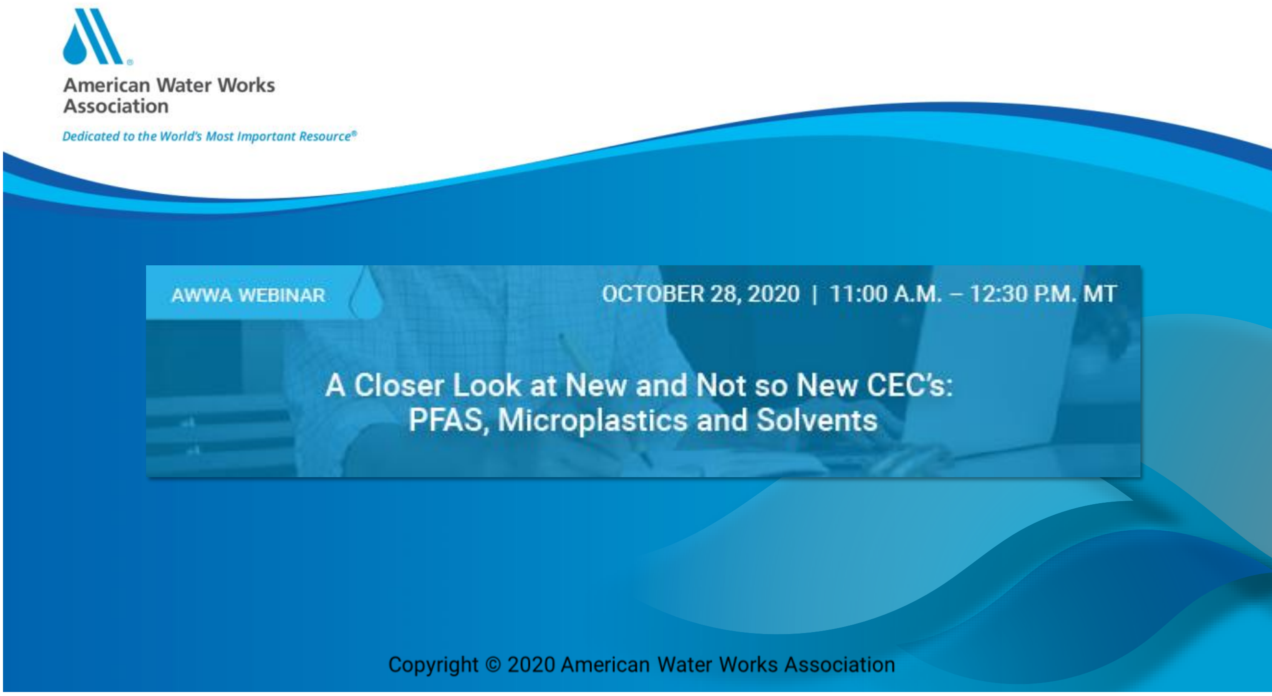
American Water Works Association
Dedicated to the World's Most Important Resource®
AWWA WEBINAR
OCTOBER 28, 2020 | 11:00 A.M. – 12:30 P.M. MT
A Closer Look at New and Not so New CEC's:
PFAS, Microplastics and Solvents
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WEBINAR MODERATOR

Chris Owen

Director of Water and Reuse Innovations

Hazen and Sawyer

Chris is the Director of Water and Reuse Innovations for Hazen and Sawyer. She has 29 years of experience in water quality, research, treatment and regulatory compliance. Her utility roles have included regulatory compliance, research, laboratory management, source water assessment and protection, and distribution system issues. Research work included investigations of UF/MF/RO membranes, online monitoring, total coliform occurrence, enhanced coagulation, biofiltration, distribution system, corrosion, biostability, ion exchange, chloramine chemistry and stability, contaminants of emerging concern, and algal toxins. She is active in regulatory issues at the state and federal levels, promoting utility concerns and science-based decisions. She served on the USEPA SAB for Drinking Water and the USEPA NACEPT.

She is an active member of the American Water Works Association (AWWA), serving as a Trustee and the current Chair of the Water Science and Research Division. She is a Trustee for WateReuse FL and the President of the Board of Directors for the American Membrane Technology Association. She has been active in the Water Research Foundation (WRF) and the WateReuse Foundation for more than 20 years.

3

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PANEL OF EXPERTS

Theresa Slifko, PhD
Water Quality Manager: Chemistry Unit
Metropolitan Water District of Southern California

Jeff Biggs
Source Water Administrator
Tucson Water

Erik Rosenfeldt, PE, PhD
Director of Drinking Water Process Technologies
Hazen and Sawyer

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AGENDA

I.	Microplastics Analytical Results: What Do They Mean?	Theresa Slifko, PhD
II.	Transformation of Tucson Water's CERCLA-to-Drinking Water Program After 25 Years	Jeff Biggs
III.	Addressing Multiple CECs at an East Coast Surface Water	Erik Rosenfeldt, PE, PhD

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ASK THE EXPERTS

Theresa Slifko, PhD
Metropolitan Water District of Southern California

Jeff Biggs
Tucson Water

Erik Rosenfeldt, PE, PhD
Hazen and Sawyer

Enter your **question** into the **question pane** on the right-hand side of the screen.

Please specify to whom you are addressing the question.

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MICROPLASTICS ANALYTICAL RESULTS: WHAT DO THEY MEAN?

October 28, 2020

AWWA Webinar

“A Closer Look at New and Not so New CEC’s: PFAS, Microplastics and Solvents”

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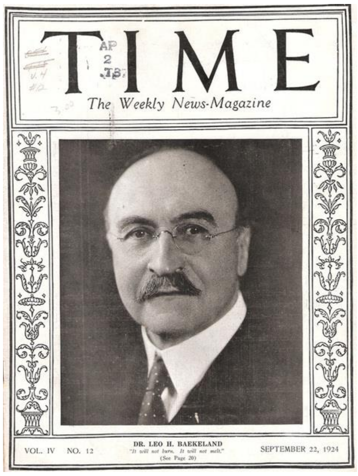
"PLASTIC"



- Polyoxybenzylmethylenglycolanhydride
- First plastic was "Bakelite"
- Invented by Dr. Leo H. Baekeland in 1907
- Mixture of phenol and formaldehyde mixed with wood or asbestos fillers under controlled conditions for pressure and temperature
- At Baekeland's death in 1944, the world production of Bakelite was ca. 175,000 tons, and it was used in over 15,000 different products

https://en.wikipedia.org/wiki/Leo_Baekeland

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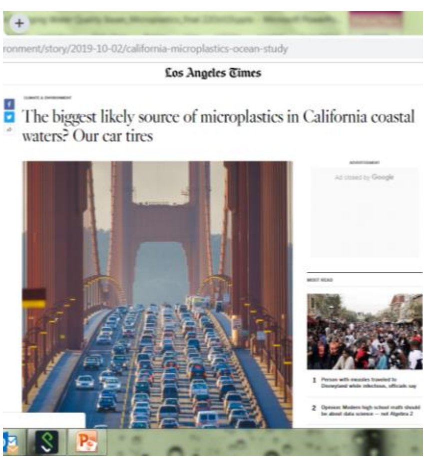

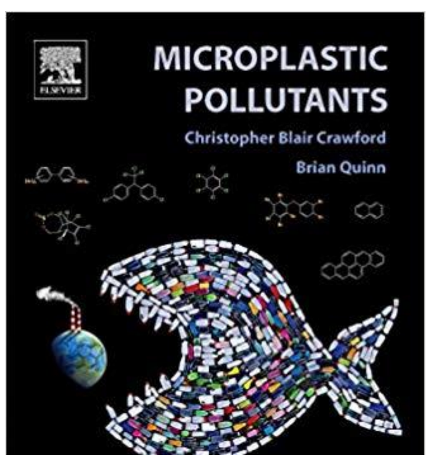

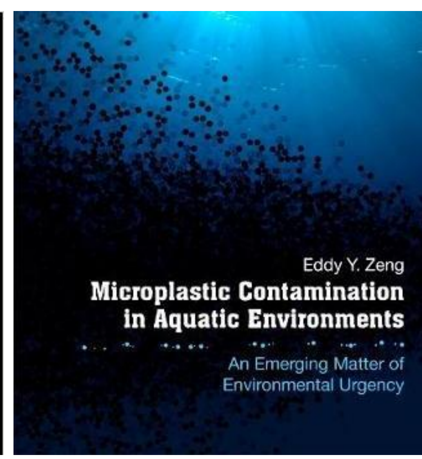

ABOUT ONE BILLION ELEPHANTS

https://www.usatoday.com/story/tech/science/2017/07/19/humans-have-produced-18-2-trillion-pounds-plastic-thats-equal-size-1-billion-elephants/491529001/

Today: 100 BILLION plastic bags are used by Americans every year.

Tied together, they would circle the Earth's 773 times!

http://www.earth-policy.org/press_room/C68/plastic_bags_fact_sheet

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WHAT A WASTE.

Photo credit: http://chrisjordan.com/gallery/midway/#CF000313%2018x24

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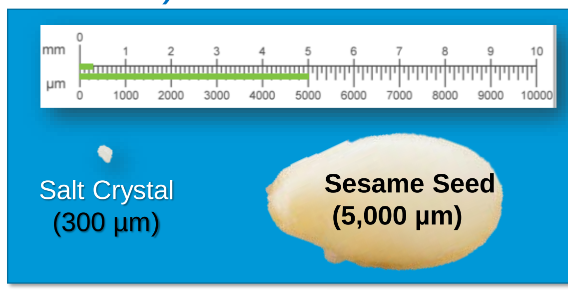
WHAT ARE "MICROPLASTICS"?

Small pieces of plastic between 1 and 5,000 µm in size (less than the size of a sesame seed)

- Fibers
- Pellets
- Films
- Fragments
- Foam
- Spheres



Mini-microplastics: 1 µm to 1,000 µm

Nanoplastics: less than 1 µm

Definition source: The Microplastics Toolbox by A Rocha International;
Images: inch calculator.com (ruler); cleanpng.com (salt); dlpng.com (sesame seed)

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DEFINING MICROPLASTICS

CALIFORNIA Water Boards
STATE WATER RESOURCES CONTROL BOARD
REGIONAL WATER QUALITY CONTROL BOARDS

California SWRCB Microplastics Definition (June 2020):

"Solid polymeric materials to which chemical additives or other substances may have been added, which are particles which have at least two dimensions that are greater than 1 and less than 5,000 micrometers (µm). Polymers that are derived in nature that have not been chemically modified (other than by hydrolysis) are excluded."

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SOME SOURCES OF MICROPLASTICS IN WATER

- Surface runoff
- Wastewater discharges
- Industrial discharges
- Atmospheric deposition

Laundry fibers

Car tires

Sources: WHO 2019. Microplastics in drinking-water; www.latimes.com/California-microplastics-ocean-study.

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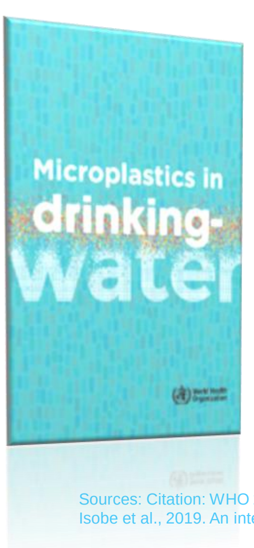
DETECTING MICROPLASTICS IN DRINKING WATER



- 9 reliable water studies (of 50)
  - Bottled > Surface Tap > Ground Tap
- Challenges with analytical methods
  - No unified definitions
  - No standard sampling, extraction, and identification methods
  - Pervasive analytical errors
- Water treatment processes have shown ~92% removal

Sources: Citation: WHO 2019. Microplastics in drinking-water.
Isobe et al., 2019. An interlaboratory comparison exercise for the determination of microplastics in standard sample bottles

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MICROPLASTICS ANALYTICAL METHODS FOR SOURCE AND TREATED DRINKING WATER

Four microplastics analytical methods

- Microscopy
- FTIR (with or without microscopy)
- Raman spectrometry
- Pyrolysis-Gas Chromatography/Mass Spectrometry (GC/MS)

Microplastics Measurement Methods Evaluation Study (2019-2021)

- Multi-laboratory evaluation
- International team of investigators
- Metropolitan is participating

FTIR = Fourier-transform infrared spectroscopy
http://www.sccwrp.org/news/international-microplastics-measurement-study

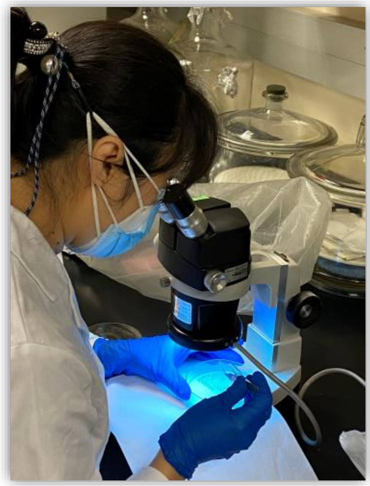

Photo credit: MWD staff performing microscopic analysis of spiked water samples 19

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METHODS USED IN 49 MICROPLASTICS ID STUDIES*

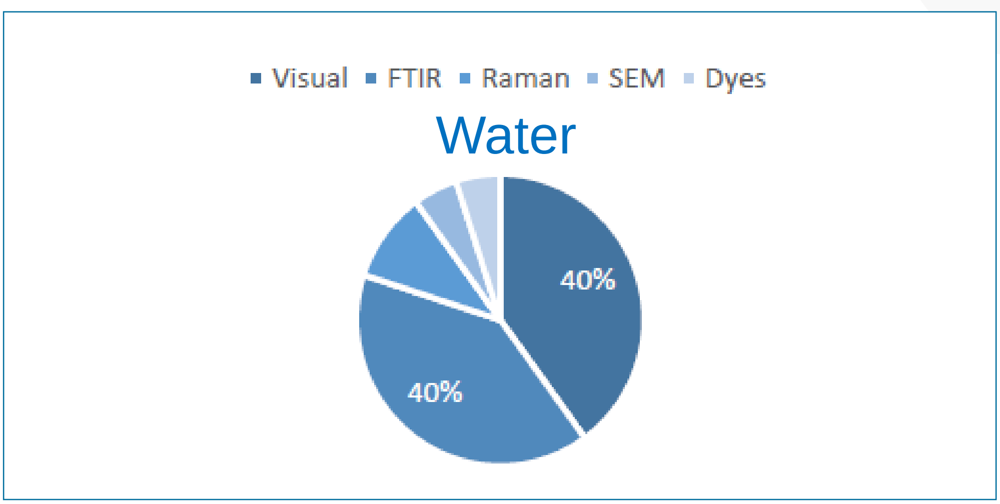

Fig. 1. Details from sampling methods reviewed from the literature for microplastics in sediment (top row, N = 20) and water (bottom row, N = 20) regarding collection, density separation, digestion, and identification.

*Literature review of 49 studies in: J.C. Prata et al. Methods for sampling and detection of microplastics in water and sediment: A critical review. Trends in Analytical Chemistry 110 (2019) 150e159

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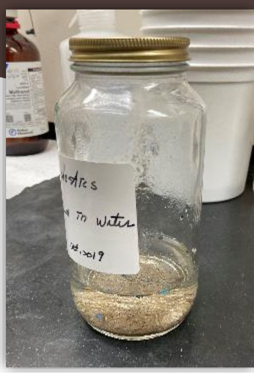
SOP FOR MICROPLASTIC EXTRACTION FROM CLEAN WATER



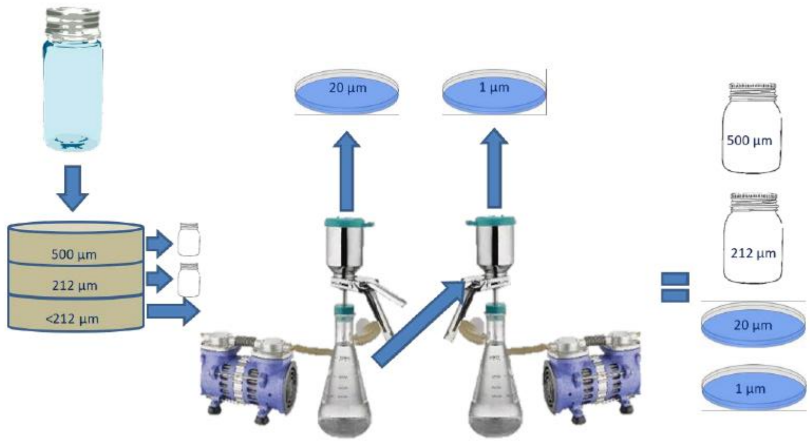


Figure from SWRCB/SCCWRP "*Microplastics Measurement Methods Evaluation Study (2019-2020)*" Study Plan; Photo credit: MWD staff

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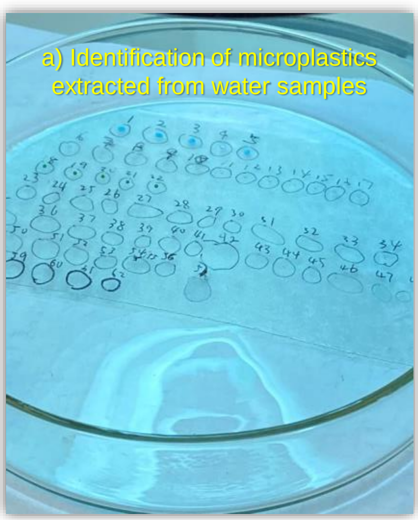
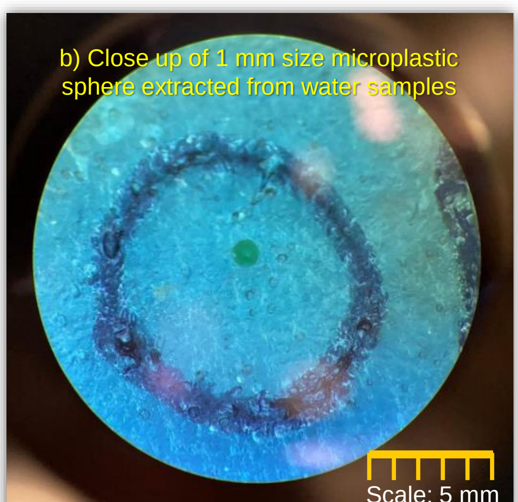
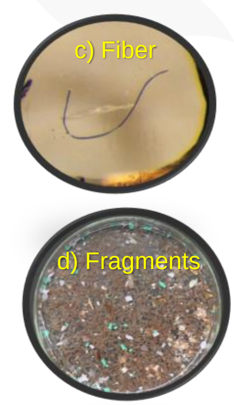
MICROPLASTICS MICROSCOPIC IDENTIFICATION







Images c-d: Rochman 2019. Microplastics workshop presentation. SCCWRP.

Images a-b: Tiffany Lee & Lucy Li, MWD Laboratories 2020.

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MICROPLASTICS ANALYTICAL METHOD OPTIONS, PROS & CONS

Instrument	Minimum Detectable Size	Description	Polymer Composite ID	Pros	Cons
Microscope	>500µm	Visual ID & quantification; Microscopic counting method with or without dye stain to confirm plastic	No	Lower cost; Simple concept; High availability	Expensive; Extensive sample prep; Slow and time consuming; Prone to false positives
FTIR with microscope	>500µm or ~20µm	Chemical ID, quantification, & characterization; Infrared (IR) absorption spectroscopy	Limited	Non-destructive to samples; Most used for marine studies. Can automate; Can use as a screening tool	Expensive; Some sample prep; <20µm cannot be detected
Raman	~1 - 20µm	Chemical ID, quantification, & characterization IR absorption spectroscopy	Yes	ID some polymer type and very small size range; Less sample preparation; Less matrix interference; Can automate	Expensive; Not well proven and tested; Complex instrumentation; Prone to interference; Can overestimate
Pyrolysis-GC/MS	~150µm	Chemical ID, quantification, & characterization; Gas chromatography – mass spectrometry	Yes	Fastest & most reliable; IDs many polymers; IDs small particle sizes	Cannot measure PVC; Destroys the sample; Requires larger particle masses

Tanaka, K. and Takada, H. 2016. Microplastic fragments and microbeads in digestive tracts of planktivorous fish from urban coastal waters. Sci. Rep. 6, 34351; doi: 10.1038/srep34351
Wu et. al., 2020. Microplastics in waters and soils: Occurrence, analytical methods and ecotoxicological effects. Ecotoxicology and Environmental Safety 202 (2020) 110910

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MICROPLASTICS ANALYTICAL METHOD OPTIONS, SCOPE, & ESTIMATED COST

Instrument	Quantitative	Minimum Detectable Particle Size	Est. Equipment Cost	Approximate Analysis Time (Hrs./Sample)	Est. Labor Cost per sample*
Microscope With or without dye stains	Manual Particle counts	>500µm	$1,000-10,000	24	$881
FTIR without microscope	Manual Polymer type	~200µm	$50,000	32	$1,175
FTIR with microscope	Automated Counts and Polymer type	~20µm	$250,000	32	$1,175
Raman	Automated Polymer type	~1µm	$250,000	40	$1,467
Pyrolysis-GC/MS	Manual Polymer mass	~150µm	$250,000	24	$881

*Estimated labor cost based on $18 per hour plus benefits multiplier of 104% for the analyst and QA to process one sample from start to finish. Materials, instrument, and supplies not included.

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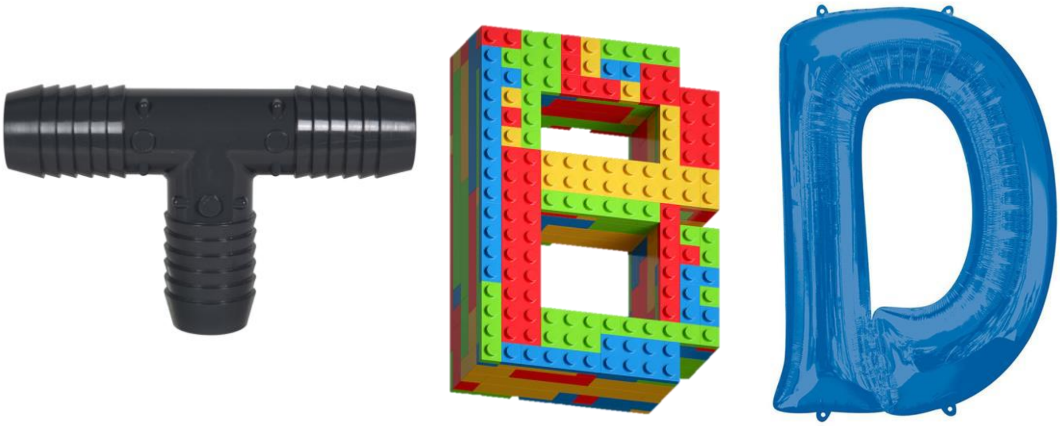
INTERPRETING MICROPLASTICS WATER QUALITY MONITORING DATA



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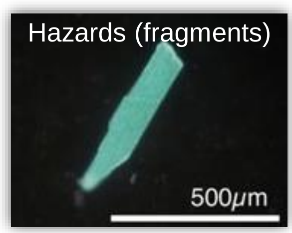
DO MICROPLASTICS IN DRINKING WATER POSE A RISK TO HUMAN HEALTH?

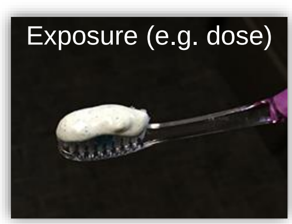
WHO finds "low or no concern of human health hazards at this time"

- Humans not likely to adsorb >150 µm

Recent human health studies are mixed

- What goes in comes out
- No cytoxicity in human gut cells
- Additional research needed to fully assess health impacts





Sources: WHO 2019. Microplastics in drinking-water. Tanaka, K. and Takada, H. 2016. Microplastic fragments and microbeads in digestive tracts of planktivorous fish

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WHAT NEXT?

Microplastics are a global concern and the science is still emerging

- SCCWRP Study will standardize & validate analytical methods (35 Labs)
- Monitoring and occurrence evaluations (ambient water, drinking water, animal tissues)
- Water Treatment efficacy
- Health effects including mixtures and chronic exposure studies

Legislative activities to limit environmental loading

- Bans: Plastic bags, single use plastics, & straws
- Restrictions: plastic pellets & personal care products
- Regulations: Trash TMDLs

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UPCOMING CALIFORNIA PUBLIC WORKSHOPS

Sources: Coffin 2020. Microplastics in Drinking Water: California's Regulatory Actions. NEMC Presentation

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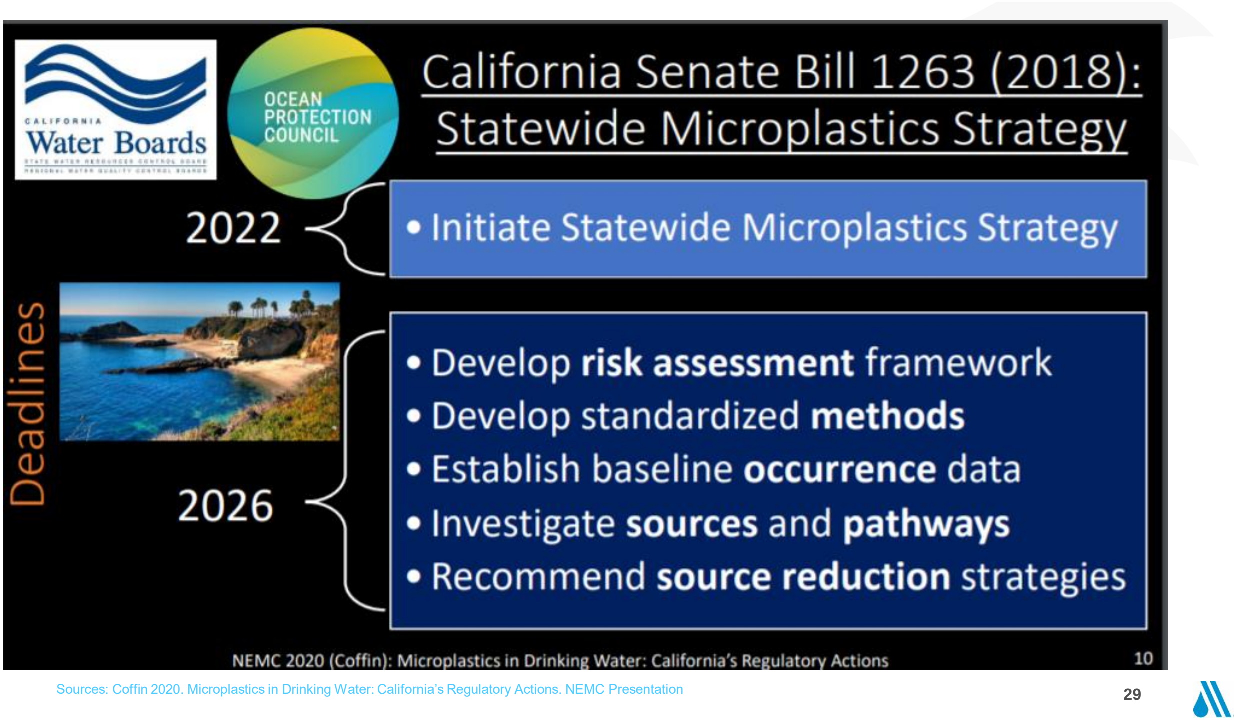
California Senate Bill 1263 (2018):
Statewide Microplastics Strategy
CALIFORNIA Water Boards
OCEAN PROTECTION COUNCIL
Deadlines
2022
• Initiate Statewide Microplastics Strategy
2026
• Develop risk assessment framework
• Develop standardized methods
• Establish baseline occurrence data
• Investigate sources and pathways
• Recommend source reduction strategies
NEMC 2020 (Coffin): Microplastics in Drinking Water: California's Regulatory Actions
10
Sources: Coffin 2020. Microplastics in Drinking Water: California's Regulatory Actions. NEMC Presentation
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MANY UNCERTAINTIES AND UNKNOWS REMAIN
Questions?
Theresa Slifko: tslifko@mwdh2o.com
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ADDITONAL SLIDES

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WHAT DO MICROPLASTICS MONITORING DATA MEAN?

"Scientists have made great progress on elucidating the ubiquitous nature of microplastic pollution, but foundational epidemiological and toxicological questions remain, including at what point microplastic concentrations become harmful, rather than just a nuisance."

Weyer et. al. 2020. *Steps Scientists Can Take to Inform Aquatic Microplastics Management: A Perspective Informed by the California Experience. Applied spectroscopy. Vol. 74(9) 971–975*

Photo credit: www.onegreenplanet.org/environment/plastic-water-bottles-and-the-oceans/

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DO WATER TREATMENT PLANTS REMOVE MICROPLASTICS?

Plastic distribution in tertiary wastewater treatment plant

Location	Microplastic Particle Count/Volume
Primary tank skimmings	Highest count*
Scum in aeration tanks	Some*
Return activated sludge	1 microplastic/20 mL**
Secondary effluent	1 microplastic/15,000 gallons
Gravity filter backwash	None found/12 gallons**
Final effluent	None found/50,898 gallons

Citation: Carr and Thompson. 2019. Chapter 4 Microplastics: transport and removal at wastewater treatment plants. *In* Microplastics in Water and Wastewater. IWA Publishing, 1 Gallon= c. 3.79 L
- = Could not be associated with an influent volume.
** = Average of 4 replicates;.

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ASK THE EXPERTS

Theresa Slifko, PhD
Metropolitan Water District of Southern California

Jeff Biggs
Tucson Water

Erik Rosenfeldt, PE, PhD
Hazen and Sawyer

Enter your **question** into the **question pane** on the right-hand side of the screen.

Please specify to whom you are addressing the question.

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TUCSON WATER
A proud part of the City of Tucson

Tucson Water's AOP Treatment Facility

Transformation of Tucson Water's CERCLA-to-Drinking Water Program After 25 Years

Jeff Biggs – Tucson Water

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PRESENTATION OUTLINE

- TCE remedy & 1,4-dioxane discovery
- Contingency planning and decisions
- Planning, design, and construction
- O&M experience and improvements
- Enhanced Recovery
- PFAS discovery
- Major results and recognition

TARP =
Tucson International Airport Area Groundwater Remediation Project

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TCE REMEDY & 1,4-DIOXANE DISCOVERY

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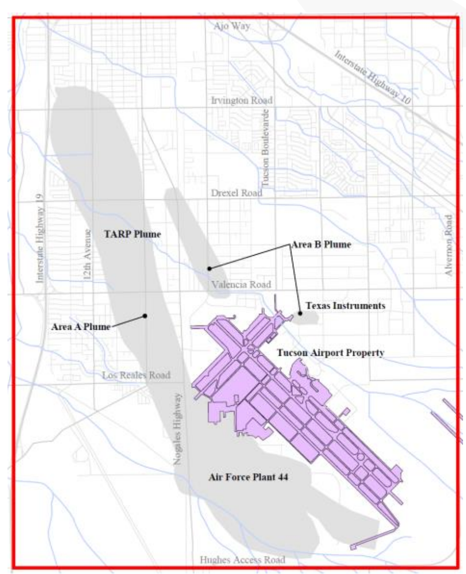
TCE DISCOVERY AND INVESTIGATION

1981 — **TCE contamination discovered by EPA and Tucson Water in Tucson Airport area wells.** 11 City wells and other private wells shut down

1982 — **EPA adds TAA site to Superfund National Priorities List**

1985 — **CERCLA Remedial Investigation completed.** Approx. 4-mile by 1-mile plume delineated

1988 — **CERCLA Feasibility Study for north area (TARP) completed; EPA issues Record of Decision**



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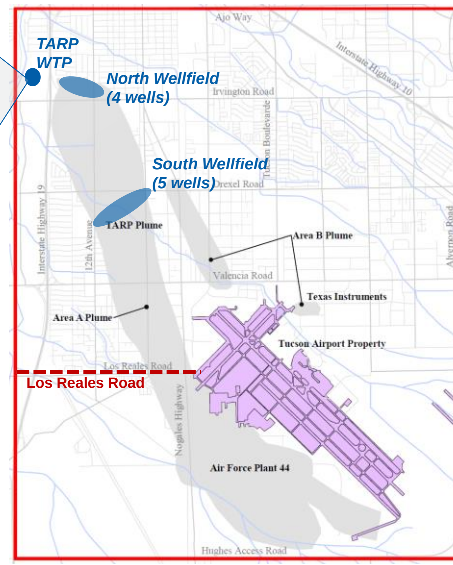
TCE REMEDY IMPLEMENTED

1990 – Settling Parties enter into Consent Decree with EPA

1991 – 1994 – Design & construction of wellfields, pipelines, and central treatment plant

1994 – Nine remediation wells and packed column aeration facility become operational

1995 – EPA-sponsored Unified Community Advisory Board (UCAB) formed

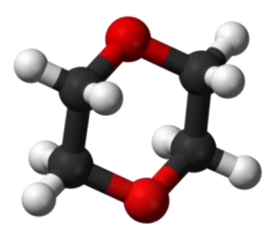


1,4-DIOXANE DISCOVERY & EARLY EFFORTS

2002 – 1,4-dioxane initially detected
Routine monitoring commenced

2003 – Initial conceptual studies for 1,4-dioxane treatment at TARP

2003 – Blending efforts initiated by Tucson Water to target ≤ 3 µg/L at the entry point to the distribution system (EPDS)



CONTINGENCY PLANNING AND DECISIONS

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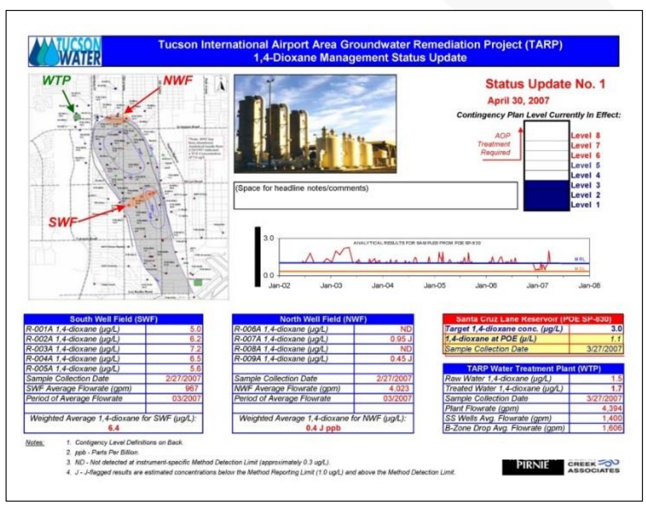
CONTINGENCY PREPARATIONS

- **2005** – Contingency Plan developed for TARP operations to manage 1,4-dioxane
- **2009** – Advanced Oxidation Process (AOP) Treatment Evaluation conducted
- **2010** – AOP Pilot Treatability Testing conducted



Tucson International Airport Area Groundwater Remediation Project (TARP)
1,4-Dioxane Management Status Update

Status Update No. 1
April 30, 2007
Contingency Plan Level Currently In Effect:
AOP Treatment Required
Level 8
Level 7
Level 6
Level 5
Level 4
Level 3
Level 2
Level 1

South Well Field (SWF)	
R-001A 1,4-dioxane (µg/L)	5.0
R-002A 1,4-dioxane (µg/L)	6.2
R-003A 1,4-dioxane (µg/L)	7.2
R-004A 1,4-dioxane (µg/L)	6.5
R-005A 1,4-dioxane (µg/L)	5.6
Sample Collection Date	2/27/2007
SWF Average Flowrate (gpm)	967
Period of Average Flowrate	03/2007
Weighted Average 1,4-dioxane for SWF (µg/L): 6.4	

North Well Field (NWF)	
R-006A 1,4-dioxane (µg/L)	ND
R-007A 1,4-dioxane (µg/L)	0.95 J
R-008A 1,4-dioxane (µg/L)	ND
R-009A 1,4-dioxane (µg/L)	0.45 J
Sample Collection Date	2/27/2007
NWF Average Flowrate (gpm)	4,023
Period of Average Flowrate	03/2007
Weighted Average 1,4-dioxane for NWF (µg/L): 0.4 J ppb	

Santa Cruz Lane Reservoir (POE SP-830)	
Target 1,4-dioxane conc. (µg/L)	3.0
1,4-dioxane at POE (µ/L)	1.1
Sample Collection Date	3/27/2007

TARP Water Treatment Plant (WTP)	
Raw Water 1,4-dioxane (µg/L)	1.5
Treated Water 1,4-dioxane (µg/L)	1.7
Sample Collection Date	3/27/2007
Plant Flowrate (gpm)	4,394
SS Wells Avg. Flowrate (gpm)	1,400
B-Zone Drop Avg. Flowrate (gpm)	1,606

Notes:
1. Contigency Level Definitions on Back.
2. ppb - Parts Per Billion.
3. ND - Not detected at instrument-specific Method Detection Limit (approximately 0.3 ug/L).
4. J - J-flagged results are estimated concentrations below the Method Reporting Limit (1.0 ug/L) and above the Method Detection Limit.

PIRNIE CREEK ASSOCIATES

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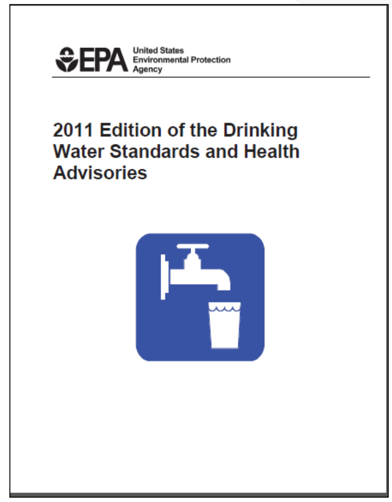
REGULATORY DEVELOPMENTS & TREATMENT IMPLEMENTATION

- **2010** – EPA publishes revised Toxicological Evaluation for 1,4-dioxane in August
- **2011** – EPA publishes new Drinking Water Health Advisory for 1,4-dioxane (0.35 µg/L at 1x10-6 excess lifetime cancer risk level)
- **2011** – AOP preliminary design
- **2011 - 2013** – AOP design and construction


EPA United States Environmental Protection Agency

2011 Edition of the Drinking Water Standards and Health Advisories

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PLANNING, DESIGN, AND CONSTRUCTION

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LPHO UV-PEROXIDE TECHNOLOGY SELECTED FOR TARP

- Exceeded treatment goals for 1,4-dioxane reduction
- No formation of bromate or unregulated byproducts
- Operational simplicity
- Demonstrated full-scale drinking water installations

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PEROXIDE QUENCHING USING GAC SELECTED FOR TARP

- Complete quenching at low contact times and high surface loading rates
- Potential to decrease byproducts
  - Assimilable Organic Carbon (AOC)
  - TTHM precursors
  - Other unregulated contaminants
- Operational and water quality stability advantages over chemical quenching

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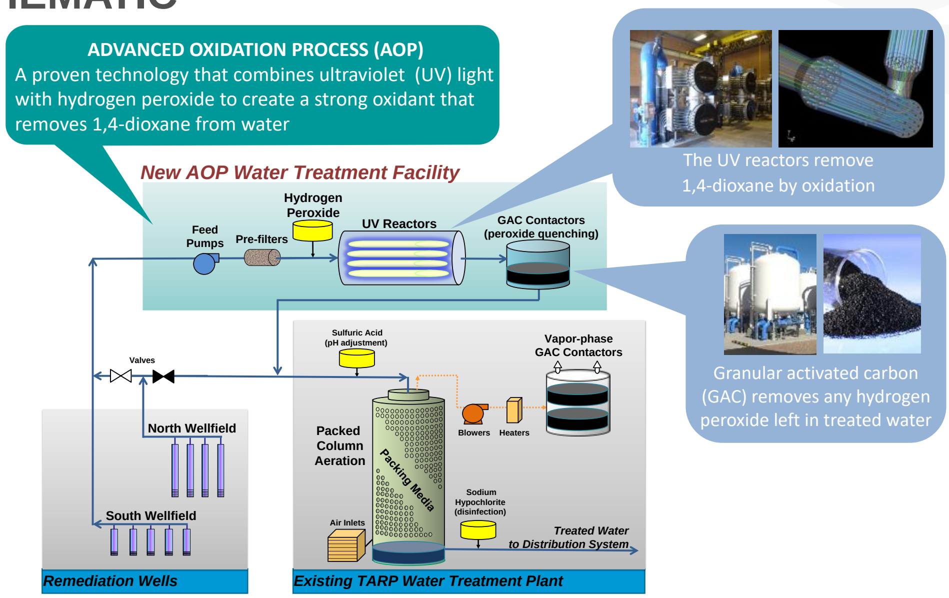
SCHEMATIC



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TECHNICAL IMPLEMENTATION

- Design/CM Services: $3.3M
- Contracting approach
  - Construction manager at risk
  - Separate GMPs for long-lead equipment purchase and general construction
- Schedule
  - Major equipment:
    - GMP-1, $4.3M awarded July 2012
  - Construction:
    - GMP-2, $11.0M awarded Sept. 2012
  - Completion: January 2014

5,800gpm
Total Capacity

$18.6M
Total CIP

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Construction Site Overview

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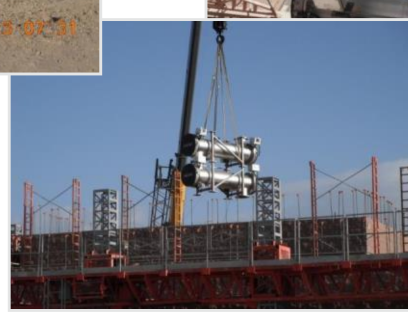

UV Building/ Equipment Construction

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Completed Facility

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Completed Facility

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AOP FOLLOW-UP TO COMPLETE TARP WTP TRANSFORMATION

- EPA coordination with CERCLA process affects timing
- Vapor-phase GAC removed from service August 2017
  - Eliminated natural gas usage for duct heaters
  - Eliminated GAC media replacement
  - Eliminated exhaust air VOC monitoring
- Packed columns to be retired
  - Eliminate power used for blowers
  - Eliminate cost and hazard of sulfuric acid
  - Avoid additional scaling and future rehabilitation
  - Reduce water quality monitoring requirements

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O&M EXPERIENCE AND IMPROVEMENTS

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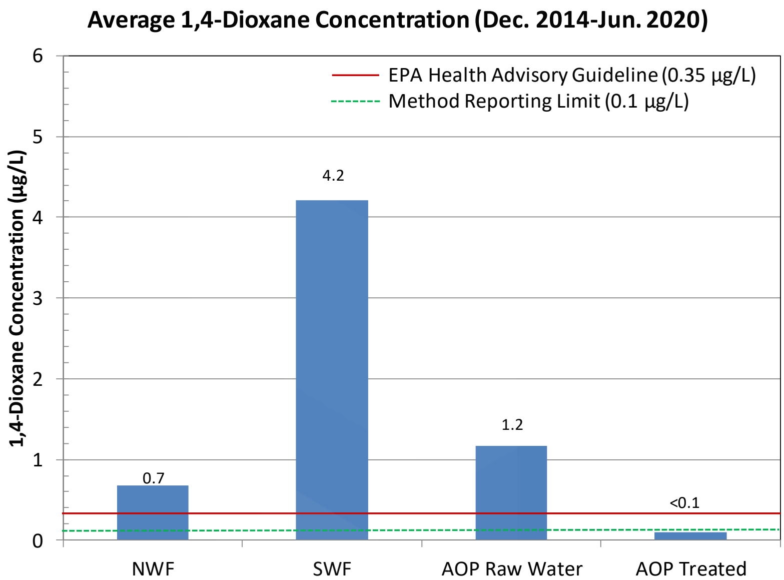
FULL-SCALE PERFORMANCE: 1,4-DIOXANE



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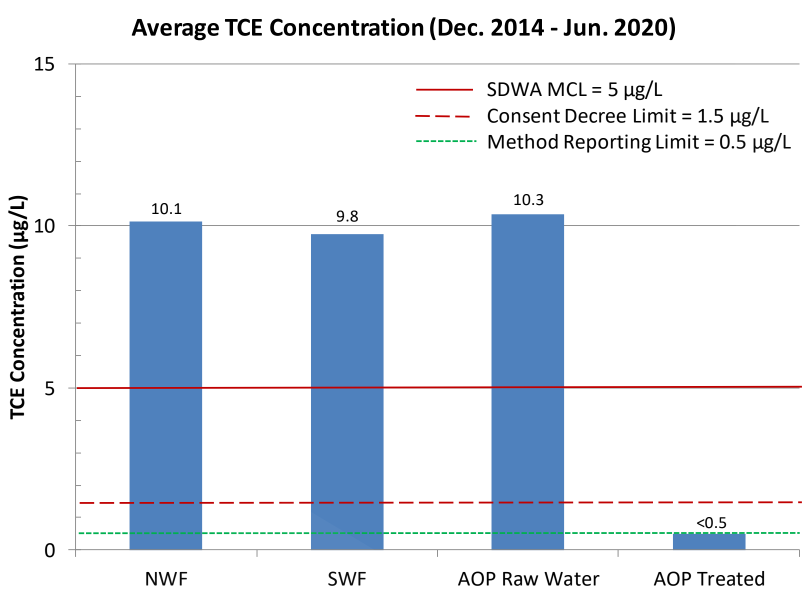
FULL-SCALE PERFORMANCE: TCE



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UV REACTORS O&M EXPERIENCE

- UV Part Replacement
  - Lamps under warranty 12,000 hours
  - Ballasts under warranty 5 years
  - Staggered lamp replacement spreads cost over several years
- UV Reactor O&M Costs
  - ~$15,000/month electric power
  - ~$10,000/month hydrogen peroxide
  - $330/replacement lamp
  - $724/replacement ballast
  - ~$164,000 for single-train lamp changeout

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NUISANCE SEDIMENT PRODUCTION

- Sources of sediment
  - Aging and failing extraction wells produce sediment
  - Deposition in wellfield collection pipelines over time
  - Flow reductions from failing wells and rehabilitation/replacements

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O&M IMPACTS OF SEDIMENT

- Periodic rapid loading/damage to basket strainers
- Overloading of cartridge filters
- UV wiper seal/function and lamp sleeve damage
- GAC acts as filter in addition to peroxide quenching

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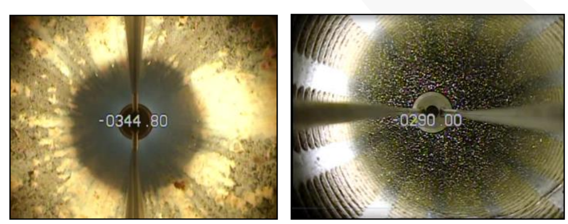
SEDIMENT MITIGATION

- Investigations
- Well rehabilitation and replacement
- WTP sediment removal



Wells → Desanders *(New)* → Basket Strainers → Cartridge Filters *(Cartridges Re-installed)* → AOP

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GAC PEROXIDE QUENCHING EXPERIENCE

- Robust performance with minimal maintenance by 8 pressure contactors
- Short (2-min) "fluffing" backwash every two weeks
- Periodic peroxide detections in top two of three bed profile sample ports
- Detections not present after backwashing
- No media replacement after 4.5 years of service to date

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ENHANCED RECOVERY

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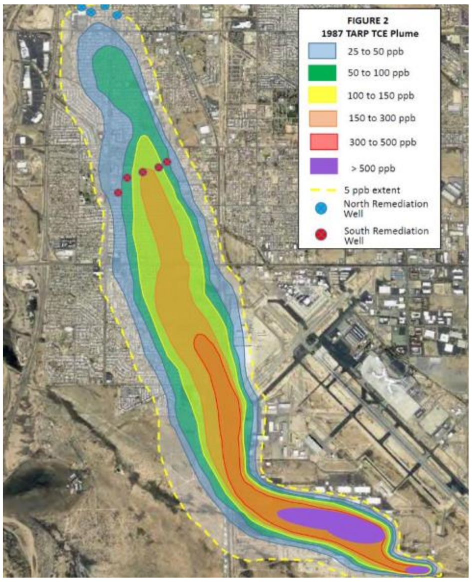
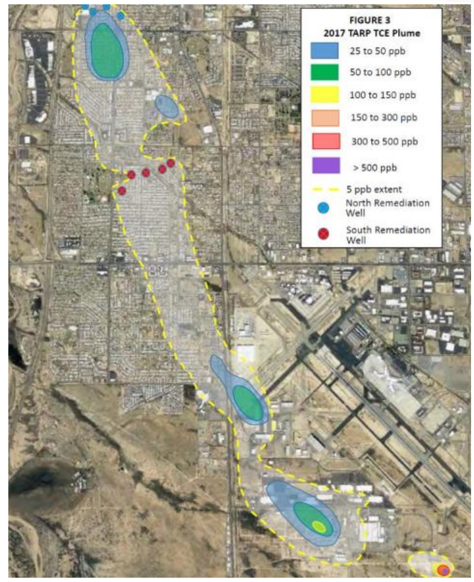
1987-TCE PLUME



2017 - TCE PLUME



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TARP TREATMENT UPGRADES FOR ENHANCED RECOVERY

- TARP treatment upgrade construction currently in progress:
  - New well being drilled and equipped for enhanced remediation
  - Treatment upgrades for additional well capacity
  - 4 GAC contactors being installed for peroxide quenching
  - Communications upgrades
  - Packed column aeration retirement demonstration
  - Potential addition of 10 – 12 GAC contactors for PFAS removal

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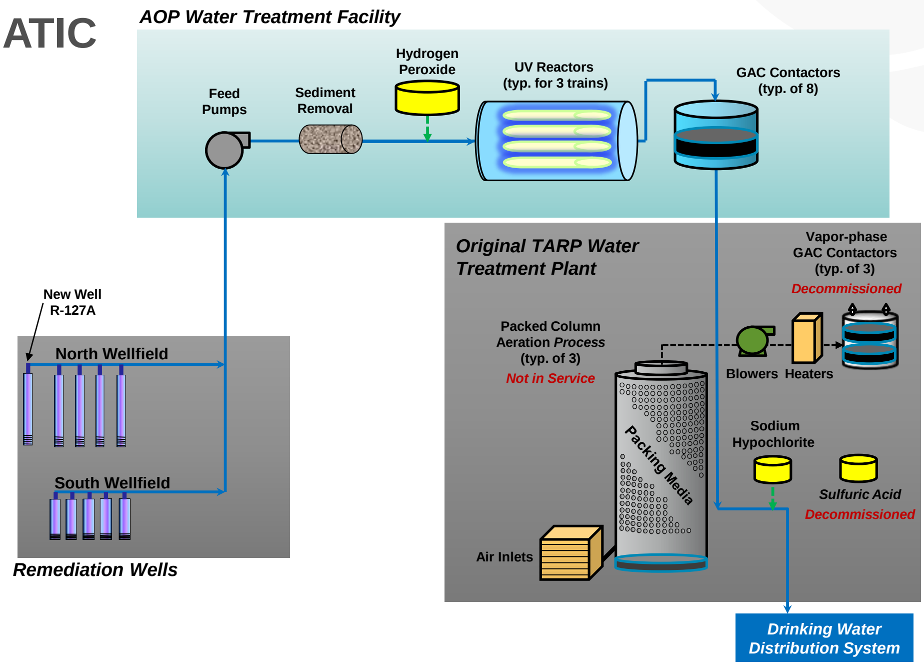
SCHEMATIC



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TECHNICAL IMPLEMENTATION

- Design/CM Services
- Contracting approach
  - Construction manager at risk
  - Separate GMPs for long-lead equipment purchase and general construction
- Schedule
  - Major equipment pre-purchase: GMP-1
  - Balance of construction: GMP-2 thru GMP-6

7,200gpm
Total Capacity

2021
Completion

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PFAS DISCOVERY

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PFAS HISTORY

2009
EPA Provisional Health Advisories:
PFOA = 400 ng/L;
PFOS = 200 ng/L

2013 – 2014
Initial detections of PFOA/PFOS at TARP well below Provisional Health Advisories

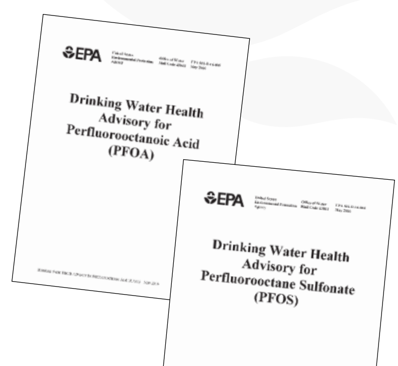
2016
Continued monitoring indicates concentrations approaching New EPA HA for PFOA + PFOS (70 ppt)
*All sample results indicate that water delivered was below the EPA HA

2016 – 2018
Continued monitoring indicates concentrations approaching EPA HA
*All sample results indicate that water delivered was below the EPA HA

Interim mitigation: Well operations, blending, and GAC change out

GAC & IX bench-scale testing (RSSCT)
Long-term mitigation selection/design
*All sample results indicate that water delivered was below operational target of 18 ng/L

2019 →
Continued GAC changeouts & capacity expansion construction


EPA
Drinking Water Health Advisory for Perfluorooctanoic Acid (PFOA)

EPA
Drinking Water Health Advisory for Perfluorooctane Sulfonate (PFOS)

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GAC CHANGEOUT

- Carbon used for hydrogen peroxide quenching replaced.
- Three carbons were used in different vessels.
- Additional 4,000 lbs of media (to 18,000 lbs) was installed in each vessel to increase EBCT.
- Weekly sampling of GAC side sample ports for 14 PFAS.
- Shorter chain species are being used as indicators for PFAS migration through carbon bed.
- Currently using bituminous coal based GAC in all vessels.
- GAC changeouts conducted:
  - Dec 2018-Feb 2019
  - Sept 2019-Jan 2020
  - Aug 2020

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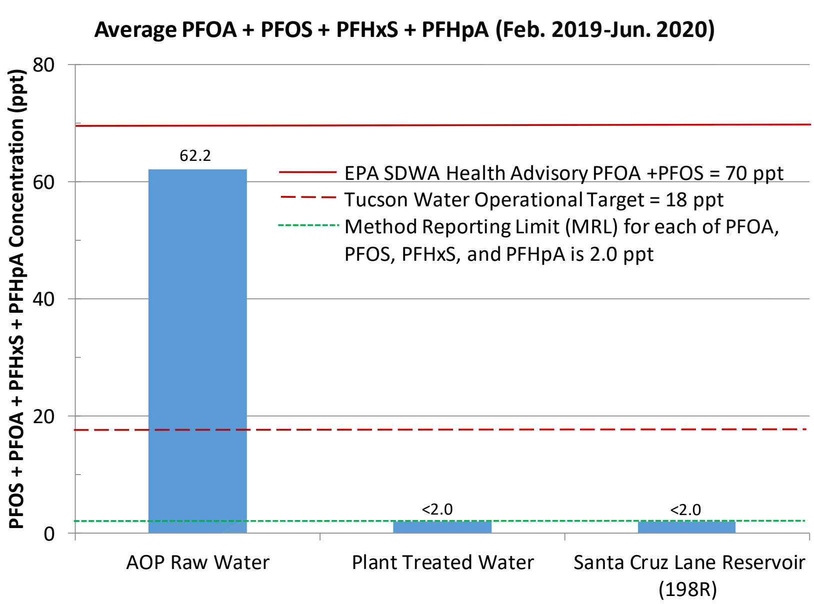
FULL-SCALE PERFORMANCE: PFAS



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MAJOR RESULTS AND RECOGNITION

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CONTINUOUS PUBLIC ENGAGEMENT

- Unified Community Advisory Board (UCAB)
- Neighborhood association meetings
- Customer communications
  - Brochures
  - Newsletters
- Groundbreaking event
- Traditional news media
- Electronic media

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AQUIFER REMEDIATION STATISTICS (THROUGH JUNE 2020)

- Remediation of 54.25 billion gallons of groundwater since 1994
- Removal of 5,848 pounds of TCE since 1994
- Removal of 135.3 pounds of 1,4-dioxane since 2014
- Significant decrease of TCE & 1,4-dioxane contamination

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NATIONAL AND STATE RECOGNITION FOR ENGINEERING EXCELLENCE

- 2016 Crescordia Award – Technology Innovation
  - Arizona Forward/SRP
- 2015 National Grand Prize - Design
  - American Academy of Environmental Engineers & Scientists (AAEES)
- 2015 National Recognition Award
  - American Council of Engineering Companies (ACEC)
- 2014 Judge's Choice Award
  - American Council of Engineering Companies of Arizona (ACEC-AZ)
- 2014 Water Treatment Project of the Year
  - AZ Water Association

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Jeff Biggs,
Tucson Water

jeff.biggs@tucsonaz.gov

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ASK THE EXPERTS

Theresa Slifko, PhD
Metropolitan Water District of Southern California

Jeff Biggs
Tucson Water

Erik Rosenfeldt, PE, PhD
Hazen and Sawyer

Enter your **question** into the **question pane** on the right-hand side of the screen.

Please specify to whom you are addressing the question.

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Hazen

Addressing Multiple CECs at an East Coast Surface Water

Erik Rosenfeldt, PhD, PE
Hazen and Sawyer

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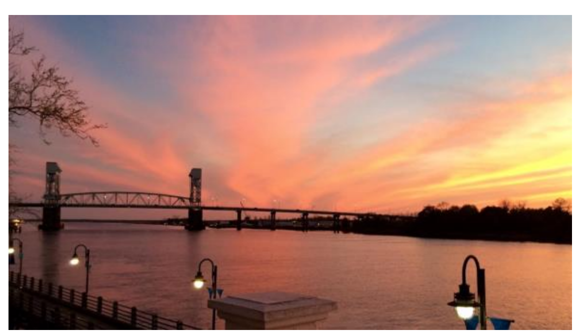
Agenda

- Defining the challenges
  - System Description - Expansion and Upgrades
  - Cape Fear Today: DBPs, dioxane, forever chemicals
  - Regulatory drivers and Public demands changes project "scope"
- Addressing the Challenges with Treatment
  - Options available
  - Bench Testing Results
- Impacts of the Testing Results
  - Several Potential Paths forward
  - Prioritizing Water Quality and Expansion
- The Path Forward
  - Prioritizing public health protection
  - Considering regulatory uncertainty



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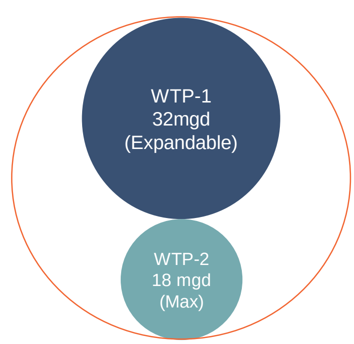
Defining the Challenges

Case Study Background

- Surface water system in North Carolina
- System currently considering expansion *and/or* implementation of advanced treatment
- Multiple Water Quality Concerns
  - **Stage 2 Compliance Concerns (infrastructure concerns)**
  - **Bromide leading to elevated TTHMs**
  - **1,4-Dioxane at elevated levels throughout watershed**
  - **"New Kid" is PFAS (specifically GenX)**

WTP 1
Source: Cape Fear River

WTP 2
Source: Reservoir & Cape Fear River

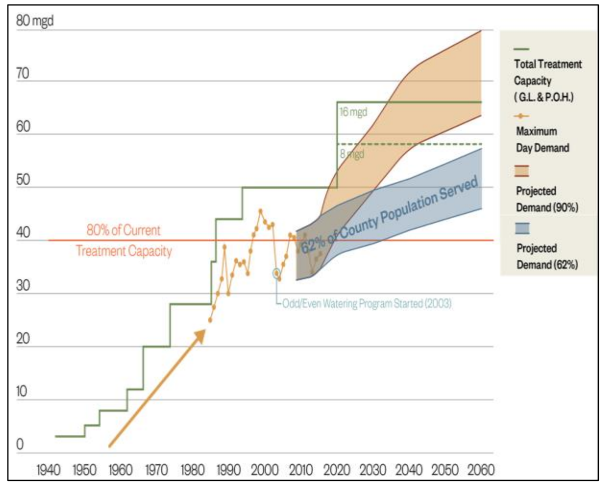


Total Permitted Capacity: 50 mgd

Case Study Background

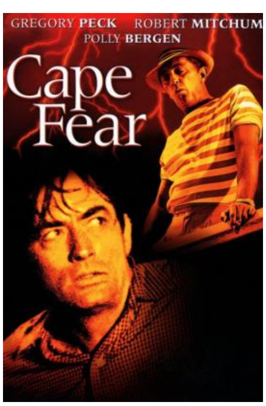
The Area is Growing, the Water is Needed

- Reliability concerns – aging infrastructure
- Expansion needs – WTP-1 (design complete)
- Phased approach
- Emerging contaminants discovered in Cape Fear River



The "Cape Fear" is an Iconic Watershed

It has faced Challenges for Decades



Cape Fear in 1962

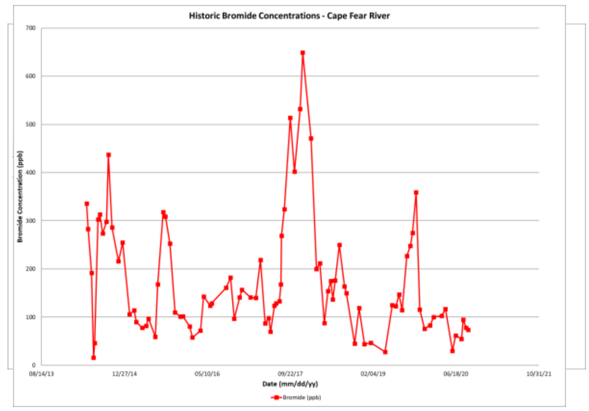
Cape Fear in 1991

Cape Fear in 2020

The Cape Fear through History

Bromide in the River is impacting THMs and unregulated HAAs

Cape Fear in 1962

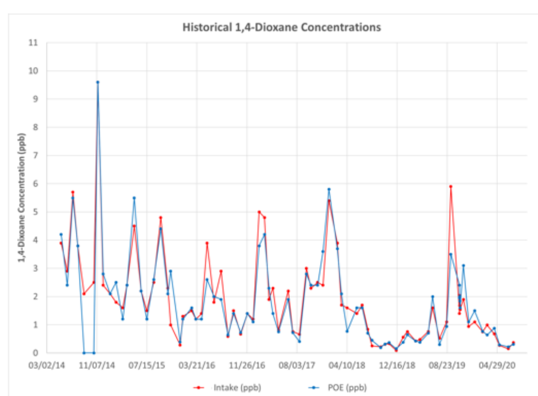


Cape Fear in 2020

The Cape Fear Through History

1,4-Dioxane

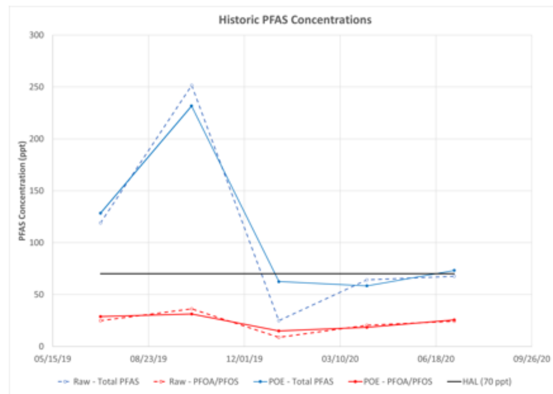
Cape Fear in 1991



Cape Fear in 2020

The Cape Fear Through History

Cape Fear in 1991



Cape Fear in 2020

Summarizing the Challenges

Contaminant	Regulatory Perspective	Historical Data Summary
DBPs	• Stage 2 regulates TTHM, HAA5, bromate • Recognition that brominated DBPs likely more toxic • UCMR4 (and Stage 3) considering HAA9 • Current ongoing work (WRF 4807) investigating toxic "Modes of Action" for bromate	• Chloramination to "control" DBPs • As bromide in Cape fear increases, DBP regs are a challenge to meet • Bromate could impact use of strong oxidants (O_3, AOP)
1,4-Dioxane	• No national MCL (No Regulatory Determination) • California has 1 ppb notification limit • New York MCL will be 1ppb • North Carolina focusing on 0.35 ppb	• 1,4-dioxane regularly detected in Cape Fear between 1 and 6 ppb • No removal across current treatment train
PFOA + PFAS	• EPA Health Advisory: PFOA + PFOS < 70ppt • No national MCL (Positive RD in Feb 2020) • *Many* states going beyond Health Advisory • New York MCL will be 10ppt PFOA, 10ppt PFOS	• PFOA + PFOS have been detected at ~ ½ the Health Advisory
Short Chain + GenX	• Some states (MA, VT) consider shorter chain PFAS in their rules • North Carolina Health Guidance Level for GenX of 140ppt	• Short chain PFAS found regularly • GenX not acute concern at this facility

Addressing the Challenges with Treatment

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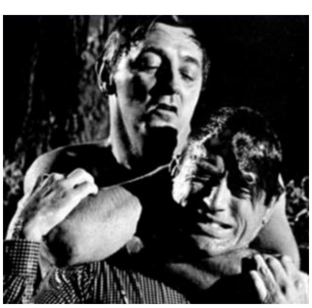
Fighting Back

Our approach may be a little less "confrontational"



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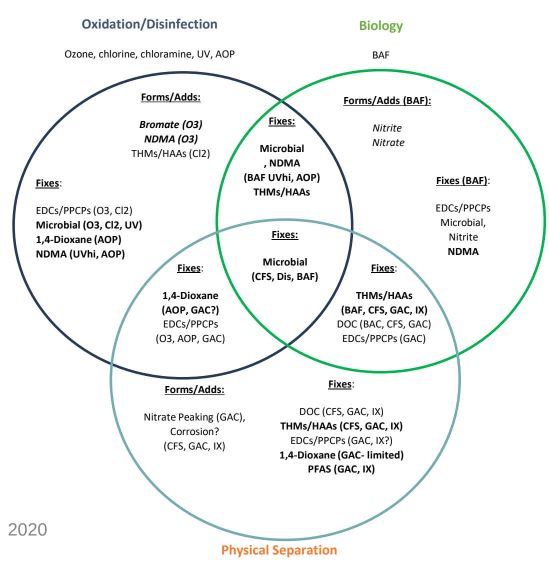
1991



2020

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Advanced Treatment Options

Unfortunately Best Treatment Options do not Overlap

Treatment Options for 1,4-dioxane

- GAC and PAC: Not effective
- Ion exchange: Not effective
- Ozone
  - Not effective in groundwater
  - Potentially effective in surface water
- AOPs (O_3/H_2O_2, UV/H_2O_2)
  - Effective in groundwater
  - Potentially effective in surface water
- High pressure membranes (NF, RO): Partially effective

Treatment Options for PFAS

- GAC and PAC
  - Effective for long-chain PFASs (PAC is somewhat effective)
  - Poor performance for short-chain PFASs (PFBA and PFPeA)
  - Higher organic matter levels in raw water impair PAC performance
- Ion Exchange
  - Can be effective for short-chain PFASs
  - Experience only in groundwater
- Ozone: No oxidation
- AOPs (O_3/H_2O_2, UV/H_2O_2) : No oxidation
- High pressure membranes (NF, RO): Effective for PFAS removal

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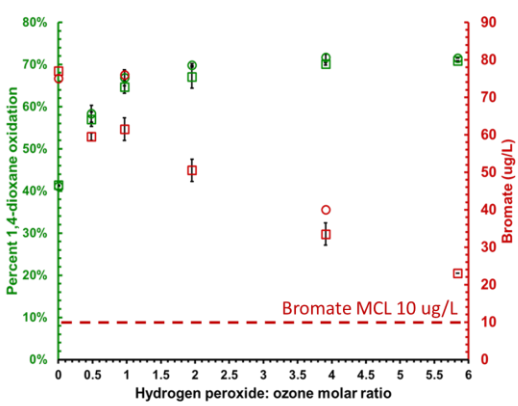
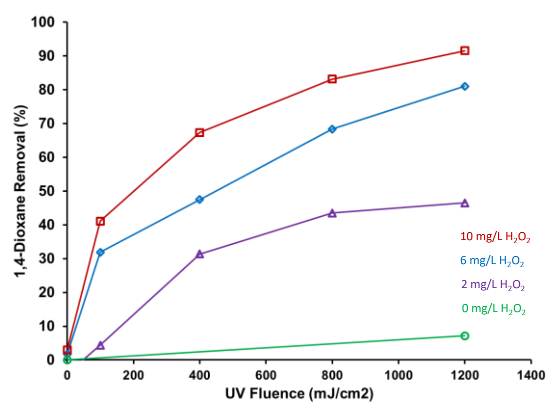
1,4-dioxane Treatment Options



Ozone / Ozone Peroxide severely hampered by bromate formation



UV AOP needs high doses of UV and peroxide for significant removal

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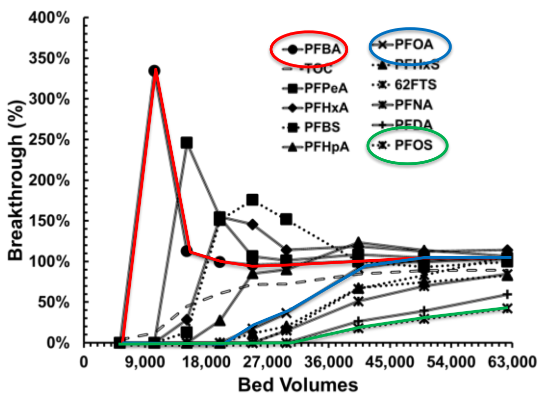
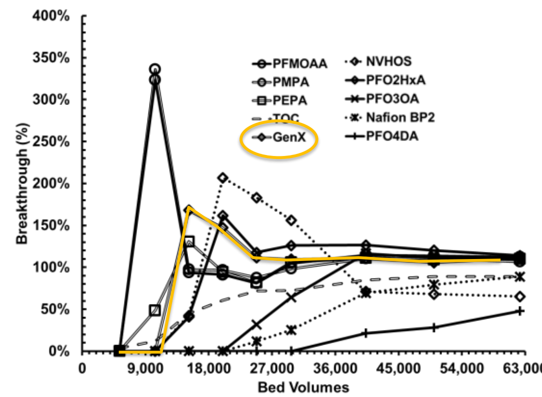
PFAS Treatment Options



Short-Chain PFAS provide treatment challenges



GenX rapid breakthrough

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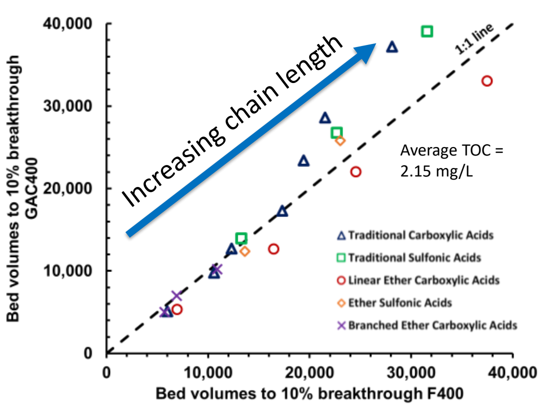
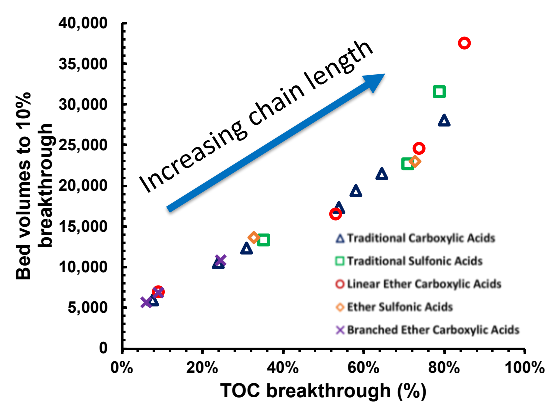
Impact of Chain length on GAC breakthrough



Reagglomerated subbituminous coal-based GACs
Average TOC = 2.15 mg/L



Carbon: F400
Average TOC = 2.15 mg/L

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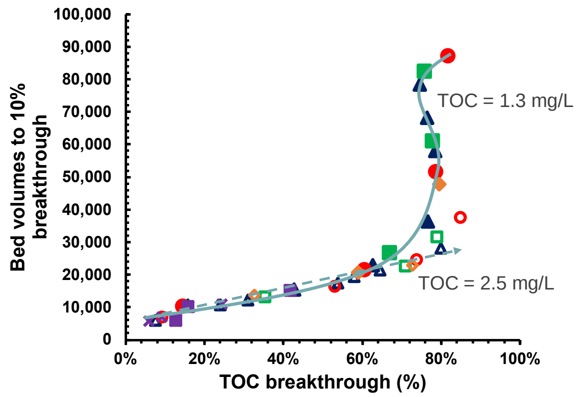
Impact of Water Quality on PFAS Breakthrough

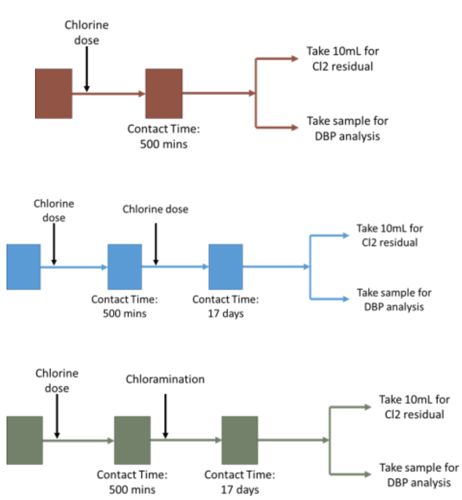
Comparing Surface Water with Groundwater

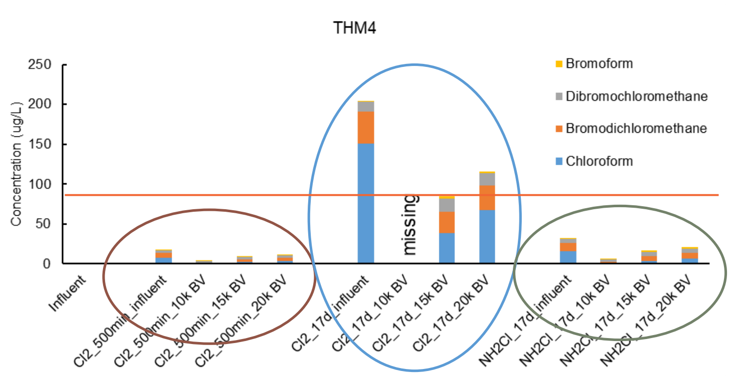
- Carbon: F400
  - Open symbol TOC = 2.15 mg/L
  - Closed Symbol TOC = 1.3 mg/L
- Significant impact of TOC at high breakthrough (~80%)
- Hypothesis – is TOC ultimately "kicking off" adsorbed PFAS?



Evaluating DBPs

Question – Could GAC facilitate a conversion to Free Chlorine?



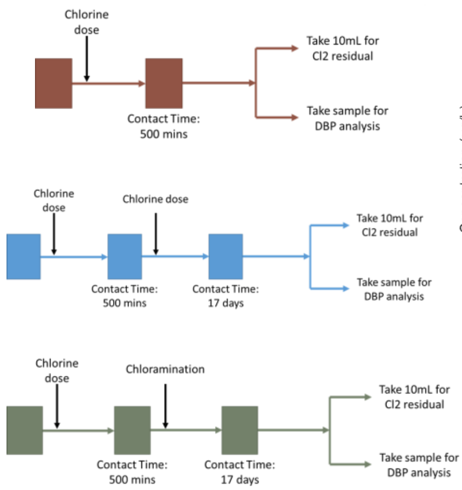


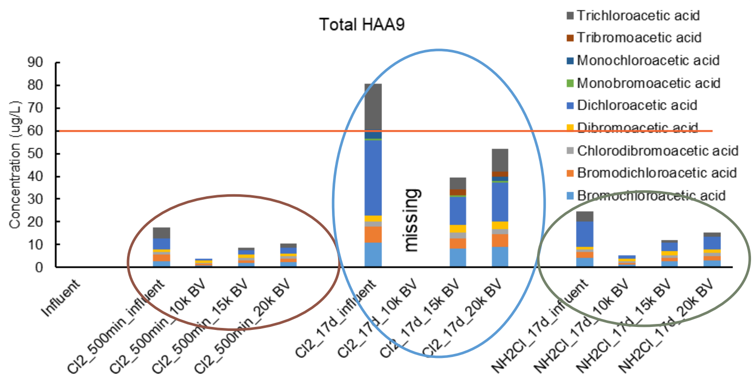
Take Home Messages

- GAC did not facilitate a conversion to free chlorine
  - (3 to 3.5-month GAC regeneration for 10 minute EBCT)
- Also, did not observe a "bromination" of THMs with GAC

Evaluating DBPs

Question – Could GAC facilitate a conversion to Free Chlorine?





Take Home Messages

- GAC was OK with free chlorine
- A little bit of tribromoacetic acid showed up after GAC

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Summarizing the Bench Testing Results

Contaminant	Oxidation Ozone	Oxidation UV AOP	Adsorption GAC	Adsorption IX
DBPs	Possibly, w/ BAF	No	Yes, 3-4 months regen. (Cl_2) 9-12 month regen (NH_2Cl)	MIEX yes Alts. in Testing
1,4-Dioxane	50 – 60%	> 90%	No	No
PFOA + PFAS	No	No	1-1.5 yr regen.	Yes
Short Chain + GenX	No	No	<6 months regen.	In testing

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Impacts of the Testing Results

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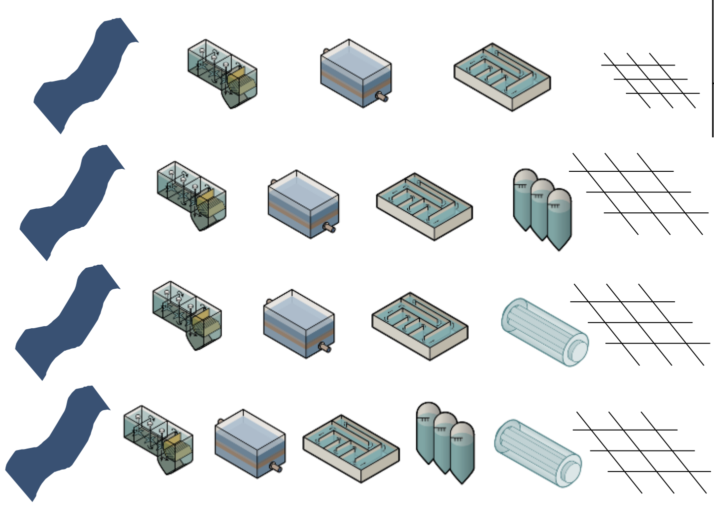
Implications on Potential Treatment Trains



Treatment Scenario	Advantages	Disadvantages
Expansion of Conventional Train	• Meets Demand Needs • Budget Available	• Does not address Water Quality

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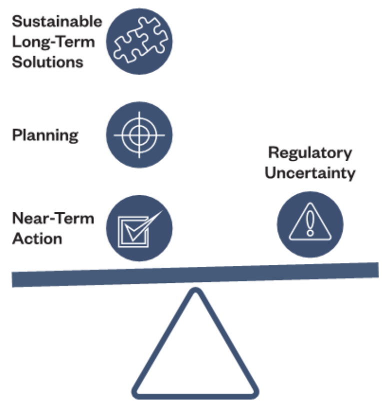
What's next?

Moving Forward with Testing and Prioritizing Public Health

- Piloting GAC for PFAS and DBP compliance
- Modeling and expanded bench-testing of ozone and UV AOP
  - **Impacts of GAC on UV AOP performance**
  - **Bromate mitigation measures for O_3/H_2O_2 (and for UV/H_2O_2)**
- Likely a Phased Approach
  - **GAC to improve water quality today**
    - *Focus on* ***REGULATED DBPs***
    - *Address PFAS of Concern*
  - **Expand when Water Quality under control**
    - *Holistic approach*
  - **AOP *if required***
    - *North Carolina working aggressively to address 1,4-dioxane dischargers into the Cape Fear*



Questions?

Erik Rosenfeldt, PhD, PE
Hazen and Sawyer
Director of Drinking Water Process Technologies
erosenfeldt@hazenandsawyer.com

ASK THE EXPERTS

Theresa Slifko, PhD
Metropolitan Water District of Southern California

Jeff Biggs
Tucson Water

Erik Rosenfeldt, PE, PhD
Hazen and Sawyer

Enter your **question** into the **question pane** on the right-hand side of the screen.

Please specify to whom you are addressing the question.

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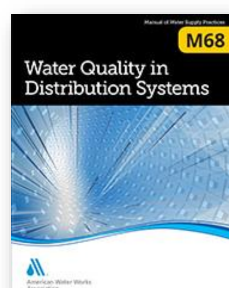
ADDITIONAL RESOURCES

- AWWA PFAS Resource Community
- Water Quality & Infrastructure Virtual Summit
  - The new AWWA Virtual Summit focusing on Water Quality and Infrastructure solutions is a 2 1/2-day, fully interactive online event that delivers premier learning and networking opportunities around the latest in water quality, managing aging infrastructure, utility risk and resilience and much more.
- M68 Water Quality in Distribution Systems
  - AWWA catalog no: 30068



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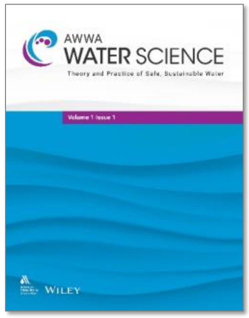

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- As part of your registration, you are entitled to an additional 30-day archive access of today's program.
- The Joint Section Resource Committee is always accepting new members! If you are interested in volunteering with AWWA please email cbertoia@awwa.org.
- For more information on volunteering and other volunteer opportunities, visit our website.

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PRESENTER BIOGRAPHY INFORMATION

Theresa Slifko is the Chemistry Unit Manager at Metropolitan's Water Quality Laboratory in La Verne, California. Terri has spent over 26 years investigating a wide range of water quality issues including the development and evaluation of analytical tools for the detection of emerging microbial and chemical contaminants in drinking water, recycled water, and recreational water. Terri and her staff are currently supporting an international effort to develop reliable testing methods to study microplastics in source and treated drinking water. Their work helps support Metropolitan's consortium of 26 cities and water districts that provide drinking water to nearly 19 million people in southern California.

Jeff Biggs has nearly 40 years of experience in the water profession, including being a certified Water Treatment & Water Distribution Operator. Jeff's experience includes water treatment and quality, water resource management, public outreach, intergovernmental affairs, and research. Jeff also has extensive management experience, is a member of numerous Boards and committees and is an AWWA Life Member and a recipient of the Water for People Kenneth J. Miller Founder's Award. Jeff is an avid golfer and was the Chair of the Southern Arizona Golf Classic for fifteen years, which raised over $410,000 for Water for People. Water for People is an international 501(c)(3) nonprofit humanitarian organization that focus on long-lasting, safe drinking water and improved sanitation for developing countries.

Erik Rosenfeldt is Hazen's Director of Drinking Water Process Technologies, and a member of the Firm's Drinking Water, Reuse, and Applied Research groups. Dr. Rosenfeldt's work focuses on implementing conventional and advanced treatment solutions for addressing emerging water quality challenges. He has lived in Richmond Virginia for 8 years with his wife and 4 kids and has enjoyed getting to know them all better in 2020.

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