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Beyond the Textbook: Disinfecting Water and Wastewater in Extreme Conditions

Disinfection and Public Health Committee Webcast

Thursday, March 7, 2019

1:00 – 3:00 PM ET

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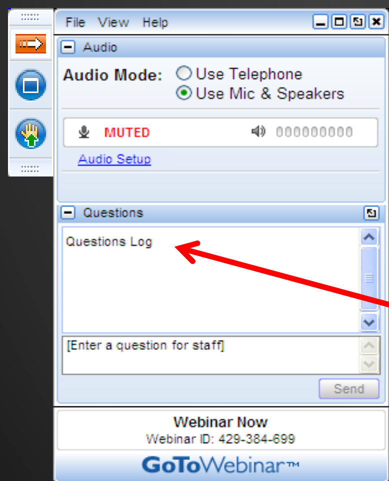
How to Participate Today



- **Audio Modes**
  - Listen using Mic & Speakers
  - Or, select "Use Telephone" and dial the conference (please remember long distance phone charges apply).
- **Submit your questions using the Questions pane.**
- **A recording will be available for replay shortly after this webcast.**

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Today's Webcast Moderator

Rasha Maal-Bared, PhD
Senior Microbiologist, EPCOR Water Services

PROVIDING MORE EPCOR

Introduction:

- Disinfection and public health
- Why focus on extreme conditions?
- Case studies:
  - Maintenance of Plant Operations (MOPO)
  - Extreme weather conditions – Flooding
  - Wildfires

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Speakers

Maintenance of Plant Operations

Joshua Goldman-Torres, PhD, PE
Environmental Engineer, CDM Smith

- Maintenance of plant operations during a peracetic acid system installation in the Houston area

Scott Schaefer, PE
Wastewater Practice leader, AE2S

- Temporary Construction Disinfection in Montana
  - Harve WWTP - UV retrofit design
  - Livingston WRF - Peracetic acid and UV

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Speakers

Extreme Weather & Flooding

Brady Skaggs, PhD
Quality Program Director, Lake Pontchartrain Basin Foundation
Disinfection challenges in centralized and decentralized wastewater treatment systems

- New Orleans WWTP after Hurricane Katrina
- Decentralized secondary aeration systems after the 2016 Louisiana floods

Sidney Bomer
Public Works & Engineering Operations Manager, Houston Public Works, City of Houston

- Bringing Houston WWTP back online after Hurricane Harvey: disinfection challenges

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Speakers

Wildfires

Monica B. Emelko, PhD, PE
Associate Professor, Civil and Environmental Engineering & Director of Water Science, Technology & Policy, University of Waterloo

- Wildfire threats to public health

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Maintenance of Plant Operations During A Peracetic Acid System Installation

Joshua Goldman-Torres, PhD, PE

CDM Smith

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Houston Area Wastewater Treatment Facility

- What is MOPO?
- Facility Background
- Existing System
- New Peracetic Acid Disinfection System
- Installation Plan
- Conclusions

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Maintenance Of Plant Operations

MOPO

Disinfection of water and wastewater is critical to public health and the environment.

↓

Must maintain disinfection during construction

Bypass pumping	Temporary systems	Detailed planning

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Facility Background

- Regional facility
- Houston Area
- Receives mostly industrial wastewater
  - Mainly petrochemical
  - Some municipal
- Max Daily Flow – 43 MGD
- Activated Sludge
- Two treatment trains
  - West twice hydraulic capacity of each

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Permit

Effluent Characteristics [3]	Discharge Limitations					Minimum Self-Monitoring Requirements	
	Daily Average		Daily Maximum		Single Grab	Report Daily Average and Daily Maximum	
	lbs/day	mg/l	lbs/day	mg/l	mg/l	Measurement Frequency	Sample Type
Flow (MGD)	(Report)		(Report)		N/A	Continuous	Totalizing Meter
Biochemical Oxygen Demand, 5-day (BOD_5)	Report	N/A	Report	N/A	160	1/day	24-hr Composite
Total Suspended Solids (TSS)	Report	N/A	Report	N/A	149	1/day	24-hr Composite
Oil and Grease	Report	N/A	Report	N/A	51.0	3/week	Grab
Total Organic Carbon (TOC)	Report	N/A	Report	N/A	262	3/week	24-hr Composite
Ammonia -Nitrogen (NH_3-N)1	Report	N/A	Report	N/A	26.0	3/week	24-hr Composite
Temperature (Degrees Fahrenheit, °F)	(105)		(115) [4]		N/A	Continuous	In-Situ
Residual Chlorine, Total	N/A	N/A	Report	N/A	0.0175	1/week	Grab
Enterococci (CFU/100 ml)	(168) [5]		(500) [6]		N/A	3/week	Grab
Fluoride	N/A	4.20	N/A	6.10	12.2	3/week	24-hr Composite

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Existing Disinfection System

- Temporary chlorination/dechlorination installed in 2012
- No existing disinfection basin
- Chlorine was dosed into secondary clarifiers

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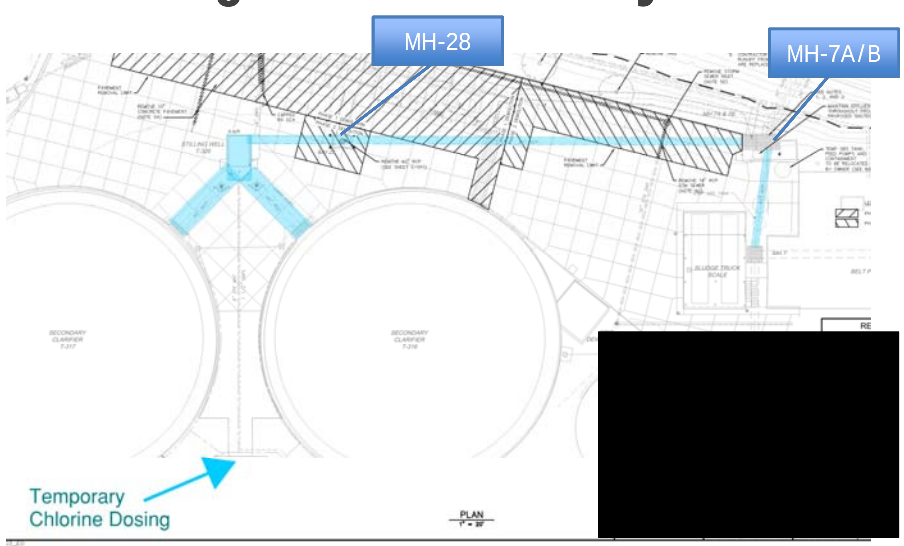
Existing Disinfection System



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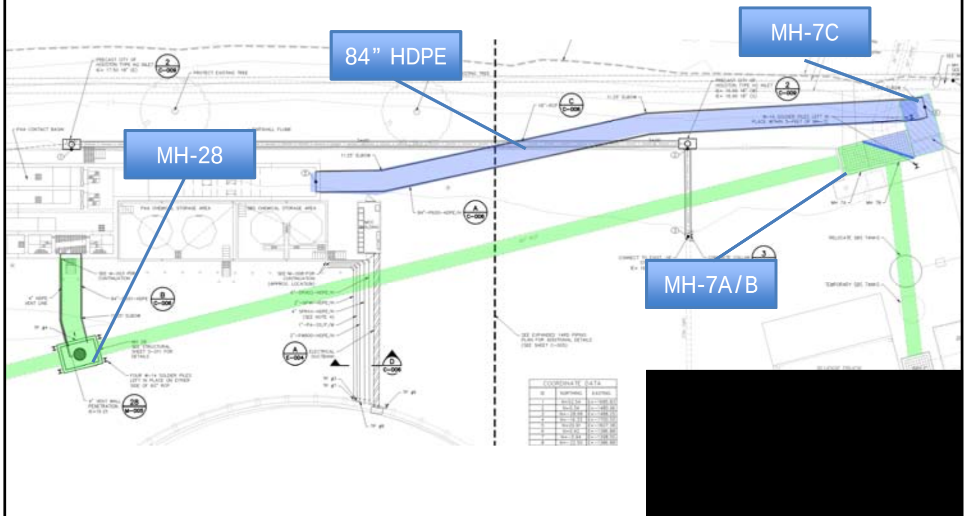
New PAA Disinfection System



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Construction Sequencing Plan

- Construct PAA disinfection tank and chemical storage areas
  - flume, instrumentation, feed piping
  - PAA, SBS
- Modify MH-28, MH-7C (no-tie ins)
- Install 84" conveyance piping
- Install temporary bypass pumping for discharge
- 7 days allowed for tie-in of MH-7B/C and MH-28

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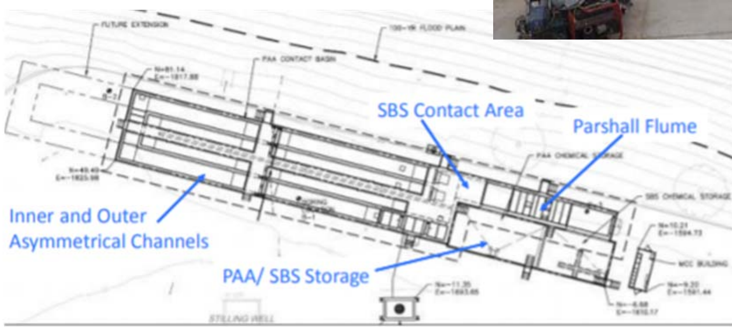
Construct PAA Tank and Chemical Storage Areas



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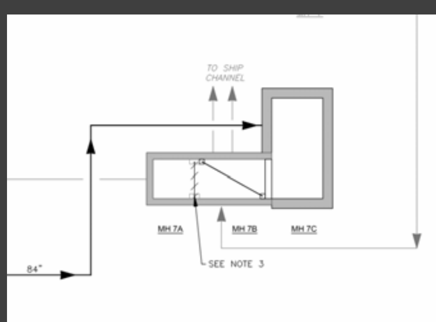

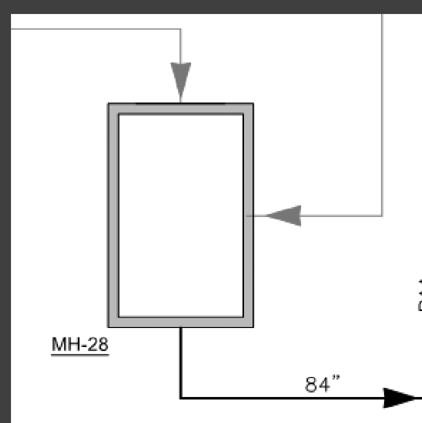

Modify MH-28 and MH-7C

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Modify MH-28 and MH-7C

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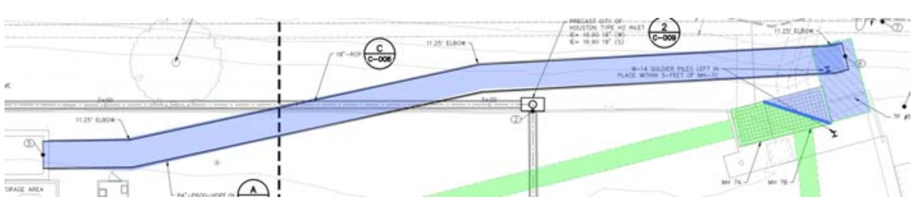
Install New 84” Piping



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Install New 84” Piping

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Install Bypass Pumping

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Construction Challenges

Modification of concrete outfall structure

- 40’ wall to separate flow and to direct effluent to discharge body

Large scale bypass pumping

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Construction Plan

Year long construction planning effort

Weekly coordination meetings client, construction team, subcontractors, CDM Smith

Periodic meetings with PAA vendor (provided packaged feed/storage equipment)

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Conclusions

- Close coordination between all parties required to meet construction deadlines and regulatory compliance
- Identify critical design and construction elements early

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DISINFECTION DURING CONSTRUCTION

for UV Retrofit Design

Scott Schaefer, PE
Harve WWTF, Montana

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TRC COMPLIANCE

- **TRC limit of 0.12 mg/L down to:**
  - 30-day 0.01 mg/L
  - Max Day 0.02 mg/L
- **Chlorination/Dechlorination Controls**

Description	Units	Average Monthly Limit	Average Weekly Limit
E. Coli (April 1 through October 31)	cfu/100 mL	126	252
E. Coli (Nov. 1 through March 31)	cfu/100 mL	630	1,260

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UV DISINFECTION

- **Industrial Dye in the wastewater**
  - 3 month UVT monitoring
- **Multiple UV lamp configurations: horizontal and diagonal lamps**

Condition	Flow, MGD	UVT
Peak Hour	4.9	55%
Max Month	2.4	50%
Annual Average	1.8	50%
Minimum	0.5	47%

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UV CONSTRUCTION PHASING

- **Series Chlorine Contact Basin**
  - Can use about half of existing CCB
- **Temporary Chlorination / Dechlorination**
- **Addendum: UV Pilot Skid**

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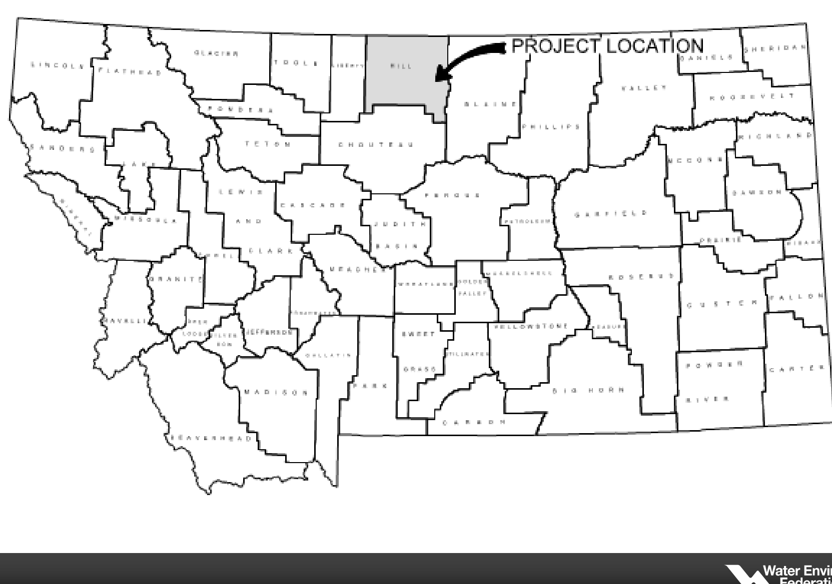
HAVRE



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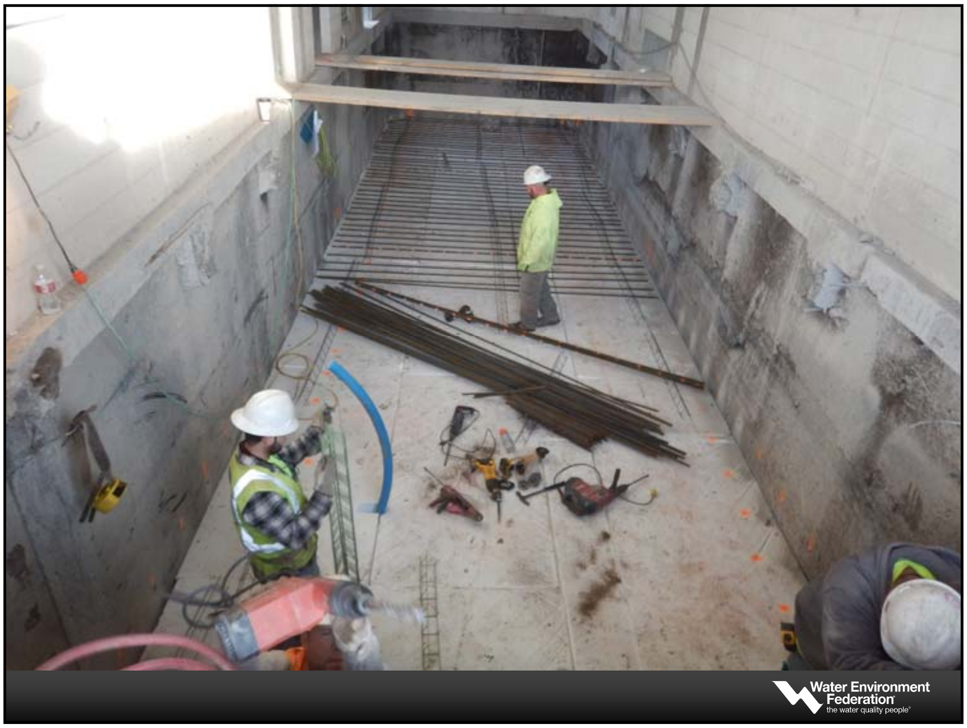
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WEDECO
a xylem brand
xylem
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TEMPORARY CONSTRUCTION DISINFECTION

with Peracetic Acid & UV

Scott Schaefer, PE
Livingston WRF, Montana

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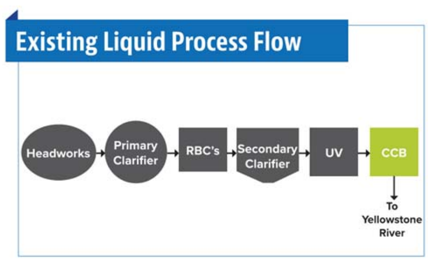
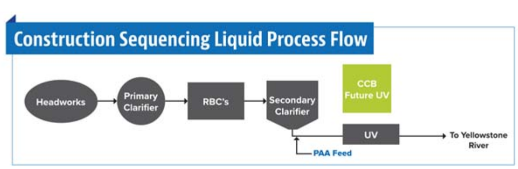
CONSTRUCTION SEQUENCING





- Repurposed Existing Chlorine Contact Basin (CCB) for new UV Channel & Facility (6.8MGD peak).
- Summer Effluent Limits (Apr 1 – Oct 31):
  - **126 CFU/100 mL**
- Existing UV Performance w/out CCB:
  - **5280 CFU/100mL (+/-)**

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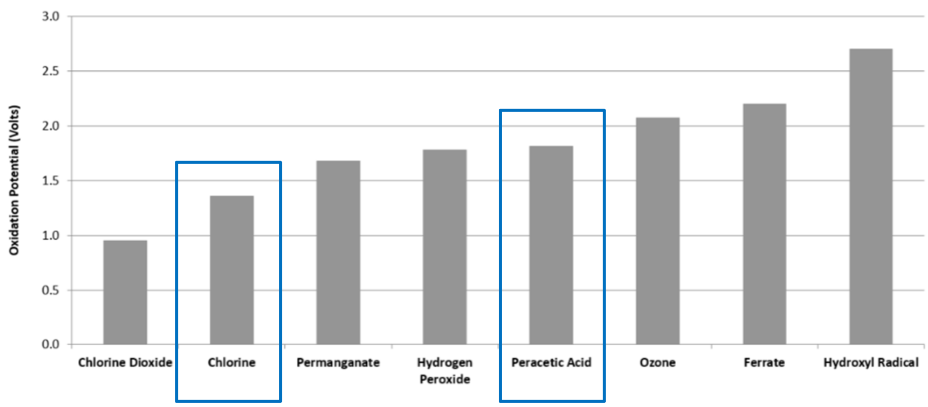
OXIDATION POTENTIAL



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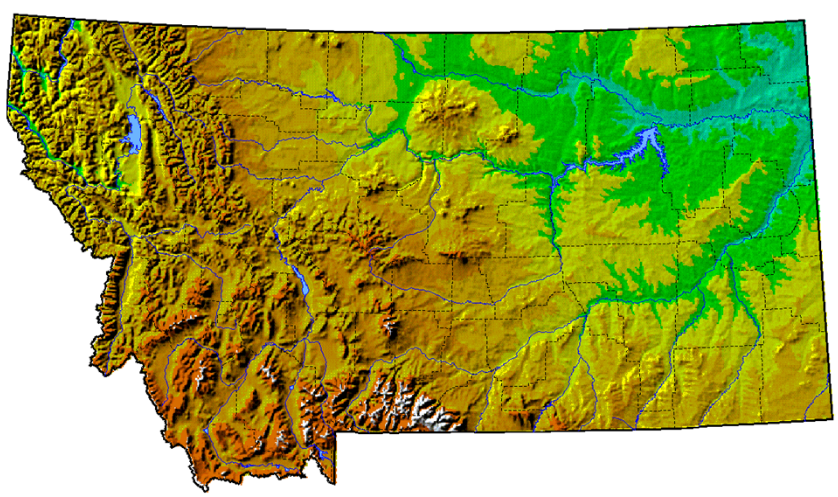
PAA:

REGULATORY APPROVAL REQUIRED



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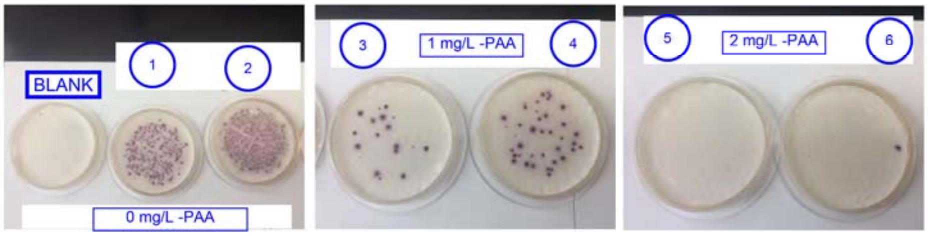
DISINFECTION RESULTS



BEFORE:
5280 CFU/100 mL

AFTER:
7 CFU/100mL

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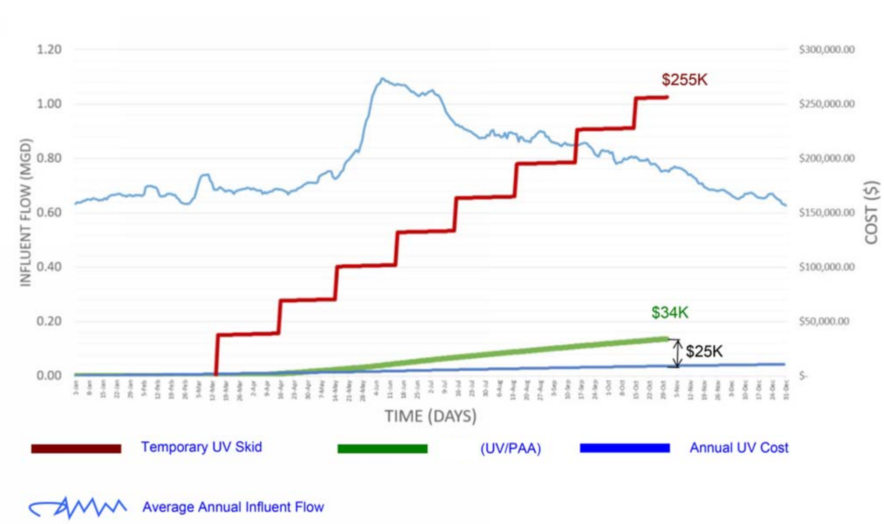
ECONOMICS



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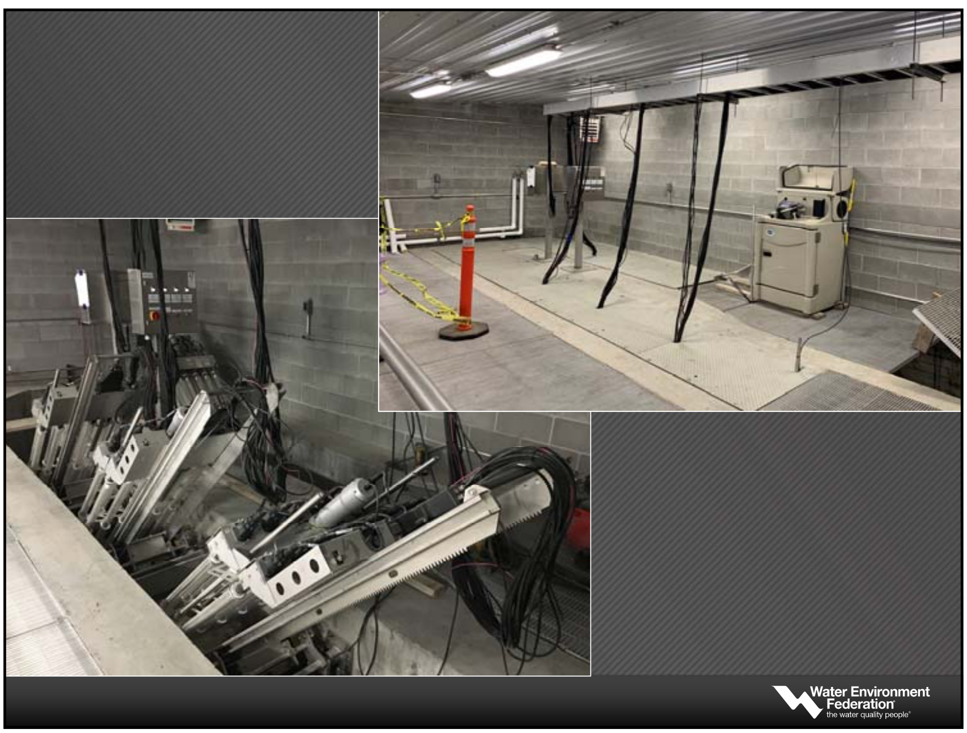
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Lake Pontchartrain Basin Foundation

Brady Skaggs, Ph.D., MSPH

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Hurricane Katrina & 2016 Floods

WEF Disinfection & Public Health Committee

Brady Skaggs, Ph.D., MSPH
Warren Bankston, Ph.D.

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Two Different Flooding Events

- 2005
- 2016

Photo courtesy of Kenny Bellau

Photo courtesy of Ashley Wolff

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New Orleans East Bank WWTP

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New Orleans East Bank WWTP

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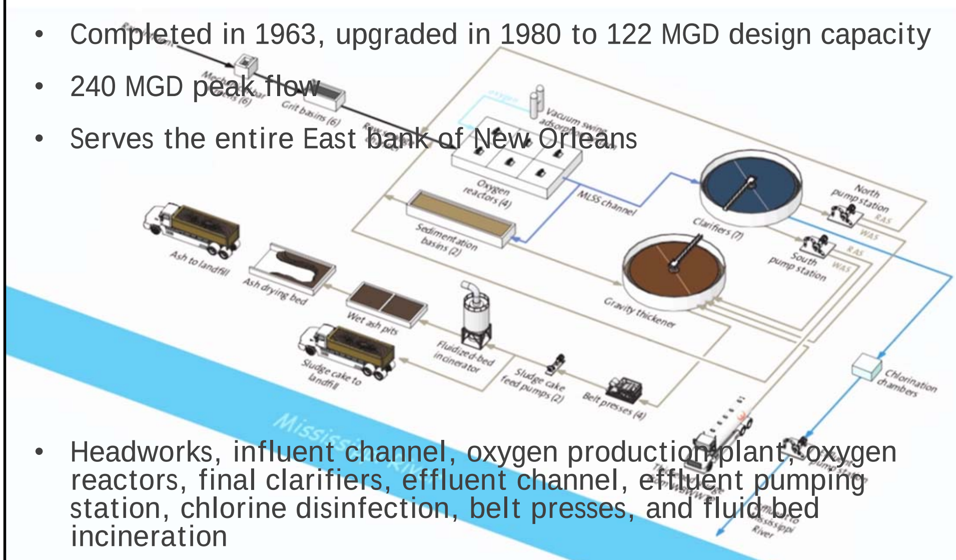
East Bank Treatment Plant

- Completed in 1963, upgraded in 1980 to 122 MGD design capacity
- 240 MGD peak flow
- Serves the entire East bank of New Orleans



- Headworks, influent channel, oxygen production plant, oxygen reactors, final clarifiers, effluent channel, effluent pumping station, chlorine disinfection, belt presses, and fluid bed incineration

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Hurricane Katrina

Photo courtesy of Warren Bankston, Ph.D.

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Hurricane Katrina

Photo courtesy of Warren Bankston, Ph.D.

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Hurricane Katrina

Photo courtesy of Warren Bankston, Ph.D.

- After **30 days**: Plant was dewatered
- After **45 days**: Facility was receiving 30 MGD
- After **95 days**: Secondary treatment was restored
- **Chlorination**

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Hurricane Katrina: Aftermath

- Over 80% of the City of New Orleans was inundated.
- Treatment plant with railcar-delivered chlorine tank was inundated.
- Alternative disinfectants were assessed, ideal disinfectant would:
  - Allow for reuse
  - Be generated onsite, of less toxic or non-toxic feedstocks
  - Could withstand future severe weather events

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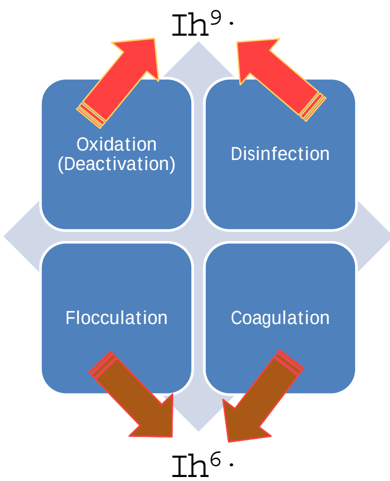
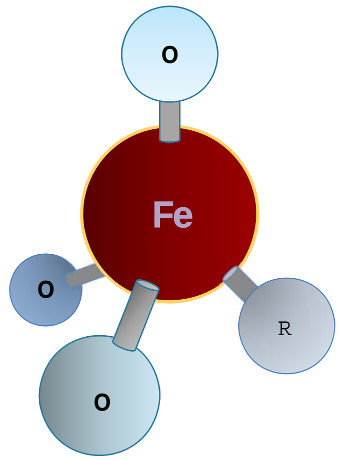
Hurricane Katrina: Alternate Disinfection





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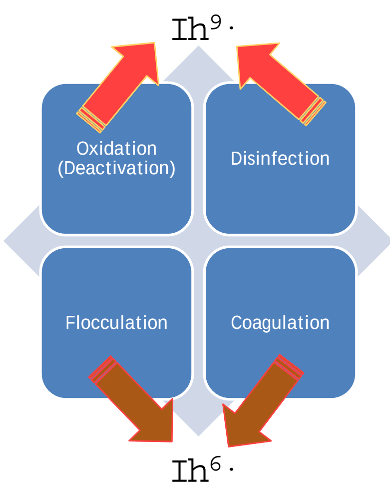
Hurricane Katrina: Alternate Disinfection



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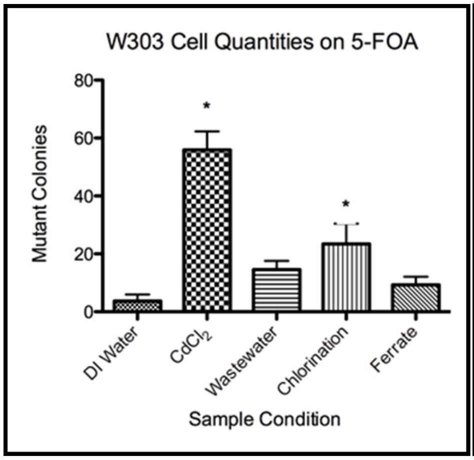
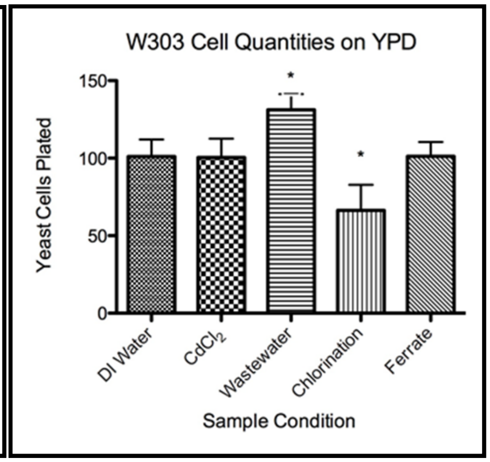
Disinfection Benefits:
Mutation Frequency

- 5-FOA Plates



- YPD Plates



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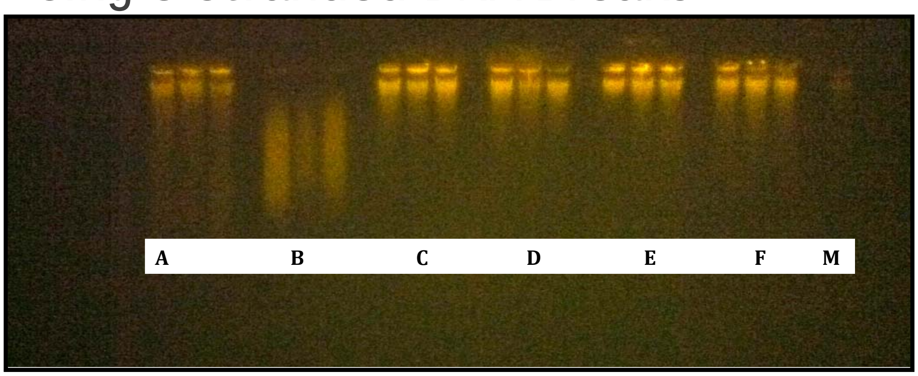
Disinfection Benefits:
Single Stranded DNA Breaks



A – **Negative Control** Buffer

B – **Positive Control** 1% H_2O_2

C – **Treatment** Chlorine

D – **Treatment** 2 ppm Ferrate

E – **Treatment** 6ppm Ferrate

F – **Treatment** 20ppm Ferrate

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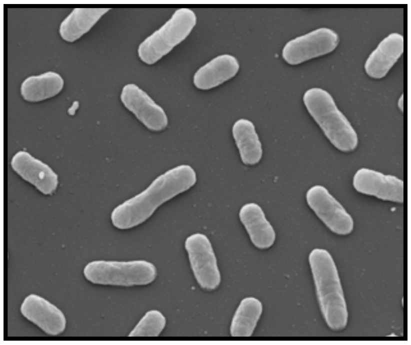
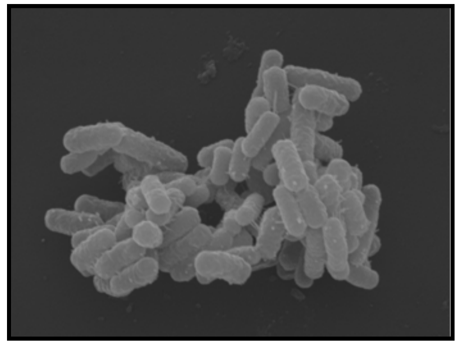
Disinfection Benefits:
Scanning Electron Microscopy



Control



Chlorine

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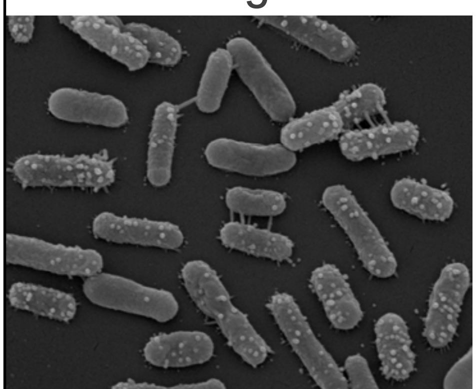
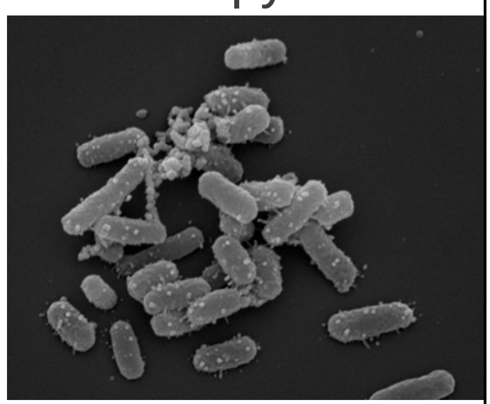
Disinfection Benefits:
Scanning Electron Microscopy



Ferrate, 2 ppm



Ferrate, 20 ppm

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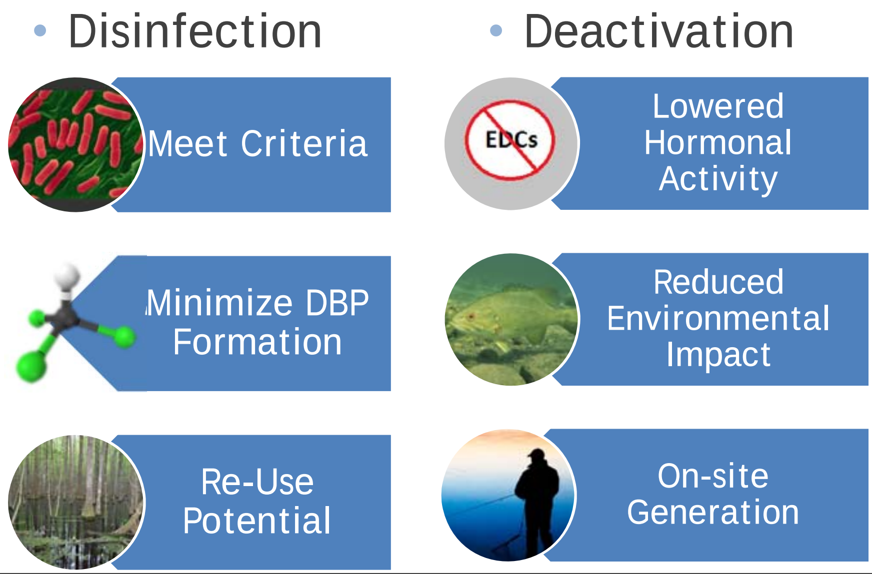
Hurricane Katrina: Alternate Disinfection



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Louisiana Floods of 2016

- Rapid urbanization in Parishes adjacent to New Orleans and Baton Rouge post-Hurricane Katrina
- Much of Southeast Louisiana is not connected to regional or community wastewater systems.
  - 2 of every 3 homes in St. Tammany Parish are un-sewered
- Septic tanks are not utilized, because the soil conditions are not conducive to drainage.
- Aerated treatment units (ATUs) are used for onsite treatment of wastewater, for discharge to stormwater drainage ditches

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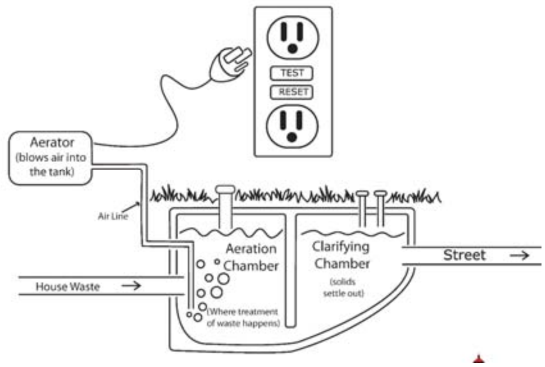
Louisiana Floods of 2016



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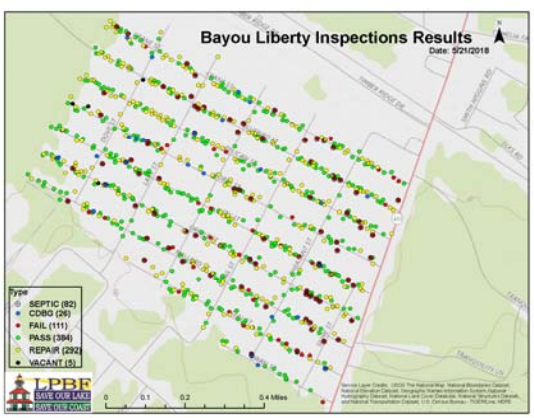
Louisiana Floods of 2016



- 826 Homes Inspected
- 48.8% Initial Failure Rate
- 582 Re-Inspections
- 1408 Total Inspections
- 82 Septic Systems
- 26 CDBG Grant Applications

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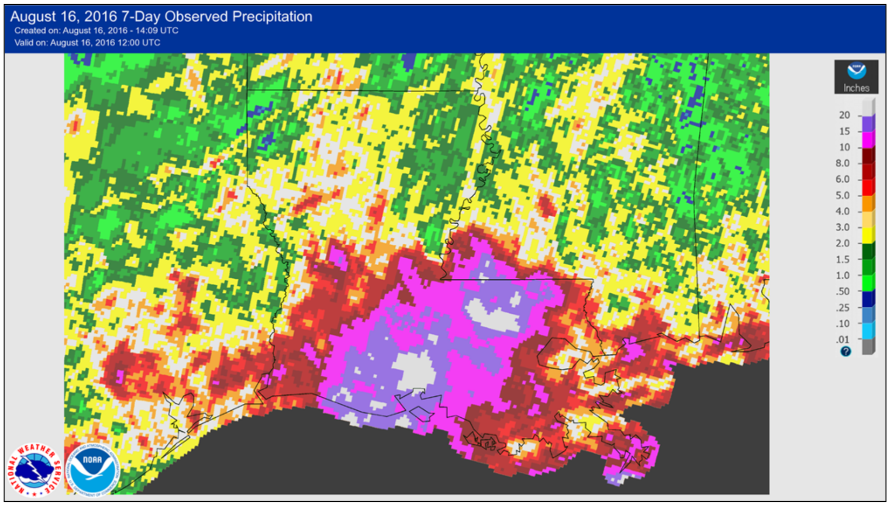
Louisiana Floods of 2016



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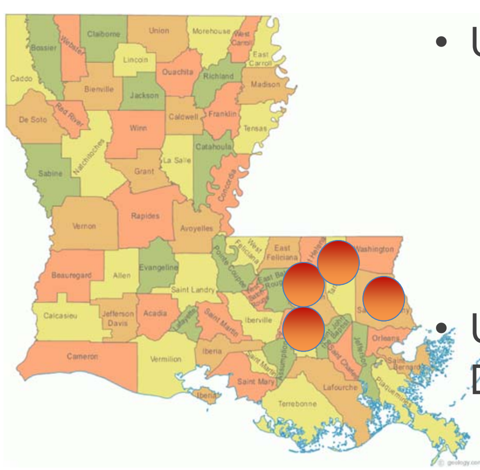
Louisiana Floods of 2016: Impact on Public Health?



- Untreated Wastewater
  - St. Tammany Parish: 25K+
  - Tangipahoa Parish: 20K+
  - Livingston Parish: 15K+
  - Ascension Parish: 15K+
- Usually lacking Disinfection
  - Chlorine tabs

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Thank you

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SAVE OUR COAST
LAKE PONTCHARTRAIN BASIN FOUNDATION

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Disinfection Challenges

A presentation by:
Mr. Sidney Bomer
P.W. Operations Manager

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City of Houston
Houston Water
Wastewater Operations

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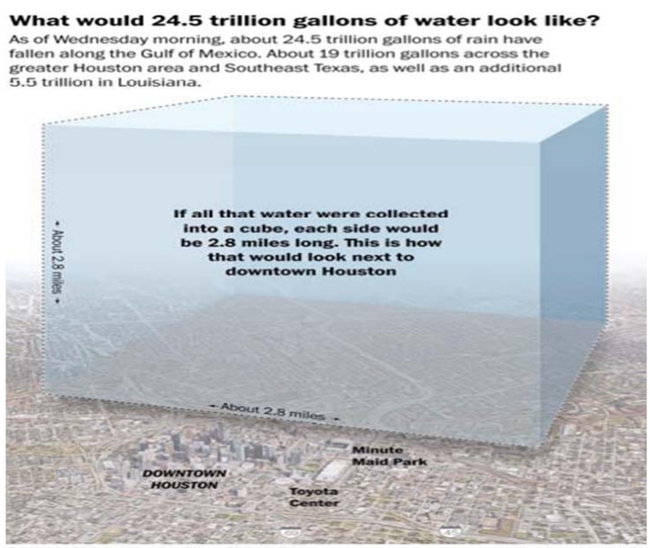
Hurricane Harvey rainfall



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Airboat arrival

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Contact Basin area – West District WWTP

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Turkey Creek WWTP

Elevated chemical tanks

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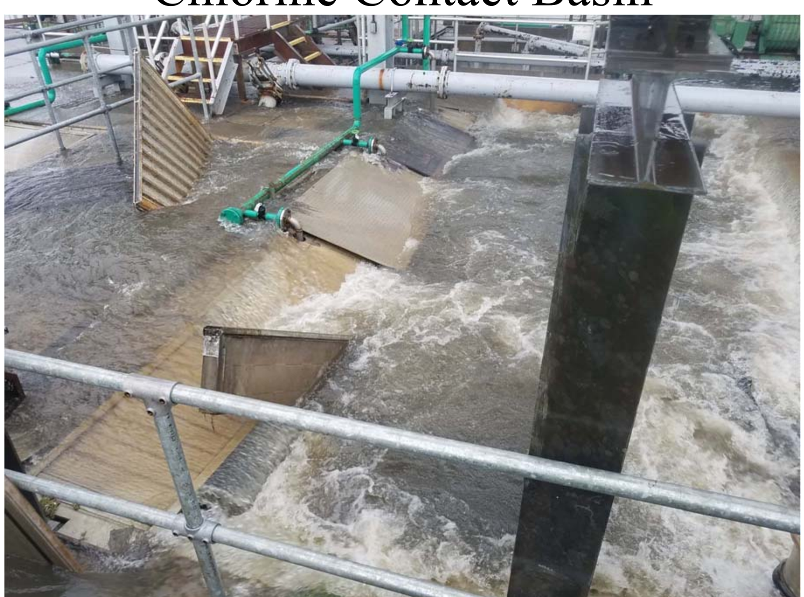
Chlorine Contact Basin



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Law enforcement for a chemical delivery

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Chemical
Bleach Pumps

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Portable generators

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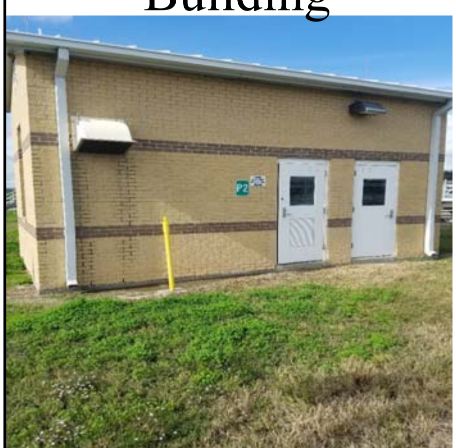
Bleach Pump Building



Elevated Motor Control Room

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Plant effluent

Disinfection chamber

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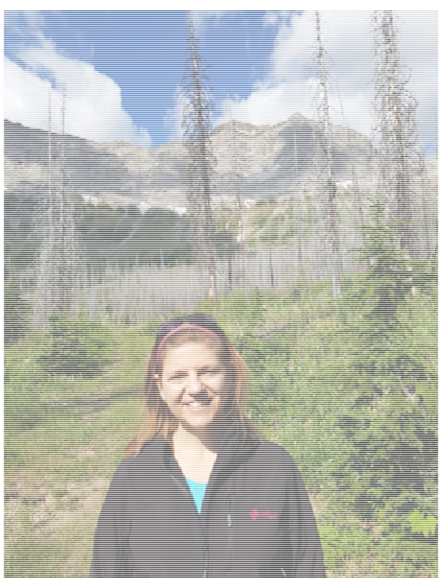

Dr. Monica B. Emelko

UNIVERSITY OF WATERLOO

WATER Science, Technology & Policy Group

Southern Rockies Watershed Project

forWater
NSERC Network for Forested Drinking Water Source Protection Technologies

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Water Disinfection in Extreme Conditions: Wildfire Threats to Public Health

Monica B. Emelko, Uldis Silins & Mike Stone

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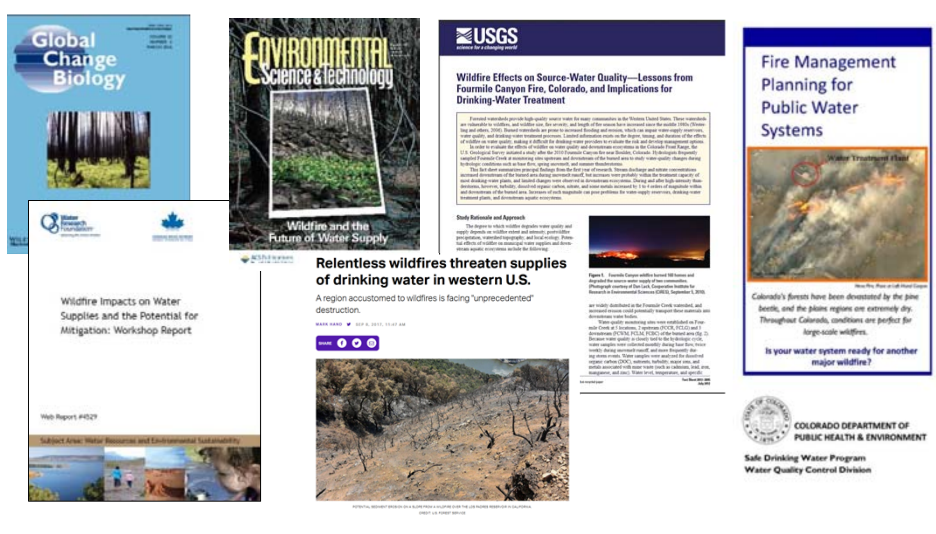
Wildfire concerns are increasing…



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Threats exacerbated by climate change…


Get used to 'extreme' weather, it's the new normal

Scientists have been warning us for years that a warmer planet would lead to more extreme weather, and now it's arrived

Connie Hedegaard
theguardian.com, Wednesday 19 September 2012 16.45 BST
Jump to comments (400)

School children encounter flood water after heavy rains in Jhabua, central India. Photograph: Sanjeev Gupta/EPA


POLICYFORUM

CLIMATE CHANGE

Stationarity Is Dead: Whither Water Management?

Climate change undermines a basic assumption that historically has facilitated management of water supplies, demands, and risks.

P. C. D. Milly,[1*] Julio Betancourt,[2] Malin Falkenmark,[3] Robert M. Hirsch,[4] Zbigniew W. Kundzewicz,[5] Dennis P. Lettenmaier,[6] Ronald J. Stouffer[7]

Systems for management of water throughout the developed world have been designed and operated under the assumption of stationarity. Stationarity—the idea that natural systems fluctuate within an unchanging envelope of variability—is a foundational concept that permeates training and practice in water-resource engineering. It implies that any variable (e.g., annual streamflow or annual flood peak) has a time-invariant (or 1-year–periodic) probability density function (pdf), whose properties can be estimated from the instrument record. Under stationarity, pdf estimation errors are acknowledged, but have been assumed to be reducible by additional observations, more efficient estimators, or regional or paleohydrologic data. The pdfs, in turn, are used to evaluate and manage risks to water supplies, water-

An uncertain future challenges water planners.

that has emerged from climate models (see figure, p. 574).

Why now? That anthropogenic climate change affects the water cycle (*9*) and water supply (*10*) is not a new finding. Nevertheless, sensible objections to discarding stationarity have been raised. For a time, hydroclimate had not demonstrably exited the envelope of natural variability and/or the effective range of optimally operated infrastructure (*11*, *12*). Accounting for the substantial uncertainties of climatic parameters estimated from short records (*13*) effectively hedged against small climate changes. Additionally, climate projections were not considered credible (*12*, *14*).

Recent developments have led us to the opinion that the time has come to move beyond the wait-and-see approach. Projections of runoff changes are bolstered by the

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Water quality deterioration can be expected after severe wildfire

Southern Rockies Watershed Project

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High quality sources are the most vulnerable to disturbance threats

87

Not all wildfires are the same…

88

Not all wildfires are the same...


Lost Creek Wildfire
2004, AB
Southern Rockies
Watershed Project

Aspen Wildfire 2003, AZ
(D. Martin, USGS)

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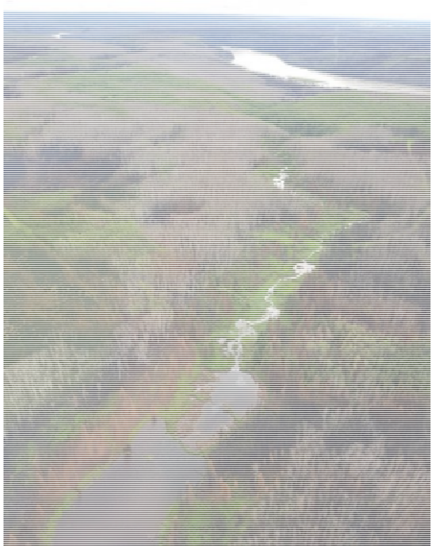
Not all wildfires are the same...




Horse River Wildfire
2016, Fort McMurray, AB
Southern Rockies Watershed Project

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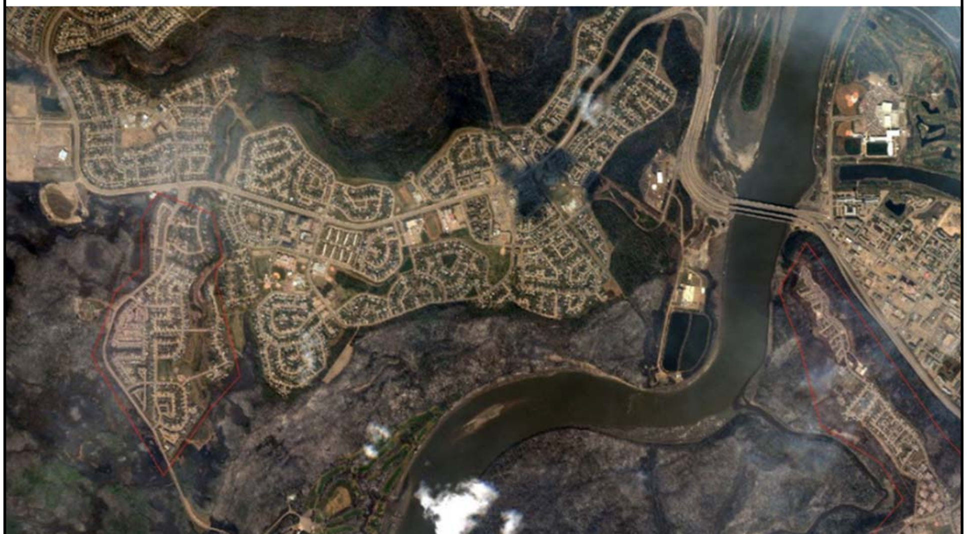
Not all wildfires are the same...



Horse River Wildfire
2016, Fort McMurray, AB

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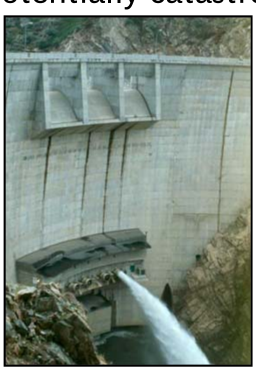
Possible "immediate" effects

- Depend on geologic setting, antecedent precipitation conditions, wildfire intensity, watershed area burned, etc.
- Erosion can be significant in some areas and may include potentially catastrophic debris flows.



Strontia Springs Reservoir (Denver, CO) after the Buffalo Creek Fire 1996 (J. Moody, USGS)

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Colorado Buffalo Creek Fire 1996, flash flood 1997. (D. Martin, USGS)

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Key water treatability impacts of wildfire...health implications?

Impact on Treatment	Parameter					
	Turbidity	TP	DON and TKN	Hg	DOC	Chl.-*a*
Need for solids removal (C/F/S)	✓	✓			✓	✓
↑ Coagulant demand	✓				✓	✓
↑ Sludge production	✓				✓	✓
↑ Oxidant demand	✓		✓		✓	✓
↑ DBPs	✓		✓		✓	✓
↑ Fluence required for UV			✓		✓	✓
↑ microcystins		✓				✓
↑ Taste and odor concerns			✓		✓	✓
Compliance concerns	✓		✓	✓	✓	✓
↑ Operating costs	✓	✓	✓	✓	✓	✓

Emelko et al. (2011) Water Research 45(2): 461-472

Groundwater and surface water threats are very different!

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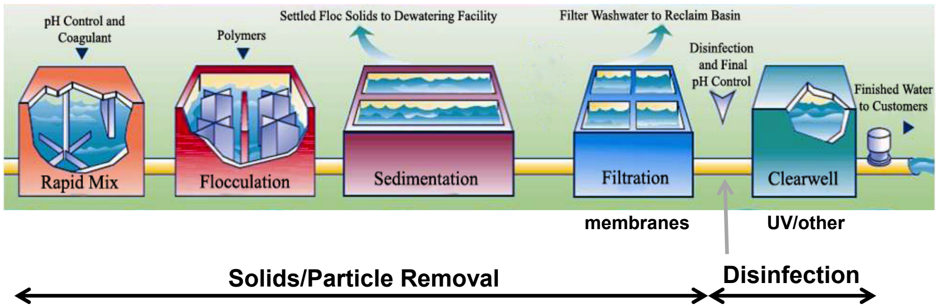
Conventional water treatment: key challenges from wildfire



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Elevated turbidity vs DOC….can overwhelm many treatment systems

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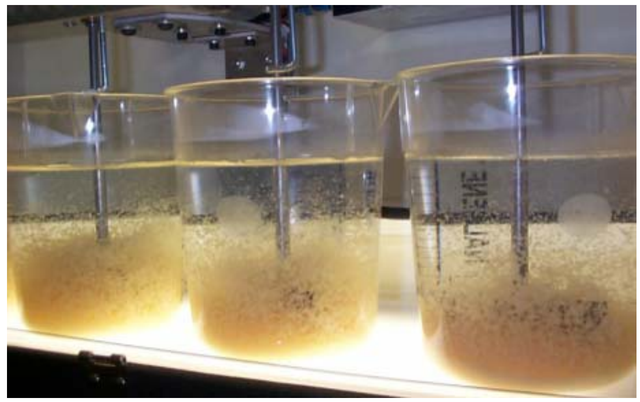

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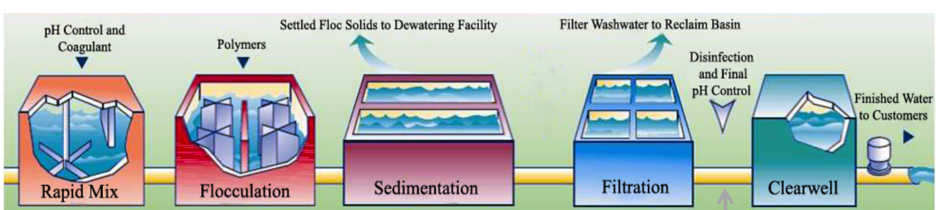
Conventional water treatment: key challenges from wildfire



membranes

UV/other

Solids/Particle Removal

Disinfection

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100

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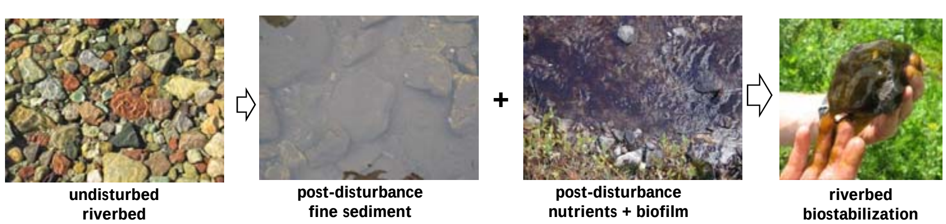
What does biostabilization mean for water treatment? Public health?



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Biostabilization: Impacts?

undisturbed riverbed

post-disturbance fine sediment

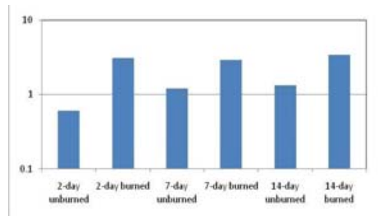
+

post-disturbance nutrients + biofilm

riverbed biostabilization

	Consolidation Period [day]	Critical Shear Stress for for Erosion (T_c) [Pa]	Erosion Depth @ T_c [mm]
Castle River	2	0.105	0.013
UNBURNED	7	0.141	0.008
	14	0.165	0.014
Lynx Creek	2	0.120	0.336
BURNED	7	0.230	0.426
	14	0.310	1.540

Physical Sediment Characteristics



Percentage of total mid-chain branched saturated biofilm by PLFA

- **Disturbance may increase risk of taste & odor events.**
- **Disturbance results in more variable downstream water quality.**
- **Disturbance results in more rapidly changing water quality.**
- **Better control over coagulation required!**

Stone et al. (2014) Water Research

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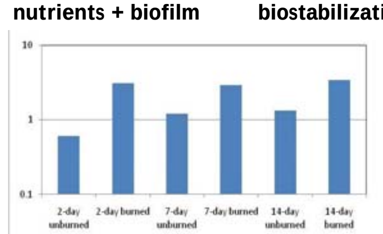

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Stone et al. (2014) Water Research

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Implications of fine sediment?

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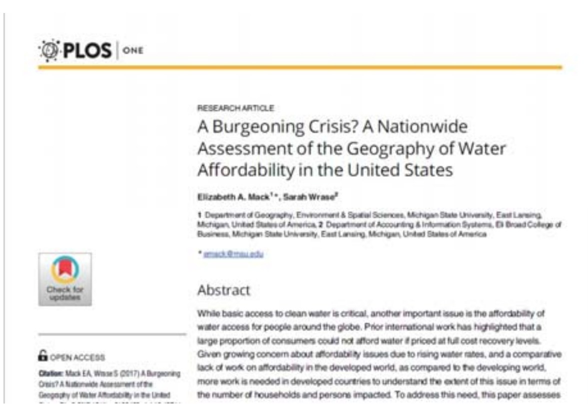
PLOS | ONE

RESEARCH ARTICLE

A Burgeoning Crisis? A Nationwide Assessment of the Geography of Water Affordability in the United States

Elizabeth A. Mack[1]*, Sarah Wrase[2]

1 Department of Geography, Environment & Spatial Sciences, Michigan State University, East Lansing, Michigan, United States of America, 2 Department of Accounting & Information Systems, Eli Broad College of Business, Michigan State University, East Lansing, Michigan, United States of America

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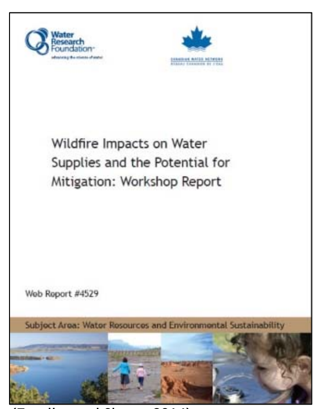
Abstract

While basic access to clean water is critical, another important issue is the affordability of water access for people around the globe. Prior international work has highlighted that a large proportion of consumers could not afford water if priced at full cost recovery levels. Given growing concern about affordability issues due to rising water rates, and a comparative lack of work on affordability in the developed world, as compared to the developing world, more work is needed in developed countries to understand the extent of this issue in terms of the number of households and persons impacted. To address this need, this paper assesses


Water Research Foundation

Wildfire Impacts on Water Supplies and the Potential for Mitigation: Workshop Report

Web Report #4529

Subject Area: Water Resources and Environmental Sustainability

(Emelko and Sham, 2014)

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Key messages

- Landscape disturbance by wildfire can have the most deleterious effects on water.
- Not all wildfires have the same effects on water.
- Landscape disturbances such as wildfire can lead to deteriorated source water quality.
- Wildfires can lead to increasingly variable water quality.
- Considering "contamination" that has direct health significance alone is inadequate.

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Key messages

- Key wildfire-associated changes in source water quality that can most threaten drinking water treatment: DOC, turbidity/solids, and P.
- Wildfire can severely challenge chemical pre-treatment processes, thereby threatening adequacy of disinfection processes.
- Wildfire impacts on water may not be evident immediately, and they may be long lasting.
- Know the source, know the limitations of infrastructure!

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Thank you!

mbemelko@uwaterloo.ca

Questions?

 **Dr. Joshua Goldman-Torres** Dr. Josh Goldman-Torres is an environmental engineer at CDM Smith in Denver with 7 years of experience. Although he specializes in wastewater disinfection, he works on a variety of projects. One of his passions is small scale piloting which he has done at number of municipal and industrial facilities, and he is currently working developing a piloting center in at the CDM Smith Denver Treatability Laboratory. Josh has a master's degree in Environmental Science from the University of South Florida and a PhD from the University of New Mexico. When not at work, Josh spends time with his family, including his 20-month old son and he is a proud member of the Denver Science Fiction Book Club.

 **Mr. Scott Schaefer** is the Wastewater Practice Leader with the upper Midwest regional consulting firm Advanced Engineering and Environmental Services, Inc. (AE2S). Mr. Schaefer specializes in wastewater collection and treatment planning and design with an emphasis on nutrient removal, disinfection, odor/corrosion control, and biosolids. He holds both bachelors master's degrees from Iowa State University and is a professional engineer in seven states. Scott is an active WEF member acting as the Vice Chair of WEF's Disinfection & Public Health committee, and serving on WEF's MRRD, Reuse, and Program committees. Scott lives in Minnesota with his wife, two kids, and two dogs. Outside of work, he can usually be found cross country skiing, snowshoeing, canoeing, fishing, or sampling at local craft breweries.

 **Dr. Brady Skaggs** is the Water Quality Program Director with the Lake Pontchartrain Basin Foundation. Dr. Skaggs obtained his masters of Public Health and PhD from Tulane University. A native of Jacksonville, FL, Brady has always been fascinated with water, growing up as a swimmer and cumulating as a lifetime letterwinner and ACC Championship finalist at Georgia Tech. Since moving to New Orleans three days before Hurricane Katrina, Brady has worked as a consultant to industry before joining LPBF. Brady enjoys cycling, triathlon, gardening, and spending time with his son.

**Mr. Sidney Bomer** joined the City of Houston in 1991 as a Plant Operator. He currently manages over 16 of the City's South area wastewater treatment plants. And assists with the management of the City's 39 wastewater treatment plants. His daily duties include overseeing each wastewater facility, monitoring effluent quality, managing emergency repairs, coordinating staffing and hiring processes, managing the municipal utility operation's service contract for Houston's Northeast area, and responding to internal and external inquiries. In addition to his City of Houston duties, the 27-year veteran also volunteers as president of the Texas Water Utilities Association's Gulf Area District chapter and as chair-elect of the Texas Water Utility Association's Southeast Regional School. In his spare time, Sidney loves riding his motorcycle and is a part of the Liberators Law Enforcement Motorcycle Club. He has been happily married for thirty years and has six children and nine grandchildren.

Dr. Monica B. Emelko is a Professor of Civil and Environmental Engineering and the Director of the Water Science, Technology & Policy group at the University of Waterloo. Her research is focused on drinking water supply and treatment and has involved numerous utilities and conservation authorities across North America. Monica co-leads the Southern Rockies Watershed Project--this team was the first globally to describe wildfire effects on drinking water treatability, and among the first cited by the Intergovernmental Panel on Climate Change for identifying quality-associated threats from climate change to water security. In 2016, Monica was recognized by the Premier for service to the province of Alberta as a first responder during the Horse River wildfire in Fort McMurray. She now co-leads "*for*Water" a Canada-wide and internationally-partnered research network of academics, water utilities, government agencies, industrial forestry companies, and NGOs focused on forest management-based approaches for drinking water source protection.