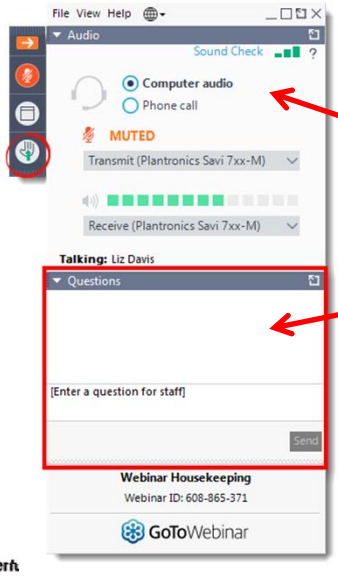
CA State Water Board Grant on Water Reuse: Introduction

Thursday, November 7, 2019

1:00 – 2:30 pm ET

1

How to Participate Today



Your Participation

Open and close your control panel

Join audio:

- Choose **Mic & Speakers** to use VoIP
- Choose **Telephone** and dial using the information provided

Submit questions and comments via the Questions panel

Note: Today's presentation is being recorded and will be available shortly after today's webcast

2

Today's Speakers

Julie Minton
The Water Research Foundation

Adam Olivieri, Ph.D.
EOA, Inc.

Jim Crook, Ph.D., PE
Environmental Engineering Consultant

Shane Trussell, Ph.D., P.E., BCEE
Trussell Technologies

Brian Pecson, Ph.D., PE
Trussell Technologies

Jean Debroux, Ph.D.
Kennedy Jenks

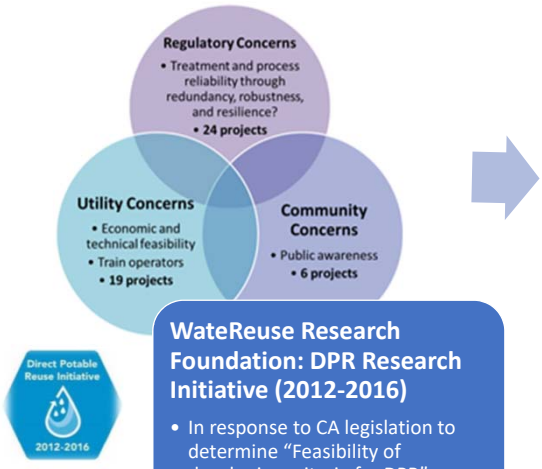
3

Agenda

- Welcome and Introduction
- Background of CA State Board and WRF Grant Investigations
  Julie Minton and Dr. Adam Olivieri
- Pathogen Monitoring in Raw Wastewater
  Dr. Brian Pecson
- Plant Reliability and Quantitative Microbial Risk Assessment
  Dr. Brian Pecson
- Identification and Control of Chemical Peaks
  Dr. Jean Debroux and Dr. Shane Trussell
- Q&A

4

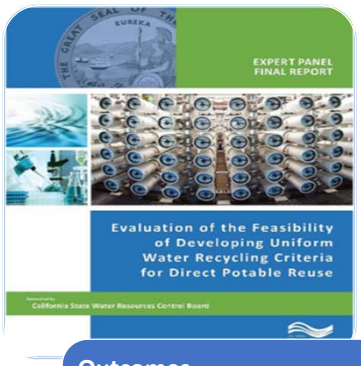
A Brief History of WRF Potable Reuse Research



Direct Potable Reuse Initiative 2012-2016

WateReuse Research Foundation: DPR Research Initiative (2012-2016)

- In response to CA legislation to determine "Feasibility of developing criteria for DPR"
- **$6 million** raised – Leveraged to **$24 million**
- 34 projects funded that informed DPR Expert Panel



Outcomes

- DPR Expert Panel report
- SWB Report to legislature → ***Yes, it is feasible to develop regulations for DPR***

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Recycled Water Grants from State Water Board

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Grant 1: $1.4M	Grant 2: $3.1M
• 5 projects recommended by the SWB DPR Expert Panel for **developing DPR regulations in California**	• 20 reuse research projects recommended by the WRF's Water Reuse Advisory Committee and SWB.
• Agreement executed February 28, 2018	• Agreement executed March 30, 2018
• Research being conducted Q4 2018 – Q4 2020	• Research being conducted Q1 2019 - 2023

California Legislation – AB 574 (2017): Established deadline for DPR legislation of 2023

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SWB Grant 1: 5 DPR Research Projects

Public Health Protection

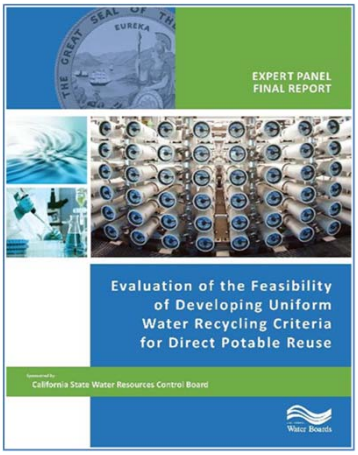
Research addressing Pathogens

- DPR-1. Quantitative Microbial Risk Assessment*
- DPR-2. Measure Pathogens in Wastewater*
- DPR-3. Collecting Pathogens in Wastewater During Outbreaks

Research addressing Chemicals

- DPR-4. Treatment for Averaging Potential Chemical Peaks
- DPR-5. Low Molecular Weight Unknown Compounds

Research implementation late 2018 – late 2020



*Co-funded by Metropolitan Water District

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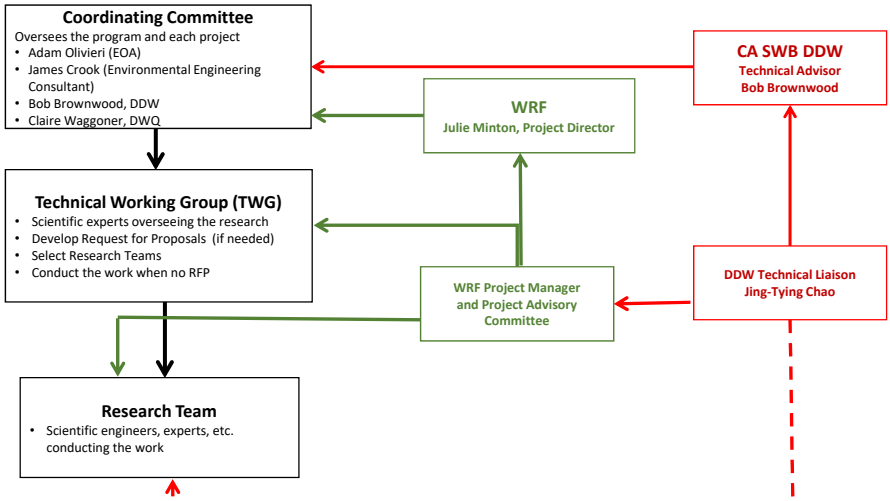
7

SWB Grant 1: Research Oversight & Communication



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Background of CA State Board and WRF Grant Investigations

Dr. Adam Olivieri

9

California's Big Question

Division of Drinking Water

Is it <u>feasible</u> to do potable reuse without an environmental buffer (DPR)?

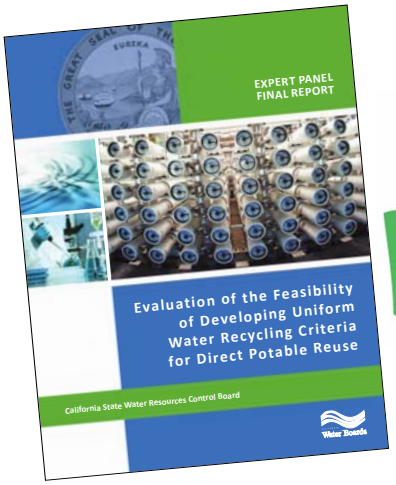
State of California Expert Panel on DPR

QUESTION: *Can we do DPR <u>safely</u>?*

10

Expert Panel Findings on Direct Potable Reuse

- CA State Expert Panel assessed DPR feasibility
- Concluded ***it is feasible*** to create uniform regulations for DPR
- Expert Panel recommended 6 topics for further research



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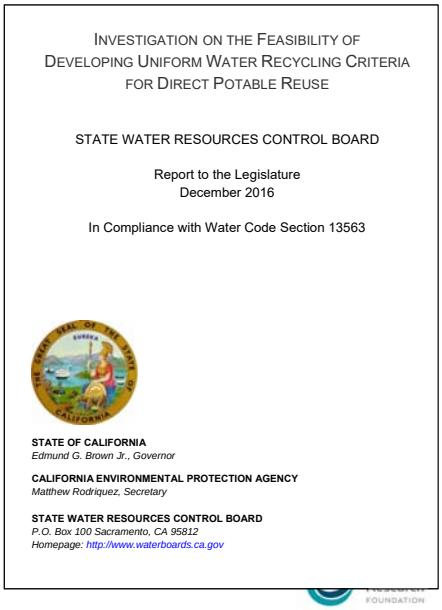
State Water Board Conclusions on DPR

- DDW concurred on feasibility of DPR
- More information on research topics needed **<u>before</u>** regulations could be written

"The use of recycled water for DPR has great potential but it presents very real scientific and technical challenges that must be addressed to ensure the public's health is reliably protected <u>at all times</u>." – SWRCB 2016

- AB 574 requires DPR regulations by 2023



INVESTIGATION ON THE FEASIBILITY OF DEVELOPING UNIFORM WATER RECYCLING CRITERIA FOR DIRECT POTABLE REUSE

STATE WATER RESOURCES CONTROL BOARD

Report to the Legislature
December 2016

In Compliance with Water Code Section 13563

STATE OF CALIFORNIA
Edmund G. Brown Jr., Governor

CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY
Matthew Rodriquez, Secretary

STATE WATER RESOURCES CONTROL BOARD
P.O. Box 100 Sacramento, CA 95812
Homepage: http://www.waterboards.ca.gov

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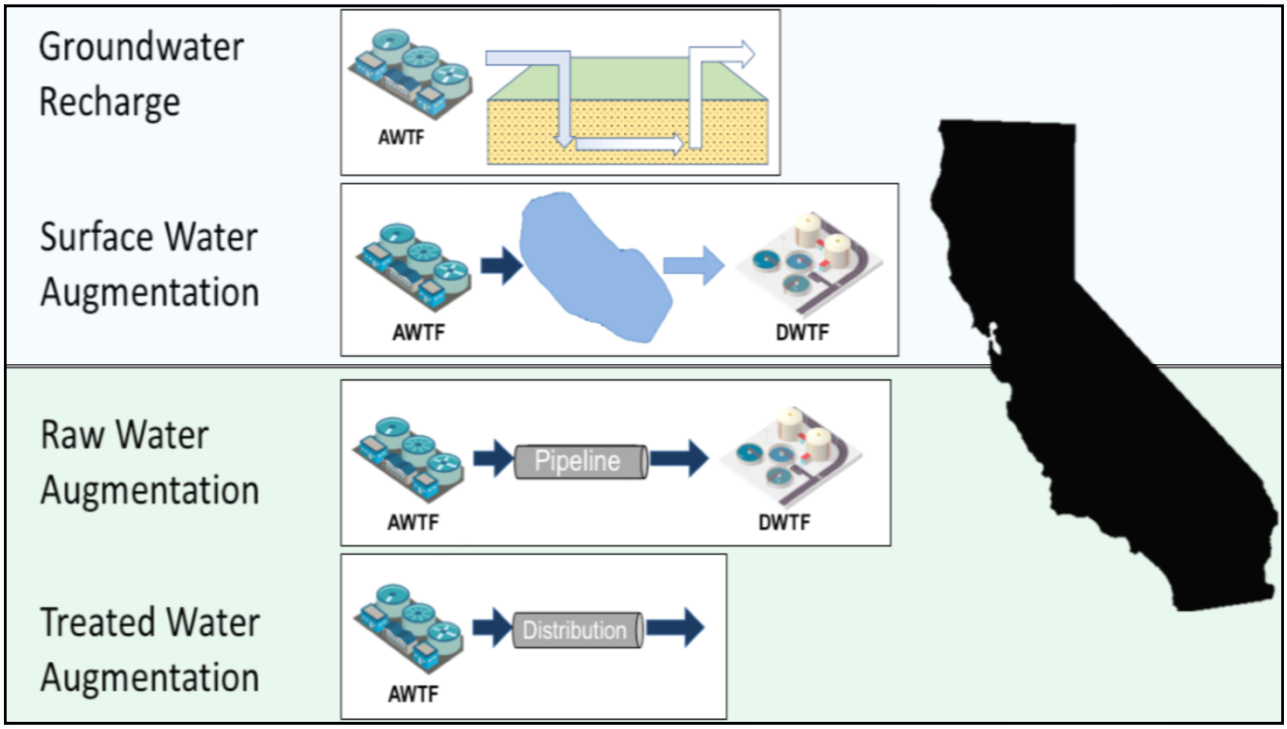
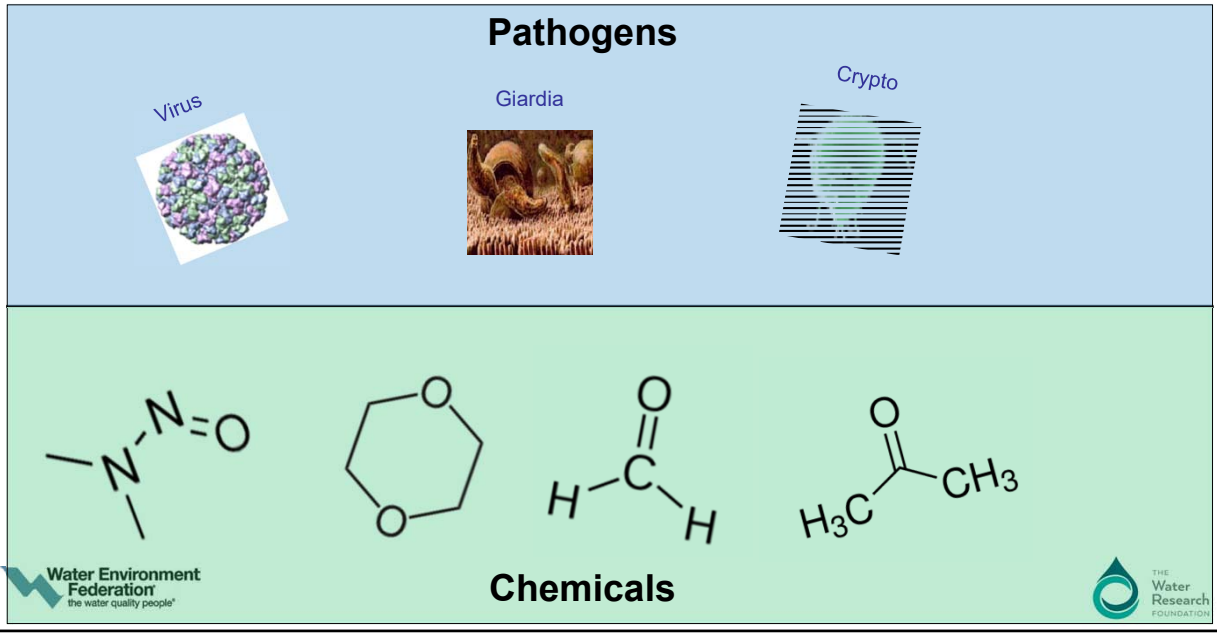
12



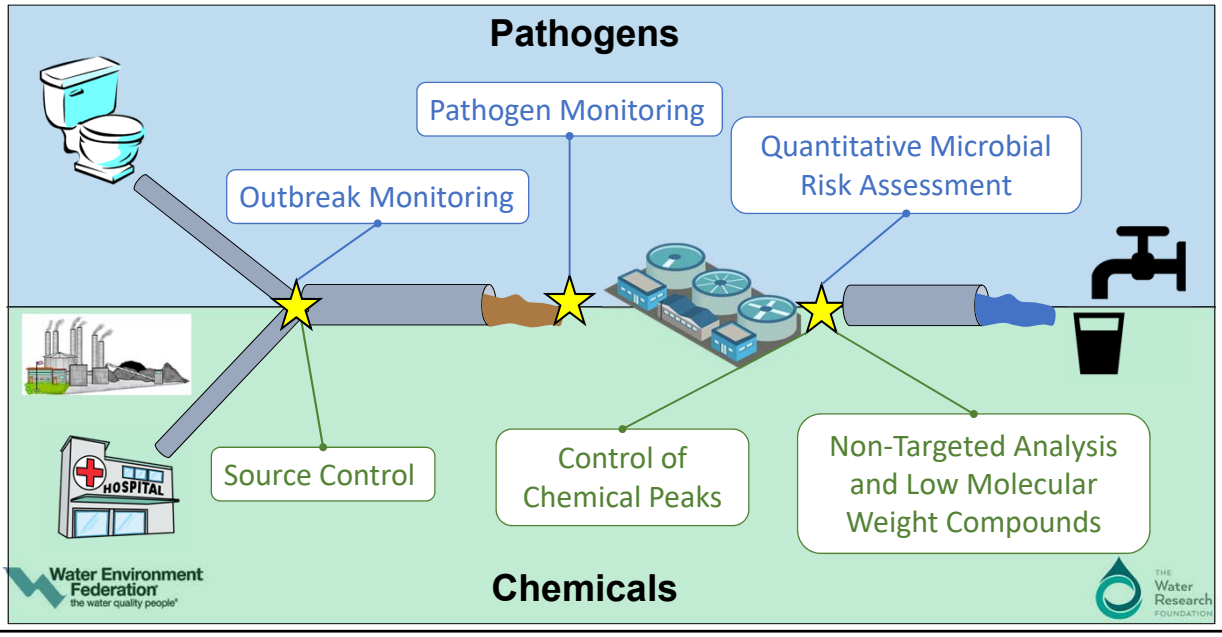
13

Research Related to Public Health Protection



14

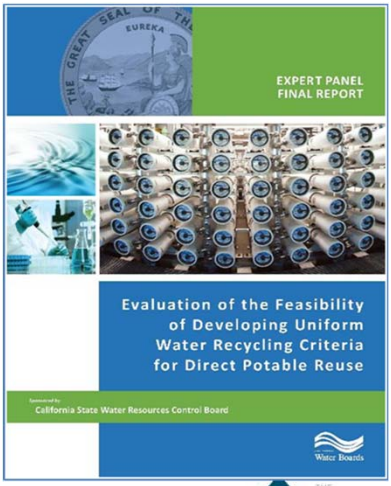
Research Related to Public Health Protection



15

SWB DPR Research Projects (1 – 5 are WRF Grant projects)

1. Develop Probabilistic Analysis Tools for DDW to Assess Treatment Performance and Quantitative Microbial Risk
2. Collect Pathogen Data in Untreated Wastewater
3. Investigate Feasibility of Collecting Pathogens in Wastewater During Outbreaks
4. Evaluate Options to Reduce Potential Chemical Peaks
5. Investigate Feasibility of Analytical Methods for Non-Targeted Analysis of Recycled Water with focus on Low Molecular Weight Compounds
6. Establish an enhanced source control program



16

16

DPR-1 Plant Reliability and Quantitative Microbial Risk Assessment

&

DPR-2 Pathogen Monitoring in Raw Wastewater

Dr. Brian Pecson

17

17

DPR Pathogen Risk and Treatment

Drinking water

18

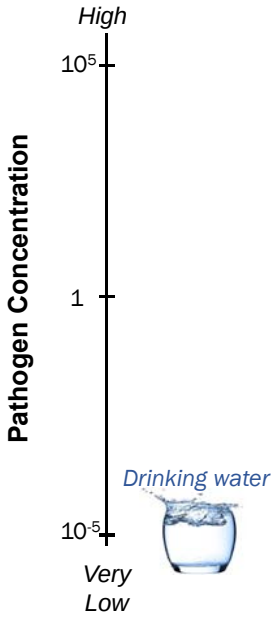
DPR Pathogen Risk and Treatment

Risk Threshold

10^{-4} infections per person per year

19

DPR Pathogen Risk and Treatment



Risk Threshold

10^{-4} infections per person per year

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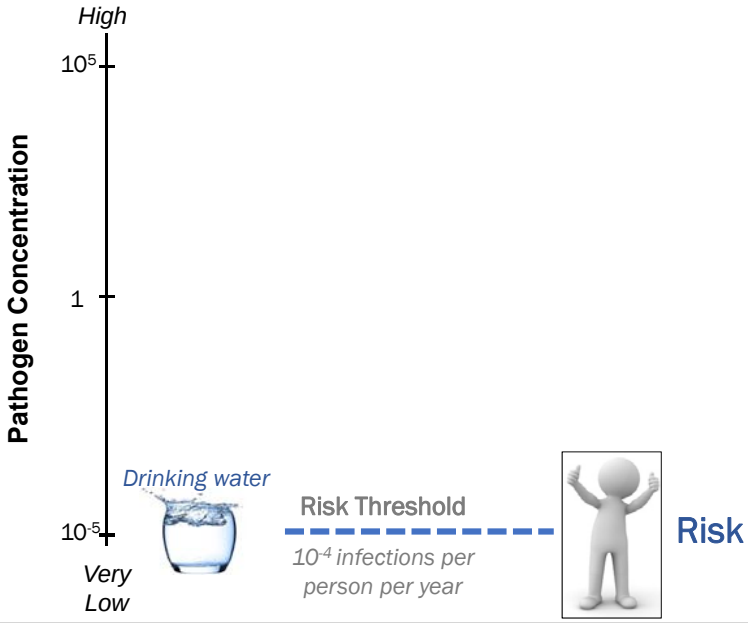
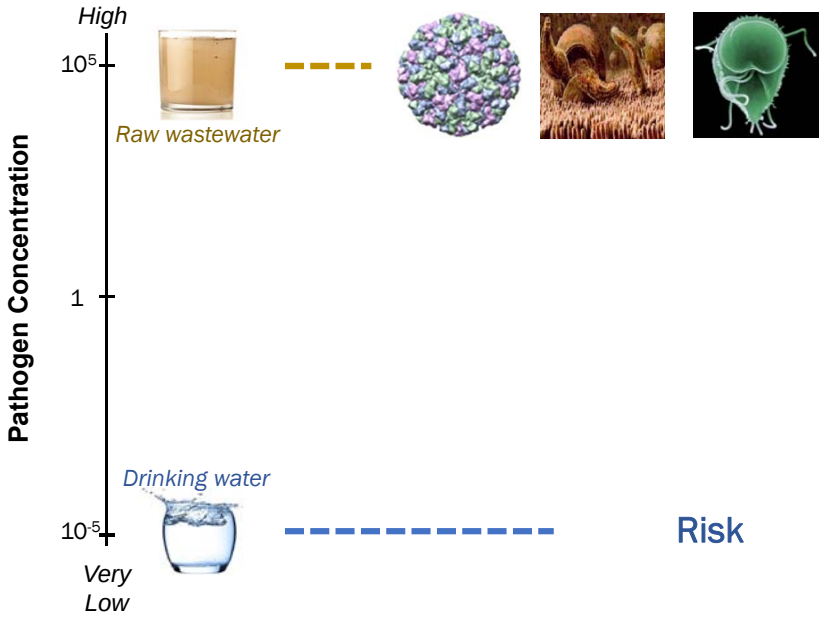
DPR Pathogen Risk and Treatment



21

DPR Pathogen Risk and Treatment



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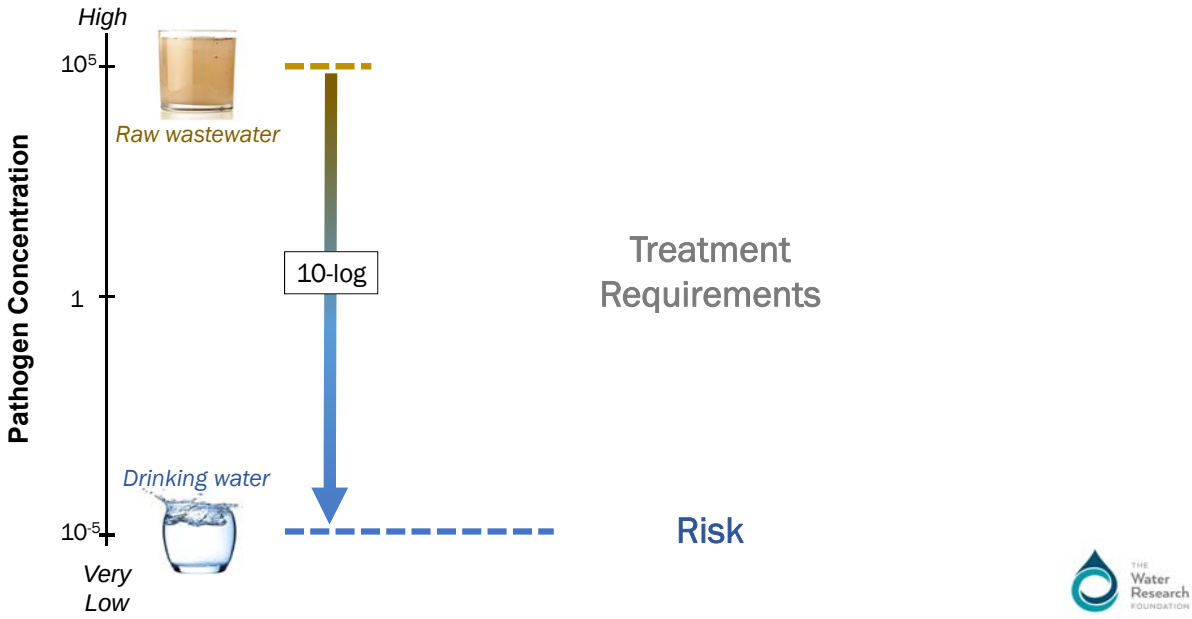
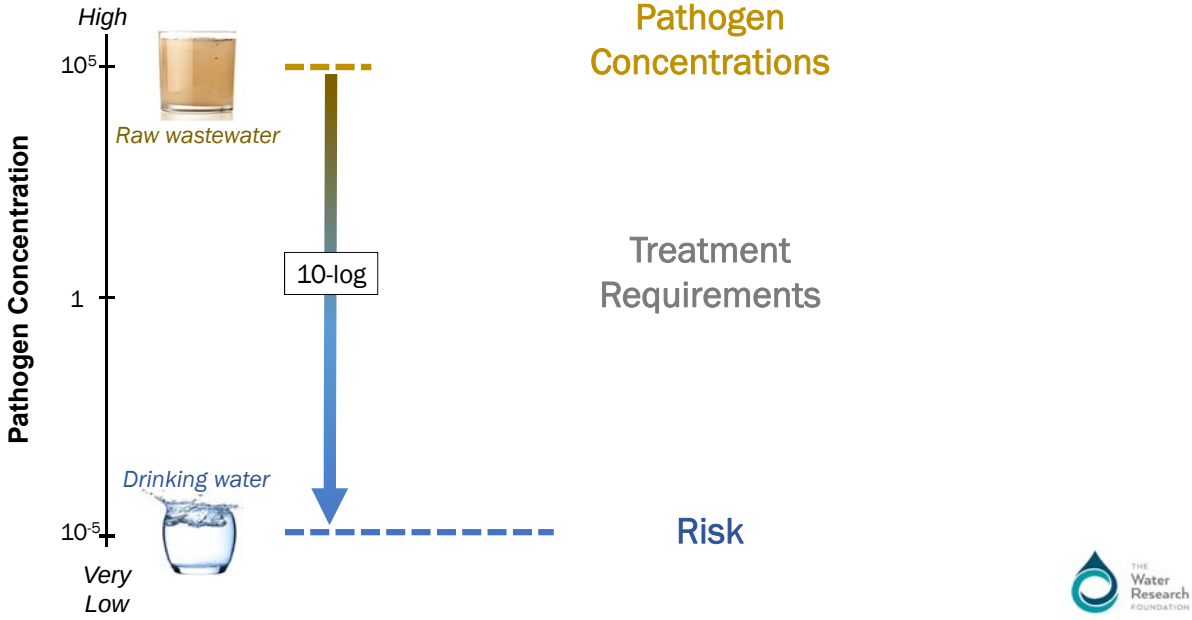
DPR Pathogen Risk and Treatment



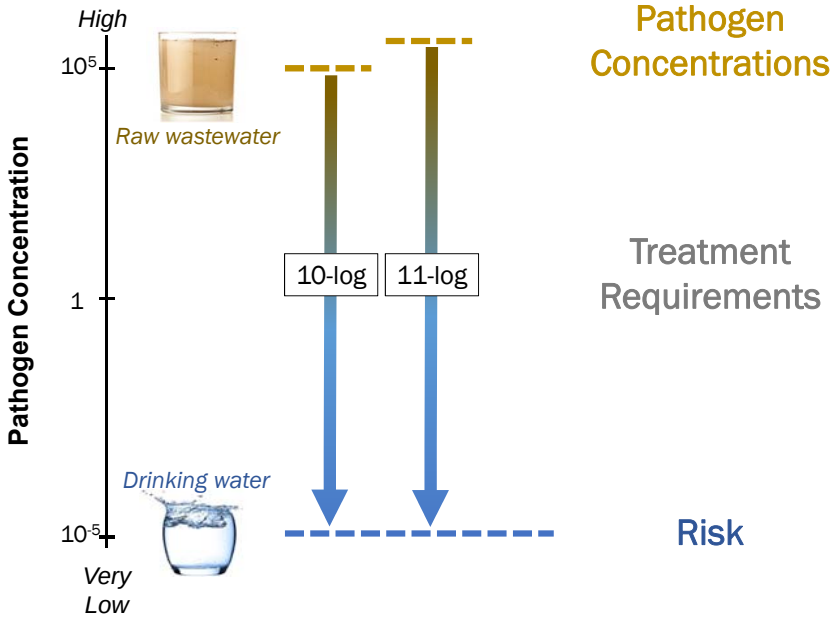
23

DPR Pathogen Risk and Treatment



24

DPR Pathogen Risk and Treatment



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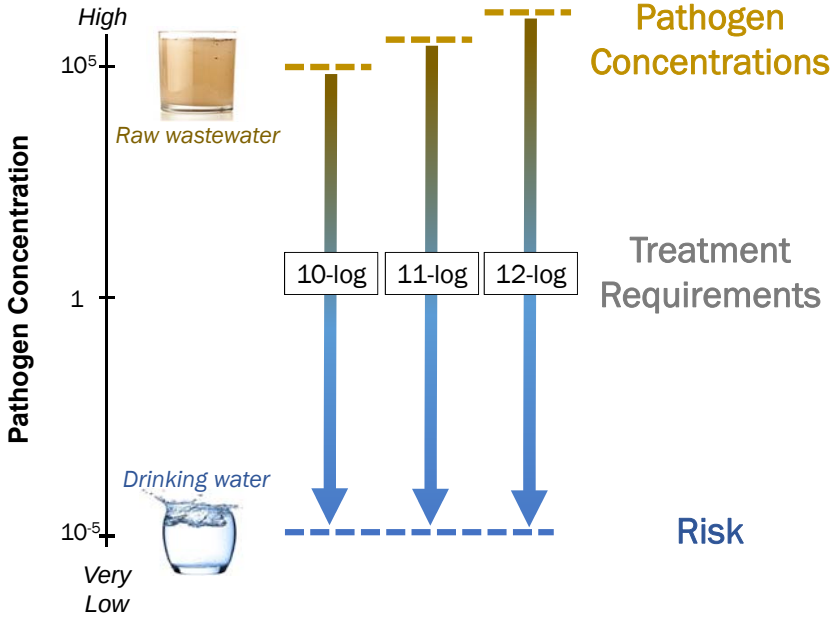
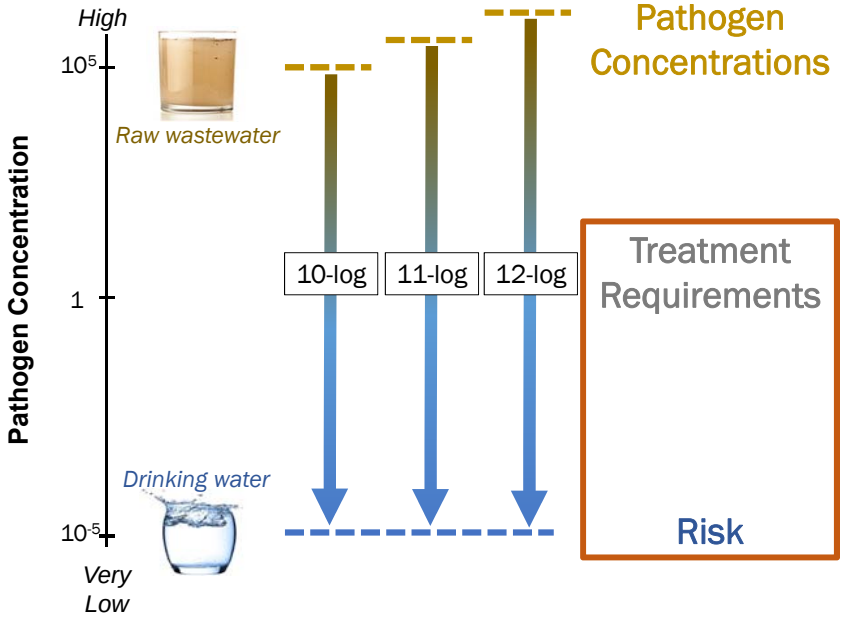
DPR Pathogen Risk and Treatment



26

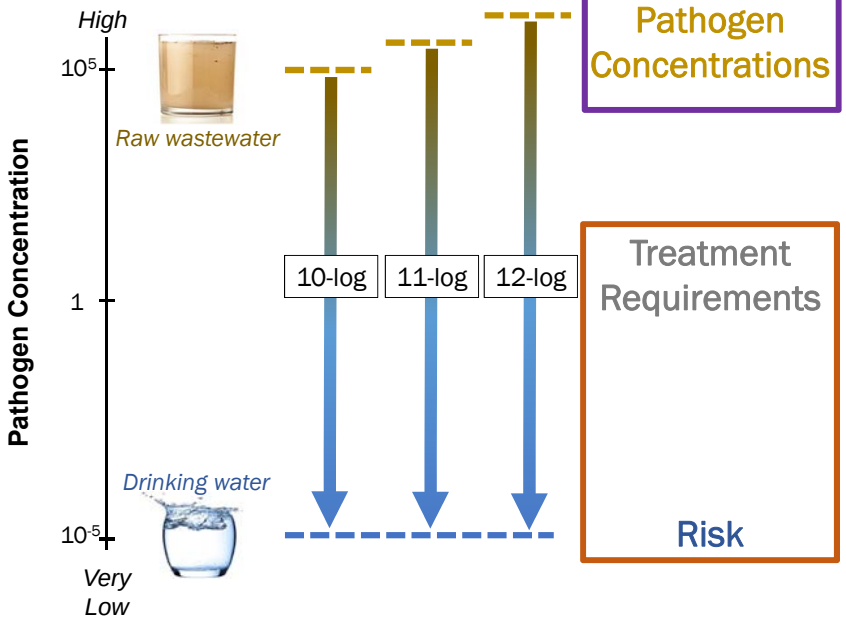
DPR Pathogen Risk and Treatment



DPR-1: Implementation of Probabilistic Treatment Train Performance and QMRA

27

DPR Pathogen Risk and Treatment



DPR-2: Pathogen Monitoring

DPR-1: Implementation of Probabilistic Treatment Train Performance and QMRA

28

DPR-1 TWG and Research Team

Technical Working Group

Nick Ashbolt
University of Alberta

Charles Haas
Drexel University

Brian Pecson (chair)
Trussell Technologies

Theresa Slifko
Metropolitan Water District

Research Team

Dan Gerrity
UNLV

Edmund Seto
University of Washington

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29

TWG is not developing DPR treatment criteria…

"So what's this? I asked for a *hammer*! A hammer! *This* is a crescent wrench! … Well, maybe it's a hammer.… Damn these stone tools."

- Development of guidelines for evaluating DPR facility treatment performance (Goal #1)
- Use of QMRA to assess the level of treatment needed to achieve risk-based targets (Goal #2)
- TWG and Research Team are developing **tools**
- The tools provide DDW with a consistent approach vetted by a team of experts

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30

Steps in QMRA

1. Exposure Assessment


Raw wastewater


Treatment


Drinking water levels


Drinking water consumption


Exposure

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31

Steps in QMRA

1. Exposure Assessment


Raw wastewater

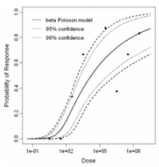

Treatment


Drinking water levels


Drinking water consumption


Exposure

2. Dose-Response


Dose-response

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32

Steps in QMRA

1. Exposure Assessment | **2. Dose-Response** | **3. Risk Characterization**

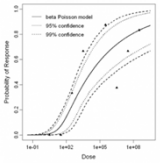

Raw wastewater


Treatment


Drinking water levels


Drinking water consumption


Exposure


Dose-response


Risk

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33

Steps in QMRA

1. Exposure Assessment | **2. Dose-Response** | **3. Risk Characterization**

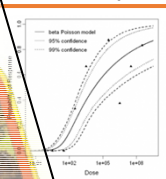

Raw wastewater


Treatment


Drinking water levels


Drinking water consumption


Exposure


Dose-response


Risk

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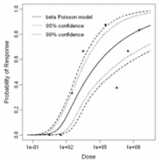
34

Multiple Decision Points in the Process

1. Exposure Assessment | 2. Dose-Response | 3. Risk Characterization





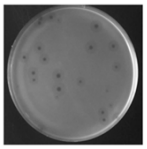
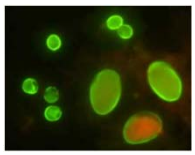
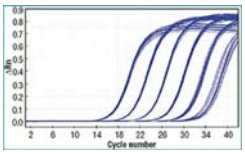

Raw wastewater | Treatment | Drinking water levels | Drinking water consumption | Exposure | Dose-response | Risk

What pathogens?

What enumeration methods?

What data sets should we use? Do we need new data?

How do we use non-culture-based data?

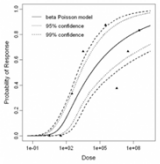
Culture | Microscopy | Molecular

Multiple Decision Points in the Process

1. Exposure Assessment | 2. Dose-Response | 3. Risk Characterization






Raw wastewater | **Treatment** | Drinking water levels | Drinking water consumption | Exposure | Dose-response | Risk

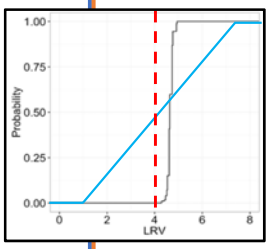
How do we quantify performance?

Use surrogates or direct pathogen measurements?

What data should we use?

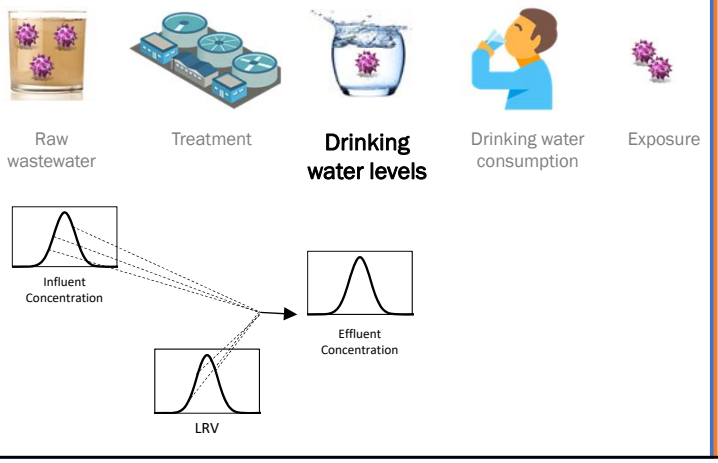
Should we use site-specific performance distributions?
Ranges from the literature?

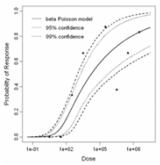
What frequency of data collection?



Multiple Decision Points in the Process

1. Exposure Assessment | 2. Dose-Response | 3. Risk Characterization

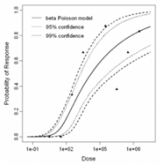




37

Multiple Decision Points in the Process

1. Exposure Assessment | 2. Dose-Response | 3. Risk Characterization



How much water do people drink?

Estimate with a distribution? Which one?

Use a point estimate? Which one?

Does it matter? How much does it matter?

38

Multiple Decision Points in the Process

1. Exposure Assessment | 2. Dose-Response | 3. Risk Characterization

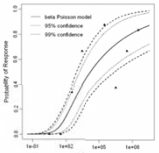

Raw wastewater


Treatment


Drinking water levels


Drinking water consumption


Exposure


Dose-response


Risk

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39

Multiple Decision Points in the Process

1. Exposure Assessment | **2. Dose-Response** | 3. Risk Characterization

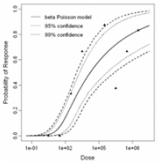

Raw wastewater


Treatment


Drinking water levels


Drinking water consumption


Exposure


Dose-response

Which D-R functions to use?

What about molecular data?


Risk

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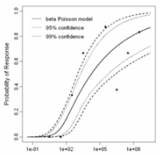
40

Multiple Decision Points in the Process

1. Exposure Assessment

Raw wastewater | Treatment | Drinking water levels | Drinking water consumption | Exposure

2. Dose-Response



Dose-response

3. Risk Characterization

Risk

Annual risk? Daily risk?

What risk framework?

What level of risk? 10^{-4}? 10^{-6}?

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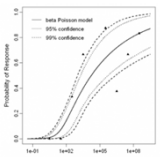
41

There are a lot of decisions….

1. Exposure Assessment

Raw wastewater | Treatment | Drinking water levels | Drinking water consumption | Exposure

2. Dose-Response



Dose-response

3. Risk Characterization

Risk

Which D-R functions to use?

What pathogens?

How much water do people drink?

What about molecular data?

How do we quantify performance?

Use surrogates or direct pathogen measurements?

Estimate with a distribution? Which one?

Use a point estimate? Which one?

What data sets should we use? Do we need new data?

Should we use site-specific performance distributions?

Ranges from the literature?

Does it matter?

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42

Task 1: Literature Review – Major Sections

PATTP & QMRA Literature Review

Table of Contents

1 *Introduction* 2
2 *Historical Context of PATTP and Risk-Based Targets* 3
3 *Influent Raw Wastewater Pathogen Concentrations* 4
3.1 Pathogens to include in QMRA and PATTP evaluations 4
3.2 Raw Wastewater Pathogen Data 6
3.2.1 What raw wastewater pathogen concentration data should be used? 6
3.2.2 How should raw wastewater pathogen concentration data be used? 8
3.2.3 How should non-detect values in a dataset be handled? 9
3.3 Enumeration Methods – Pros and Cons 10
3.3.1 Culture-Based Enumeration 10
3.3.2 Microscopy-Based Enumeration 11
3.3.3 Molecular Enumeration 11
4 *Treatment Train Performance* 12
4.1 Quantifying Pathogen Removal 12
4.2 Describing Performance 14
4.3 Quantifying Failures 15
5 *QMRA Approach* 17
5.1 Pathogen Exposure 17
5.2 Dose-Response Analysis 20
5.2.1 Norovirus Dose-Response 21
5.3 Risk Characterization 24
5.4 QMRA Process Assumptions 25
6 *Linking Performance and QMRA Results* 27
7 *Conclusions* 29
8 *References* 29

- Raw wastewater pathogen concentrations
- Treatment Train Performance
- QMRA
- Linking Performance and QMRA

- General approach:
  - Provide discussion on the topic
  - Give TWG recommendation on how to proceed

43

Task 1: Literature Review – Major Sections

Water Research Foundation Project #4951
DPR-1: QMRA Implementation
Literature Review
June 30, 2019

PATTP & QMRA Literature Review

Table of Contents

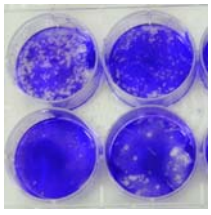
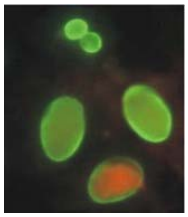
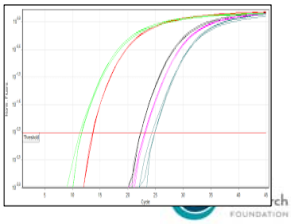
1 *Introduction* 2
2 *Historical Context of PATTP and Risk-Based Targets* 3
3 *Influent Raw Wastewater Pathogen Concentrations* 4
3.1 Pathogens to include in QMRA and PATTP evaluations 4
3.2 Raw Wastewater Pathogen Data 6
3.2.1 What raw wastewater pathogen concentration data should be used? 6
3.2.2 How should raw wastewater pathogen concentration data be used? 8
3.2.3 How should non-detect values in a dataset be handled? 9
3.3 Enumeration Methods – Pros and Cons 10
3.3.1 Culture-Based Enumeration 10
3.3.2 Microscopy-Based Enumeration 11
3.3.3 Molecular Enumeration 11
4 *Treatment Train Performance* 12
4.1 Quantifying Pathogen Removal 12
4.2 Describing Performance 14
4.3 Quantifying Failures 15
5 *QMRA Approach* 17
5.1 Pathogen Exposure 17
5.2 Dose-Response Analysis 20
5.2.1 Norovirus Dose-Response 21
5.3 Risk Characterization 24
5.4 QMRA Process Assumptions 25
6 *Linking Performance and QMRA Results* 27
7 *Conclusions* 29
8 *References* 29

- Raw wastewater pathogen concentrations

Which pathogens?

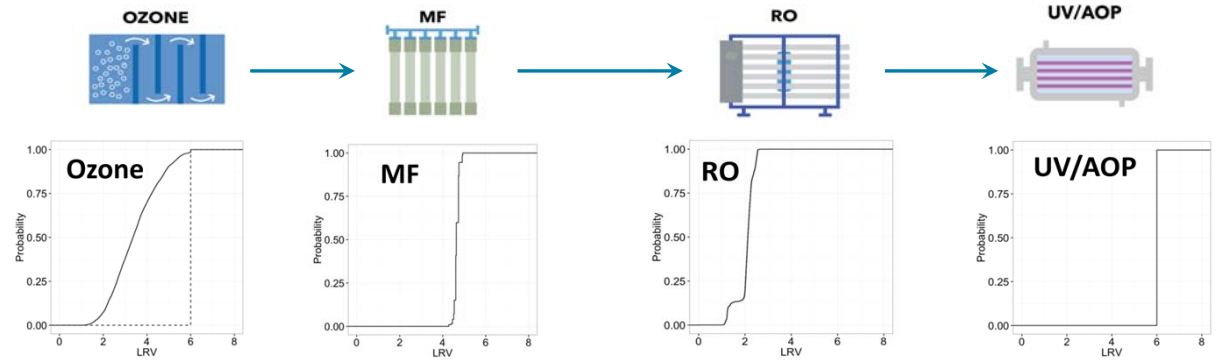
Pathogen / Indicator	Enumeration	Method
Enterovirus	Culture and molecular	EPA 1615
Adenovirus	Culture and molecular	Rigotto et al. (2011) and Ko et al. (2005)
Norovirus	Molecular	EPA 1615
Male-specific coliphages	Culture and molecular	EPA 1601 and 1602
***Giardia* cysts**	Microscopy	EPA 1693
***Cryptosporidium* oocysts**	Microscopy	EPA 1693

Which enumeration methods?

44

Evaluating Treatment Train Performance



LRV Credits for *Cryptosporidium*

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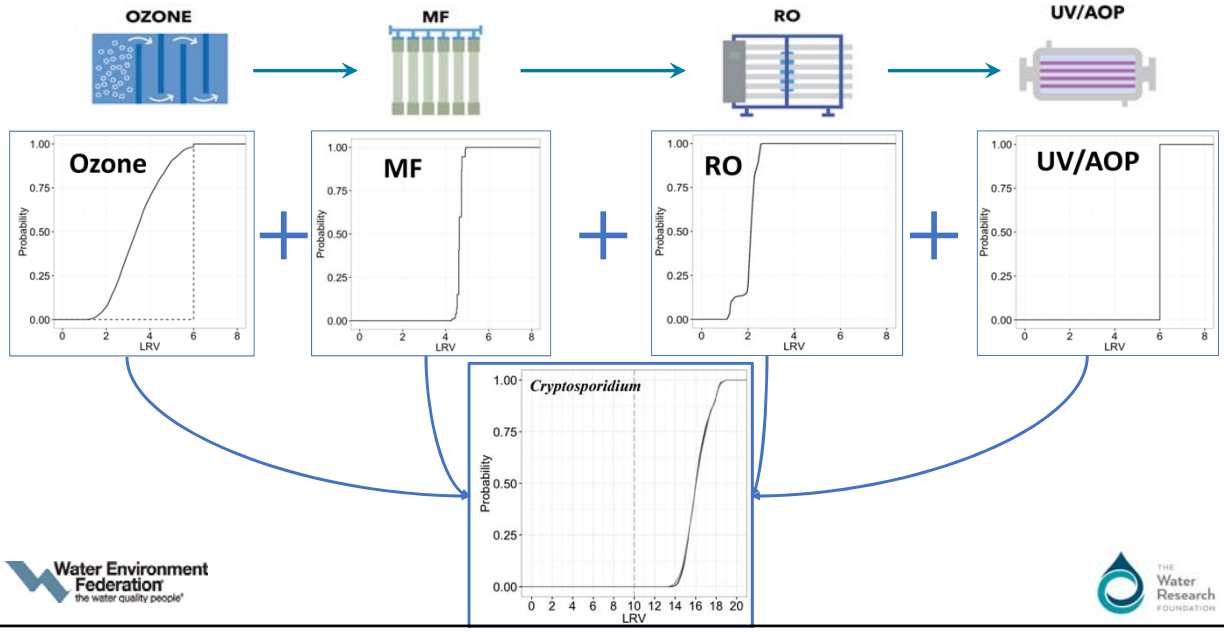
45

Evaluating Treatment Train Performance



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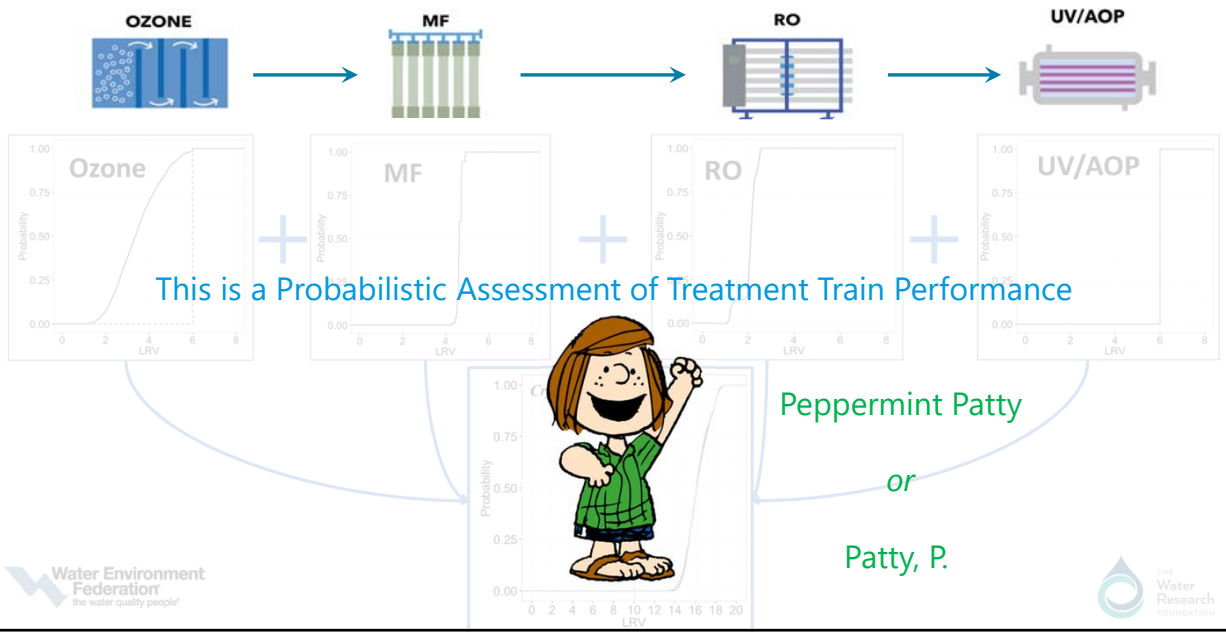
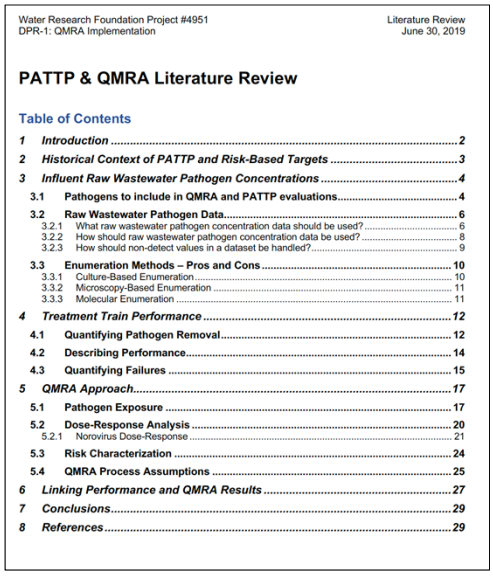
46

Evaluating Treatment Train Performance



47

Task 1: Literature Review – Major Sections



Water Research Foundation Project #4951
DPR-1: QMRA Implementation

Literature Review
June 30, 2019

PATTP & QMRA Literature Review

Table of Contents

1 *Introduction* 2
2 *Historical Context of PATTP and Risk-Based Targets* 3
3 *Influent Raw Wastewater Pathogen Concentrations* 4
3.1 Pathogens to include in QMRA and PATTP evaluations 4
3.2 Raw Wastewater Pathogen Data 6
3.2.1 What raw wastewater pathogen concentration data should be used? 6
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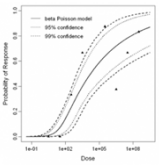
7 *Conclusions* 29
8 *References* 29

- QMRA

Drinking water consumption

1 L?
2.5 L?
Published distributions?



Dose-response

Pathogen	Dose-Response Model	Equation	Parameter Values
Adenovirus	Exponential (Crabtree et al. 1997)	$1-e^{-r\cdot d}$	r =0.4172
	Exact Beta Poisson (Teunis, Schijven, and Rutjes 2016)	$1-{}_1F_1(\alpha,\alpha+\beta,-d)$	α = 5.11 β = 2.8
Cryptosporidium spp.	Exponential (EPA 2006)	$1-e^{-r\cdot d}$	r = 0.09
	Exponential (Haas et al. 1999; Barbeau et al., 2000; Zhang et al., 2012)	$1-e^{-r\cdot d}$	r = 0.00419
	Fractional Poisson (Messner and Berger 2016)	$P\times\left(1-e^{\frac{-d}{\beta}}\right)$	P = 0.737 α = 1
	Beta-Poisson (Messner and Berger 2016)	$P=1-\left[1+\frac{d}{\beta}\right]^{-\alpha}$	α = 0.116 β = 0.121
	Exponential with Immunity (Messner and Berger 2016)	$P_{Inf}=P\times(1-e^{-rd})$	P = 0.737 r = 0.608
Giardia lamblia	Exponential (Teunis et al. 1997)	$1-e^{-r\cdot d}$	r = 0.0199
Norovirus	Exact Beta Poisson (Teunis et al. 2008)	$1-{}_1F_1(\alpha,\alpha+\beta,-d)$	α = 0.04 β =0.055
	Fractional Poisson (Messner, Berger, and Nappier 2014)	$P\times\left(1-e^{\frac{-d}{\beta}}\right)$	P = 0.72 α = 1106
	Weighted model (Soller, Schoen, et al. 2017)		
	Upper Bound – Hypergeometric (Teunis et al. 2008)	$1-{}_1F_1(\alpha,\alpha+\beta,-d)$	α = 0.04 β =0.055
	Lower Bound – Fractional Poisson (Messner, Berger, and Nappier 2014, Atmar et al. 2014, Atmar et al. 2008)	$P\times\left(1-e^{\frac{-d}{\beta}}\right)$	P = 0.72 α = 1106
Rotavirus (to be used for enterovirus)	Beta-Poisson (Ward et al. 1986)	$P=1-\left[1+\frac{d}{\beta}\right]^{-\alpha}$	α = 0.253 β = 0.426

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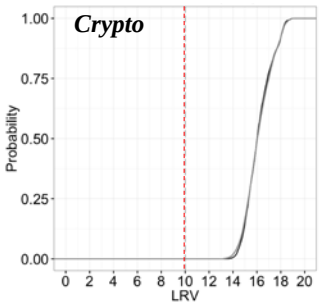
48

Tools can be used together to develop DPR criteria

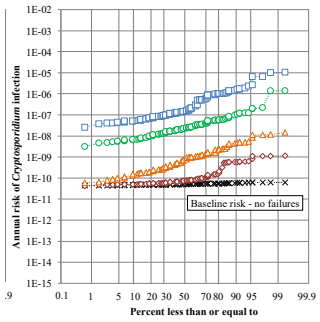
Treatment Requirements

12 / 10 / 10

Performance Evaluation



QMRA



49

Tools can be used together to develop DPR criteria

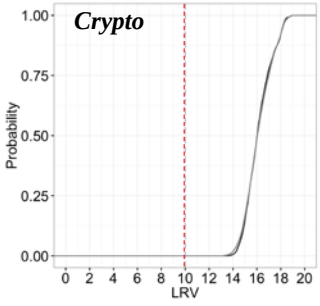
Treatment Requirements

12 / 10 / 10

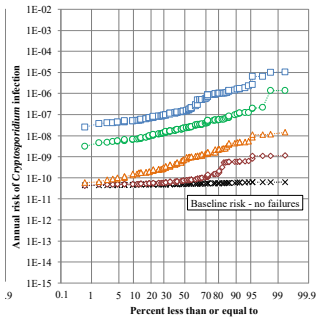
13 / 11 / 11

14 / 12 / 12

Performance Evaluation



QMRA

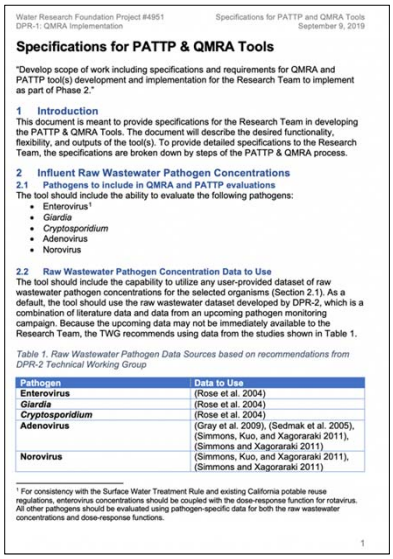


If we shift the treatment requirements….

…what is the impact on public health?

50

Task 1: Specifications and Scope of Work



Water Research Foundation Project #4951 — Specifications for PATTP and QMRA Tools
DPR-1: QMRA Implementation — September 9, 2019

Specifications for PATTP & QMRA Tools

"Develop scope of work including specifications and requirements for QMRA and PATTP tool(s) development and implementation for the Research Team to implement as part of Phase 2."

1 Introduction

This document is meant to provide specifications for the Research Team in developing the PATTP & QMRA Tools. The document will describe the desired functionality, flexibility, and outputs of the tool(s). To provide detailed specifications to the Research Team, the specifications are broken down by steps of the PATTP & QMRA process.

2 Influent Raw Wastewater Pathogen Concentrations

2.1 Pathogens to include in QMRA and PATTP evaluations

The tool should include the ability to evaluate the following pathogens:

- Enterovirus[1]
- *Giardia*
- *Cryptosporidium*
- Adenovirus
- Norovirus

2.2 Raw Wastewater Pathogen Concentration Data to Use

The tool should include the capability to utilize any user-provided dataset of raw wastewater pathogen concentrations for the selected organisms (Section 2.1). As a default, the tool should use the raw wastewater dataset developed by DPR-2, which is a combination of literature data and data from an upcoming pathogen monitoring campaign. Because the upcoming data may not be immediately available to the Research Team, the TWG recommends using data from the studies shown in Table 1.

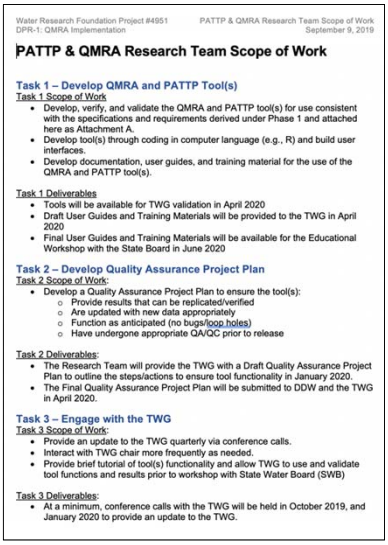
Table 1. Raw Wastewater Pathogen Data Sources based on recommendations from DPR-2 Technical Working Group

Pathogen	Data to Use
Enterovirus	(Rose et al. 2004)
Giardia	(Rose et al. 2004)
Cryptosporidium	(Rose et al. 2004)
Adenovirus	(Gray et al. 2009), (Sedmak et al. 2005), (Simmons, Kuo, and Xagoraraki 2011), (Simmons and Xagoraraki 2011)
Norovirus	(Simmons, Kuo, and Xagoraraki 2011), (Simmons and Xagoraraki 2011)

[1] For consistency with the Surface Water Treatment Rule and existing California potable reuse regulations, enterovirus concentrations should be coupled with the dose-response function for rotavirus. All other pathogens should be evaluated using pathogen-specific data for both the raw wastewater concentrations and dose-response functions.

1

July 2019



Water Research Foundation Project #4951 — PATTP & QMRA Research Team Scope of Work
DPR-1: QMRA Implementation — September 9, 2019

PATTP & QMRA Research Team Scope of Work

Task 1 – Develop QMRA and PATTP Tool(s)

Task 1 Scope of Work

- Develop, verify, and validate the QMRA and PATTP tool(s) for use consistent with the specifications and requirements derived under Phase 1 and attached here as Attachment A.
- Develop tool(s) through coding in computer language (e.g., R) and build user interfaces.
- Develop documentation, user guides, and training material for the use of the QMRA and PATTP tool(s).

Task 1 Deliverables

- Tools will be available for TWG validation in April 2020
- Draft User Guides and Training Materials will be provided to the TWG in April 2020
- Final User Guides and Training Materials will be available for the Educational Workshop with the State Board in June 2020

Task 2 – Develop Quality Assurance Project Plan

Task 2 Scope of Work:

- Develop a Quality Assurance Project Plan to ensure the tool(s):
  - Provide results that can be replicated/verified
  - Are updated with new data appropriately
  - Function as anticipated (no bugs/loop holes)
  - Have undergone appropriate QA/QC prior to release

Task 2 Deliverables:

- The Research Team will provide the TWG with a Draft Quality Assurance Project Plan to outline the steps/actions to ensure tool functionality in January 2020.
- The Final Quality Assurance Project Plan will be submitted to DDW and the TWG in April 2020.

Task 3 – Engage with the TWG

Task 3 Scope of Work:

- Provide an update to the TWG quarterly via conference calls.
- Interact with TWG chair more frequently as needed.
- Provide brief tutorial of tool(s) functionality and allow TWG to use and validate tool functions and results prior to workshop with State Water Board (SWB)

Task 3 Deliverables:

- At a minimum, conference calls with the TWG will be held in October 2019, and January 2020 to provide an update to the TWG.

August 2019

51

Remaining Project Schedule

- Task 2: Develop Performance and QMRA Tools
  - Draft PATTP and QMRA tools — April 2020
  - Final PATTP and QMRA tools — June 2020
  - Training workshop with State Board — June 2020

- Task 3: Final Report — Fall 2020

52

Approach used to calculate treatment requirements

		V / G / C
Surface Water Treatment Rule		4 / 3 / 2
Indirect Potable Reuse Regulations		12 / 10 / 10

53

Approach used to calculate treatment requirements

		V / G / C
Surface Water Treatment Rule		4 / 3 / 2
Indirect Potable Reuse Regulations		12 / 10 / 10
Raw Water Augmentation		? / ? / ?
Treated Water Augmentation		? / ? / ?

54

Importance of Research for DPR

- We set risk-based goals for drinking water
- DPR should provide the same level of protection
- Tools allow DDW to quantify public health protection provided by different treatment requirements
- Informs DPR regulations by providing insight into treatment criteria

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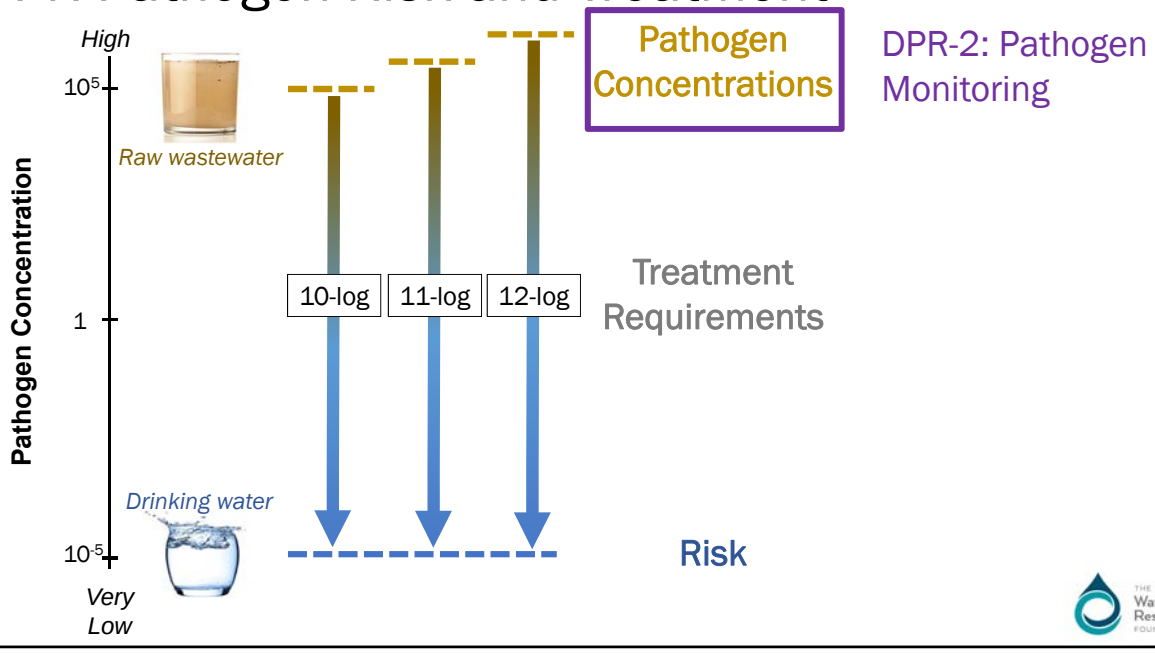
55

DPR Pathogen Risk and Treatment



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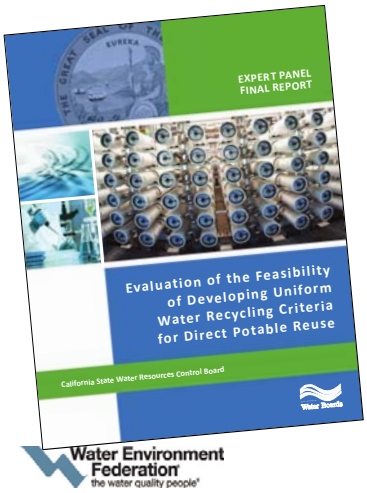
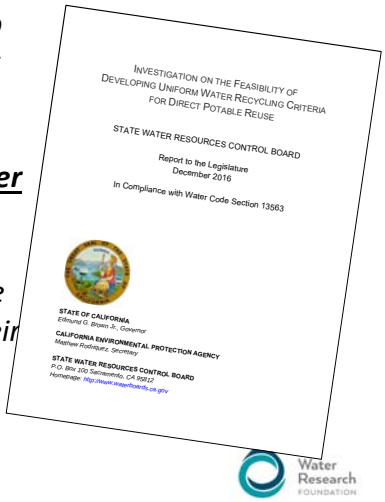
56

Study Background: CA DDW Expert Panel Report



*"The State Water Board will work…to include **monitoring requirements** for pathogens in the **raw wastewater** feeding potable reuse systems, using **improved methods** that allow for **better characterization and improved precision** of concentrations of pathogens, to provide more complete information on concentrations and their variability"*
(DDW, 2016)



57

Pathogen Monitoring TWG and Project Goals

Technical Working Group

George DiGiovanni
Metropolitan Water District

Menu Leddy

Kara Nelson
UC, Berkeley

Brian Pecson
Trussell Technologies

Channah Rock
University of Arizona

Theresa Slifko (chair)
Metropolitan Water District

- Goals:
  - Develop recommendations for the collection and analysis of pathogen data in raw wastewater
  - Conduct pathogen monitoring of raw wastewater as inputs to DPR-1

58

Review of DPR-2 Scope

- Scope
  - Task 1: Literature and methods review
  - Task 2: Develop monitoring plan and RFQ
  - Task 3: Conduct pathogen monitoring campaign
  - Task 4: Data analysis and preparation of guidance

59

Task 1 – Literature and Methods Review

TWG Recommendations for Pathogens and Enumeration Methods

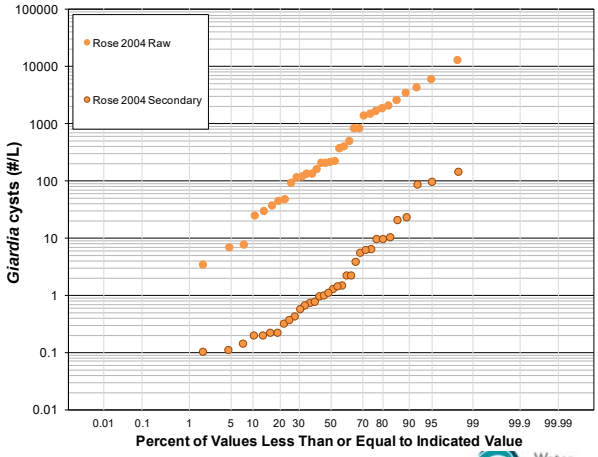
Virus	Protozoa
Enterovirus (*culture* and *molecular*) Adenovirus (*culture* and *molecular*) Norovirus (*molecular*) Bacteriophage (*culture* and *molecular*)	*Giardia* (*microscopy*) *Cryptosporidium* (*microscopy*)

- Includes historical drinking water and IPR pathogens
- Includes additional viral pathogens and indicators
- Uses both traditional (non-molecular) and molecular enumeration methods

60

Task 1 – Literature and Methods Review

- Completed literature review to support sampling plan and RFP
- Industry needs **more** pathogen data
  - Current "standard": Rose et al. 2004
    - Six facilities with 5-6 samples
    - Mostly small utilities outside CA



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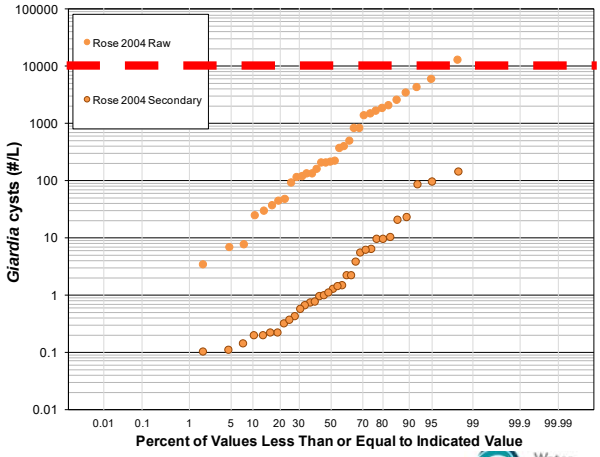
61

Task 1 – Literature and Methods Review

- Completed literature review to support sampling plan and RFP
- Industry needs **more** pathogen data
  - Current "standard": Rose et al. 2004
    - Six facilities with 5-6 samples
    - Mostly small utilities outside CA
  - IPR's 12/10/10 based on highest concentrations in the literature



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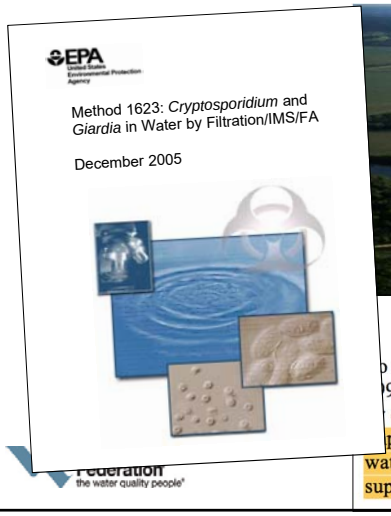
62

Industry needs high quality pathogen data

- Drinking water methods pose challenges for wastewater matrices



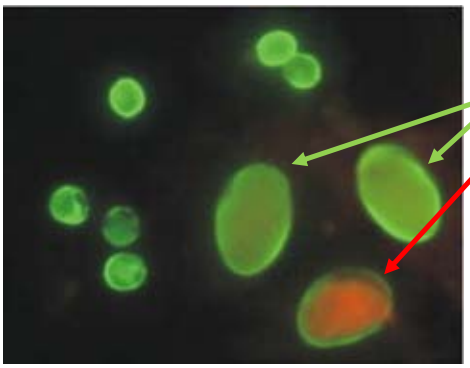
Introduction

o support future regulation of protozoa in drinking water, the Safe Drinking Water Act Amendments of 96 require the U.S. Environmental Protection Agency (EPA) to evaluate the risk to public health posed drinking water contaminants, including waterborne parasites, such as *Cryptosporidium* and *Giardia*. To plement these requirements, EPA must assess *Cryptosporidium* and *Giardia* occurrence in raw surface waters used as source waters for drinking water treatment plants. EPA Method 1623 was developed to support this assessment.

63

Industry needs high quality pathogen data

- Previous studies have not reported recoveries



Giardia counted: 2
Colorseed counted: 1
Colorseed added: 10
Recovery percentage: 10%

Actual Giardia in sample: 2 x 10 = 20

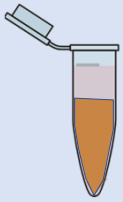
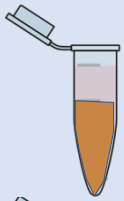
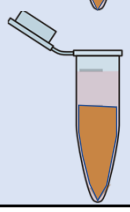
- QA/QC is important for high-quality data

64

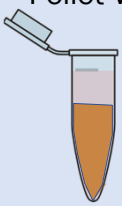
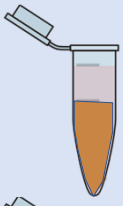
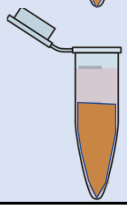
Task 2 –Methods Pre-Testing: *Cryptosporidium*

Concentration Step	Sample Volume
 *Filtration*	 *100 mL*
 *Centrifugation*	 *500 mL*
	 *1000 mL*

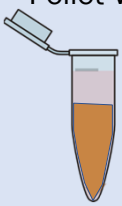
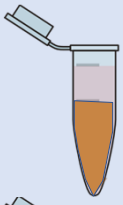
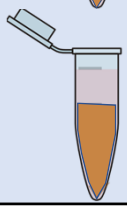
Task 2 –Methods Pre-Testing: *Cryptosporidium*

Concentration Step	Sample Volume	Pellet Volume
 *Filtration*	 *100 mL*	 *1 mL*
 *Centrifugation*	 *500 mL*	 *2 mL*
	 *1000 mL*	 *4 mL*

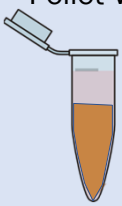
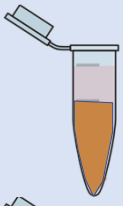
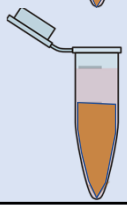
Task 2 –Methods Pre-Testing: *Cryptosporidium*

Concentration Step	Sample Volume	Pellet Volume	Concentration (oocysts/L)
 *Filtration*	 *100 mL*	 *1 mL*	ND (<10-12)
 *Centrifugation*	 *500 mL*	 *2 mL*	ND (<3-6)
	 *1000 mL*	 *4 mL*	5-9

Task 2 –Methods Pre-Testing: *Cryptosporidium*

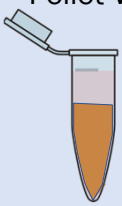
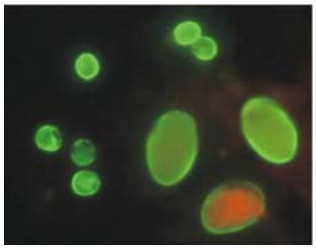
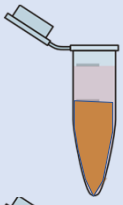
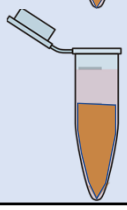
Concentration Step	Sample Volume	Pellet Volume	Concentration (oocysts/L)	Average Recovery	Corrected Conc. (oocysts/L)
 *Filtration*	 *100 mL*	 *1 mL*	ND (<10-12)		
 *Centrifugation*	 *500 mL*	 *2 mL*	ND (<3-6)		
	 *1000 mL*	 *4 mL*	5-9	26%	6-18

Task 2 –Methods Pre-Testing: *Cryptosporidium*

Concentration Step	Sample Volume	Pellet Volume	Concentration (oocysts/L)	Average Recovery	Corrected Conc. (oocysts/L)
 *Filtration*	 *100 mL*	 *1 mL*	ND (<10-12)		
 *Centrifugation*	 *500 mL*	 *2 mL*	ND (<3-6)		
	 *1000 mL*	 *4 mL*	***Site 1*** 5-9 ***Site 2*** 18-32	26% 30%	6-18 40-55

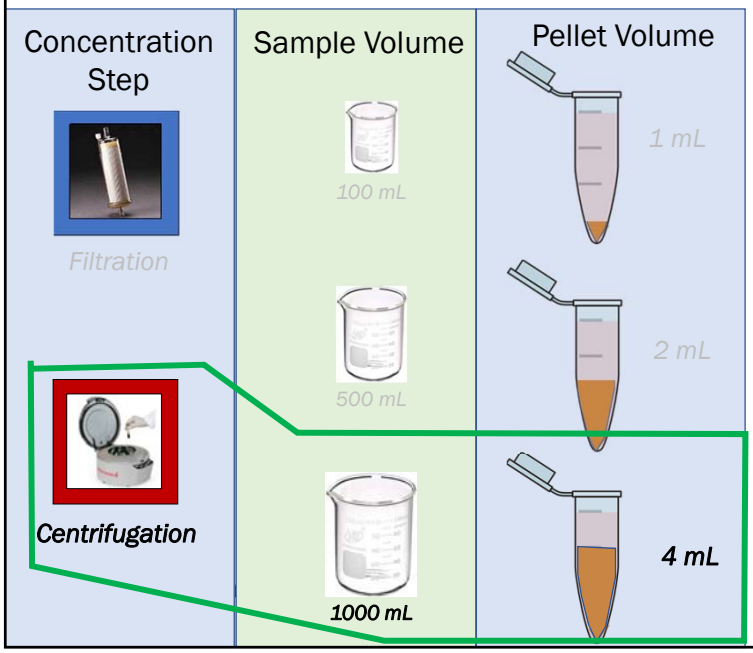
69

Task 2 –Methods Pre-Testing: *Cryptosporidium*

Concentration Step	Sample Volume	Pellet Volume	Concentration (oocysts/L)		
 *Filtration*	 *100 mL*	 *1 mL*	ND (<10-12)	 Also suitable for *Giardia* cysts	
 *Centrifugation*	 *500 mL*	 *2 mL*	ND (<3-6)		
	 *1000 mL*	 *4 mL*	***Site 1*** 5-9 ***Site 2*** 18-32	Average Recovery 26% 30%	Corrected Conc. (oocysts/L) 6-18 40-55

70

Task 2 –Methods Pre-Testing: *Cryptosporidium*



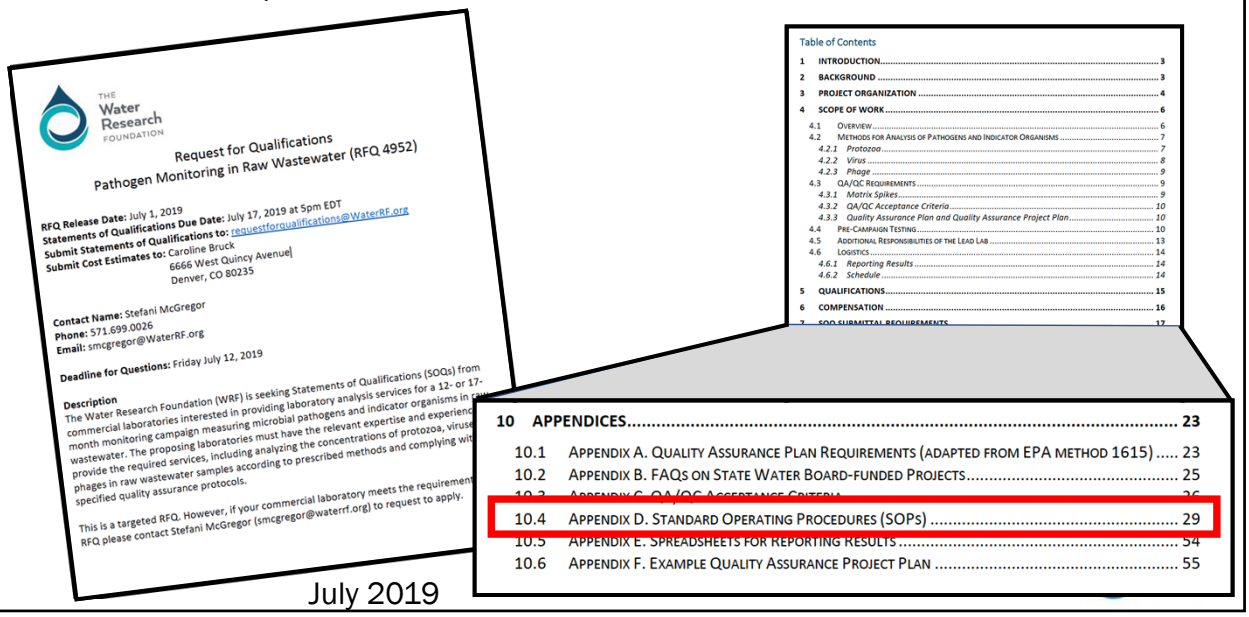
Standard Operating Procedures (SOPs)

Method 1:

Method 2:

71

Task 2 –RFQ and Selection of Laboratories



Request for Qualifications
Pathogen Monitoring in Raw Wastewater (RFQ 4952)

RFQ Release Date: July 1, 2019
Statements of Qualifications Due Date: July 17, 2019 at 5pm EDT
Submit Statements of Qualifications to: requestforqualifications@WaterRF.org
Submit Cost Estimates to: Caroline Bruck
6666 West Quincy Avenue
Denver, CO 80235

Contact Name: Stefani McGregor
Phone: 571.699.0026
Email: smcgregor@WaterRF.org

Deadline for Questions: Friday July 12, 2019

Description
The Water Research Foundation (WRF) is seeking Statements of Qualifications (SOQs) from commercial laboratories interested in providing laboratory analysis services for a 12- or 17-month monitoring campaign measuring microbial pathogens and indicator organisms in [illegible] wastewater. The proposing laboratories must have the relevant expertise and experienc[illegible] provide the required services, including analyzing the concentrations of protozoa, virus[illegible] phages in raw wastewater samples according to prescribed methods and complying wit[illegible] specified quality assurance protocols.

This is a targeted RFQ. However, if your commercial laboratory meets the requirement[illegible] RFQ please contact Stefani McGregor (smcgregor@waterrf.org) to request to apply.

Table of Contents

1 INTRODUCTION 3
2 BACKGROUND 3
3 PROJECT ORGANIZATION 4
4 SCOPE OF WORK 6
4.1 Overview 6
4.2 Methods for Analysis of Pathogens and Indicator Organisms 7
4.2.1 Protozoa 7
4.2.2 Virus 8
4.2.3 Phage 9
4.3 QA/QC Requirements 9
4.3.1 Matrix Spikes 9
4.3.2 QA/QC Acceptance Criteria 10
4.3.3 Quality Assurance Plan and Quality Assurance Project Plan 10
4.4 Pre-Campaign Testing 10
4.5 Additional Responsibilities of the Lead Lab 13
4.6 Logistics 14
4.6.1 Reporting Results 14
4.6.2 Schedule 14
5 QUALIFICATIONS 15
6 COMPENSATION 16
7 SOQ SUBMITTAL REQUIREMENTS 17

10 APPENDICES 23
10.1 Appendix A. Quality Assurance Plan Requirements (adapted from EPA Method 1615) 23
10.2 Appendix B. FAQs on State Water Board-funded Projects 25
10.3 Appendix C. QA/QC Acceptance Criteria 26
10.4 Appendix D. Standard Operating Procedures (SOPs) 29
10.5 Appendix E. Spreadsheets for Reporting Results 54
10.6 Appendix F. Example Quality Assurance Project Plan 55

July 2019

72

Task 2 –RFQ and Selection of Laboratories

cel analytical, inc.
water, wastewater, and soil laboratory services

Lead lab

BIOLOGICAL CONSULTING SERVICES OF NORTH FLORIDA, INC.

Methods Development Lab

SCIENTIFIC METHODS

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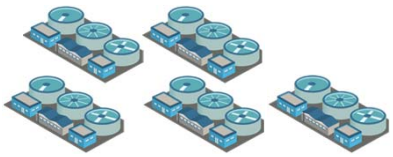
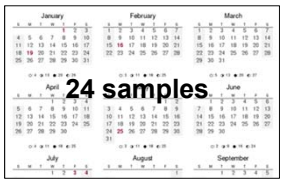
73

Task 2 –Full-Scale Campaign



Five facilities



24 samples

120-point datasets for:

- **3 pathogenic viruses**
- **2 pathogenic protozoa**
- **1 viral indicator**

74

Next Steps

- Task 3: Conduct pathogen monitoring campaign
  - Methods optimization for 5 wastewaters
  - Demonstration of capability
  - Full-scale campaign until January 2021 including two winters

Walt Jakubowski
QA/QC

- Task 4: Analyze data and develop recommendations

75

Importance of Research for DPR

- Raw wastewater pathogen concentrations a key input for evaluations of DPR in California
- Industry does not have sufficient high-quality pathogen data for regulatory development
- New SOPs will address the limitations of previous monitoring efforts
- Provides industry with the largest dataset of raw pathogen concentrations
- Data from DPR-2 will feed into evaluation in DPR-1 (Treatment and QMRA)

76

DPR-4 Identification and Control of Chemical Peaks

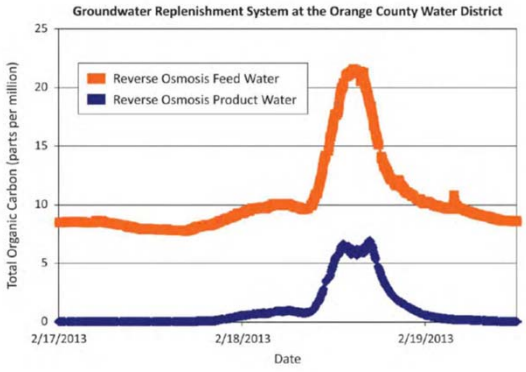
Drs. Jean Debroux and Shane Trussell

77

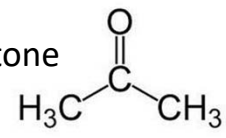
77

DPR-4: Treatment for Averaging Potential Chemical Peaks

- Full advanced treatment (MF/RO/UV-AOP) is a highly effective treatment train employed today for groundwater recharge
- Water quality excursions have been observed



Acetone



78

Project Scope

- Task 1 – Literature Review
- Task 2 – Case Study Report
- Task 3 – Experimentation to Address Knowledge Gaps

Project Schedule

Project Initiation	December 1, 2018
Task 1 – Literature Review	May 31, 2019
Task 2 – Case Study Report	July 31, 2019
Task 3 – Experimentation	January 31, 2020
Final Report	**March 31, 2020**

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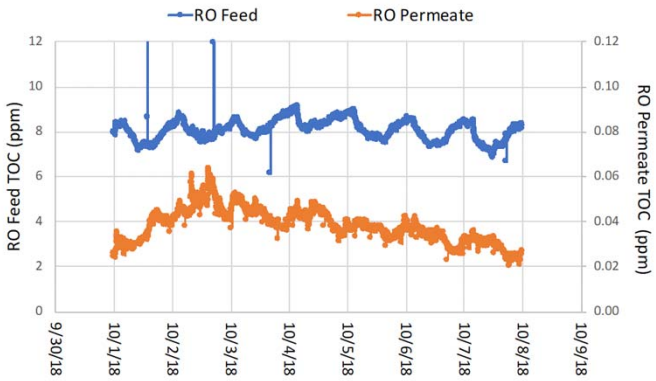
79

What is a chemical peak?

- Diurnal and process-related TOC baseline variations
- Outliers



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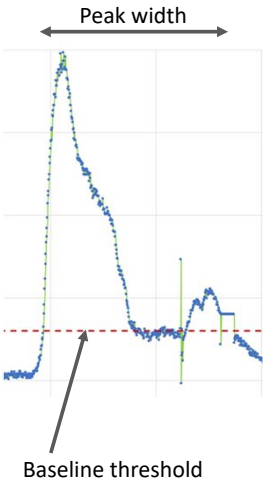
Defining a chemical peak

- Peak height – must exceed baseline threshold
  - Due to outliers, non-normal distribution
  - All data used
  - Baseline Threshold = Q3 + 1.5 * IQR, where IQR = Q3- Q1
- Peak width – Due to non-plug flow processes and recycle flows in WWTP, an instantaneous illicit discharge results in a peak width of hours to days
  - On-line data every 15 minutes



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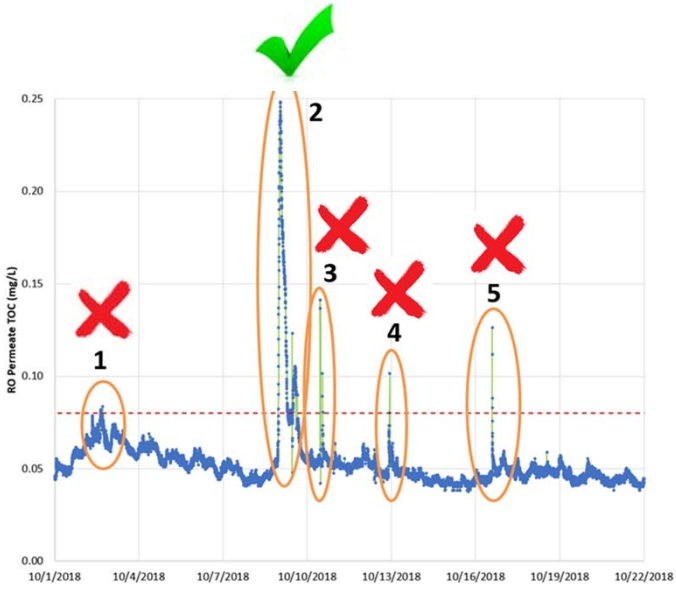
81

Example excursions from baseline



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What chemicals can pass through FAT?

Summary of RO rejection of organic compounds and chemical families

Chemical Family	Sub-group	Good (>90%)	Intermediate (50-90%)	Poor (<50%)
VOCs	Solvents and Industrial Compounds	Ethers	Halobenzenes; 1,1,2-TCE	Nitriles; Haloalkenes
	Haloalkanes	CCl_4; Ethanes with 3-4 Cl atoms; Most C_{4+} haloalkanes	Some C_1-C_3 haloalkanes	C_1-C_2 haloalkanes with 1-2 halogen atoms
	Alkylbenzenes	C_{10+}	C_6-C_9	
	Pesticides/ Herbicides	1,2,3-TCP		MITC
LMW Oxygenated Compounds	Alcohols	Branched C_{4+} alcohols	Isopropyl alcohol; Most unbranched alcohols	Methanol; Ethanol;
	Aldehydes, Ketones	Methyl isobutyl ketone (MIBK)	Acetone; Most Ketones	Formaldehyde; Most Aldehydes
PPCPs	Flame Retardants	Chlorophosphates; PFAS		
	Pharmaceuticals	Steroids; β-blockers; NSAIDs; X-ray Contrast Media		
DBPs	Nitrosamines	C_{4+} nitrosamines; NMOR	NDMA; NDEA	
	Halogenated DBPs	HAAs	HANs	THMs

References: Howe 2019, Zeng 2016, Rodriguez 2011, Snyder 2007, Kiso 2011, Tackaert 2019, Fujioka 2012; Doederer 2014

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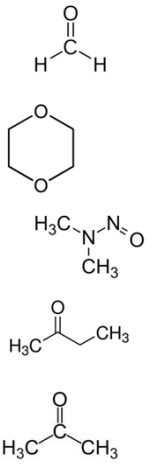
Predicted removal of organic compounds via AOP

Family	Greater than 1,4-dioxane	Less than 1,4-dioxane
VOCs	Haloalkenes Halobenzenes Alkylbenzenes C_4+ Alcohols C_4+ Aldehydes C_6+ Ketones Acrylonitrile	C_1-C_3 Haloalkanes C_1-C_3 Alcohols C_1-C_3 Aldehydes C_3-C_5 Ketones Acetonitrile MITC
PPCPs	Most pharmaceuticals	Flame Retardants
DBPs	Nitrosamines[1]	THMs

Notes: 1. High removal in UV/AOP systems
References: Drewes 2008, Howe 2019, Ahmed 2017, Drewes 2006, Buxton 1988, Swancutt 2010



Organic compounds poorly removed by FAT

Family	Compounds poorly removed by FAT
VOCs	LMW haloalkanes LMW alcohols, aldehydes, ketones Acetonitrile MITC
DBPs	THMs

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Potential Treatment/Blending Technologies

Ozone/BAC Pre-treatment


Blending

Air Stripping

Additional RO/AOP Treatment


Activated Carbon

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85

Case Studies

- Compare elements of source control measures, experiences, monitoring and detection of chemical peaks
  - Orange County Water District Ground Water Replenishment System
  - Singapore Public Utilities Board
  - City of San Diego North City Pure Water Demonstration Facility
- Compare strategies for averaging Chemical Peaks

Orange County Water District SINCE 1933

PUB Water for All: Conserve, Value, Enjoy

SD Pure Water San Diego

NWRI

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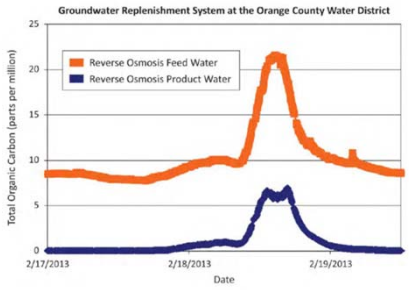
86

TOC and Acetone grab sample results during 2013 GWRS Acetone event



Sample Date	Sample Location	EPA 524.2 Acetone	Theoretical TOC from Acetone[1]	EPA 415.3 TOC	Baseline TOC[2]	Acetone Contribution to Elevated TOC[3]
2/18/2013 6:00AM	RO Feed	1,940 µg/L	1.2 mg/L	9.39 mg/L	~ 8.0 mg/L	~ 86%
	RO Permeate	1,410 µg/L	0.9 mg/L	1.18 mg/L	~ 0.025 mg/L	~ 78%

1 – acetone carbon contribution is approximately 62%
2 – from online TOC data preceding the acetone event
3 – Baseline TOC subtracted from EPA 415.3 TOC used to calculate % acetone that contributed to elevated TOC
(e.g., for RO feed → 1.2 mg/L / (9.39 mg/L – 8.0 mg/L) = 86%

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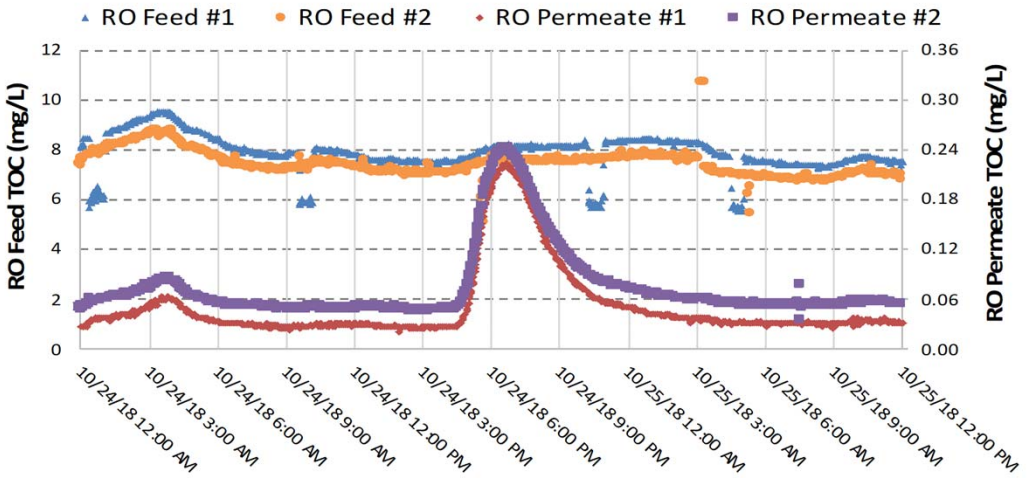
87

OCWD TOC monitoring October 24, 2018 acetone event



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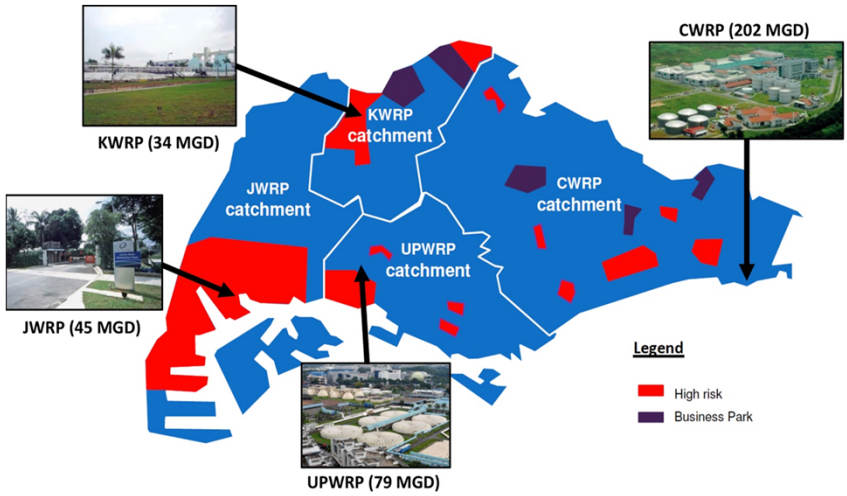
88

Singapore PUB



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89

Singapore PUB

List of Prohibited Organic Compounds (PUB)		
1,2,4-Trimethylbenzene	Furan	Octane
1,1,1-Trichloroethane	Heptane	Polybrominated diphenyl ether
1,1,2-Trichloroethane	Hexane	Styrene
Benzene	Isobutanol	Tetra-chloromethane
Decane	Isopropyl ether	Tetra-chloroethylene
Diethyl ether	Methyl ethyl ketone	THF (Tetrahydrofuran)
Dimethyl sulphide	Methyl isobutyl ketone	Toluene
Dimethyl sulphoxide	Methyl tert-butyl-ether	Trichloroethylene
DMF (N,N-Dimethylformamide)	Methylene chloride	Turpentine
Ethylbenzene	Nonane	Xylene (o,m,p)

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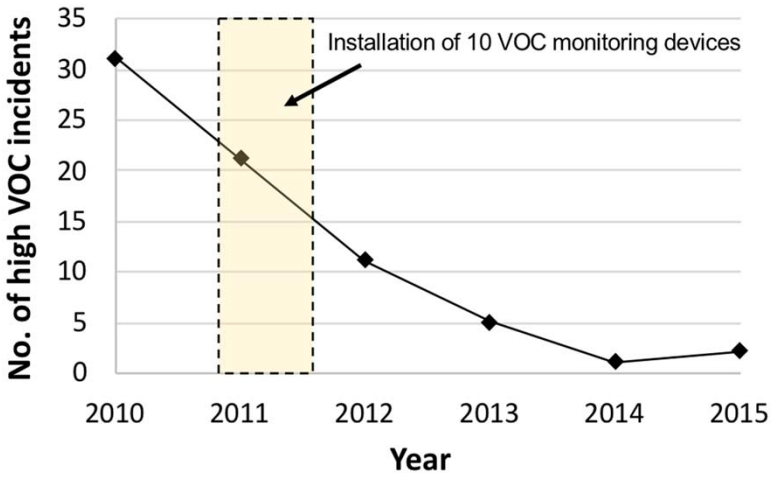
90

Singapore PUB VOC Monitoring in the Sewershed



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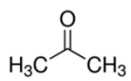
San Diego Pure Water Demonstration Facility Chemical Challenge Testing

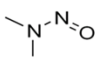
- Spike of Acetone, NDMA, Formaldehyde, and 1,4-dioxane into Feed Water
- Evaluate O_3 & BAC as additional barrier
- Test removal of O_3-BAC-MF-RO-UV/AOP vs. MF-RO-UV/AOP

Formaldehyde ~300 µg/L



Acetone ~2,600 µg/L

1,4-dioxane ~900 µg/L



NDMA ~500 ng/L

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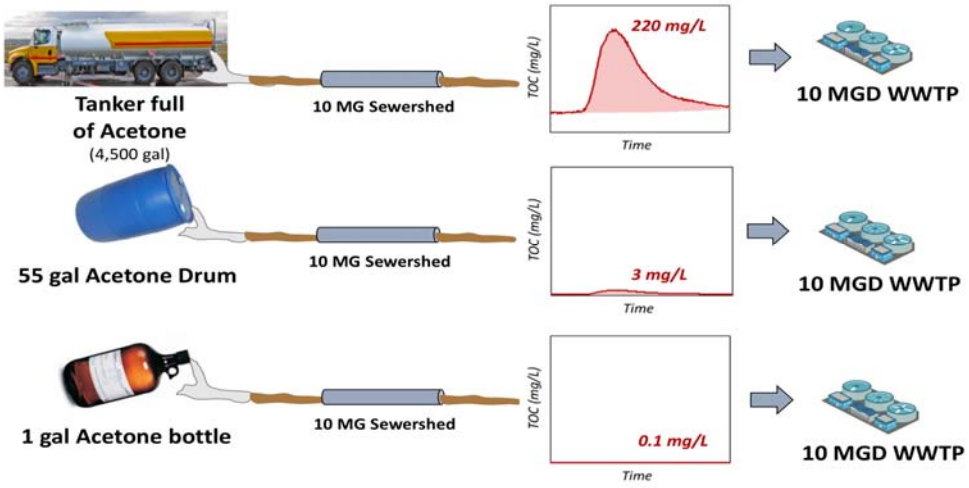
92

Discharge Volume



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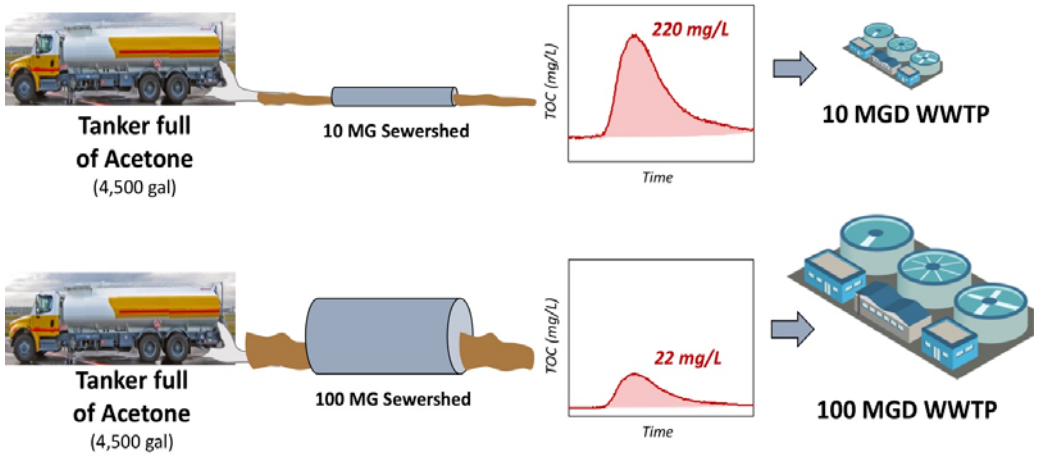
93

Impact of Sewershed Size



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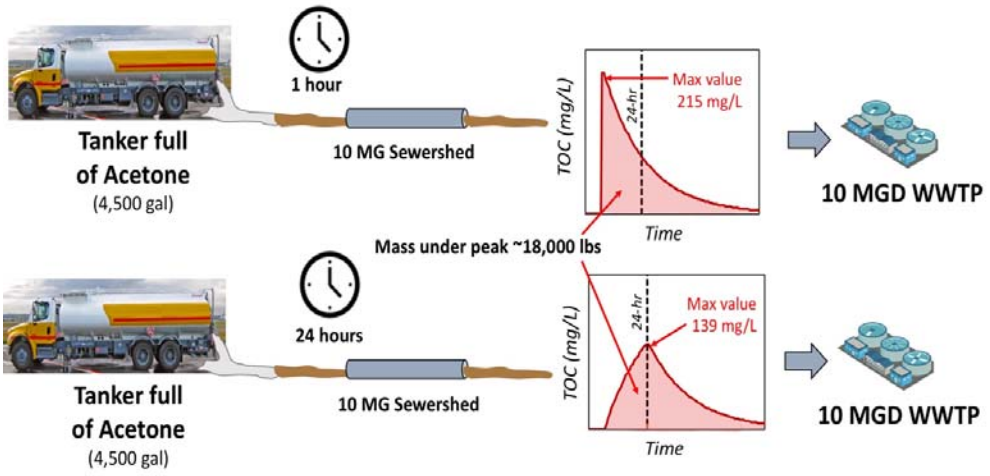
Chemical Discharge Duration



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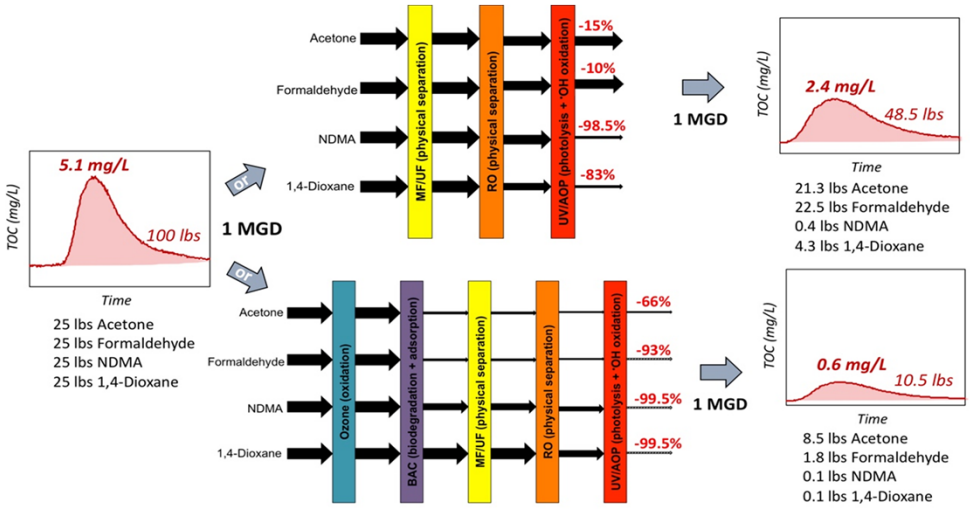
95

Treatment Robustness for Averaging Chemical Peaks



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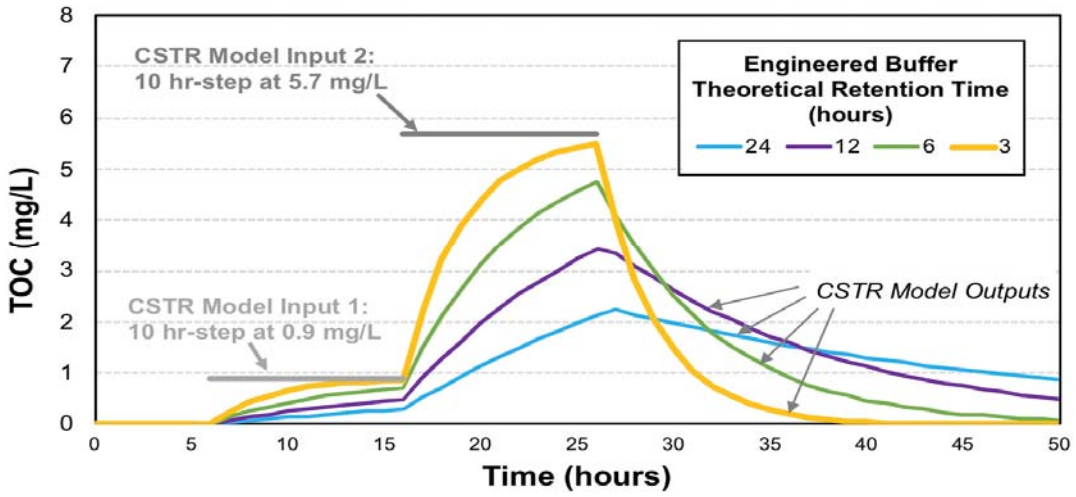
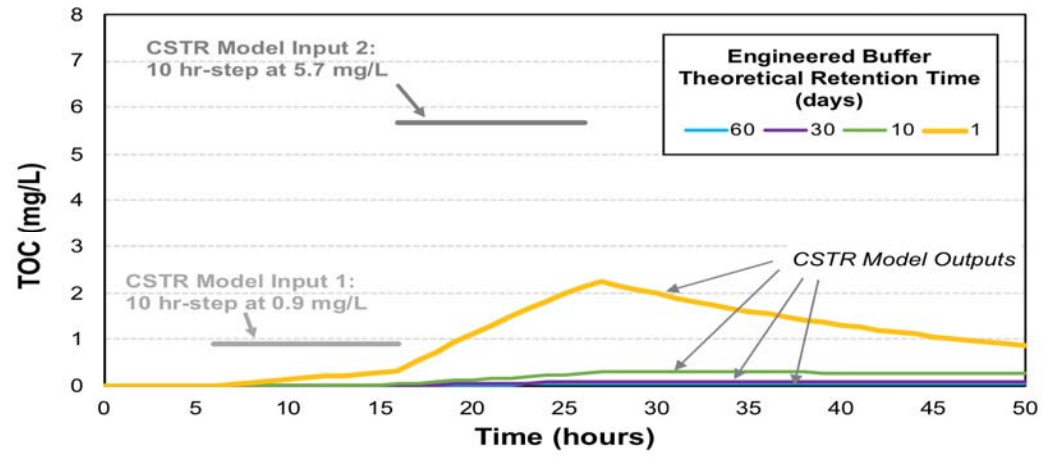
96

Engineered Buffer with Residence up to 24 Hours



97

Engineered Buffer with Residence up to 60 Days



98

How will online TOC analyzers be used?

- Advanced oxidation reactions to mineralize organic carbon in sample (UV/persulfate and O_3/hydroxide)
- Expert panel expressed concern that highly volatile organics might not be captured with online TOC

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Experimental matrix

Southern Nevada Water Authority

Principal Investigator
Eric Dickenson, PhD, PE

*OH rate constant (k_{*OH}, L/Mol*s)	Henry's Law Constant (Hyc)		
	HYC > 1.0	0.1 < HYC < 1.0	0.01 < HYC < 0.1
$k_{*OH} > 1 \times 10^9$	Vinyl chloride	Toluene	MIBK
$1 \times 10^8 < k_{*OH} < 1 \times 10^9$			Acetone
$1 \times 10^7 < k_{*OH} < 1 \times 10^8$		Methylene chloride	

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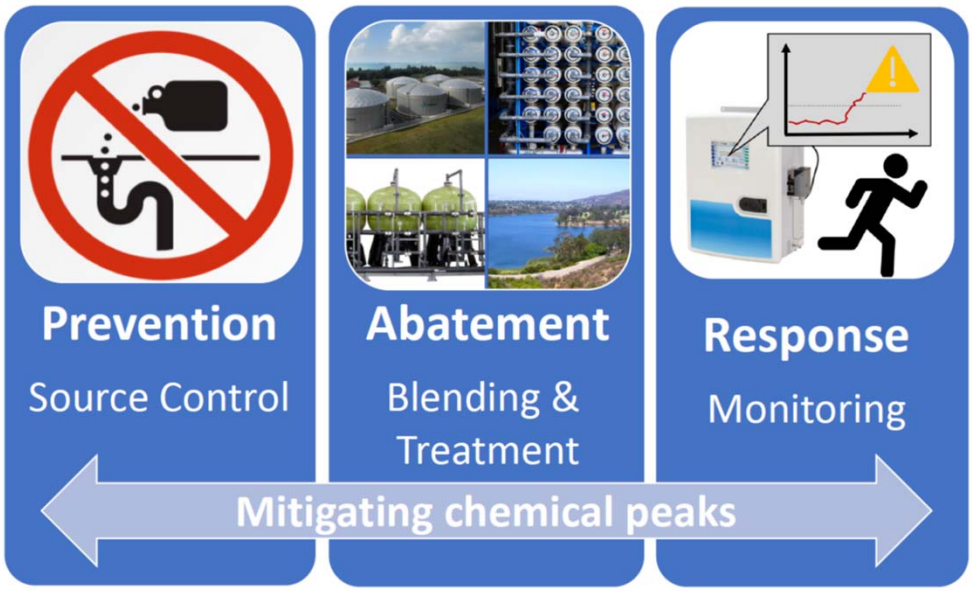
100



101

DPR-4:Treatment for Averaging Potential Chemical Peaks

Thank you to:

Research Team: Stephen Timko, PhD, Rodrigo Tackaert, PhD, Aleks Pisarenko, PhD

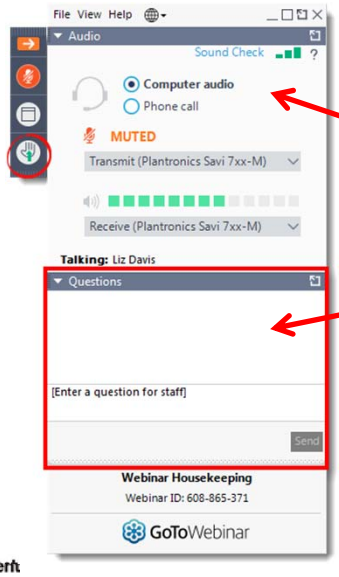
TWG: Jim Crook, PhD and Adam Olivieri, Dr. PH

PAC: Mehul Patel, PE

Guidance: SWRCB, Water Research Foundation, California DDW

102

Time for Questions: Facilitated by Dr. Jim Crook



Your Participation

Open and close your control panel

Join audio:

- Choose **Mic & Speakers** to use VoIP
- Choose **Telephone** and dial using the information provided

Submit questions and comments via the Questions panel

Note: Today's presentation is being recorded and will be available shortly after today's webcast

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Thank You!

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104