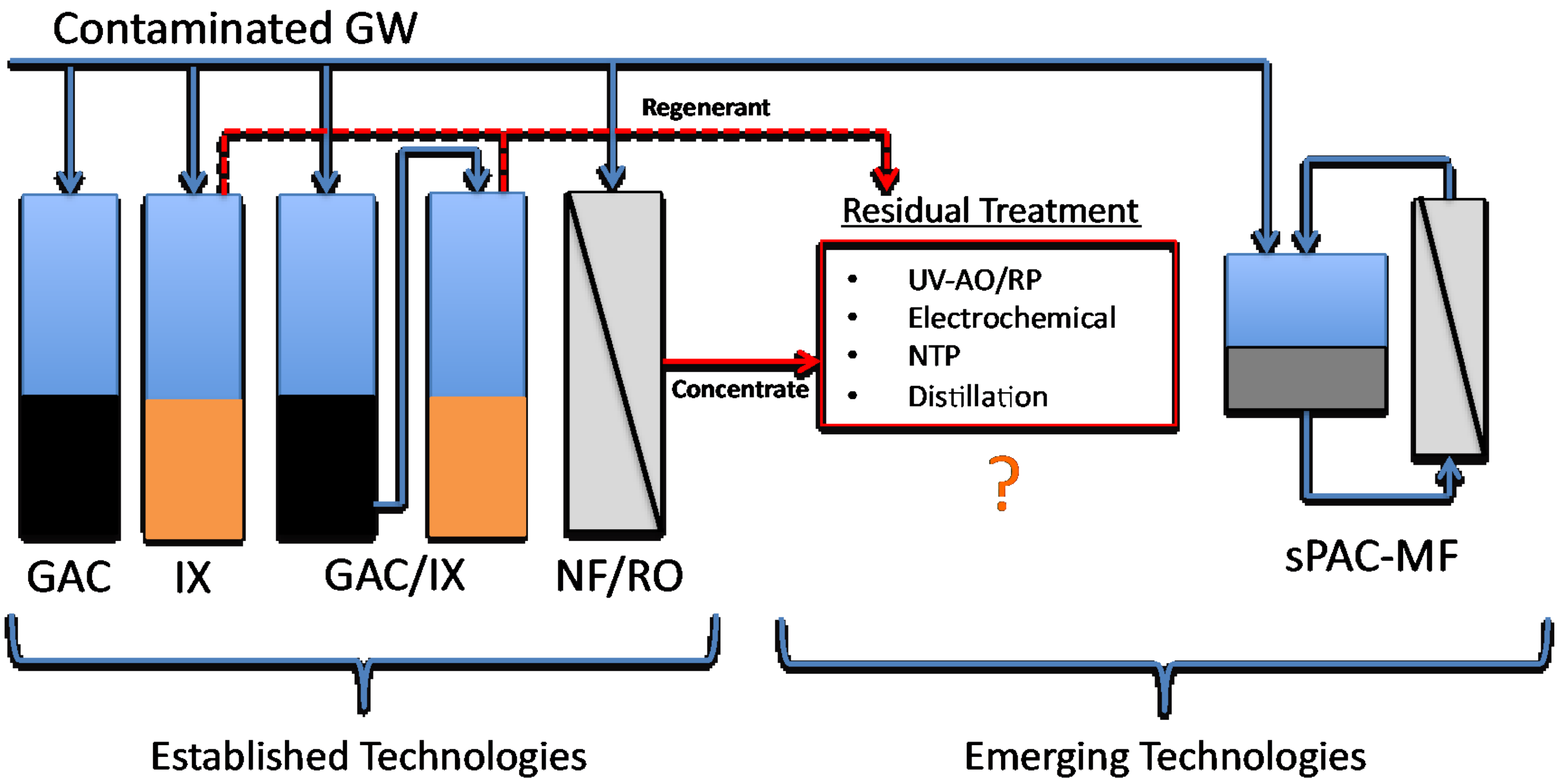
GAC - high level interim results

- Data collection full-scale plants (both drinking water and reuse) to evaluate short-chain PFAS removal (39 plants from 16 states)
- Generating breakthrough curves in the lab
- Validating the promising treatment approaches at the pilot-scale
  - PFAS removal depends on PFAS chain-length
  - EBCT have little to no effect for short-chain PFAS removal
  - Ion Exchange ineffective for short-chain PFAS
  - Short chain PFAS desorbs due to substitution by long-chain PFAS
  - GAC service life for PFAS removal strongly depends on TOC
  - Removing TOC prior to GAC will lower GAC use rate

Ion Exchange – high level interim results

- Generating breakthrough curves in the lab
- Short chain PFAS are more challenging to remove than long chain PFAS
- Removal effectiveness of IX resins for PFAS increases exponentially as the PFAS chain length increases
- Perfluoroalkyl sulfonic acids (PFSAs) are more readily removed by IX than perfluoroalkyl carboxylic acids (PFCAs)

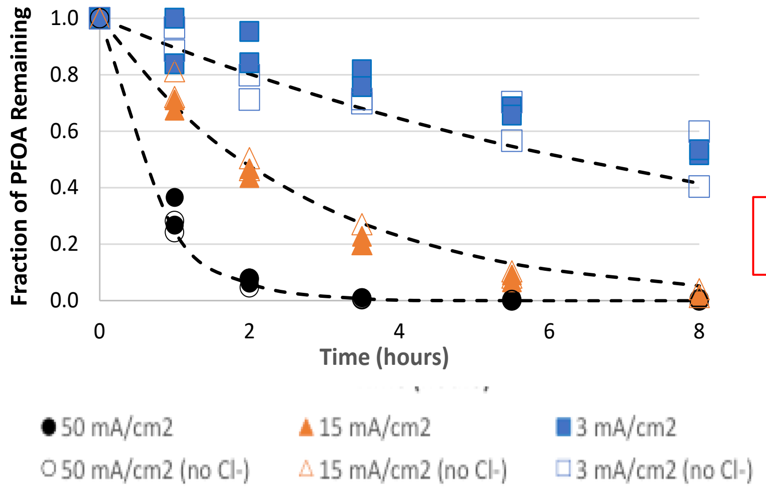
Project 5011: Evaluation and Life Cycle Comparison of Ex-Situ Treatment Technologies for PFASs in Groundwater



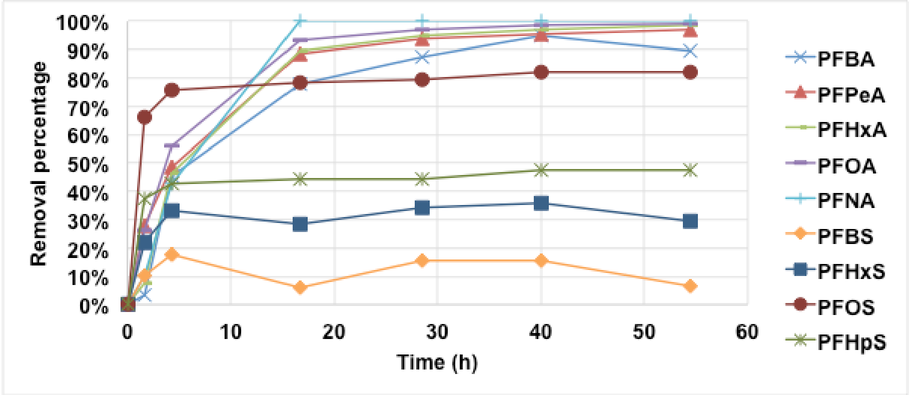
Status: On-going, DOD project

Destructive Technologies

- Various approaches in development, most promising:
  - Electrochemical treatment (EC)
  - Ultraviolet light with persulfate and/or bisulfite (UV-AO/RP)
  - Non-thermal plasma treatment (NTP)
- In development, may be more appropriate for residual treatment (e.g., NF concentrate, IX regenerant)



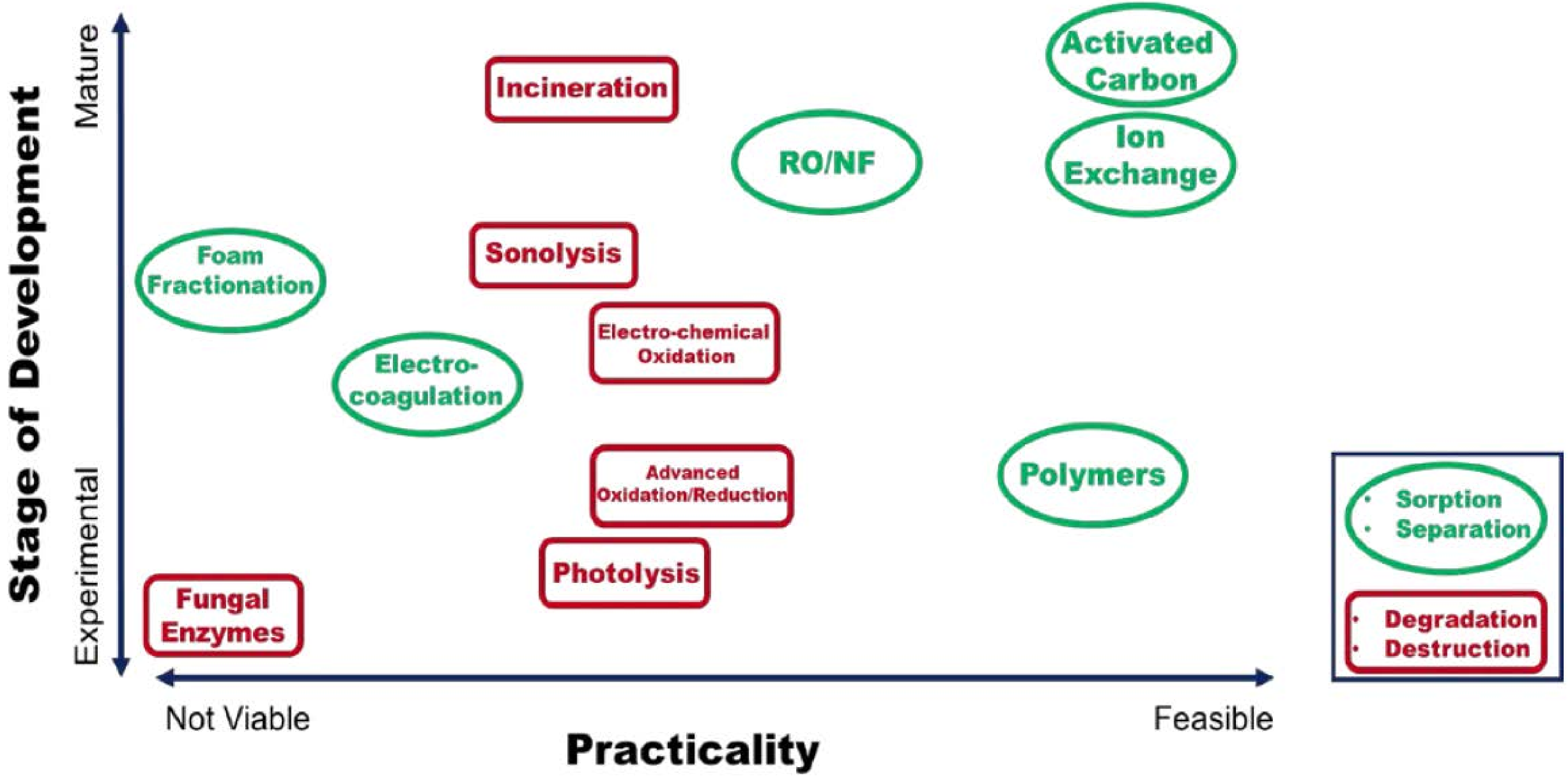
EC



UV-ARP

Source: Bellona, 2017

Current PFAS Water Treatment Technologies



Courtesy of – Dr. Tanju Karanfil, Clemson University

PFAS in Wastewater and Biosolids

- Concern regarding potential re-release of PFAS to environment from land application of biosolids, current land application restrictions in some states

Occurrence of PFAS Compounds in US Wastewater Treatment Plants (WRF #5031)

- Will quantify occurrence of a wide range of PFAS in solid and liquid streams and assess behavior and transformation through treatment
- Datasets from 40 water resource recovery facilities at 34 utilities

Assessing PFAS Release from Finished Biosolids (WRF #5042)

- Will examine release as a function of PFAS loading in finished biosolids, post-digestion processing of biosolids, and age of biosolids (fresh vs field-aged)

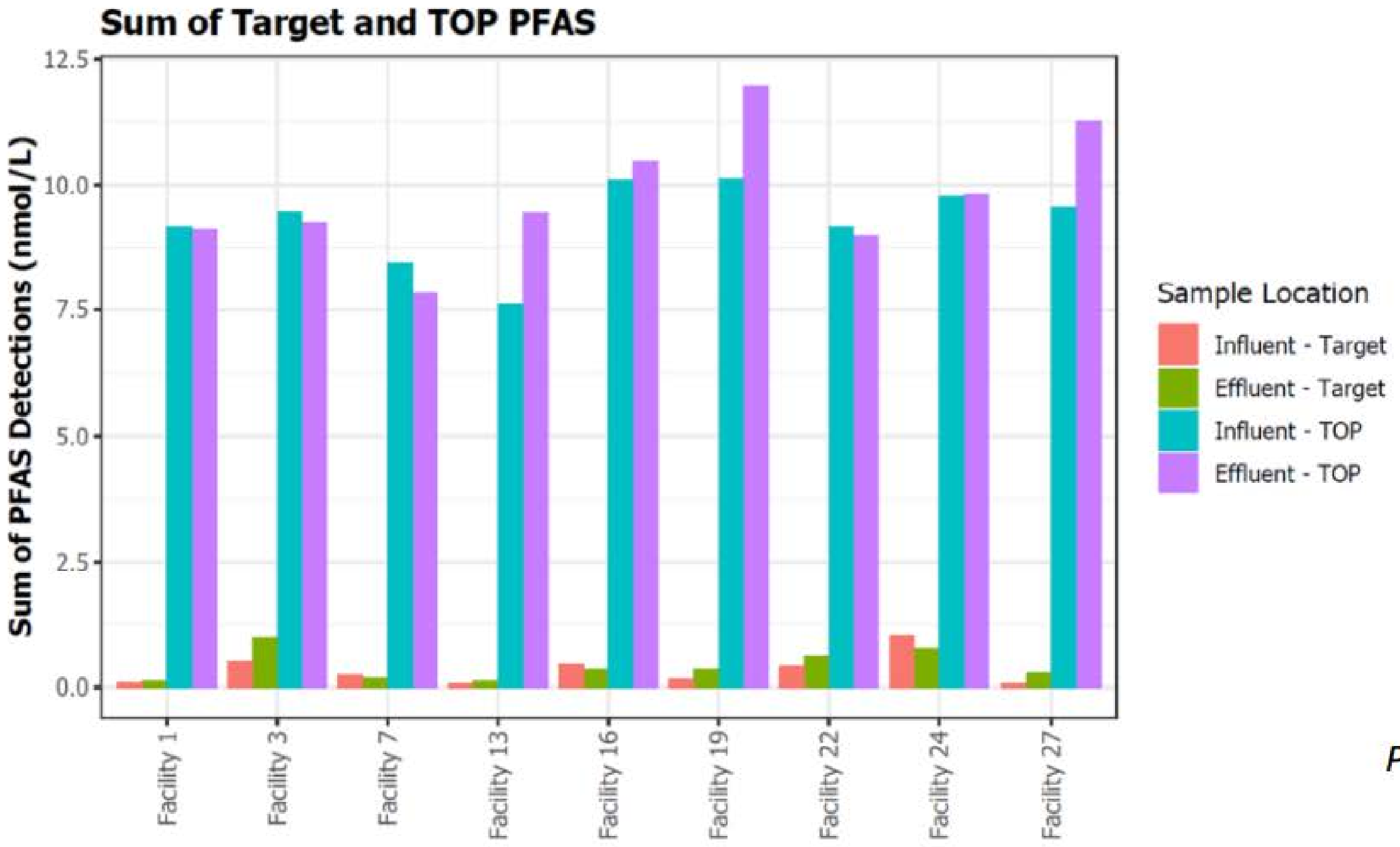
Determining the Role of Organic Matter Quality on PFAS Leaching from Sewage Sludge and Biosolids (WRF #5002)

- Partnership with NSF

PFAS in Biosolids

- Recent webcast 10/14/21, highlighting multiple projects that will soon be complete
- PFAS levels similar among all biosolids studied
- Majority of organic fluorine associated with precursors not currently quantified in commercial laboratories
- Precursor transformation to perfluorinated carboxylates likely occurs during land application of biosolids
- The extent to which release of PFAS (100s of ng/L) poses a risk needs further assessment

WRF 5031: Oxidizable Precursors in Influent and Effluent Streams



Preliminary data

PFAS Technologies on WRF TechLink

PFAS remediation in groundwater

REMWell

WATERHOUND

Predictive analytics for treatment including PFAS removal

PFAS destruction via pyrolysis

CHAR technologies

Genifuel

PFAS destruction via hydrothermal processing

Kore Infrastructure

ECOREMEDY
Ecological ~ Economical

BIOFORCETECH Corporation

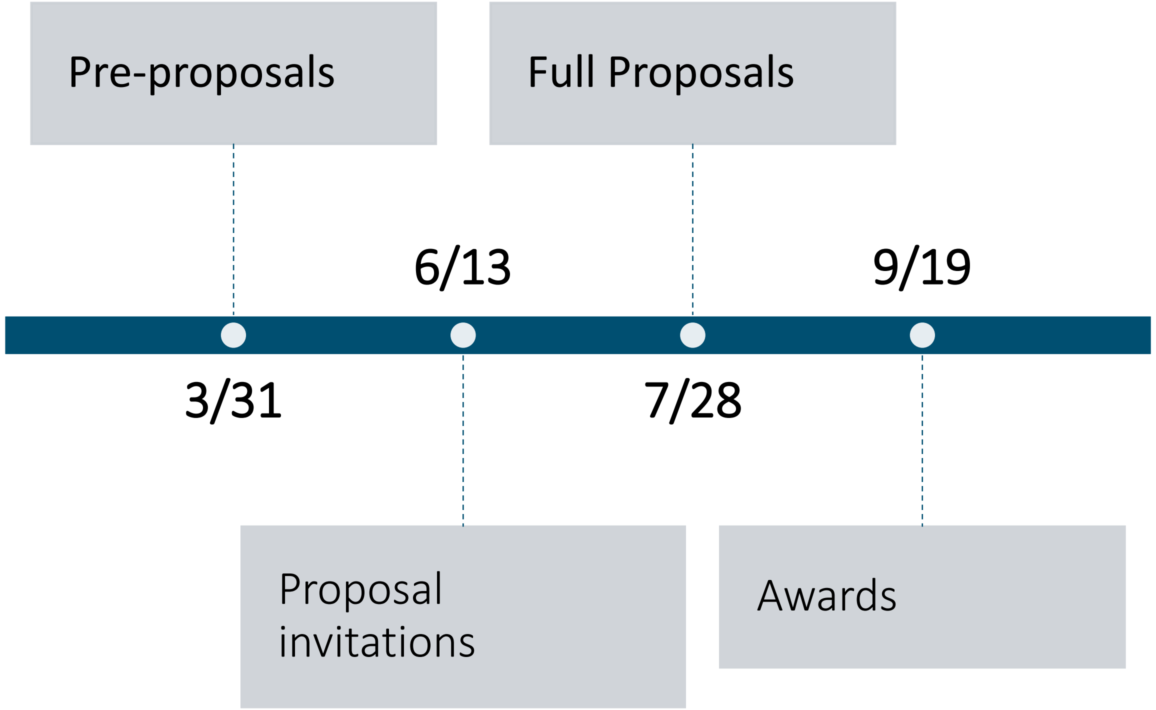
The Water Research Foundation
WRF TechLink

Research Programs

60%	10%	20%	10%	Subscriber/ Partner Funded	Grant Funded	$100,000
Research Priority Program	Unsolicited Program	Tailored Collaboration Program	Emerging Opportunities Program	Facilitated Research Program	Sponsored Research	Paul L. Busch Award

Unsolicited Program 2022

- Funds innovative research projects that will significantly advance knowledge and scientific understanding and that could provide fundamentally transformative results
- 10% of research budget, every other year with two years of funding
  - **Almost $1M!**
  - Maximum $175K per project
- For more information, visit: https://www.waterrf.org/unsolicited-research-program-0



Tailored Collaboration Program 2022

- 20% research budget
- Utility Sponsor
- WRF matches 1:1 funding up to $150K !

Pre-proposals – 6/6

Proposal invitations – 8/9

Full Proposals – 9/19

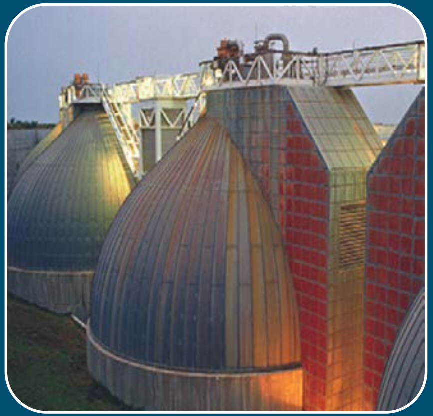
Awards – 11/10

2021 TC Awards

- Impact of UV Treatment on Microbial Communities in a Full-Scale Drinking Water Distribution System (City of Ann Arbor)
- Identifying Service Line Materials without Excavation: Distinguishing LSLs from non-LSLs (DC Water)
- Evaluation of Bench-Scale Methods to Predict Drinking Water PFAS Removal Performance of Ion Exchange and Novel Adsorbents at Pilot- and Full-Scale (Orange County Water District)
- Autonomous In Situ Monitoring of Harmful Algal Blooms (Great Lakes Water Authority)
- Developing Strategic Consumer Messaging for Microplastics in Drinking Water Supplies (Golden State Water Company)

Research Priority Program Themes

- **Resource Efficiency and Recovery**
  Advancing the water sector toward a circular economy.
- **Treatment Optimization**
  Maximizing performance of treatment processes and technologies to produce clean and safe water.
- **Resilient Infrastructure**
  Improving the water sector's resilience by overcoming infrastructure and water quality challenges.
- **Utility Operations and Management**
  Supporting financially sustainable, optimized, and forward-thinking utilities.
- **Healthy Communities and Environment**
  Improving watershed resilience, enhancing community benefits, and protecting public health and the environment.



Efficient Resource Use & Recovery

- **Energy Efficiency, Intensification & Resource Recovery**
- **Climate Change Mitigation** (GHG Emission Reduction, Decarbonization, Carbon Capture)
- **Nutrient Removal & Recovery**
- **Biosolids**

Treatment Optimization & Intensification

- **Treatment & Process Optimization**
- **Nature-based Solutions**

Resilient Infrastructure

- **Asset Management** (Risk Management, Data Management, Condition Assessment)
- **Distribution System Integrity & Water Quality**
- **Collection Systems Integrity & Water Quality Impacts**

Utility Operations & Management

- **Supply Planning** (Conservation, Demand Management)
- **Workforce Management** (Succession Planning, Digital Utility, DE&I)
- **Digital Utility** (Digital Twin, Advanced Data Use, Accessibility)
- **Financial Management** (Affordability)

Healthy Communities & Environment

- **Holistic Watershed Management & Integrated Planning**
- **Monitoring Tools at Watershed & Sewershed Scale**
- **Receiving Water Quality Management** (PFAS, CECs, Microplastics, Nutrients)

Involvement Opportunities

- ***Become a Member!***
- Volunteer to be a Project Advisory Committee member
- Volunteer to be a Participating Utility
- WRF TechLink Reviewers –
  - Particularly need drinking water reviewers
- Upcoming Webcasts Register Here - available On Demand
  - 2022 Tailored Collaboration Research Program Update – 4/4/22
  - WRF Technology Scan Update: Innovative Monitoring Tools – 4/12/22

Regional Workshops

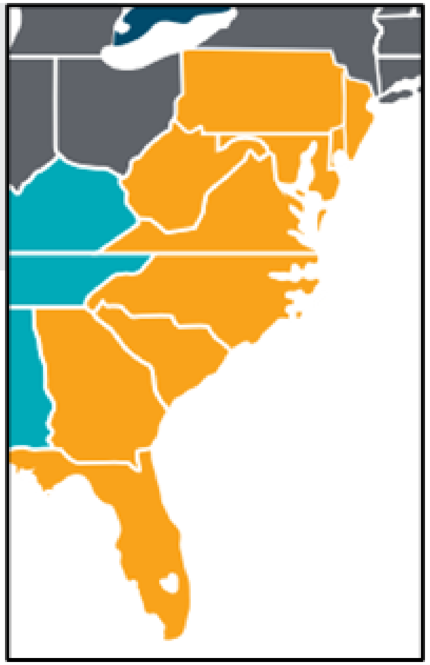
- Coordinated with the Regional Liaison
- Deeper dive into a topic
- Highly flexible in content, structure
- Recent and upcoming workshops:
    - Cyanotoxins
    - Biofiltration
    - Taste and Odor
    - Biosolids
- Topics of Interest?

Florida Utility Subscribers

- American Water – Florida – Pensacola
- Bal Harbour – Bal Harbour
- Bay Harbor Islands – Bay Harbor Islands
- City of Cocoa – Cocoa
- City of Coral Gables – Miami
- City of Florida City – Florida City
- City of Hialeah – Hialeah
- City of Hialeah Gardens – Hialeah Gardens
- City of Hollywood – Hollywood
- City of Homestead – Homestead
- City of Miami Beach – Miami
- City of New Port Richey – Port Richey
- City of North Miami – North Miami
- City of North Miami Beach – North Miami Beach
- City of Orlando, FL – Orlando
- City of Tallahassee Water & Sewer Dept – Tallahassee
- City of Tampa Water Department – Tampa
- City of West Miami – West Miami
- City Opa Locka – Opa Locka
- Florida Keys Aqueduct Authority – Key West
- Fort Lauderdale Utilities Administration – Fort Lauderdale
- Hillsborough County – Tampa
- Indian Creek Village – Indian Creek Village
- JEA Water & Wastewater Treatment RRWTP – Jacksonville
- Miami-Dade County, Department of Environmental Resource Mgmt – Miami
- Miami- Dade Water & Sewer Department – Miami
- North Bay Village – North Bay Village
- Orange County Utilities – Orlando
- Pasco County Utilities – New Port Richey
- Pinellas County Utilities – Clearwater
- Sarasota County Utilities Department – Sarasota
- Seacoast utility Authority – Palm Beach Gardens
- Seminole County Environmental Services – Sanford
- Severn Trent Services, Inc. – Tampa
- St. Petersburg Water Department – St. Petersburg
- Tampa Bay Water – Clearwater
- Toho Water Authority – Kissimmee
- Town of Medley – Medley
- Town of Surfside – Surfside
- Virginia Gardens – Virginia Gardens

THE Water Research FOUNDATION

Thank You!



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