Measuring Pathogens in Wastewater and Linkages to Risk Assessment and Plant Reliability

June 2, 2021

Housekeeping

- Submit questions through the question box at any time. We will do a Q&A at the end of the webcast.
- Slides and a recording of the webcast will be available at www.waterrf.org. You can download the slides now under Event Resources on the bottom left of your screen.
- A certificate of completion will be automatically generated after the webcast. Any questions, please contact msuazo@waterrf.org.
- There is a quick survey at the end of the webcast. Please take the time to help us improve our future webcasts.

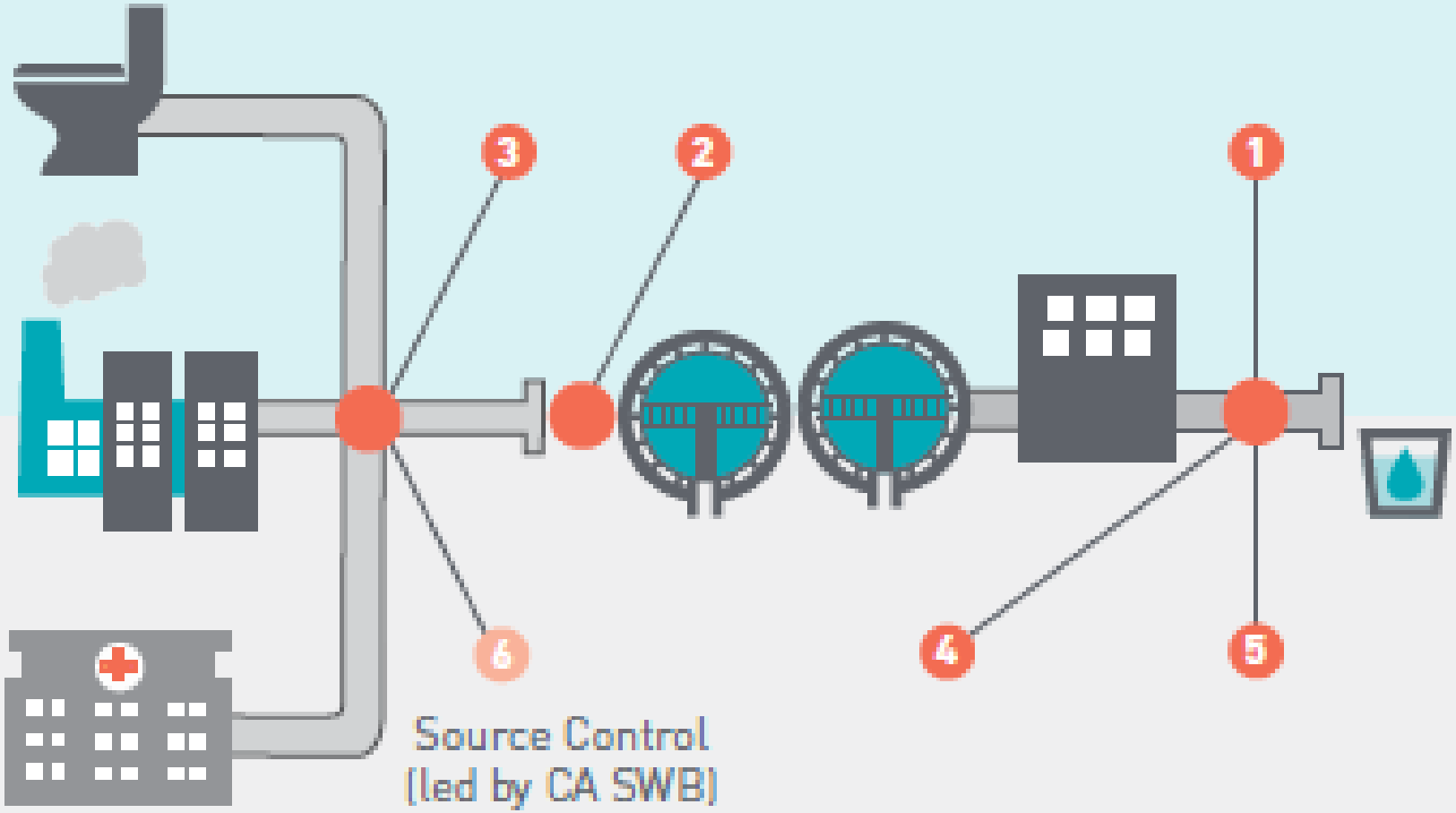
PROJECTS TO INFORM THE DEVELOPMENT OF DPR REGULATIONS

PATHOGENS

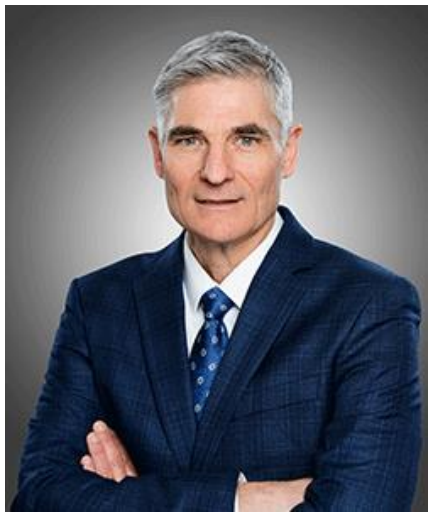
1. Tools to Evaluate Quantitative Microbial Risk and Plant Performance/Reliability
2. Measuring Pathogens in Wastewater
3. Collecting Pathogens in Wastewater During Outbreaks

CHEMICALS

4. Defining Potential Chemical Peaks and Management Options
5. Evaluating Analytical Methods for Detecting Unknown Chemicals in Recycled Water



Today's Presenters



Peter Grevatt, PhD
CEO
The Water Research Foundation

E. Joaquin Esquivel, Chair, State Water Resources Control Board

Deven Upadhyay, Assistant General Manager/Chief Operating Officer, Metropolitan Water District of Southern California

Randy Barnard, PE
Technical Operations Section Chief,
State Water Resources Control Board
Division of Drinking Water

Brian Pecson, PhD, PE
Principal Engineer
Trussell Technologies

Today's Presenters

Anya Kaufmann, PE
Senior Engineer
Trussell Technologies, Inc.

Daniel Gerrity, PhD
Principal Research Scientist
Southern Nevada Water Authority

Emily Darby, PE
Trussell Technologies, Inc.

Robert Hultquist
State Water Board Division of Drinking Water, Retired

Adam Olivieri, Dr.PH, PE
Principal and Founder, EOA, Inc.
DDW Expert Panel Co-Chair

Welcome and Opening Remarks

Peter Grevatt, PhD
Chief Executive Officer
The Water Research Foundation

DPR Research

E. Joaquin Esquivel
Chair, State Water Resources Control Board

Protecting Public Health

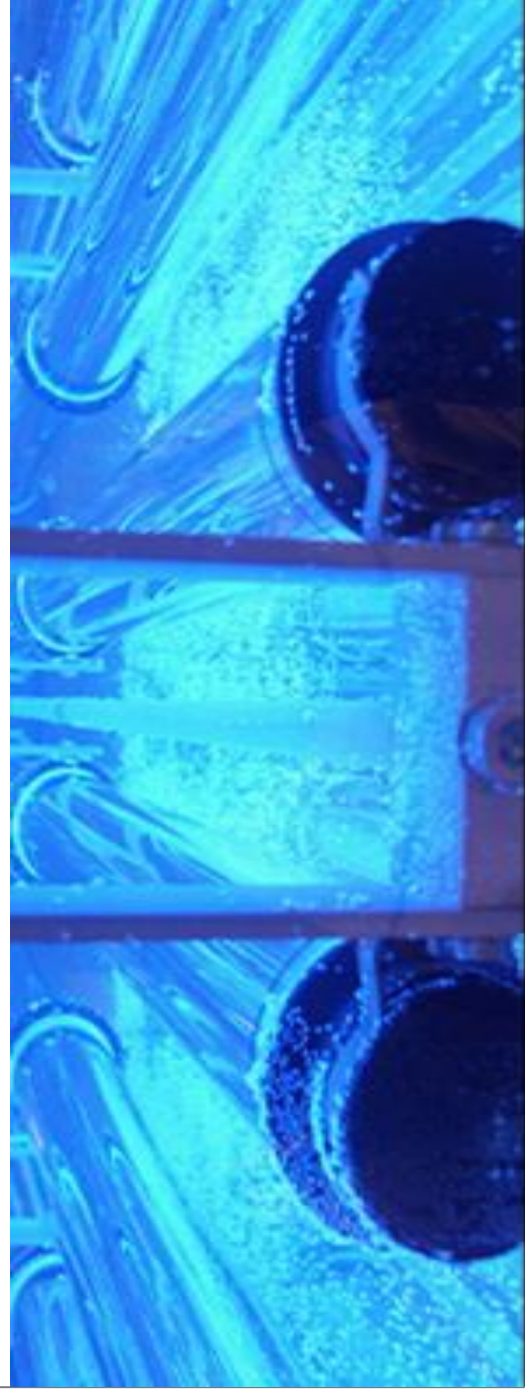
- The State Board is charged with ensuring that water delivered by public water systems shall at all times be pure, wholesome, and potable.
- Every citizen of California has the right to pure and safe drinking water.
- The State Water Board establishes uniform statewide regulations for each type of use of recycled water for the protection of public health.
- Criteria for DPR must be protective of public health.

Water Resiliency

- Changes in our environment related to climate change means more droughts in our future, so we must expand our water resource options.
- We need to take a thoughtful and deliberate approach to diversifying and securing our long-term water resilience.
- Direct potable reuse is one part of a multifaceted effort that includes a wide range of sources, including indirect potable reuse through groundwater recharge, surface water augmentation, storm water capture, and desalination.
- The completion of the DPR research is an important step in our path to develop regulations for DPR protective of public health.

Research for Direct Potable Reuse

- There is great potential with DPR, but it also presents very real scientific and technical challenges that must be addressed to ensure public health is reliably protected at all times.
- The current research provides information to fill knowledge gaps in development of criteria
- Ongoing research will continue to expand our collective knowledge of the risks and the means to address the risks of DPR as the State continues to develop options for water resiliency.



MWD Welcome & Opening Remarks

Deven Upadhyay
Assistant General Manager/Chief Operating Officer
Metropolitan Water District

DPR Research

Randy Barnard
Chief, Technical Operations Section,
Division of Drinking Water,
State Water Board

Background

Need for Research

"The State Water Board finds the research results will make a significant contribution to the development of criteria for DPR, and most importantly, will provide a higher level of certainty that the criteria are protective of public health, and therefore must be conducted concurrently with the development of DPR criteria."

(2016 Report to Legislature on the Feasibility of Developing Uniform Water Recycling Criteria for Direct Potable Reuse)

5 DPR Research Projects

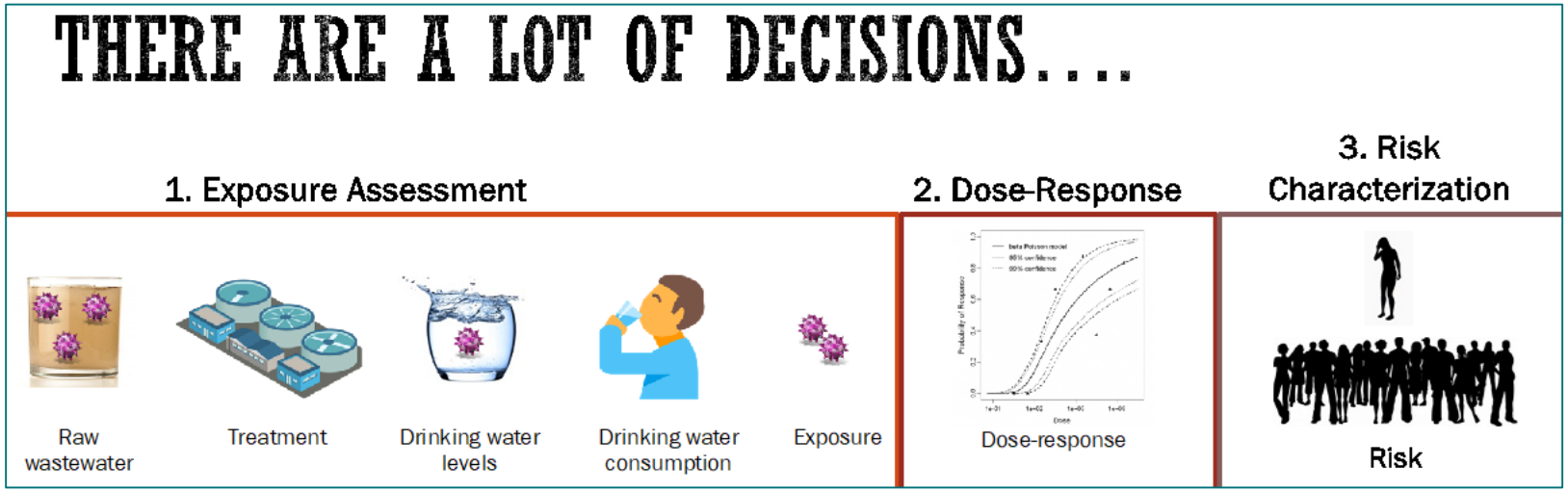
Most began in early 2019, Completed in early 2021:

- ✓DPR-1 Quantitative Microbial Risk Assessment
- ✓DPR-2 Raw pathogen data
- ✓DPR-3 Worst case raw pathogen levels (outbreak)
- ✓DPR-4 Reduce chemical spikes
- ✓DPR-5 Analytical methods for unknown low molecular weight chemicals

https://www.waterrf.org/california-state-water-board-grant

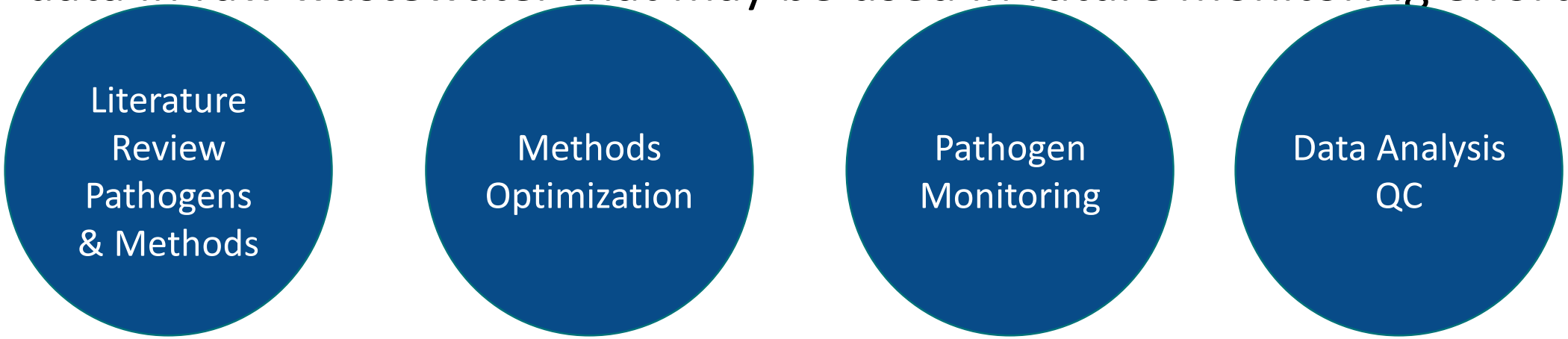
DPR-1 Tool to Evaluate Quantitative Microbial Risk and Plant Performance/Reliability

- Develop probabilistic QMRA Tool and Guidance
- State Board will consider probabilistic QMRA as part of criteria development and see whether/how it can be implemented



DPR-2 Measure Pathogens in Wastewater

- Provide better empirical data on the concentration and variability of pathogens in raw wastewater for the purpose of verifying log removal values necessary to adequately protect public health in DPR projects
- Develop recommendations for the collection and analysis of pathogen data in raw wastewater that may be used in future monitoring efforts



Addendum Public Comment Period

- Written comments due June 25, 2021 noon
- Email DDWrecycledwater@waterboards.ca.gov

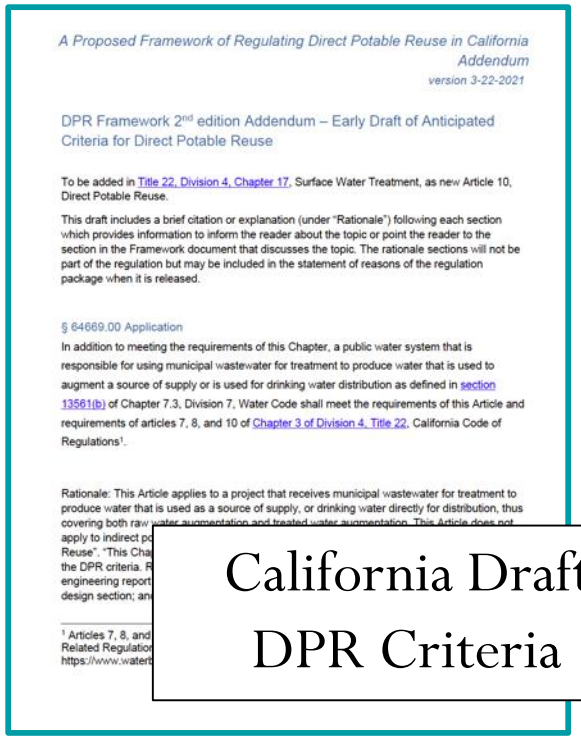
Submit comments on the Framework	
By email	DDWrecycledwater@waterboards.ca.gov PDF preferred (15 MB max)
By mail	Jing Chao Division of Drinking Water, Technical Operations Section State Water Resources Control Board 1350 Front Street, Room 2050 San Diego, CA 92101

Today's Discussion

Past

Present

FUTURE



A Proposed Framework of Regulating Direct Potable Reuse in California Addendum

version 3-22-2021

DPR Framework 2nd edition Addendum – Early Draft of Anticipated Criteria for Direct Potable Reuse

To be added in Title 22, Division 4, Chapter 17, Surface Water Treatment, as new Article 10, Direct Potable Reuse.

This draft includes a brief citation or explanation (under "Rationale") following each section which provides information to inform the reader about the topic or point the reader to the section in the Framework document that discusses the topic. The rationale sections will not be part of the regulation but may be included in the statement of reasons of the regulation package when it is released.

§ 64669.00 Application

In addition to meeting the requirements of this Chapter, a public water system that is responsible for using municipal wastewater for treatment to produce water that is used to augment a source of supply or is used for drinking water distribution as defined in section 13561(b) of Chapter 7.3, Division 7, Water Code shall meet the requirements of this Article and requirements of articles 7, 8, and 10 of Chapter 3 of Division 4, Title 22, California Code of Regulations[1].

Rationale: This Article applies to a project that receives municipal wastewater for treatment to produce water that is used as a source of supply, or drinking water directly for distribution, thus covering both raw water augmentation and treated water augmentation. This Article does not apply to indirect po
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engineering report
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[1] Articles 7, 8, and
Related Regulation
https://www.waterb

California Draft DPR Criteria

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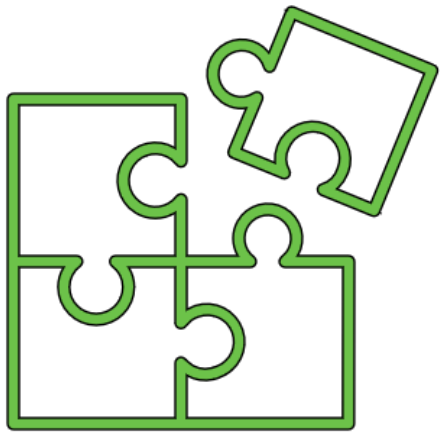
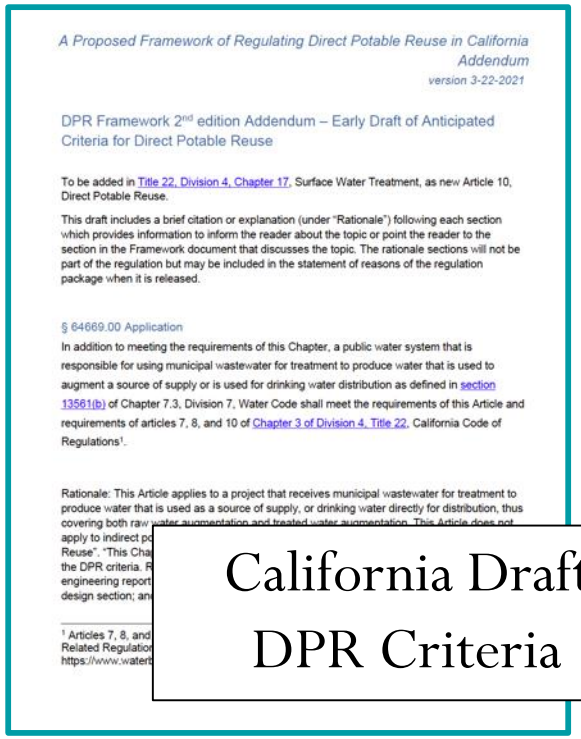


Pathogen Research



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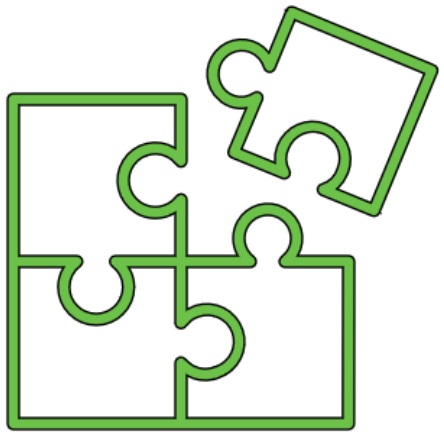

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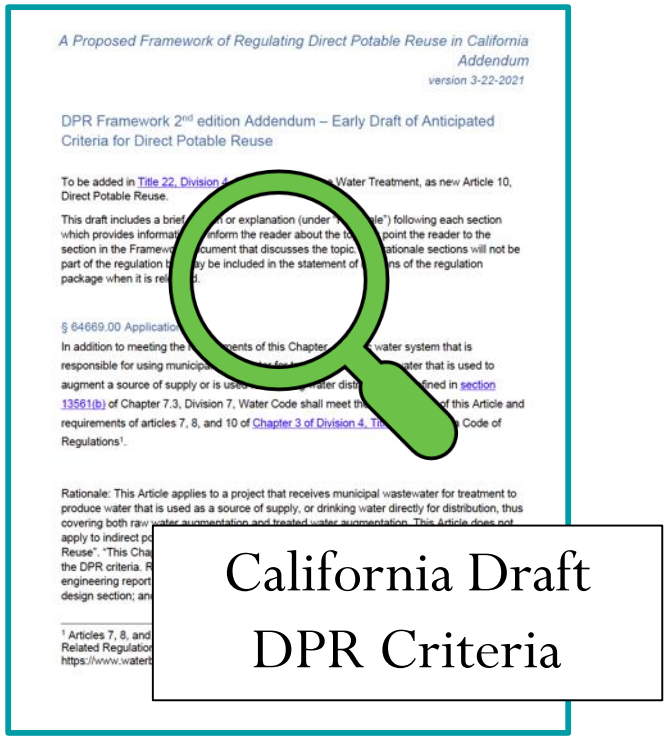

California Draft DPR Criteria

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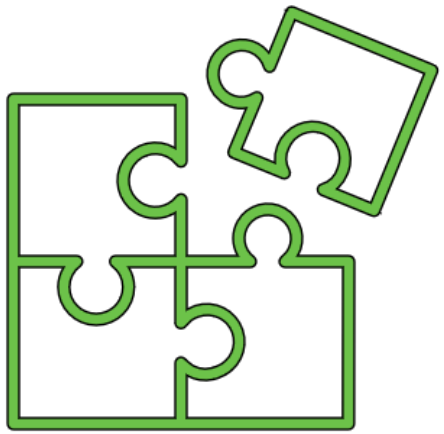

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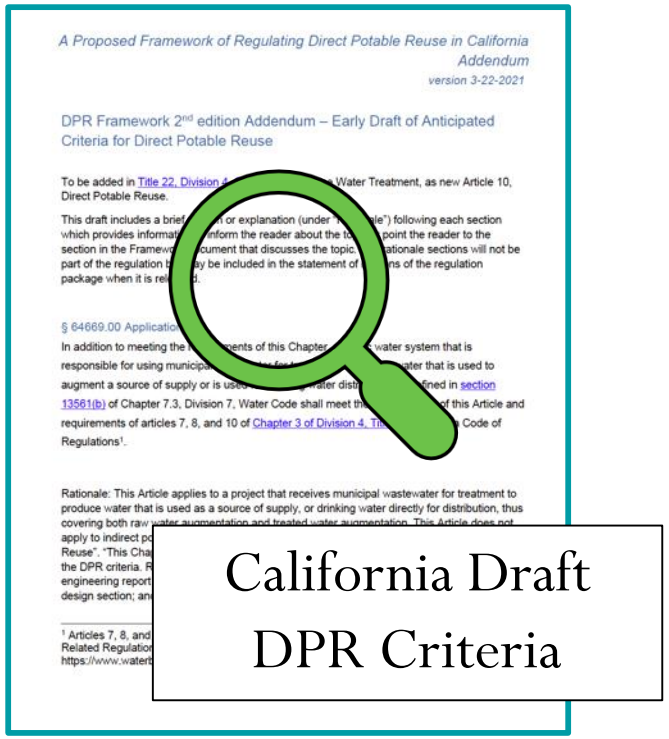

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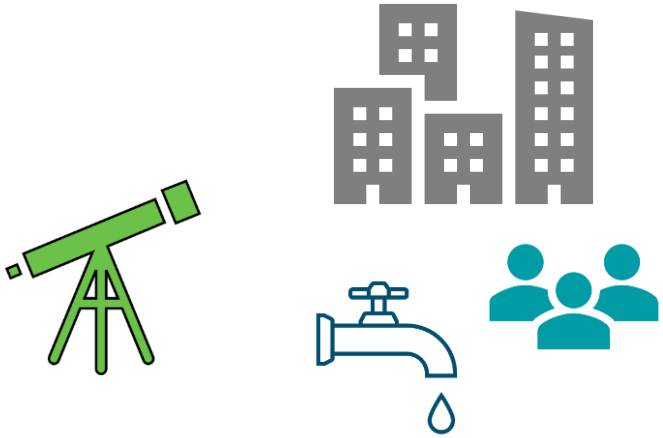


ASSESS DPR PROJECTS OTHER REGULATIONS

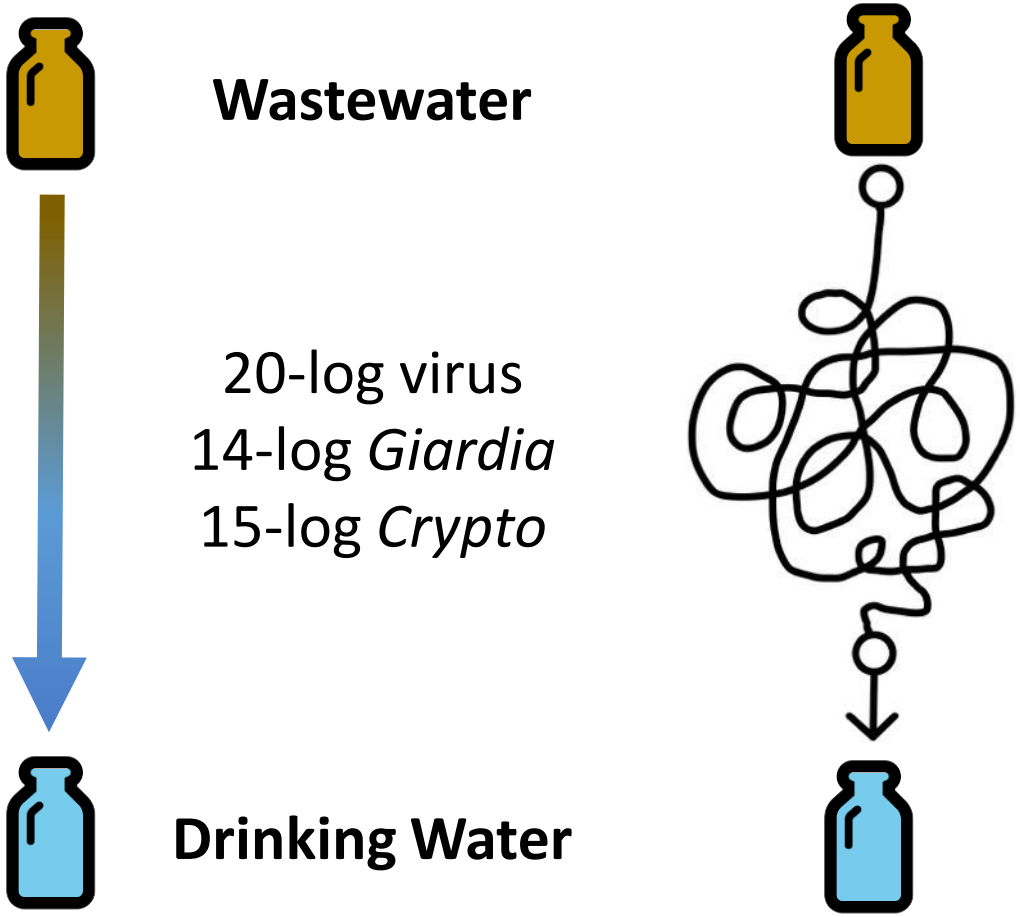
How Much Pathogen Treatment?

Wastewater

20-log virus
14-log *Giardia*
15-log *Crypto*

Drinking Water

How Much Pathogen Treatment?



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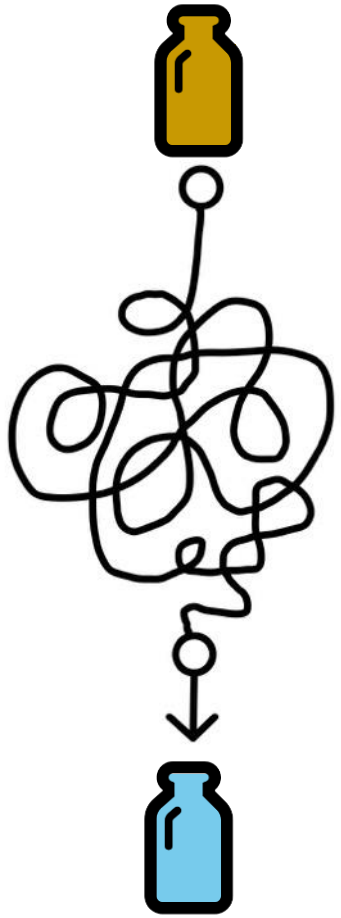
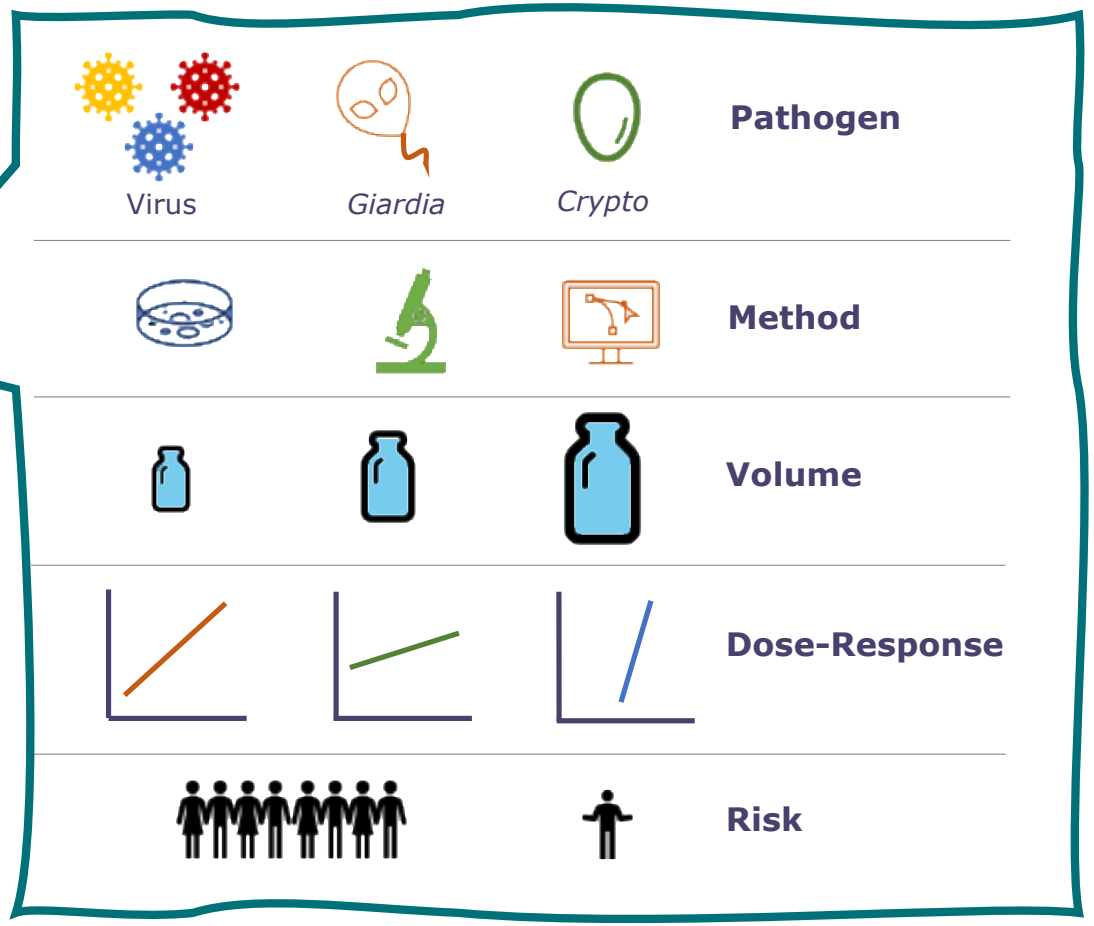
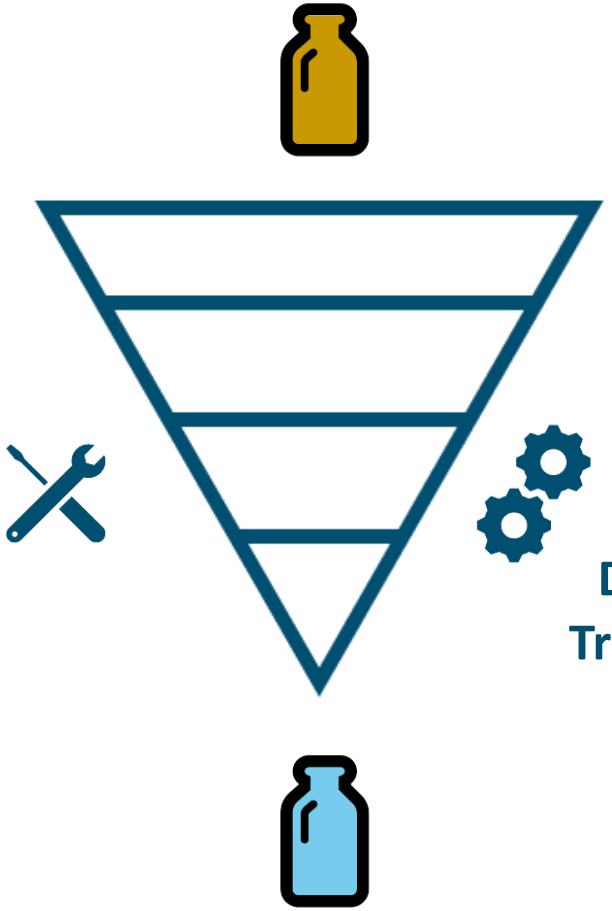




How Much Pathogen Treatment?

DPR-1: Pathogen Treatment and Risk

How Much Pathogen Treatment?



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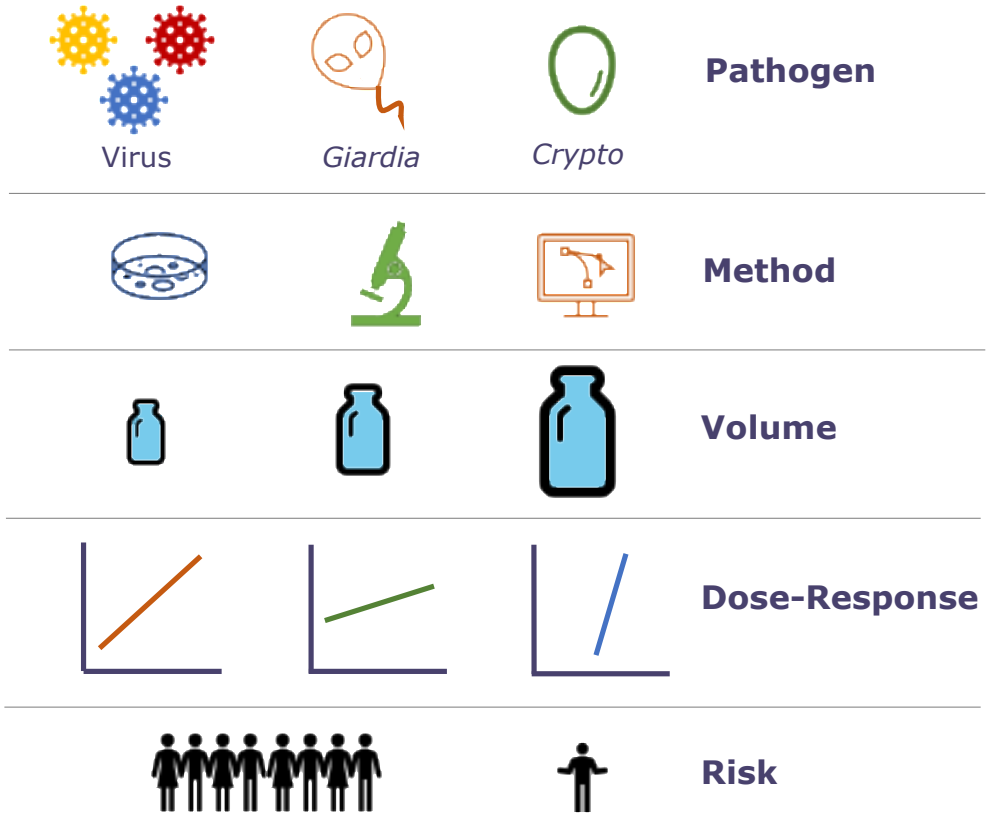
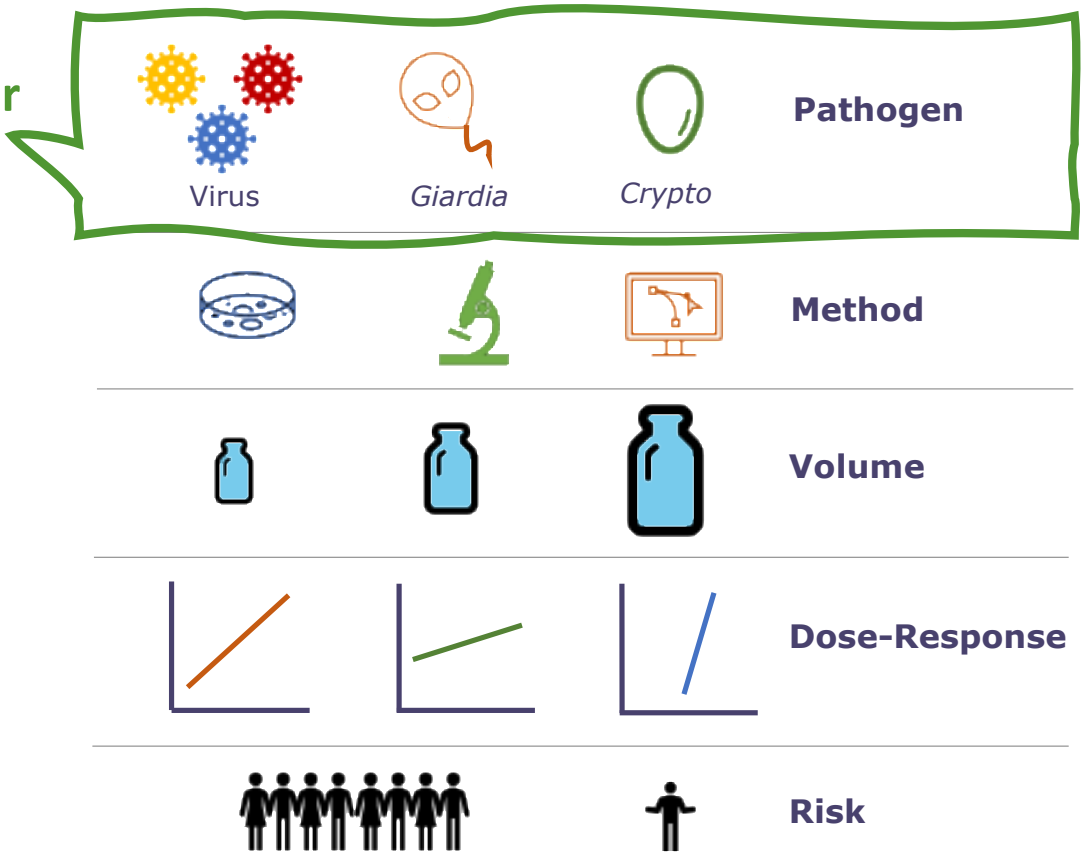


How Much Pathogen Treatment?

DPR-1: Pathogen Treatment and Risk

DPR-2: Raw Wastewater Pathogen Monitoring

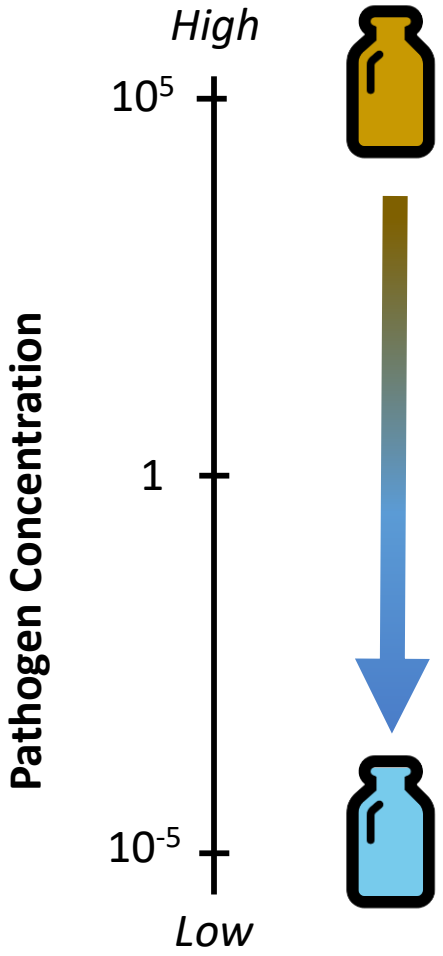


Raw Wastewater Pathogen Monitoring (DPR-2)

Brian Pecson, Ph.D., P.E., Trussell Technologies

Emily Darby, P.E., Trussell Technologies

Motivation for Research



- Wastewater pathogen concentrations are key inputs
- Industry does not have sufficient high-quality data
- SOPs needed to address previous limitations

DPR-2 Technical Work Group

George Di Giovanni
Metropolitan Water District

Menu Leddy
Essential Environmental & Engineering Systems

Kara Nelson
UC, Berkeley

Brian Pecson
Trussell Technologies

Channah Rock
University of Arizona

Theresa Slifko (chair)
Metropolitan Water District

Additional Staff:

Emily Darby
Trussell Technologies

Adam Olivieri
WRF/State Board Coordination

DPR-2 Laboratories and QA/QC

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

Lead Lab

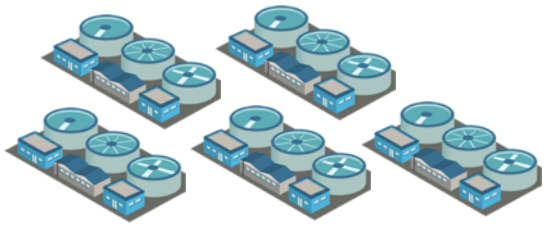
BIOLOGICAL CONSULTING SERVICES OF NORTH FLORIDA, INC.

Method Development Lab

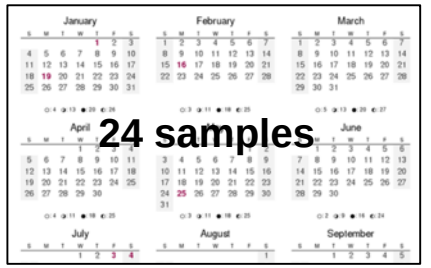
SCIENTIFIC METHODS

Walt Jakubowski
QA/QC Officer

Extensive new dataset from 14-month campaign



Five facilities



24 samples

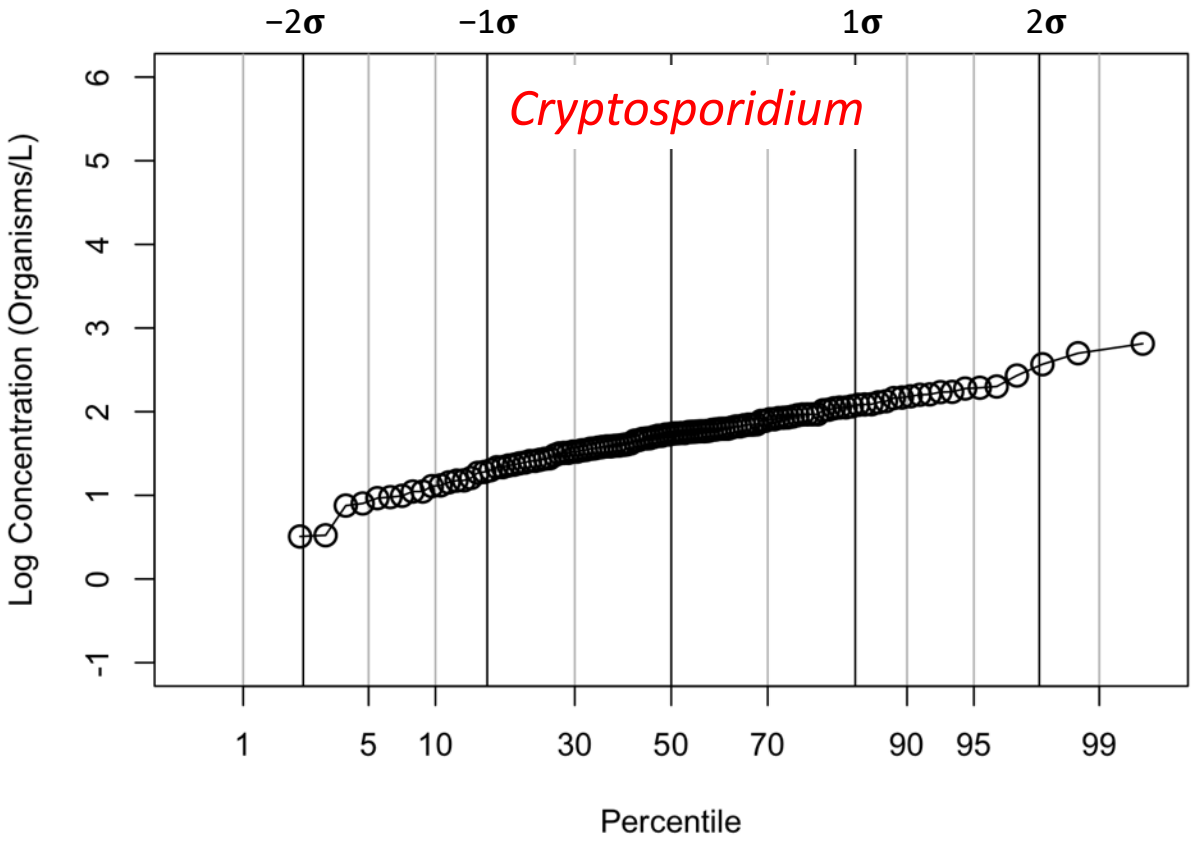
120 Samples of Pathogens & Indicators

- Enterovirus (culture)
- Enterovirus (PCR)
- Adenovirus (culture)
- Adenovirus (PCR)
- Norovirus (PCR)
- SARS-CoV-2 (PCR)

- *Giardia*

- *Crypto*

A Closer Look: Pathogen Distributions



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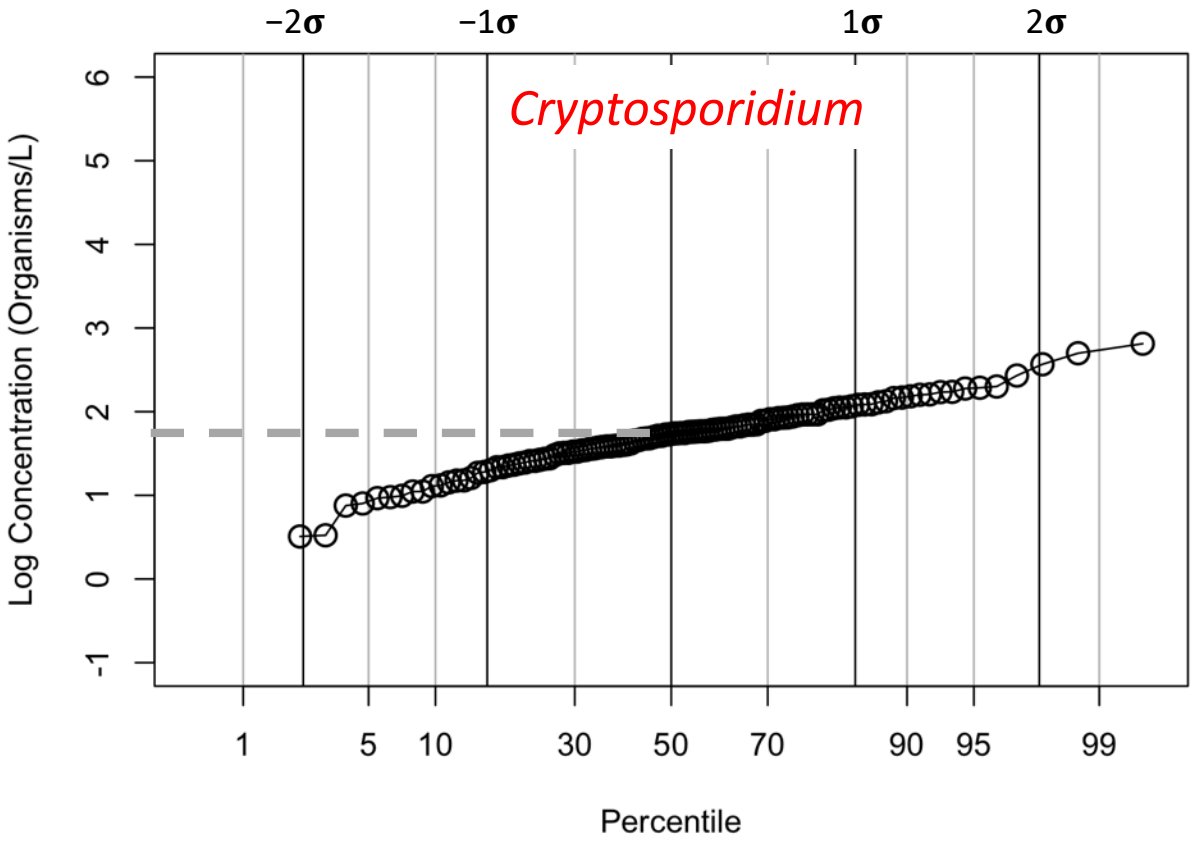
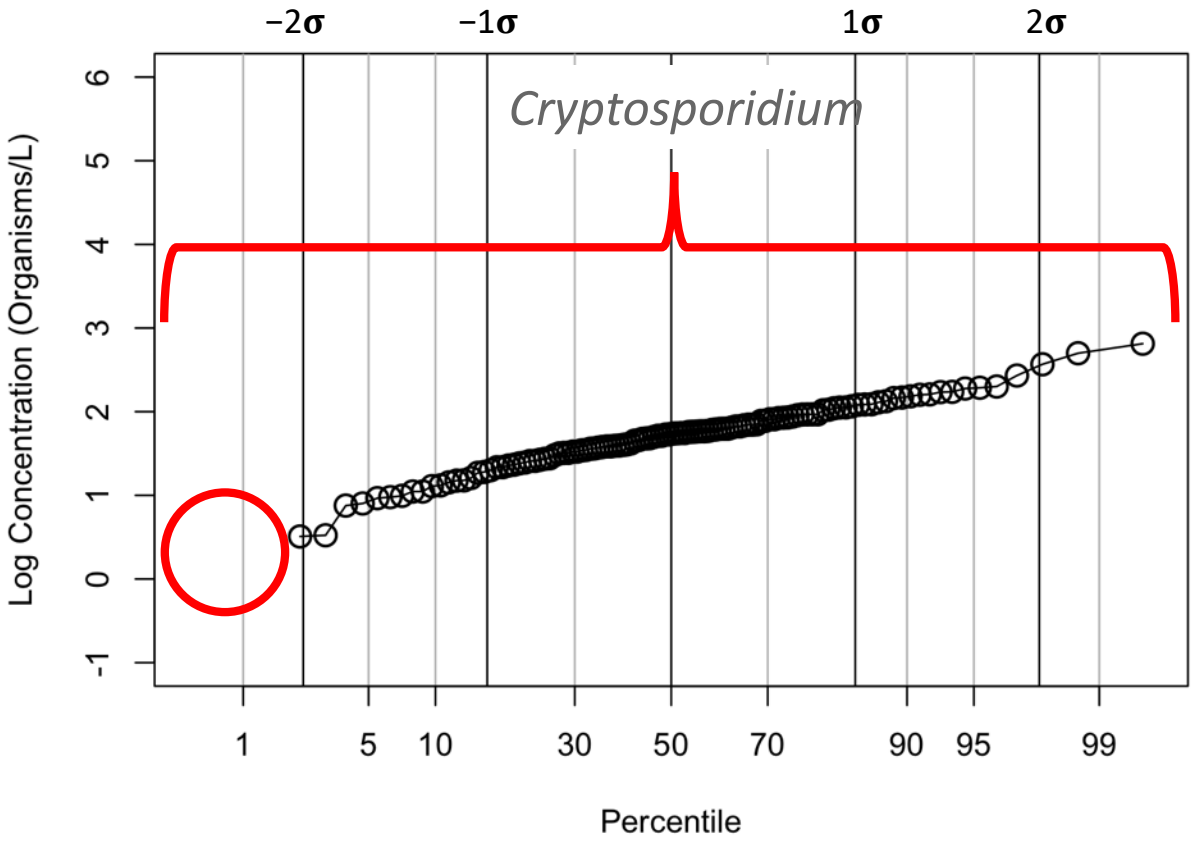


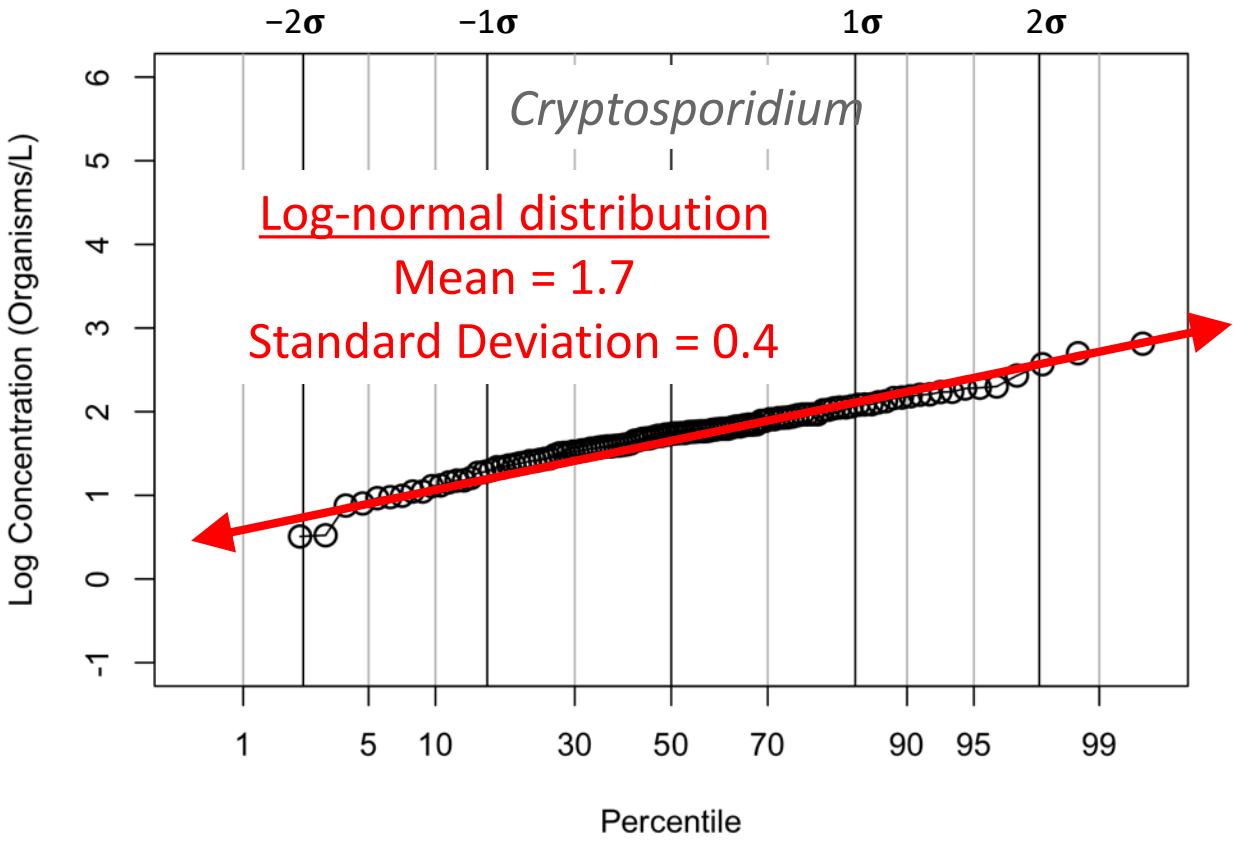
50^{th} percentile: $10^{1.7} = 50$
Expect half of your values to be < 50 oocysts/L

A Closer Look: Pathogen Distributions



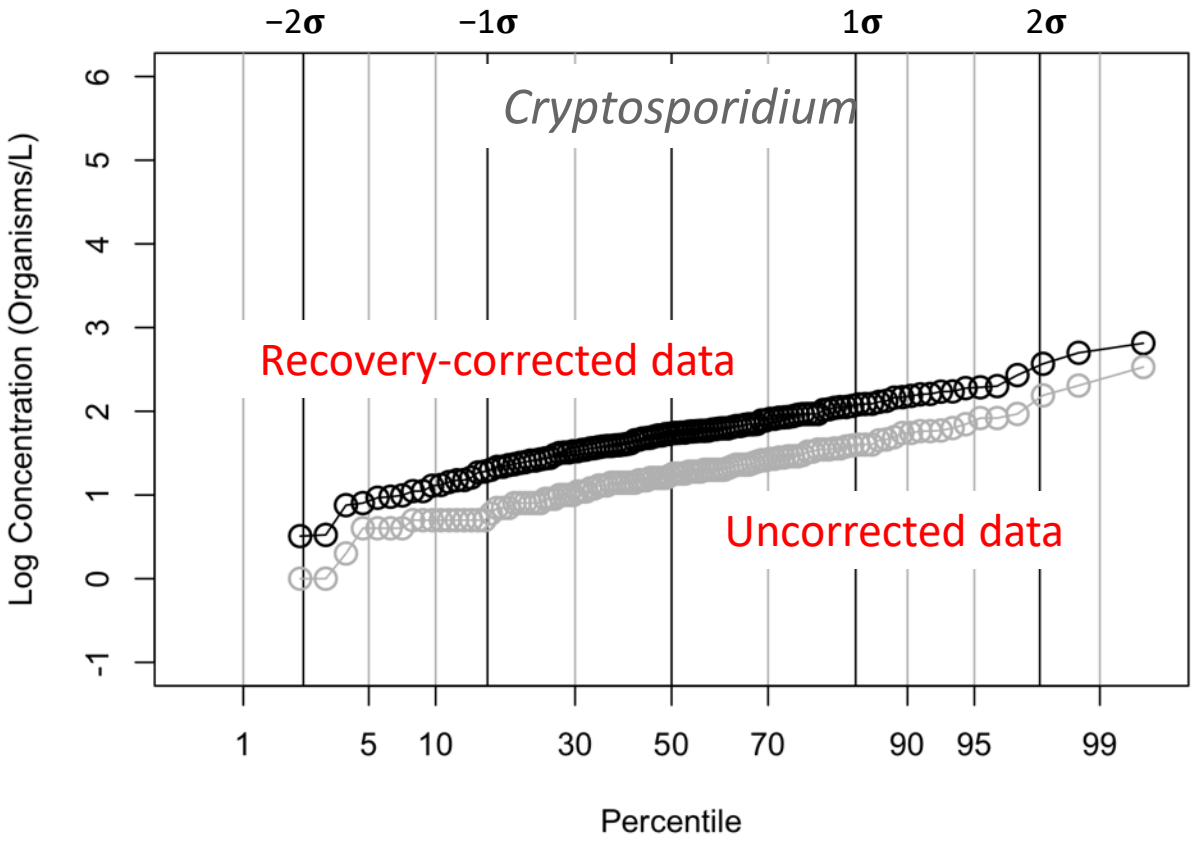
- High rate of <u>detects</u> across full range

A Closer Look: Pathogen Distributions



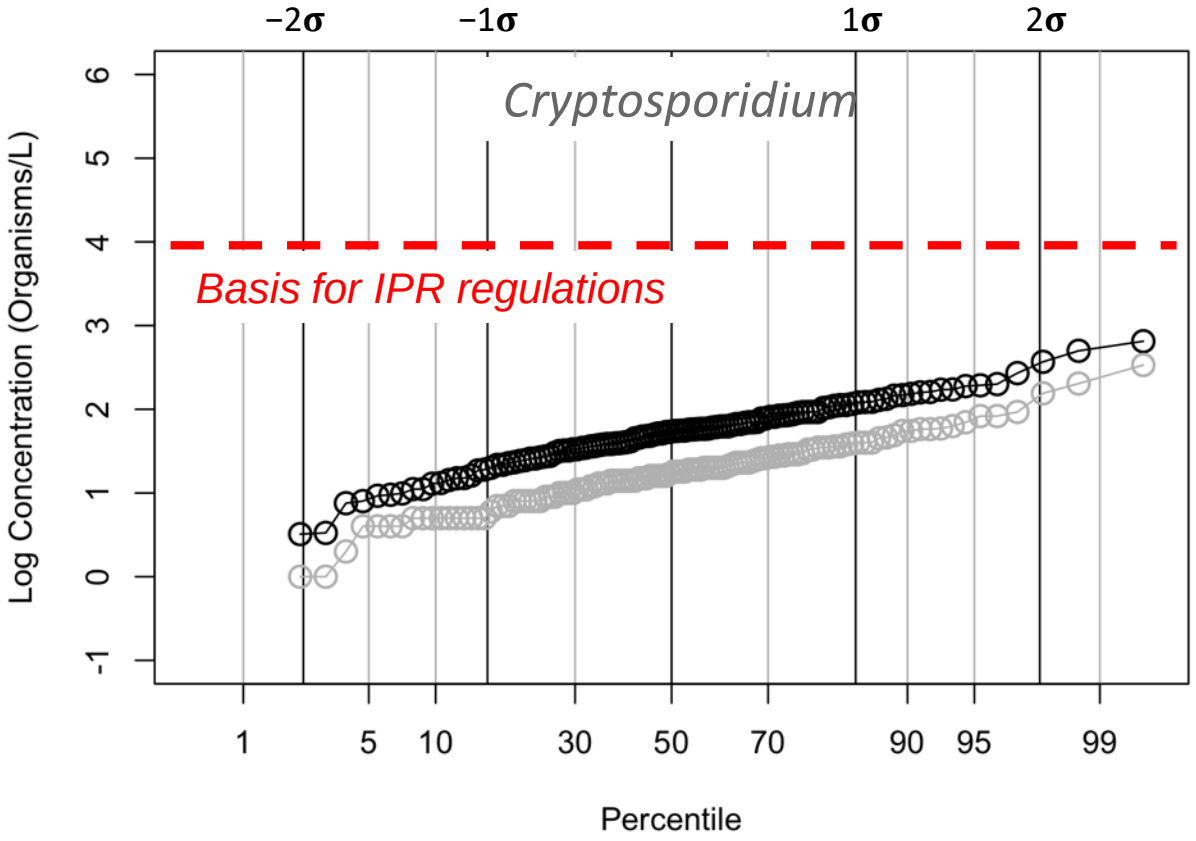
- High rate of <u>detects</u> across full range
- Distribution <u>models</u> used to estimate concentrations beyond measured range

A Closer Look: Pathogen Distributions



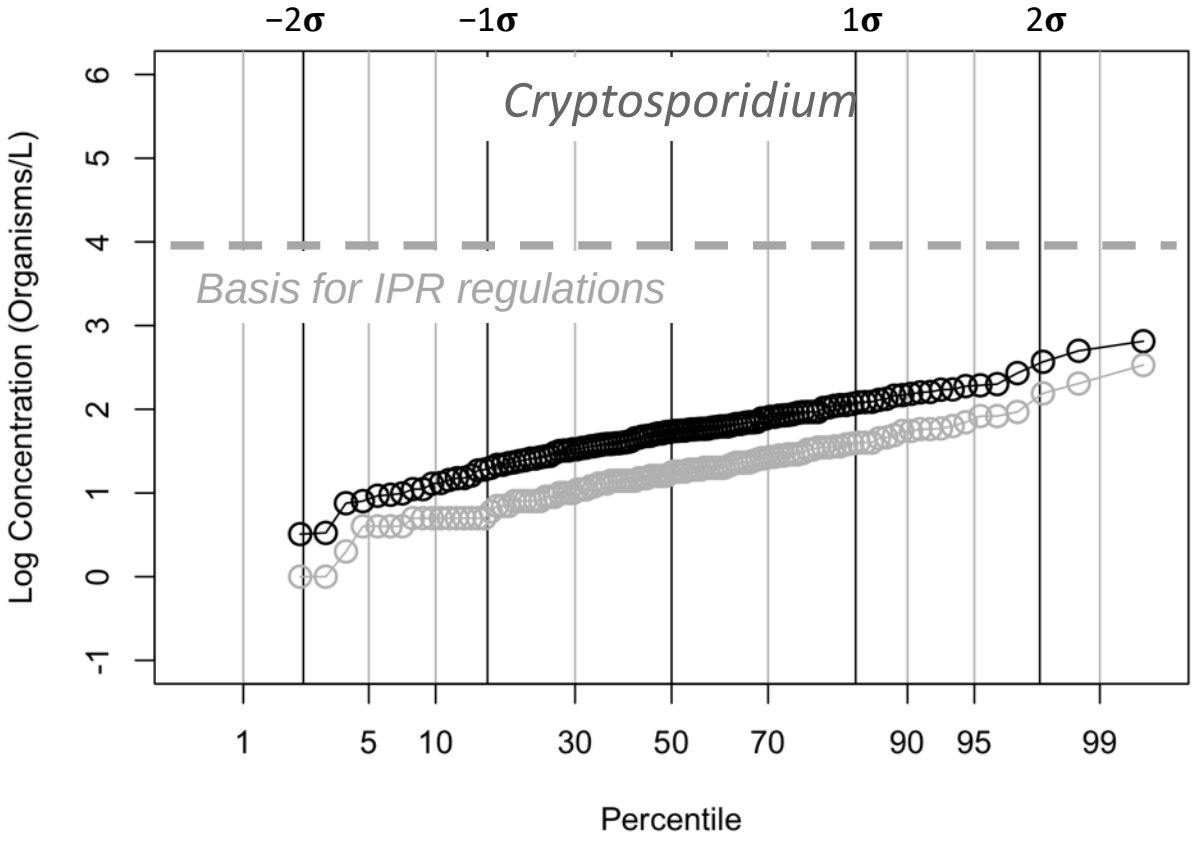
- High rate of <u>detects</u> across full range
- Distribution <u>models</u> used to estimate concentrations beyond measured range
- Values <u>corrected</u> to account for losses

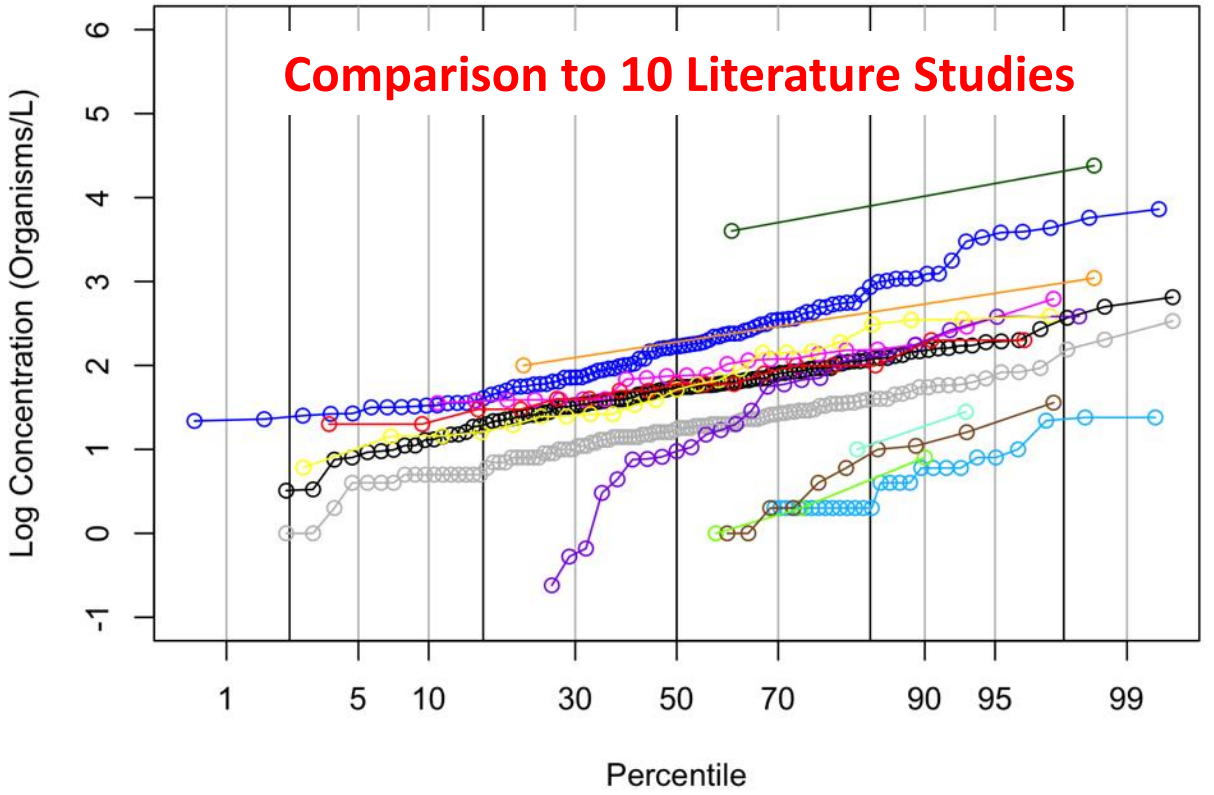
A Closer Look: Pathogen Distributions



- High rate of <u>detects</u> across full range
- Distribution <u>models</u> used to estimate concentrations beyond measured range
- Values <u>corrected</u> to account for losses
- Allows for <u>comparison</u> with IPR pathogen assumptions

A Closer Look: Pathogen Distributions

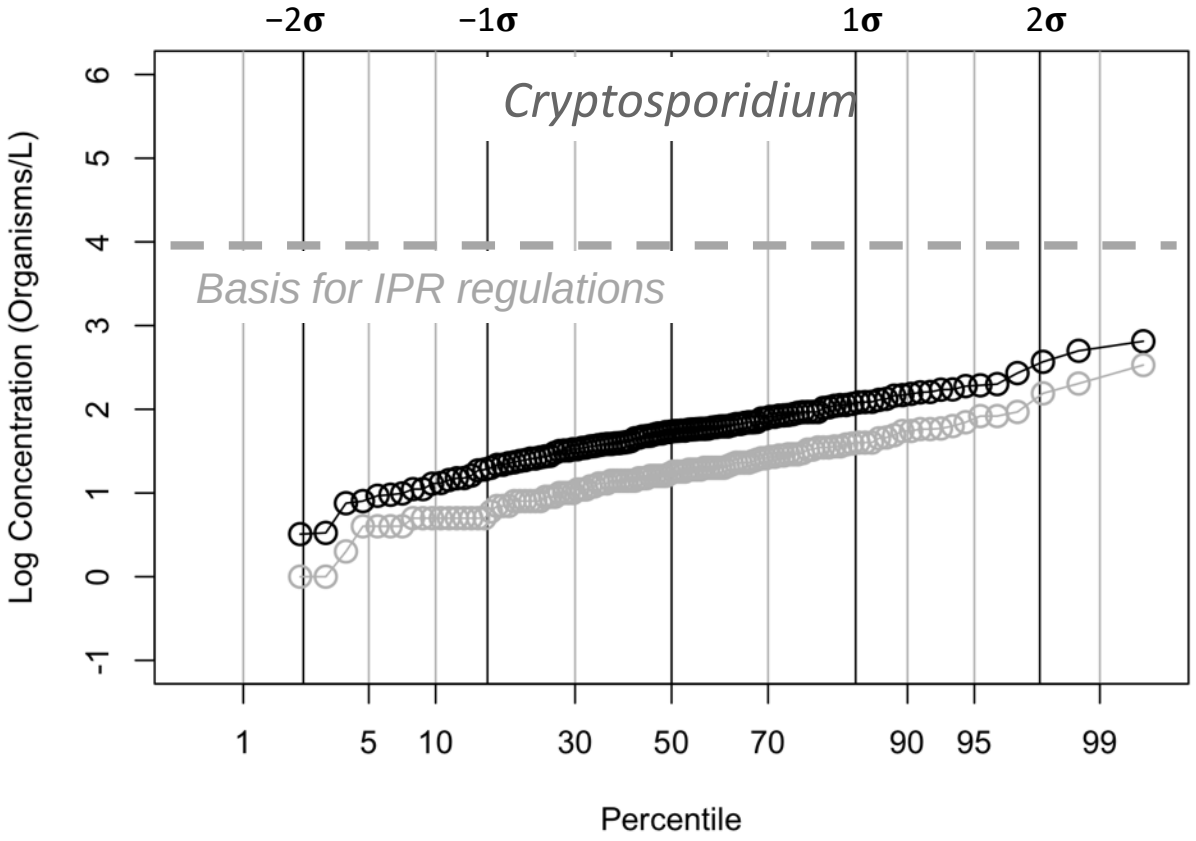


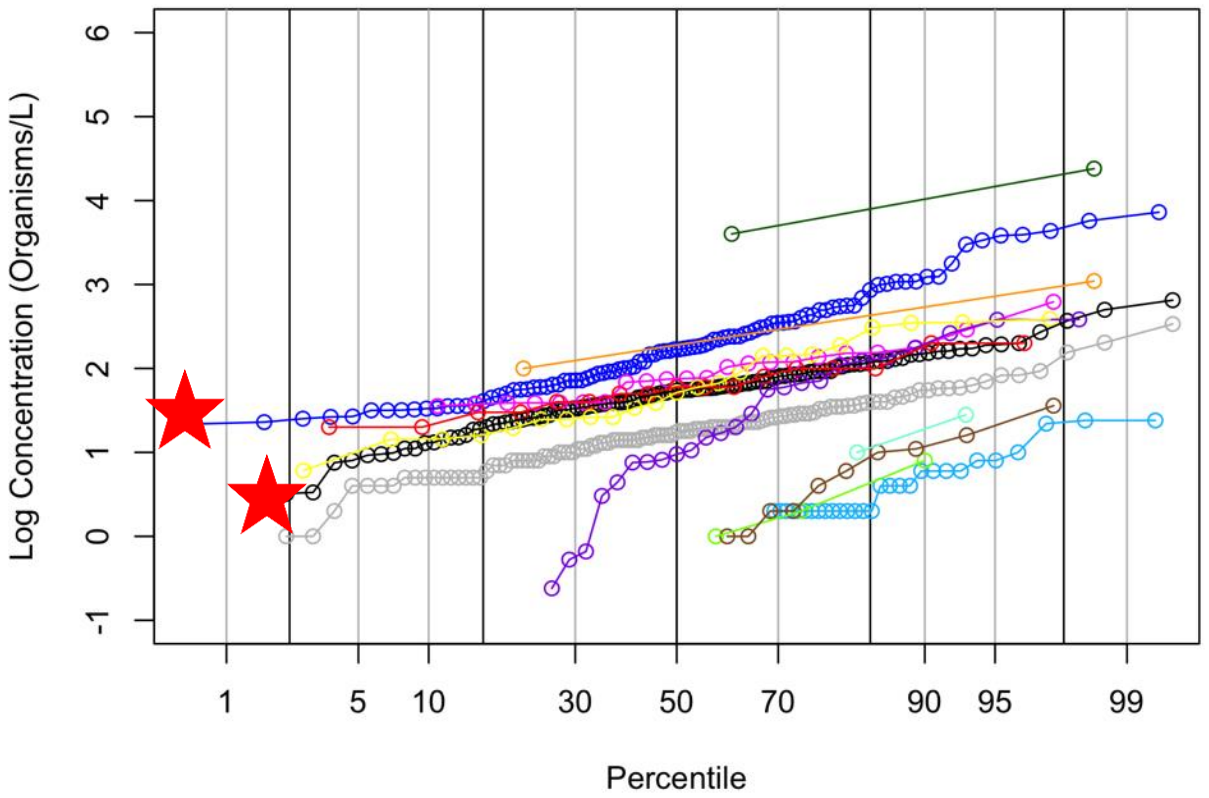


Legend

- This work - corrected data
- This work - raw data
- Tetra Tech & Melbourne Water 2011
- Gray et al. 2009
- Kitajima et al. 2014
- McCuin & Clancy 2005
- Rose et al. 2004
- Robertson et al. 2006 (50 µL samples)
- Robertson et al. 2006 (2 mL samples)
- Monterey 2013
- Oceanside 2015
- San Diego 2016
- San Diego 2019

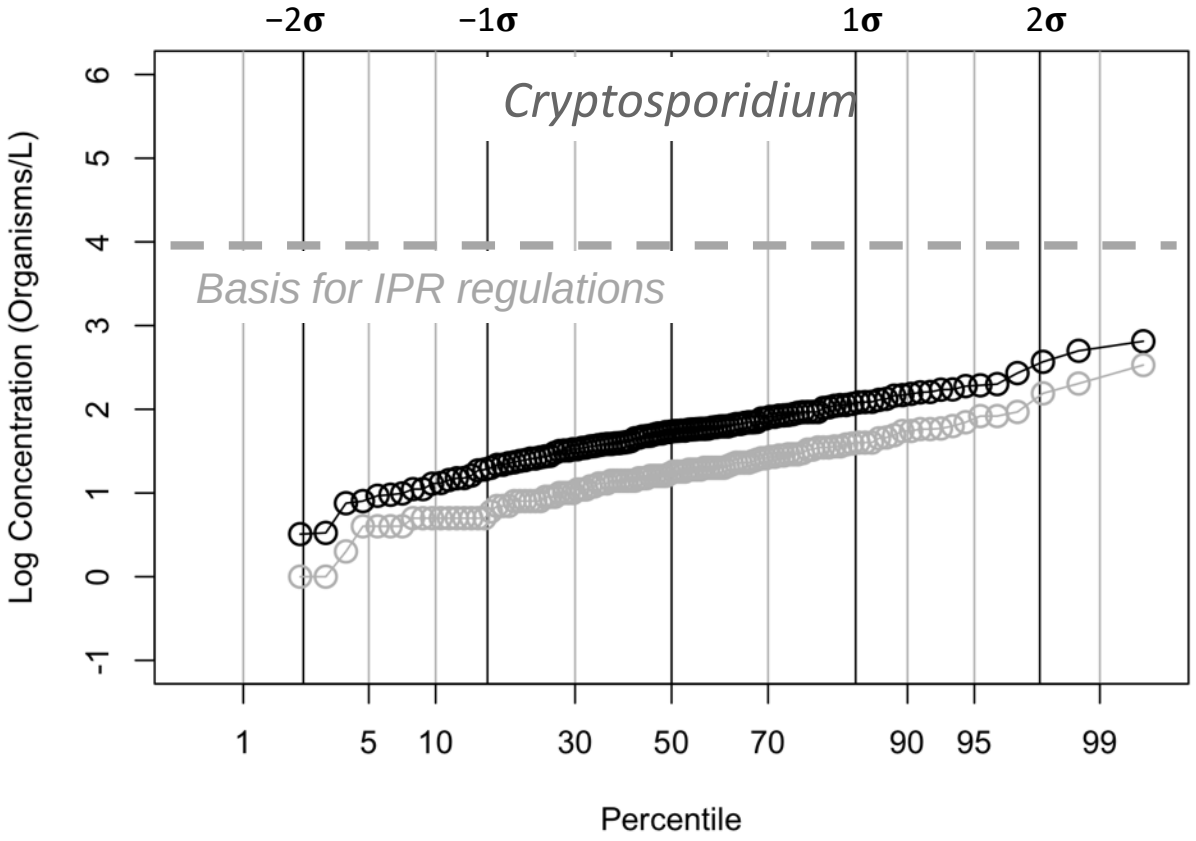
A Closer Look: Pathogen Distributions

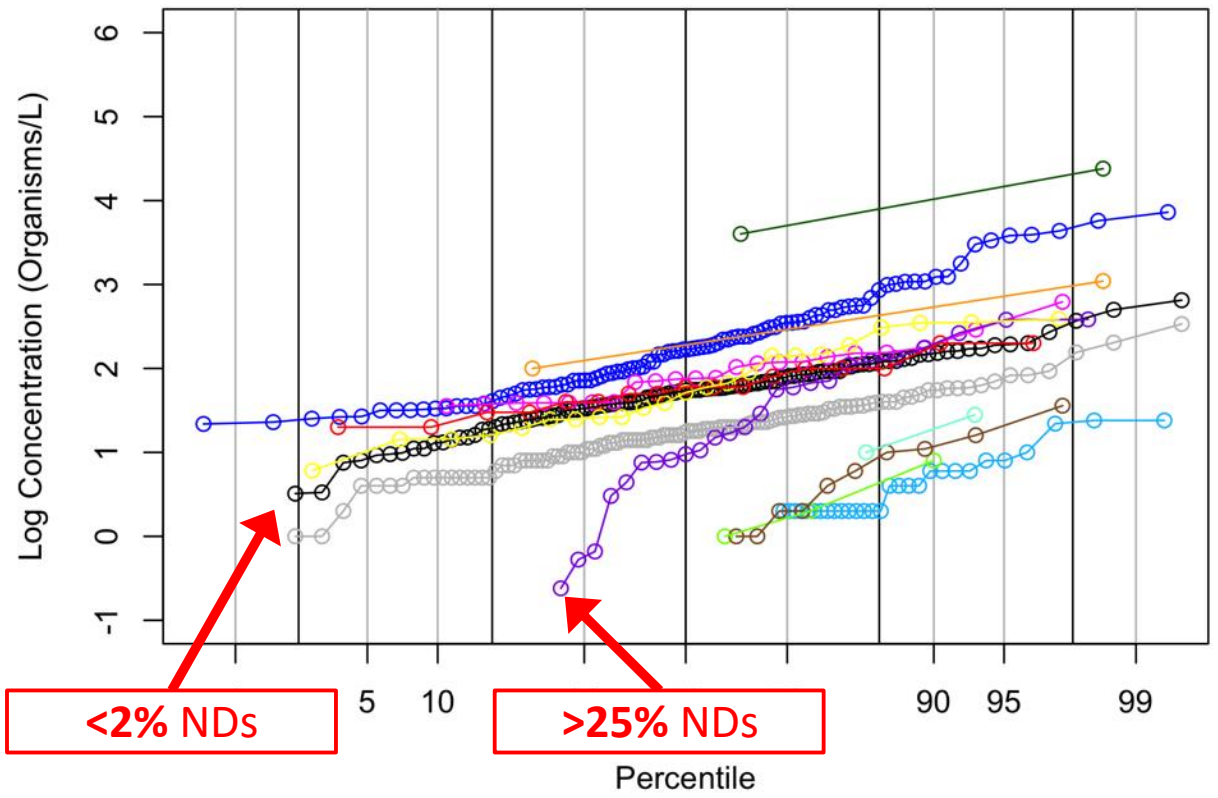




- Only two studies correct for recovery

A Closer Look: Pathogen Distributions

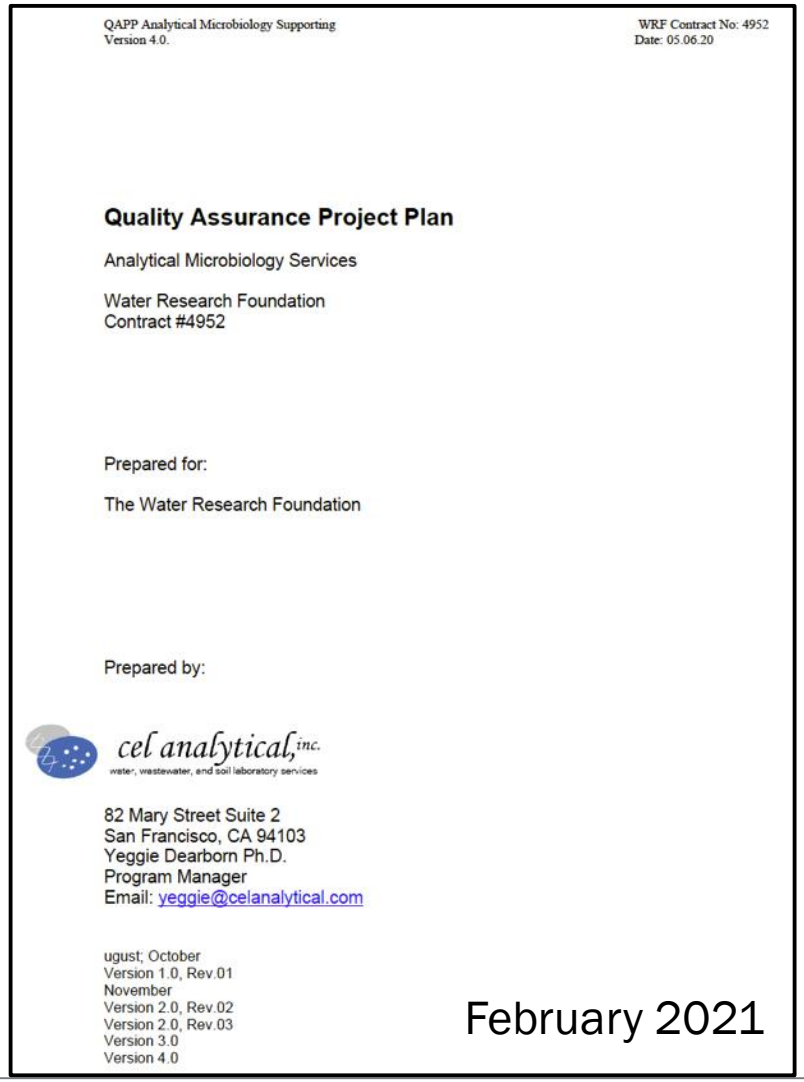




- Only two studies correct for recovery
- DPR-2 among highest rate of detects

Quality Assurance Project Plan sets bar for quality

- SOPs optimized to minimize non-detects
  - 94% detection rate for all culture and microscopy assays
- Extensive QA/QC requirements
  - Matrix spikes provide ability to correct for recovery
- Effective in wastewater from 5 different facilities
- Reproducible across 3 different labs



QAPP Analytical Microbiology Supporting
Version 4.0.

WRF Contract No: 4952
Date: 05.06.20

Quality Assurance Project Plan

Analytical Microbiology Services

Water Research Foundation
Contract #4952

Prepared for:

The Water Research Foundation

Prepared by:

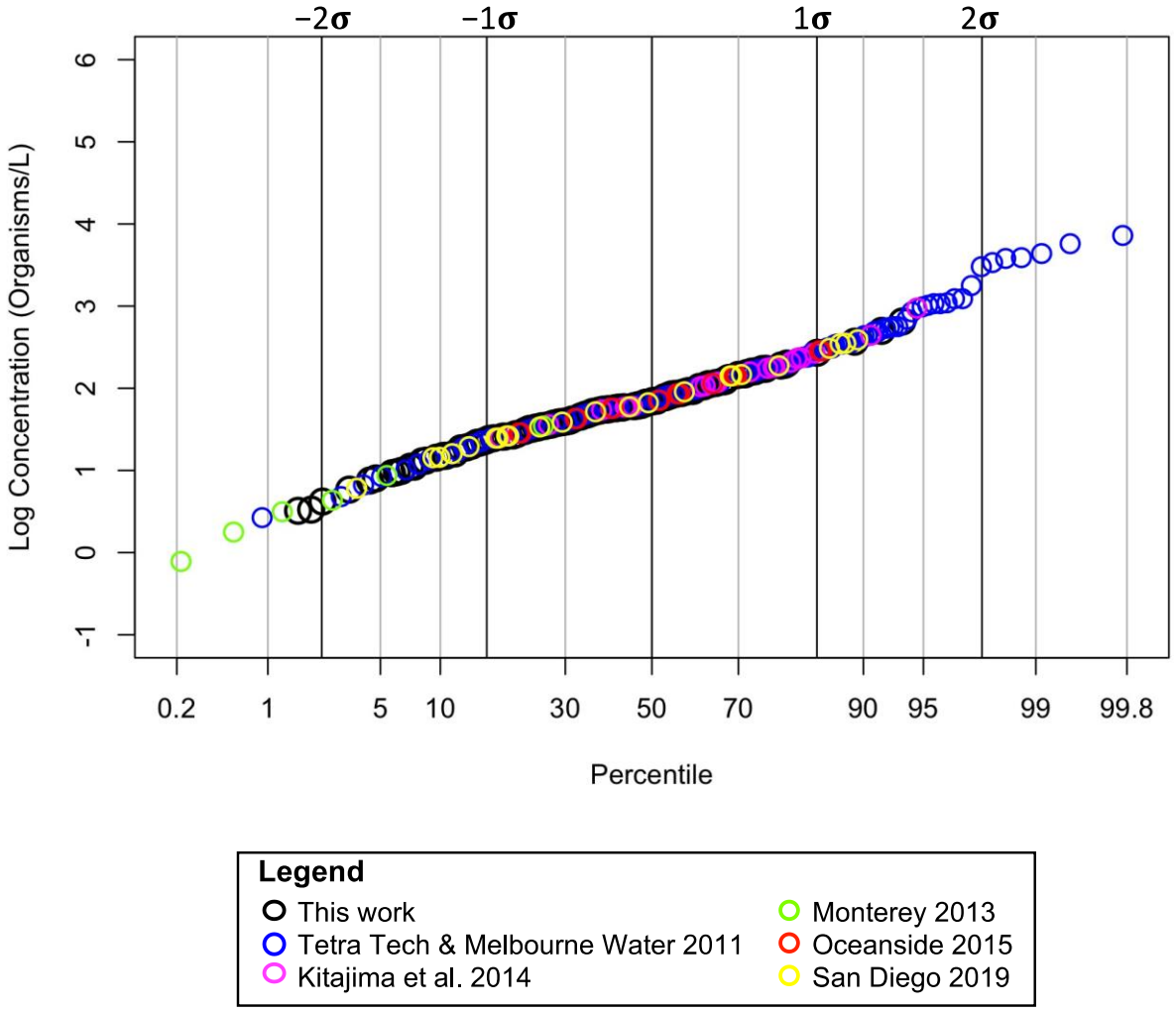
cel analytical, inc.
water, wastewater, and soil laboratory services

82 Mary Street Suite 2
San Francisco, CA 94103
Yeggie Dearborn Ph.D.
Program Manager
Email: yeggie@celanalytical.com

ugust; October
Version 1.0, Rev.01
November
Version 2.0, Rev.02
Version 2.0, Rev.03
Version 3.0
Version 4.0

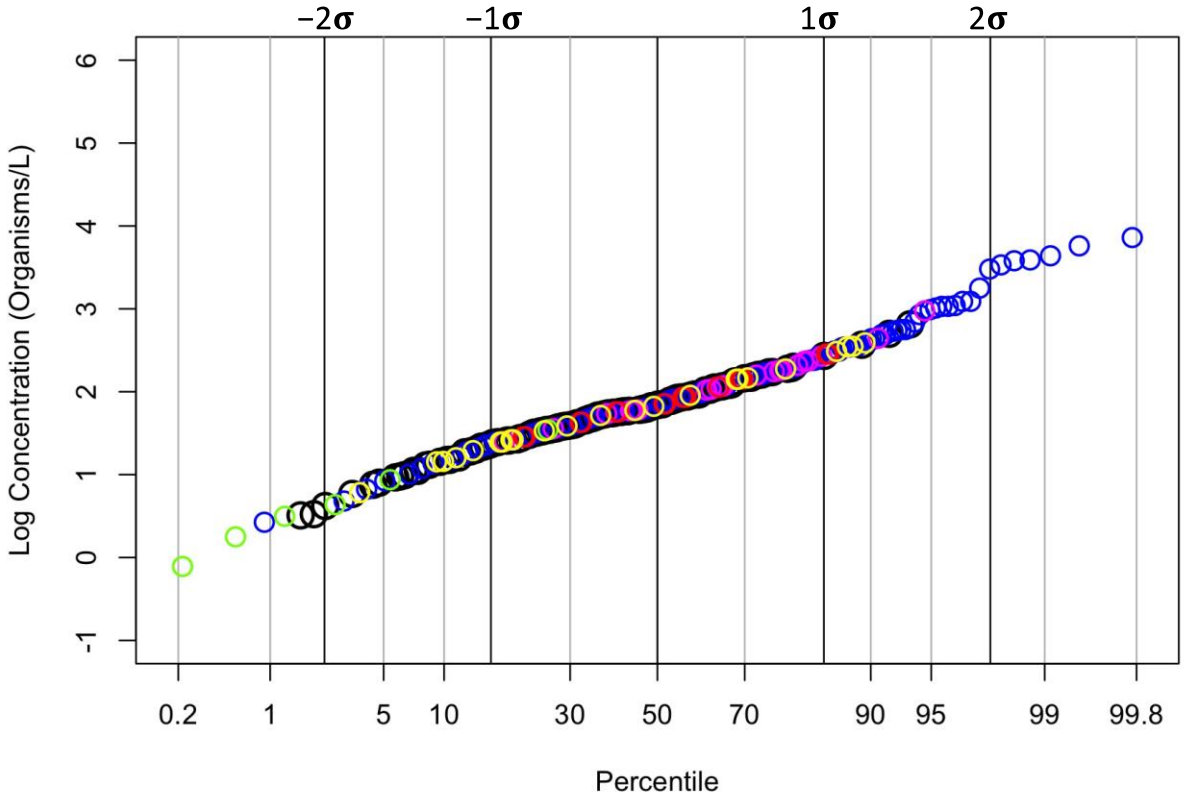
February 2021

Combining DPR-2 with other selected studies



- TWG selected studies meeting minimum quality criteria:
  - Recovery reported
  - Percent detectable (>50%)
- Aggregated all recovery-corrected values into single distribution

Combining DPR-2 with other selected studies



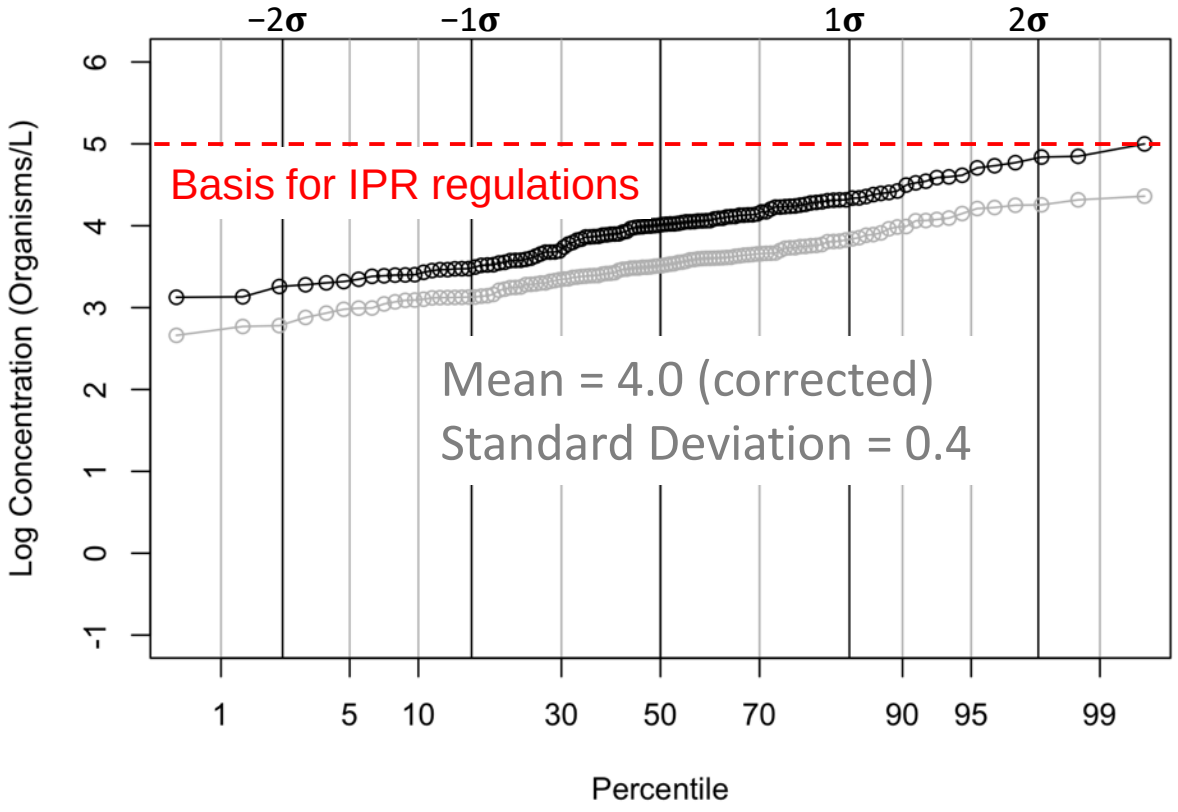
Legend

- This work
- Tetra Tech & Melbourne Water 2011
- Kitajima et al. 2014
- Monterey 2013
- Oceanside 2015
- San Diego 2019

- TWG selected studies meeting minimum quality criteria:
  - Recovery reported
  - Percent detectable (>50%)
- Aggregated all recovery-corrected values into single distribution
- Combined distribution very similar to DPR-2 alone

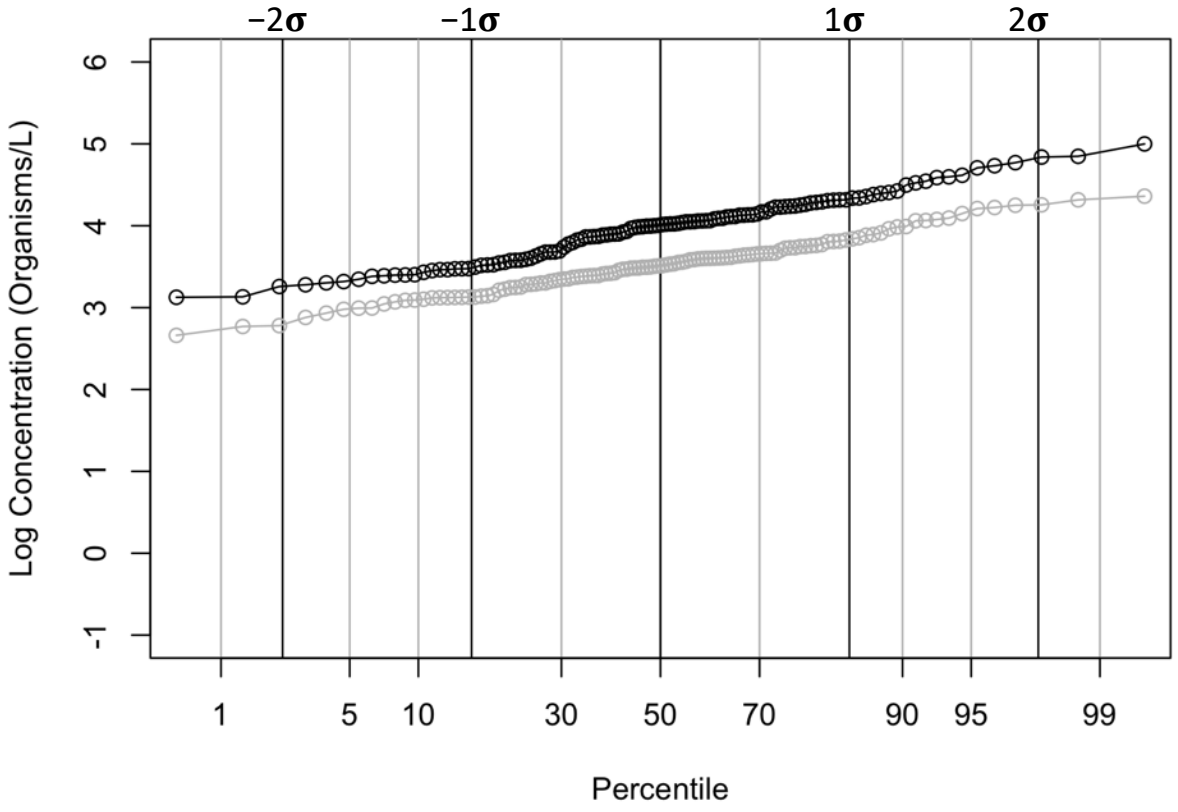
	Mean	St. Dev.
DPR-2 Alone	1.7	0.4
Aggregated Data	1.9	0.6

Pathogen Distributions: *Giardia*

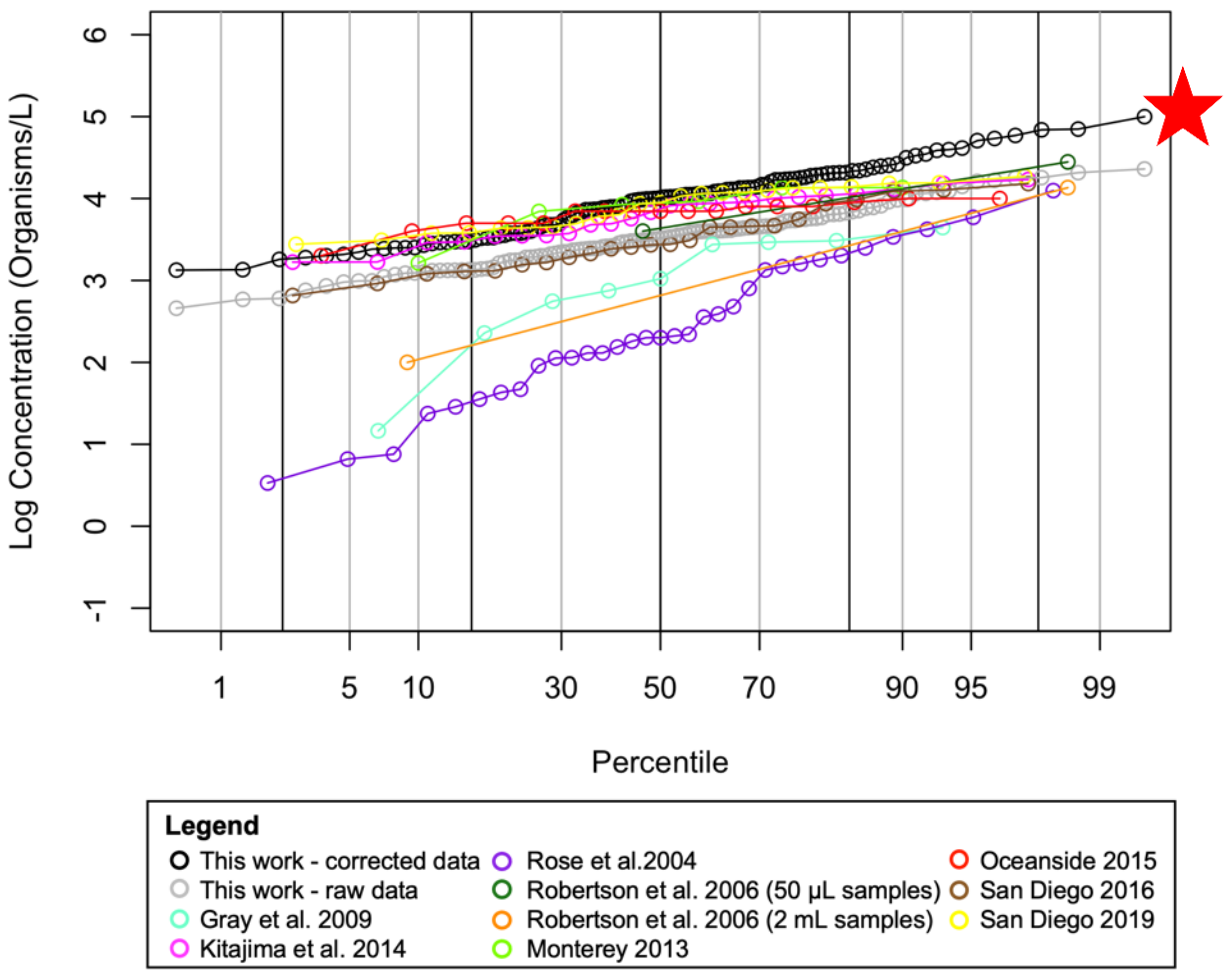


- Reached 10^5 cyst/L at 99th percentile

Pathogen Distributions: *Giardia*

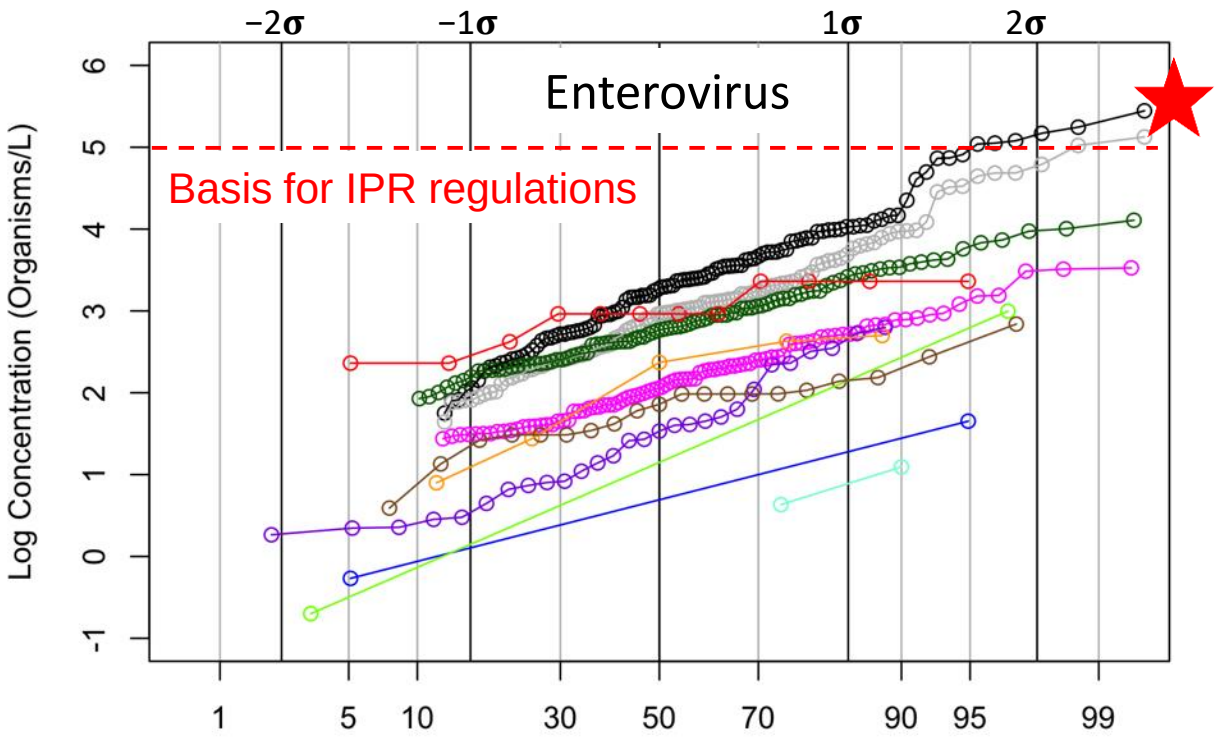


One of the highest distributions in the literature

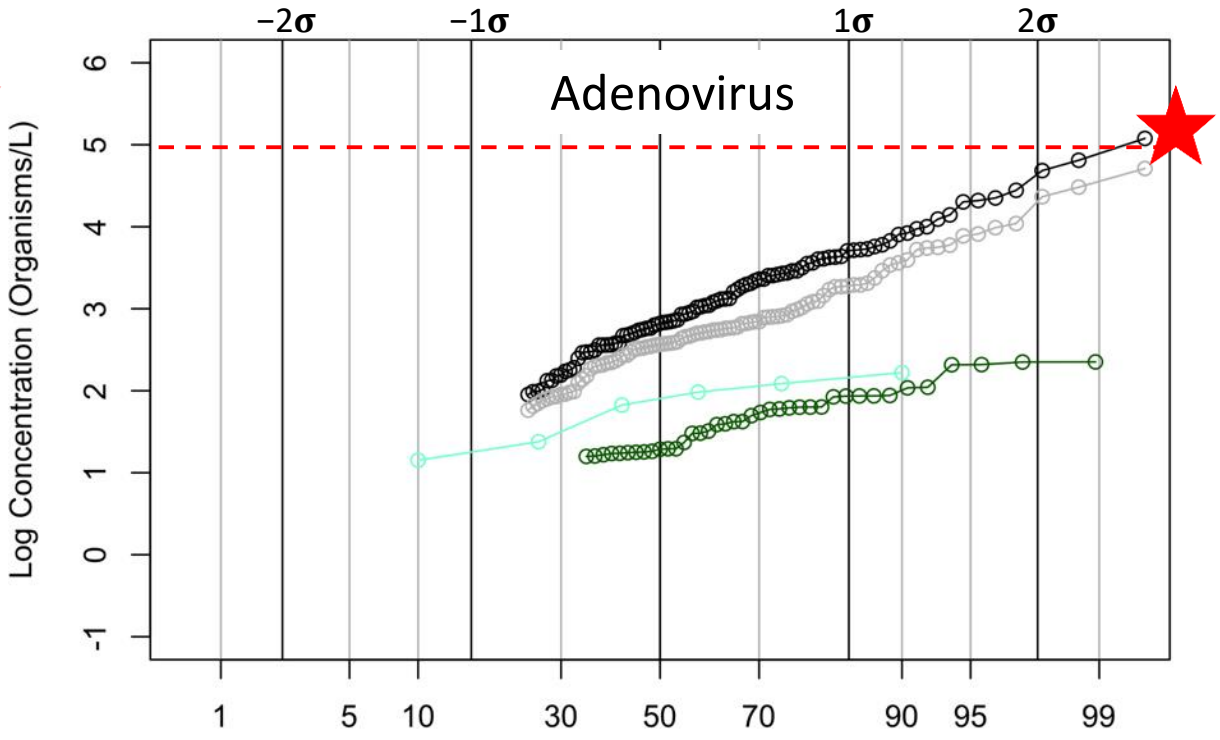


Pathogen Distributions: Virus Culture

- Reached 10^5 MPN/L at 95th (Enterovirus) and 99th percentile (Adenovirus)
- Concentrations higher than past studies



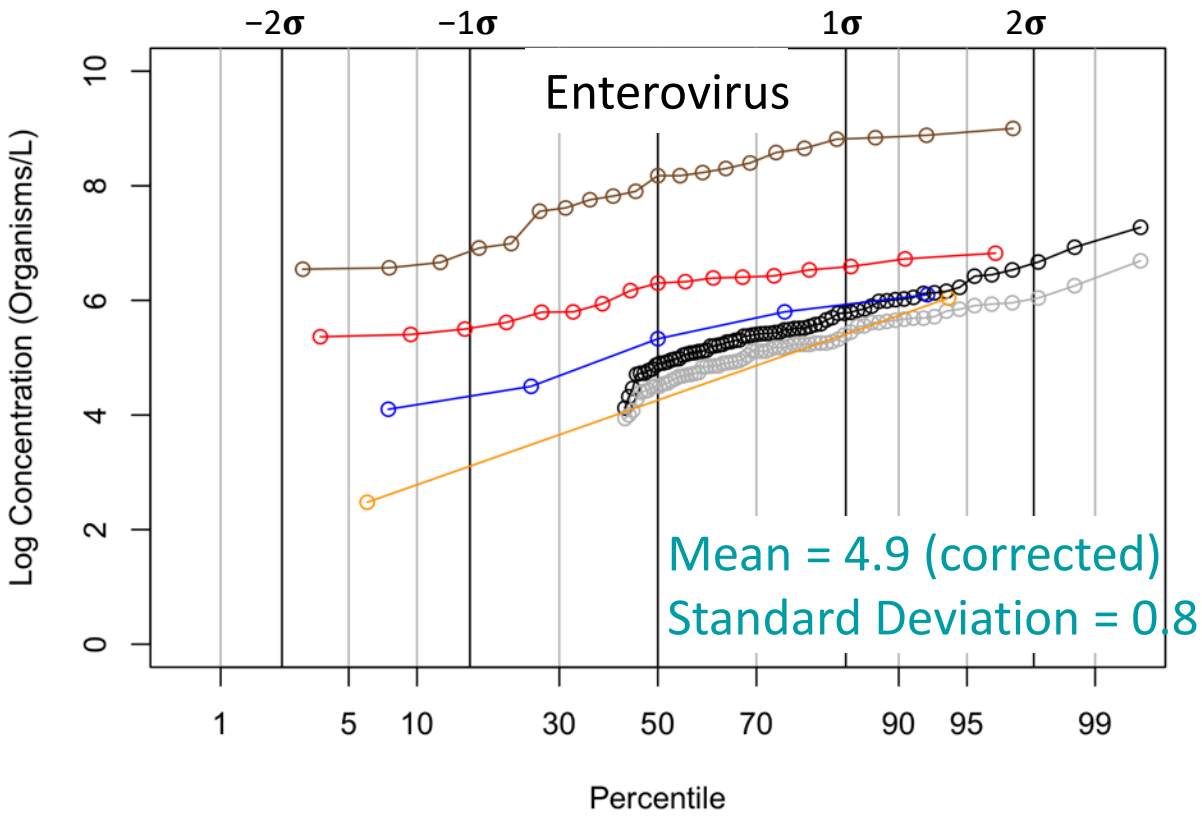
Mean = 3.2 (corrected)
SD = 1.0

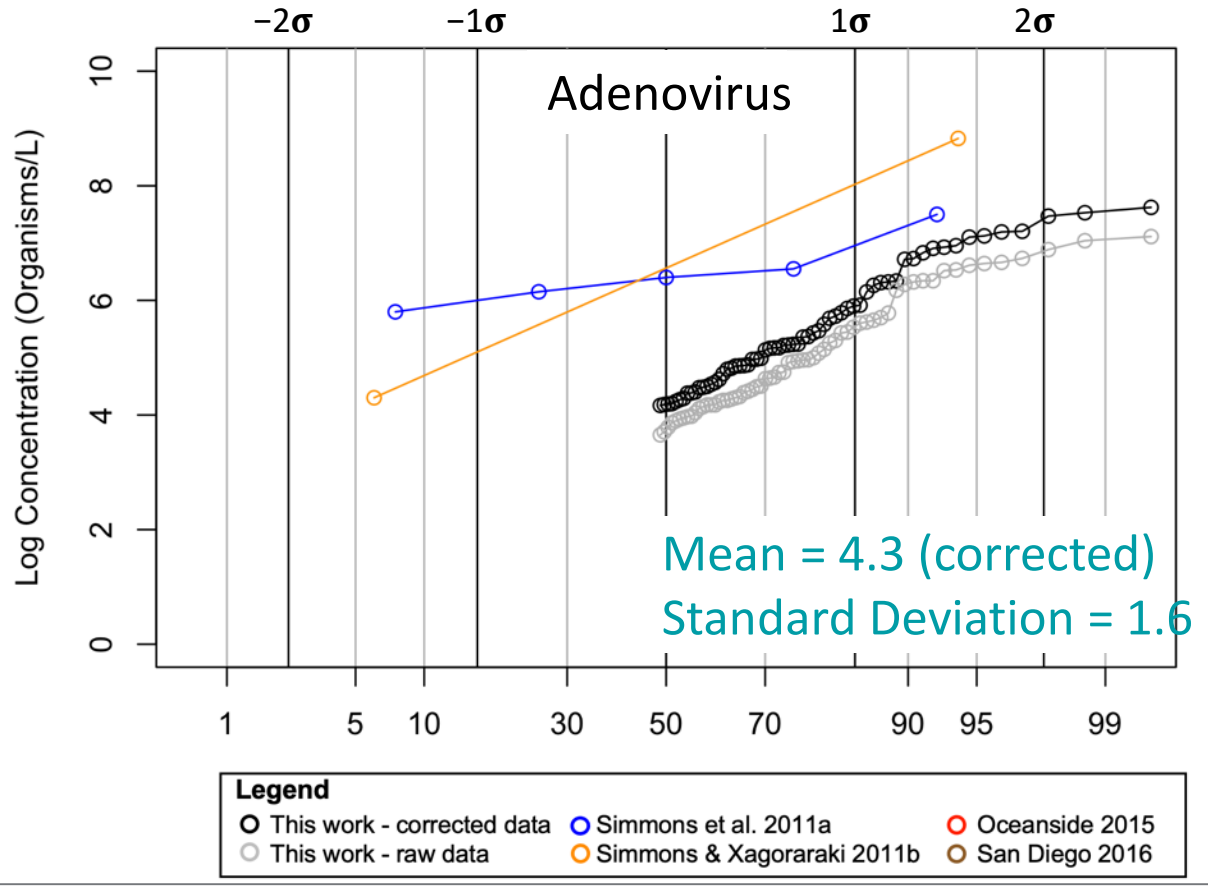


Mean = 2.8 (corrected)
SD = 1.0

Pathogen Distributions: Virus Molecular

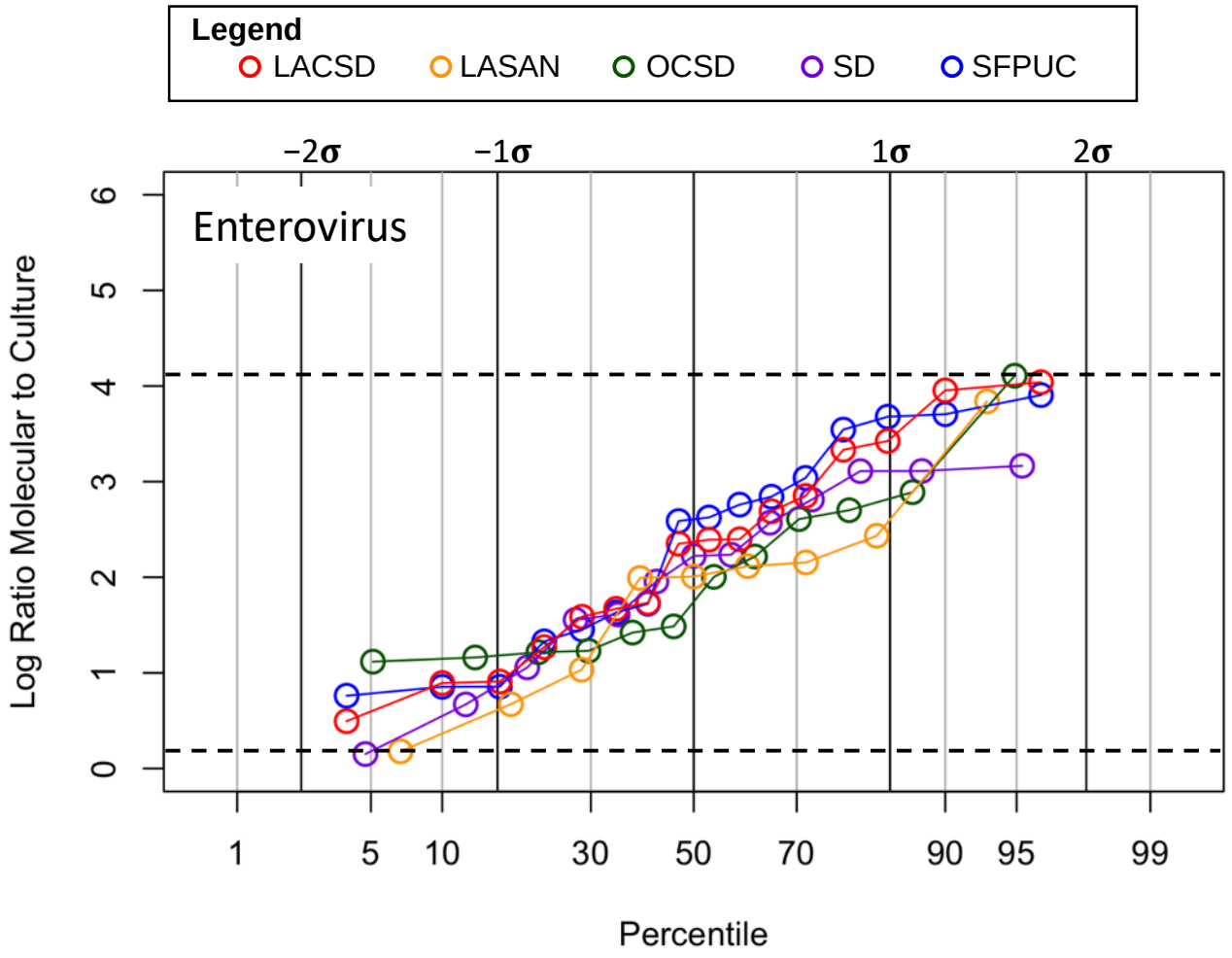
- Lower detection rate than culture due to higher LOQ
- Concentrations **lower** than past studies





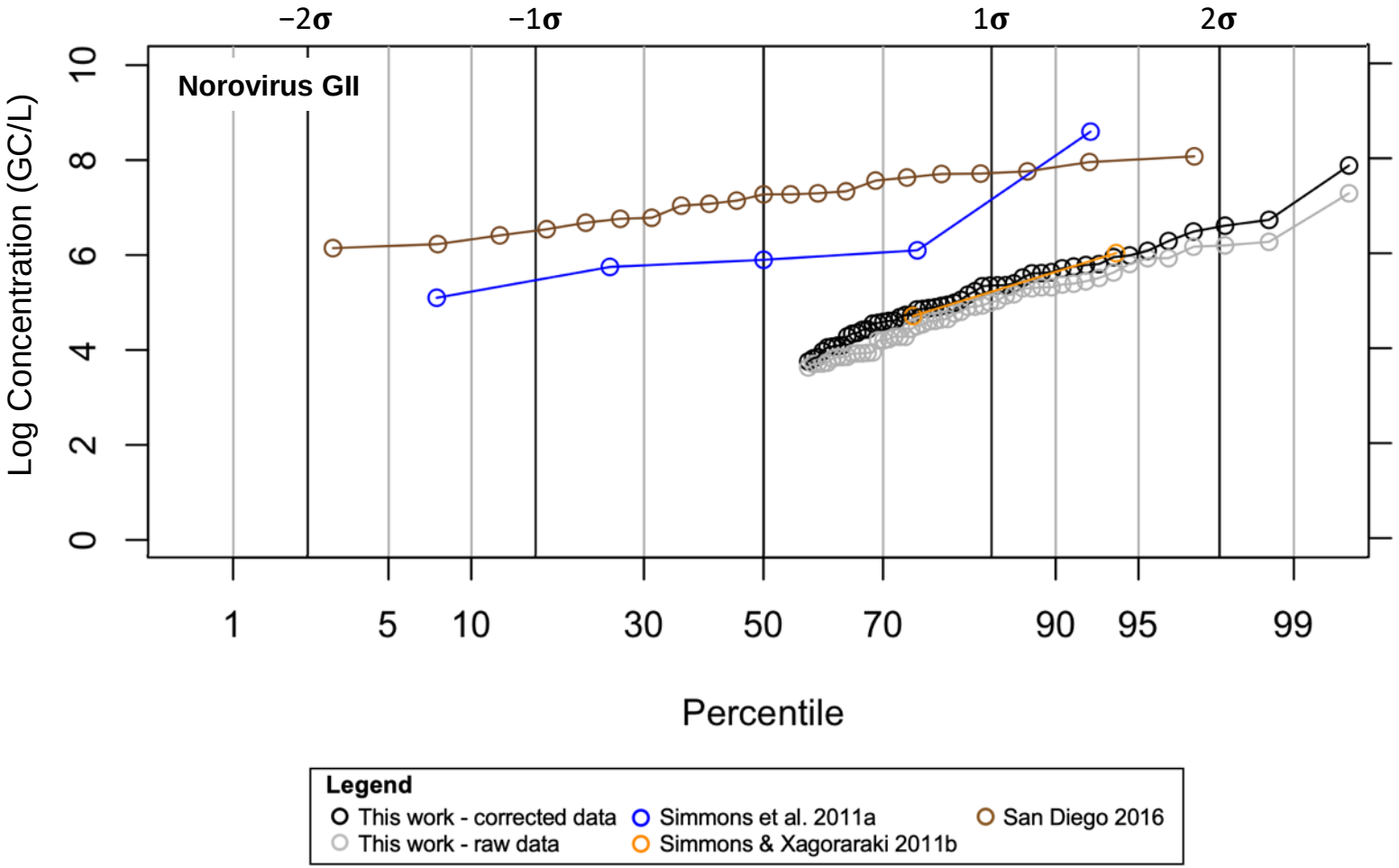
Culture vs. Molecular: What to use?

- Genome copies (GC) are not necessarily associated with *infective* virus
- Difficult to translate between GC and infective virus
- DPR-2 virus data show ratios of GC:infectious virus spanning 4-5 orders of magnitude:
  - 10,000:1 to 1:1 (enterovirus)
  - 100,000:1 to 1:1 (adenovirus)



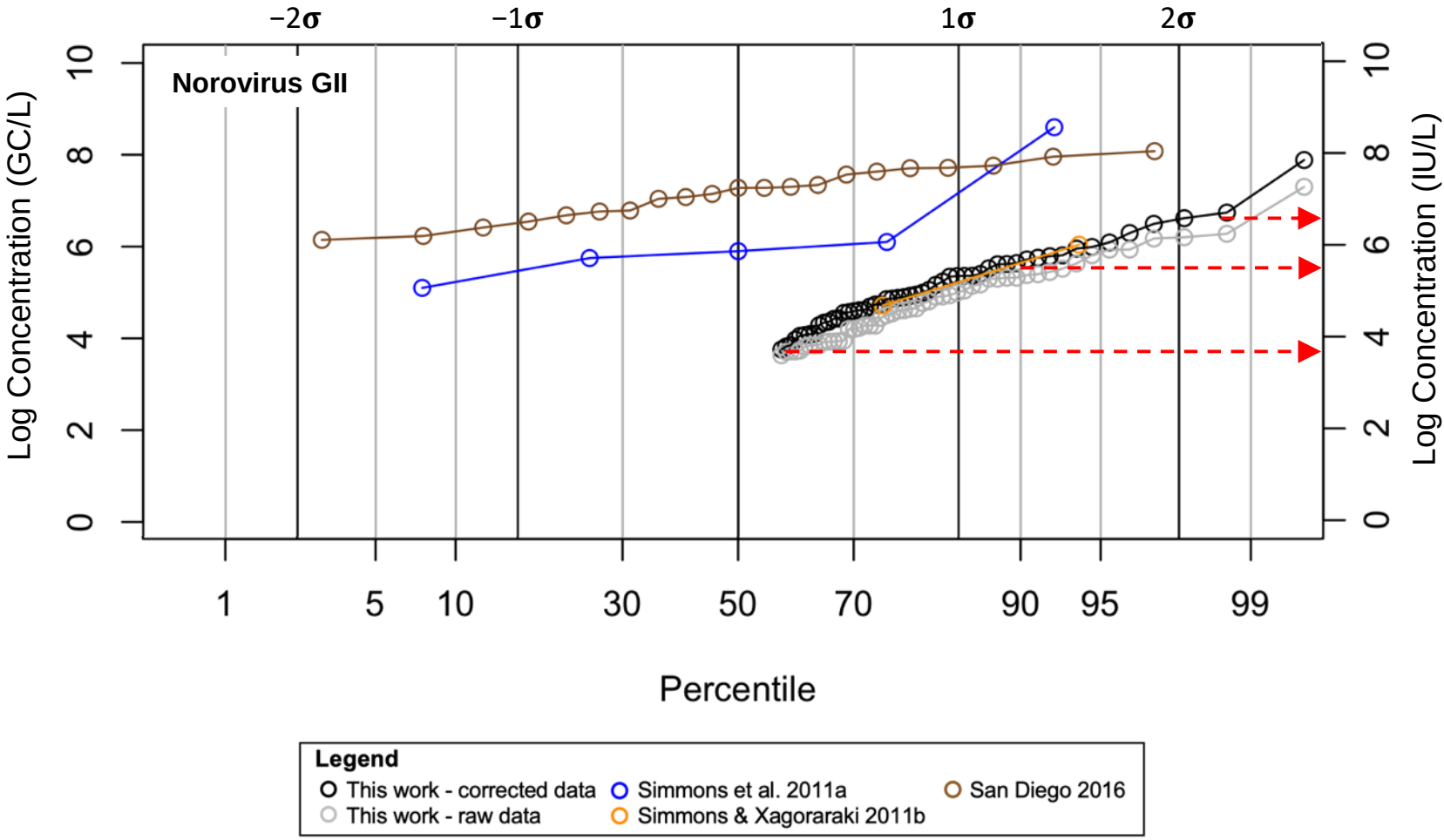
When is this important?

- Norovirus (NoV) is an important pathogen that cannot be cultured
- Need to make assumptions about the “infectivity” of a NoV GC



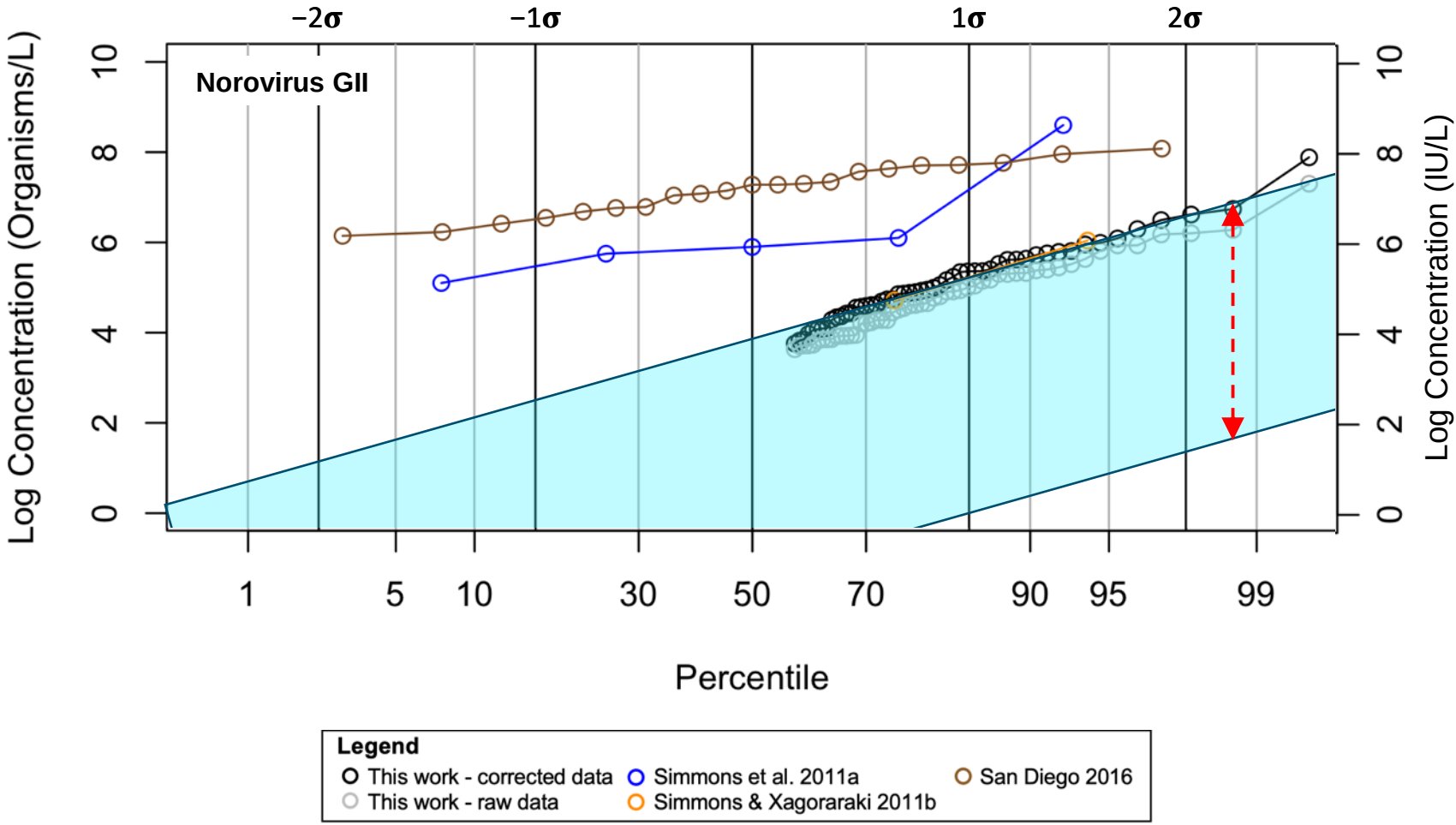
When is this important?

- Norovirus (NoV) is an important pathogen that cannot be cultured
- Need to make assumptions about the “infectivity” of a NoV GC
- If we assume 1:1, then each GC is an infectious unit (IU)

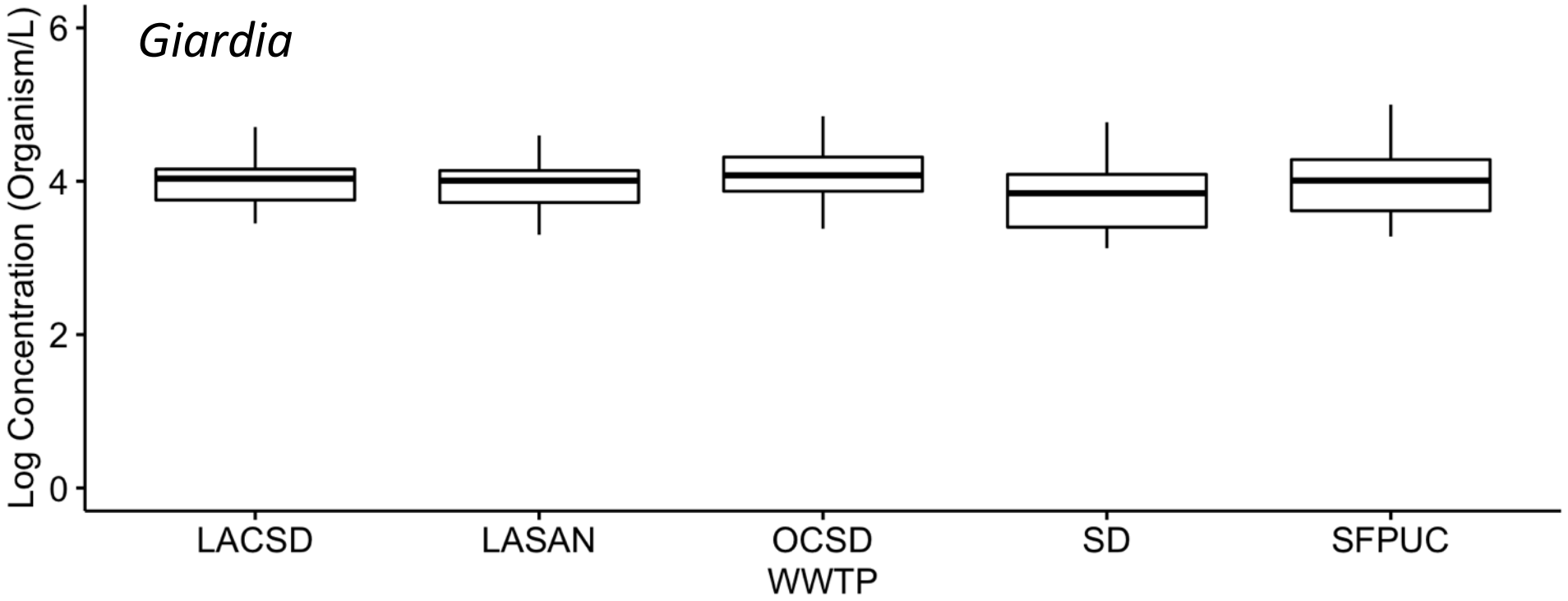


When is this important?

- But DPR-2 shows a wide range of ratios
- TWG recommends seeing distribution as a “band” of potential values
- Interpretation of molecular data is <u>not</u> straightforward



Applicability of findings across treatment plants



- Generally, no statistical difference in concentrations between facilities
- Findings are widely applicable for the California population

Recommendations for Regulatory Development

- Use high-quality DPR-2 data as the raw wastewater inputs for QMRA
- Use recovery-corrected data
- Use modeled distributions (DPR-2 data + relevant literature) for probabilistic assessments

DPR-2 Conclusions

- Pathogen concentrations are critical for defining treatment
- DPR-2 data can be used by regulators / practitioners across the nation
- QAPP/SOPs provide a template for future pathogen monitoring studies

3–Minute Break

DPR-1: Tools to Evaluate Quantitative Microbial Risk and Plant Performance/Reliability

Brian Pecson, Trussell Technologies, Inc.

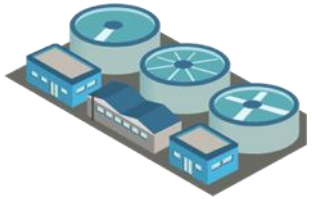
Daniel Gerrity, Southern Nevada Water Authority

Anya Kaufmann, Trussell Technologies, Inc.

How Much Pathogen Treatment?

Wastewater

What concentration of pathogens are we starting with?



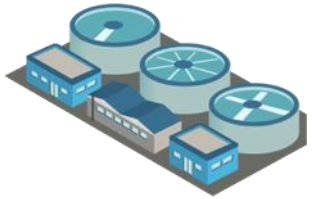
Drinking Water

How Much Pathogen Treatment?

Wastewater

What concentration of pathogens are we starting with?

DPR-2: Raw Wastewater Pathogen Monitoring



Drinking Water

How Much Pathogen Treatment?

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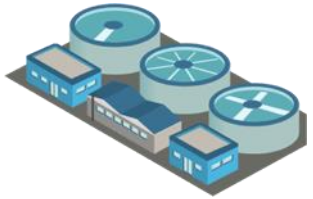
What concentration of pathogens are we starting with?

DPR-2: Raw Wastewater Pathogen Monitoring



How much treatment is needed?

Drinking Water

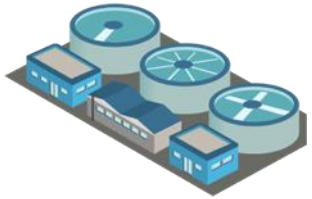
Can we meet our risk goals?

How Much Pathogen Treatment?

Wastewater

What concentration of pathogens are we starting with?

DPR-2: Raw Wastewater Pathogen Monitoring



How much treatment is needed?

DPR-1: Pathogen Treatment and Risk

Drinking Water

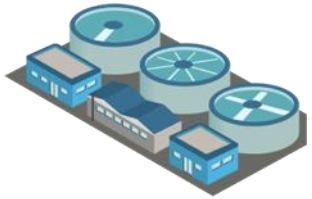
Can we meet our risk goals?

How Much Pathogen Treatment?

Wastewater

What concentration of pathogens are we starting with?

DPR-2: Raw Wastewater Pathogen Monitoring



How much treatment is needed?

DPR-1: Pathogen Treatment and Risk

Drinking Water

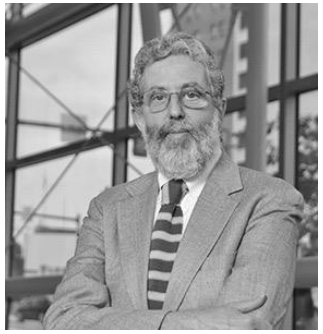
Can we meet our risk goals?

- Develop guidelines for evaluating DPR facility treatment performance
- Use QMRA to confirm the level of treatment needed to achieve risk-based targets

TWG and Research Team

Technical Work Group

Nick Ashbolt
Southern Cross University



Charles Haas
Drexel University

Brian Pecson (chair)
Trussell Technologies

Theresa Slifko
Metropolitan Water District

Research Team

Dan Gerrity
SNWA

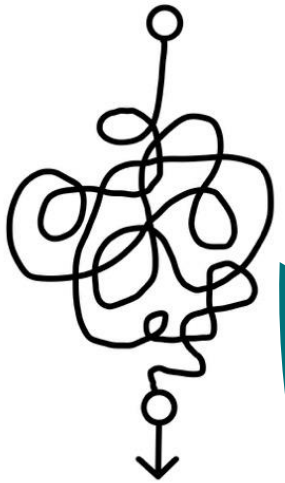
Edmund Seto
University of Washington

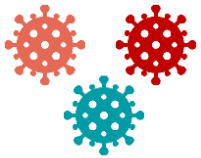
Additional Staff

Anya Kaufmann
Trussell Technologies

Adam Olivieri
WRF/State Board Coordination

Steps in QMRA





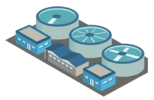
Virus

Giardia

Crypto

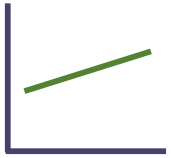
Pathogen Concentrations

Method



Treatment

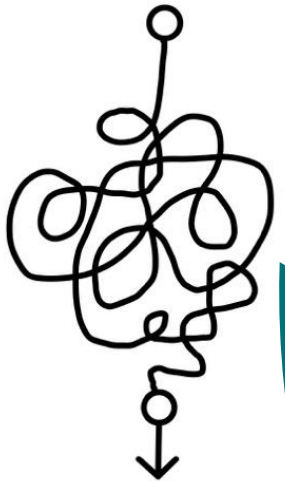
Volume

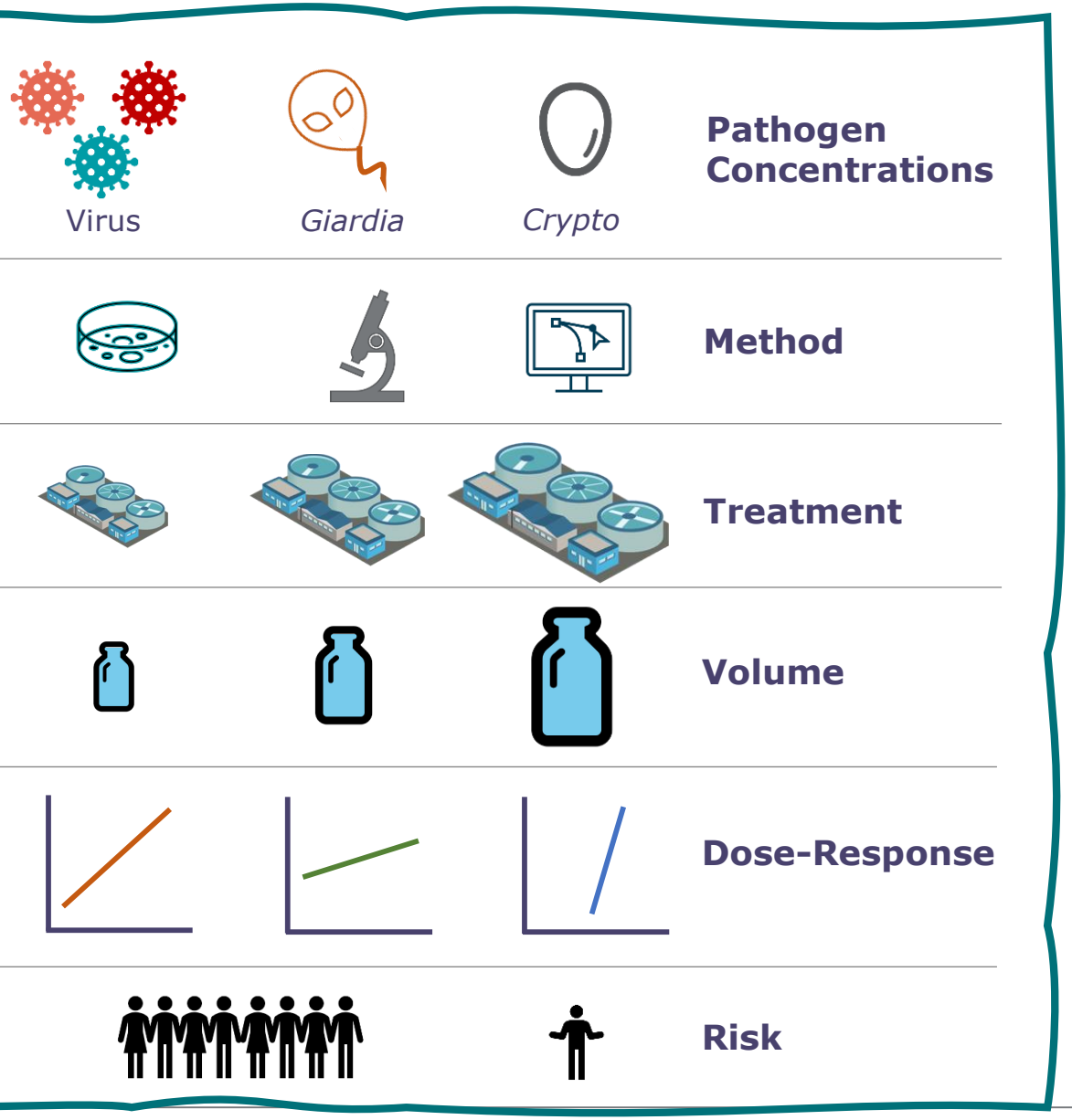


Dose-Response

Risk

Steps in QMRA





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

Literature Review
November 30, 2020

PATTP & QMRA Literature Review

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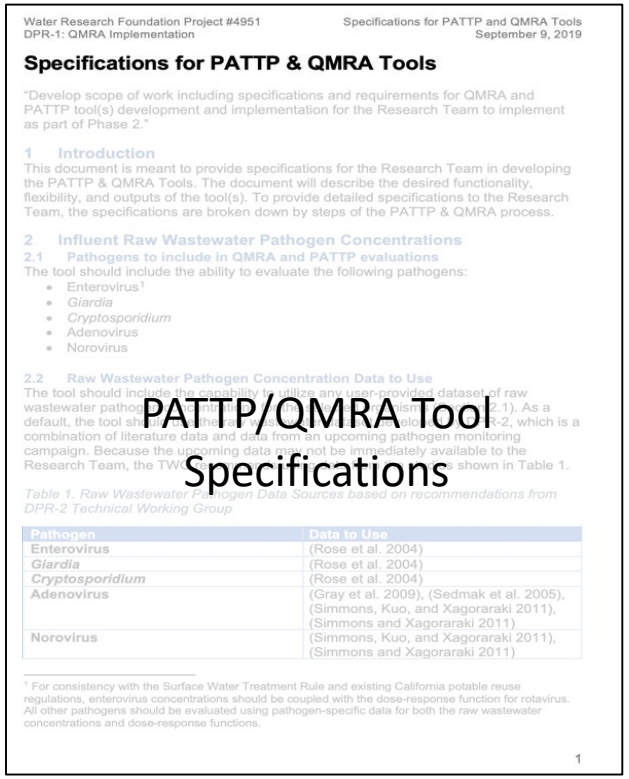
Literature Review
on
Probabilistic Assessment of Treatment Train Performance (PATTP)
and
QMRA

Consistent Framework for PATTP/QMRA



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 patho… 1). As a default, the tool sh… 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 TW… shown in Table 1.

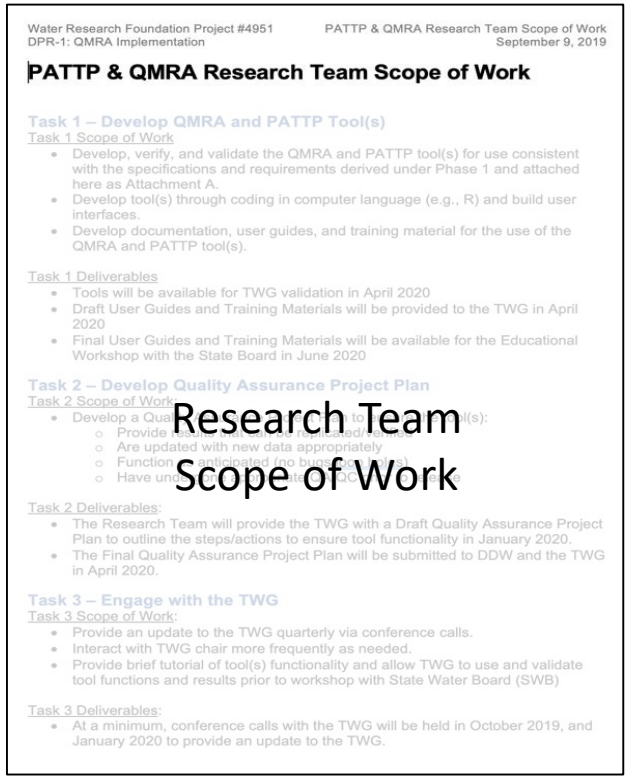
Table 1. Raw Wastewater Pathogen Data Sources based on recommendations from DPR-2 Technical Working Group

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

PATTP/QMRA Tool Specifications



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 Qua… tool(s):
  - Provide…
  - Are updated with new data appropriately
  - Function … anticipated (no bugs, errors)
  - Have un…

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

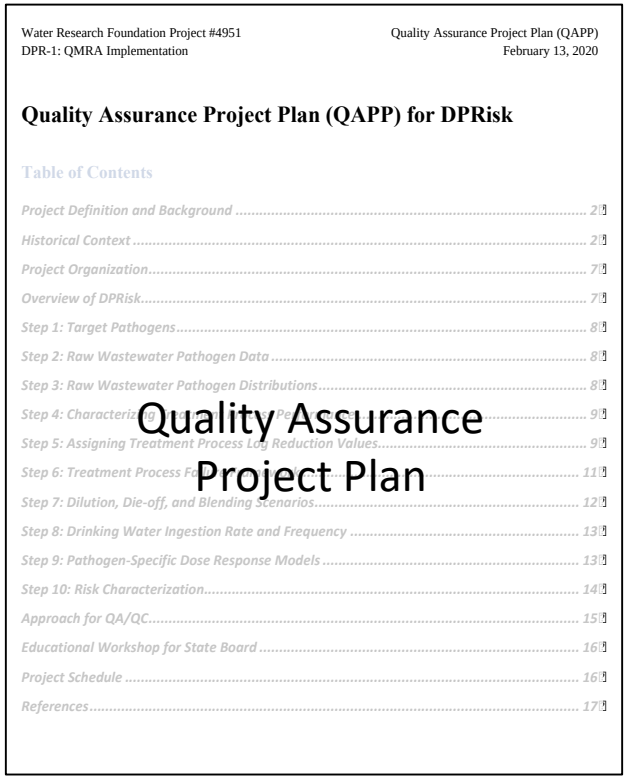
Task 3 Scope of Work:

- 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.

Research Team Scope of Work



Water Research Foundation Project #4951 — Quality Assurance Project Plan (QAPP)
DPR-1: QMRA Implementation — February 13, 2020

Quality Assurance Project Plan (QAPP) for DPRisk

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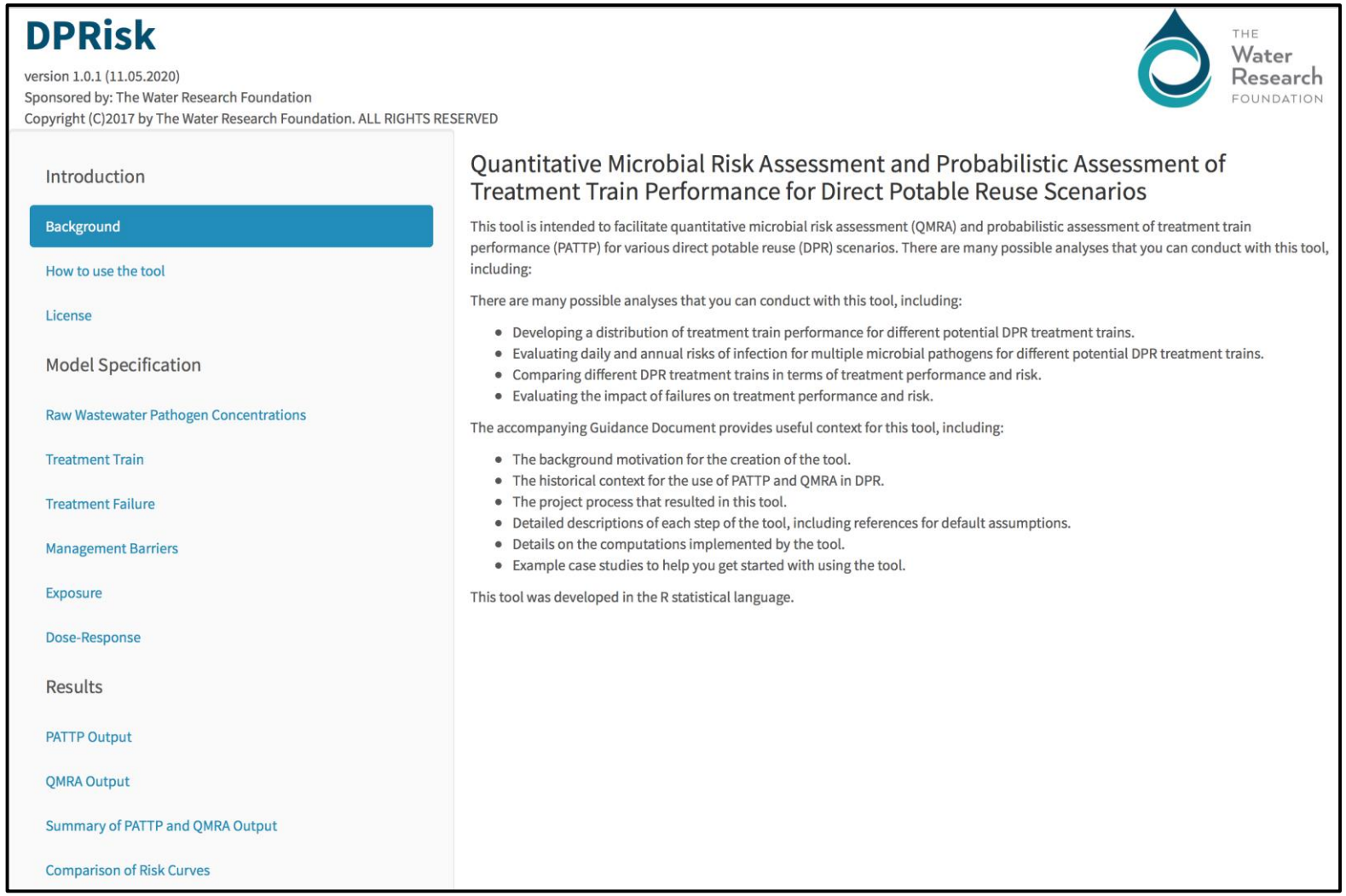
Quality Assurance Project Plan

DPRisk Tool and Guidance Document

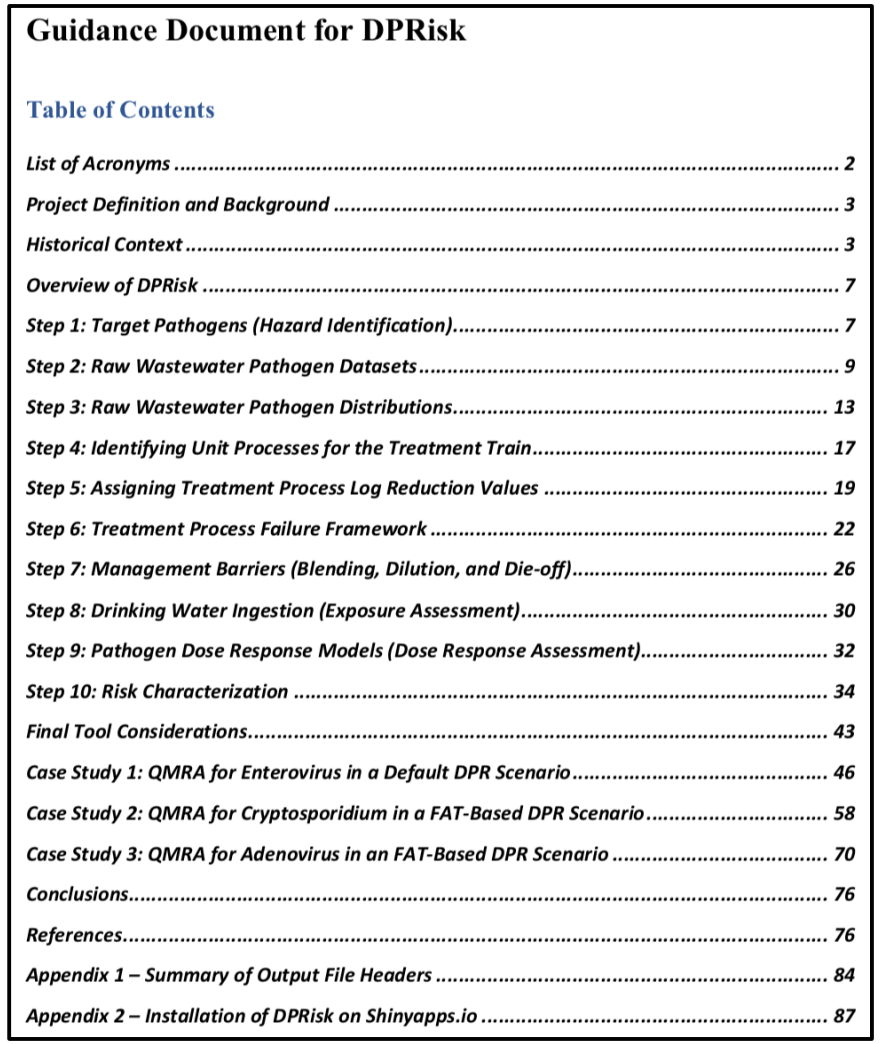
Daniel Gerrity, PhD, Southern Nevada Water Authority

DPRisk Tool and Guidance Document

DPRisk: QMRA Tool



DPRisk: Guidance Document



Also: User Input Files for 3 Case Studies

DPRisk Tool

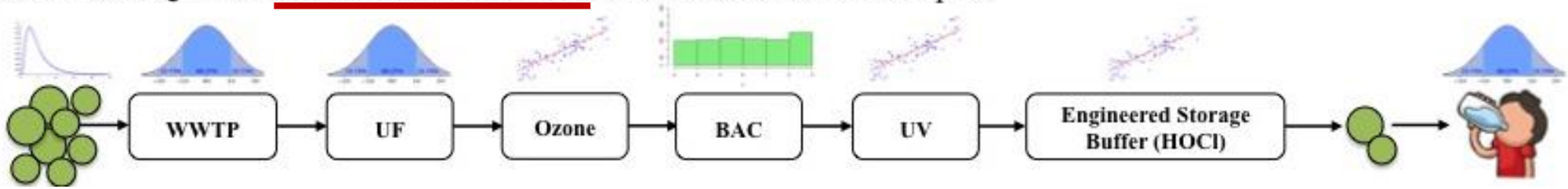
- Developed in **R** using the **R Shiny** web-based platform (Dr. Seto at UW)
- Quantitative Microbial Risk Assessment (QMRA)
- Probabilistic Assessment of Treatment Train Performance (PATTP)

Deterministic QMRA: point estimates used for model inputs

Raw Sewage Virus Concentration:	→	Acceptable Virus Concentration:	→	Required LRV:
10^5 MPN/L		2.2×10^{-7} MPN/L		12 logs

Basis for CA IPR Regulations

Stochastic QMRA: statistical distributions for one or more model inputs



Basis for CA DPR Regulations?

DPRisk Tool

- Developed in **R** using the **R Shiny** web-based platform (Dr. Seto at UW)
- Quantitative Microbial Risk Assessment (QMRA)
- Probabilistic Assessment of Treatment Train Performance (PATTP)

California State Water Board:

The QRMA tool, DPRisk, is a Shiny web-based application. A copy of DPRisk is available at cawaterdatadive.shinyapps.io/DPRisk with an approved shinyapps.io account. To obtain authorization, please send an email to DDWrecycledwater@waterboards.ca.gov with your name, phone number, organization, and project (if any) with your request. Please include "DPRisk" in the subject of your email. DDW will review all requests after TWRF posts the guidance document for the DPRisk tool.

Source:
https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/direct_potable_reuse.html

Water Research Foundation:

Source:https://www.waterrf.org/research/projects/tools-evaluate-quantitative-microbial-risk-and-plant-performancereliability

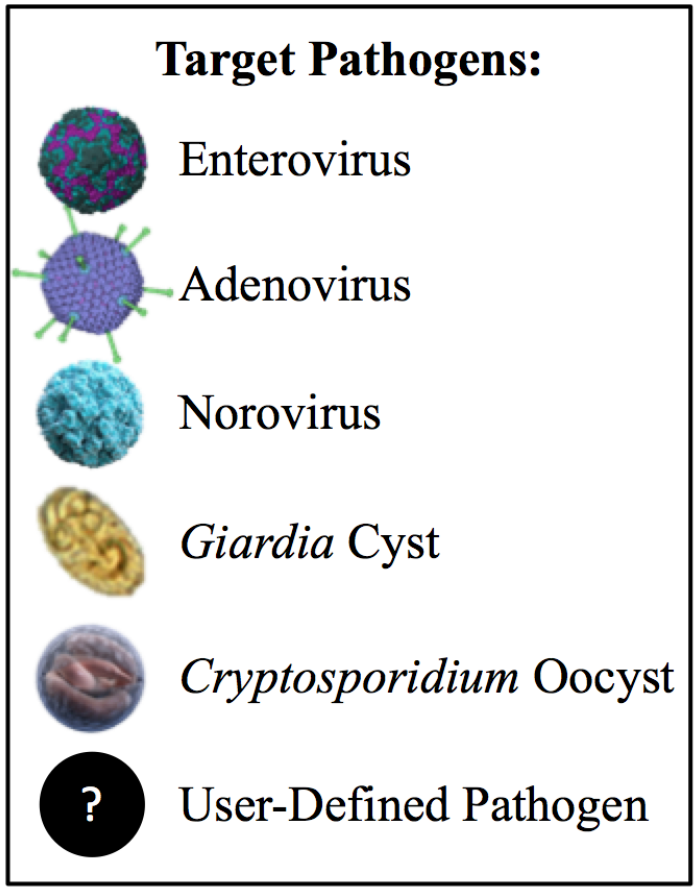
Development of DPRisk

- **Initial Goal:**
  - Provide the California State Water Board with a tool to inform the development of draft and final regulations for DPR
- **Considerations:**
  - *Accessible* to a wide range of users (***easy to use!***) → 3 case studies
  - *Flexible* to allow for diverse modeling scenarios and future updates
  - *Transparent* to increase confidence and understanding → Guidance Doc
- **Potential Uses:**
  - Understand basis behind regulations and reproduce past studies
  - Explore nuances of a specific system or scenario (e.g., point vs. distribution)
  - Demonstrate suitability of a proposed alternative (or DPR in other states?)

DPRisk Features

INPUTS:

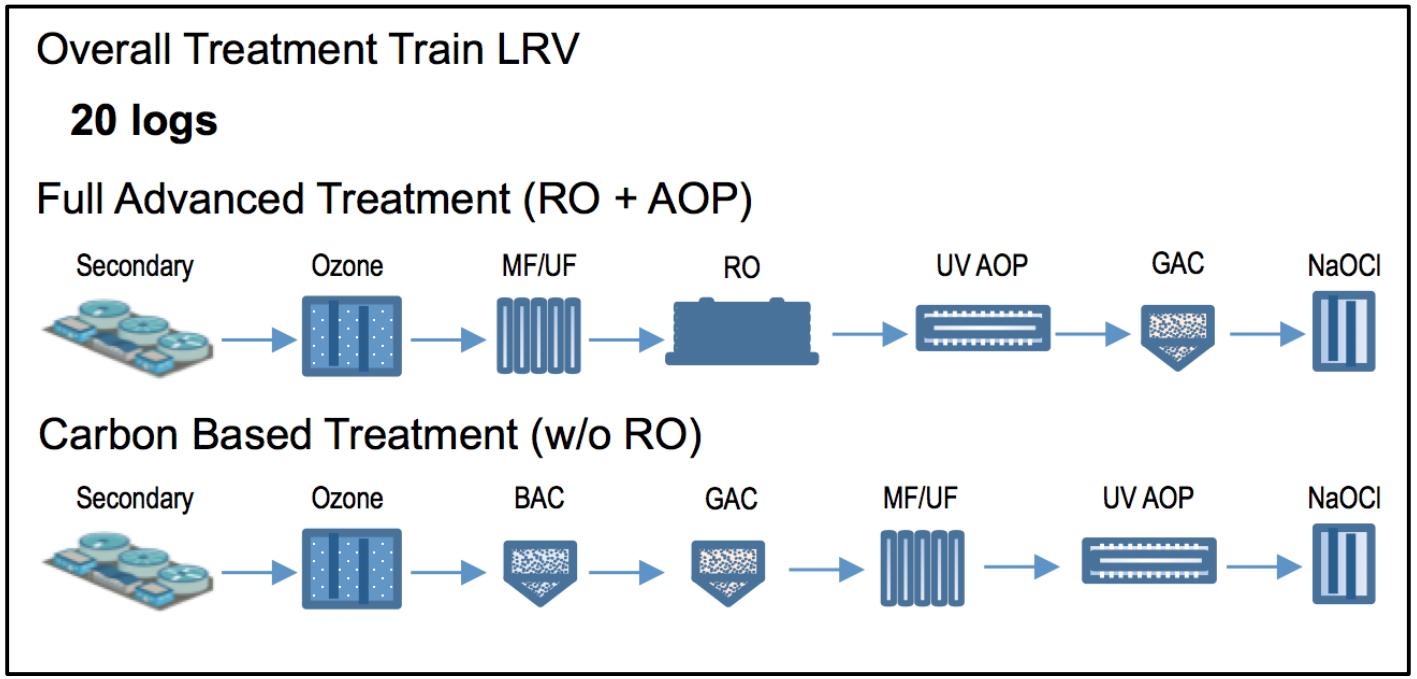
- **Raw Wastewater Pathogen Concentrations (Guidance Document will reference DPR-2 dataset)**
  - Point Estimate, Distribution, Input File



DPRisk Features

INPUTS:

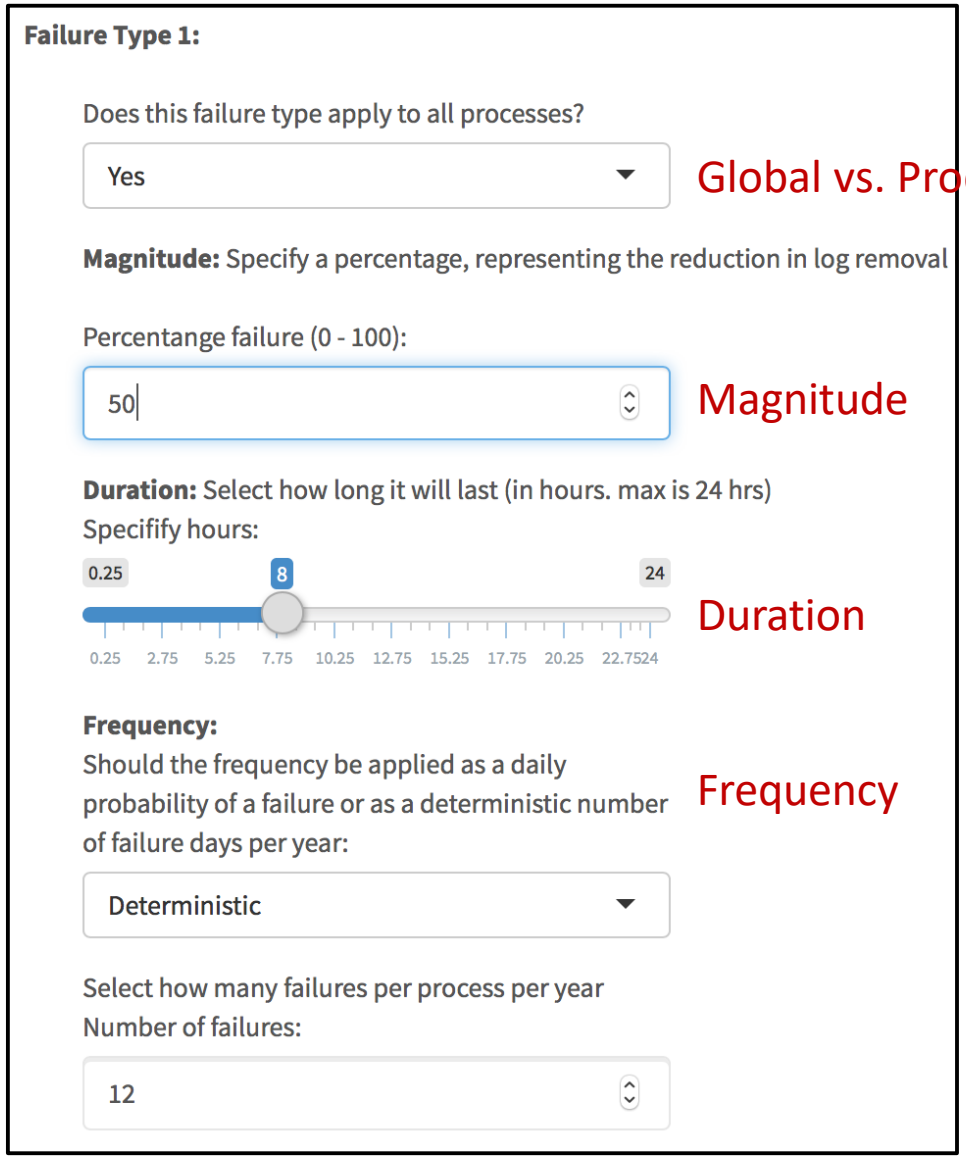
- **Raw Wastewater Pathogen Concentrations**
  - Point Estimate, Distribution, Input File
- **Treatment Train**
  - Overall LRV, Unit Processes, LRV Guidance



DPRisk Features

INPUTS:

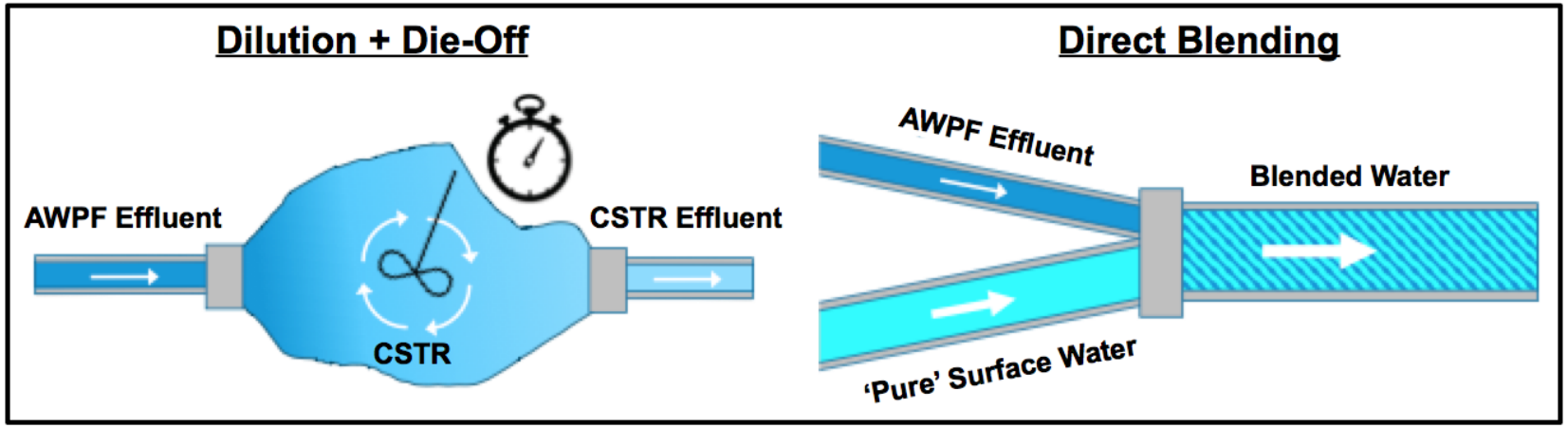
- **Raw Wastewater Pathogen Concentrations**
  - Point Estimate, Distribution, Input File
- **Treatment Train**
  - Overall LRV, Unit Processes, LRV Guidance
- **Treatment Failure**
  - Global, Process-Specific
  - Magnitude, Duration, Frequency
  - Deterministic (Forced), Probabilistic



DPRisk Features

INPUTS:

- **Raw Wastewater Pathogen Concentrations**
  - Point Estimate, Distribution, Input File
- **Treatment Train**
  - Overall LRV, Unit Processes, LRV Guidance
- **Treatment Failure**
  - Global, Process-Specific
  - Magnitude, Duration, Frequency
  - Deterministic (Forced), Probabilistic
- **Management Barriers**
  - Blending, Dilution, Die-Off



DPRisk Features

INPUTS:

- **Raw Wastewater Pathogen Concentrations**
  - Point Estimate, Distribution, Input File
- **Treatment Train**
  - Overall LRV, Unit Processes, LRV Guidance
- **Treatment Failure**
  - Global, Process-Specific
  - Magnitude, Duration, Frequency
  - Deterministic (Forced), Probabilistic
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  - Volume, Frequency (1 to 96 per day)

vs.

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  - Default Models, User-Defined Parameters

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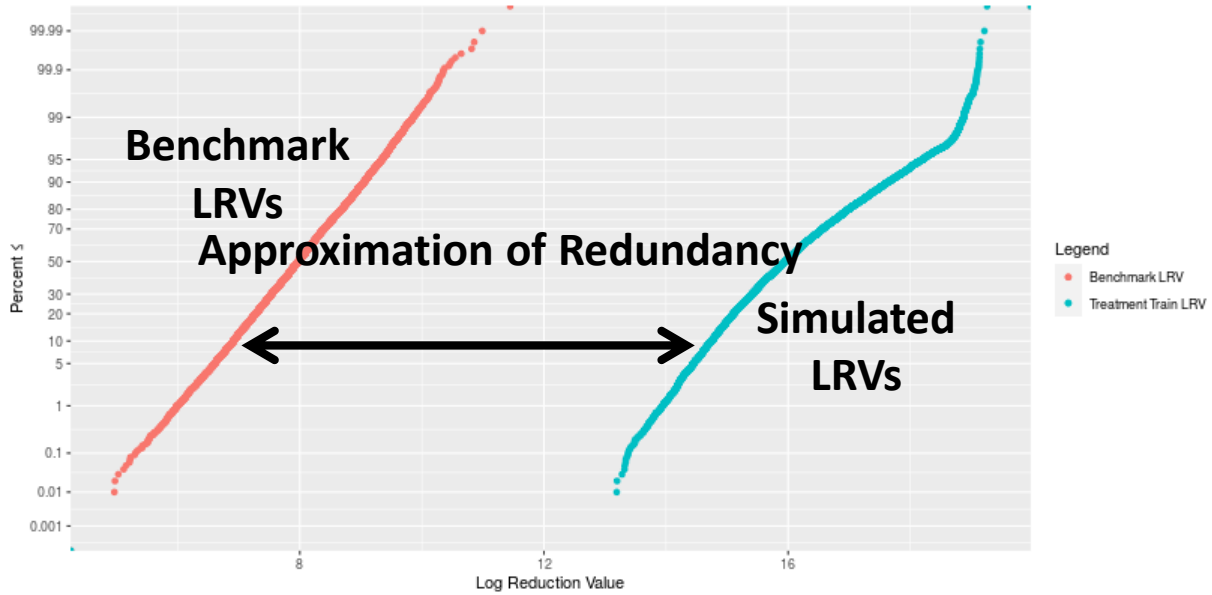
OUTPUTS:

- **Probabilistic Assessment of Treatment Train Performance**
  - Simulated Treatment Train LRVs
  - Simulated Unit Process LRVs
  - Benchmark LRVs (exact LRV to achieve target risk)



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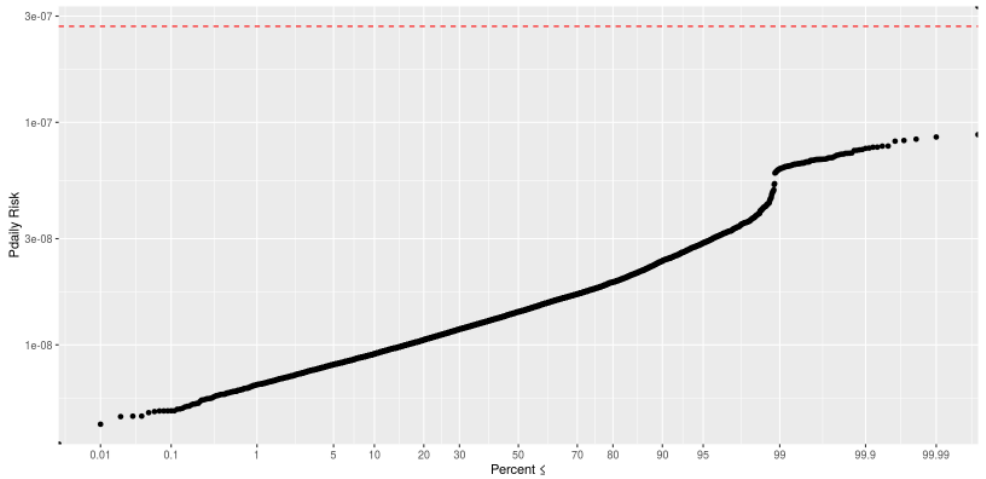
  - Distributions for QMRA Inputs
  - Daily Risk
  - Annual Risk



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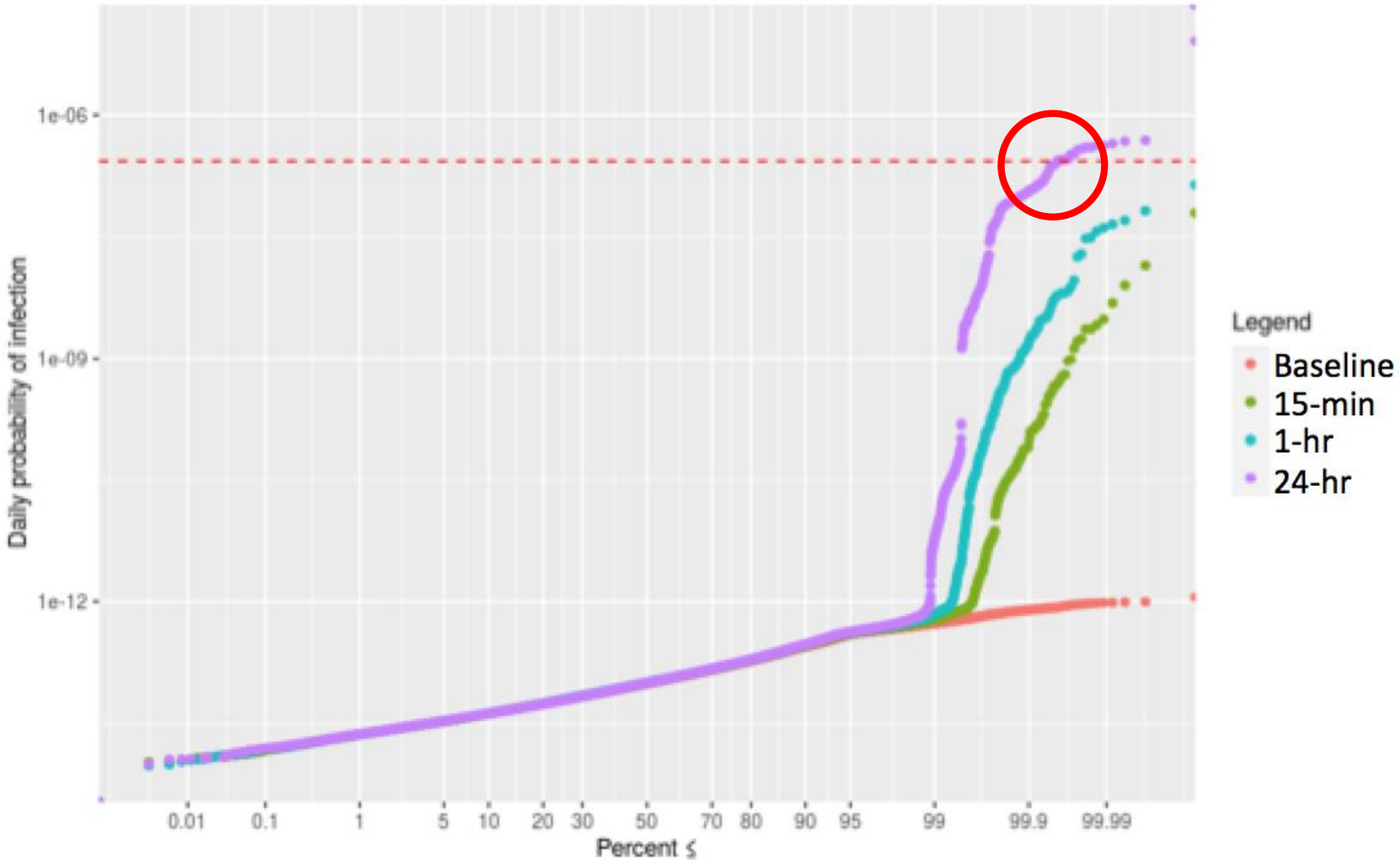
- **Quantitative Microbial Risk Assessment**
  - Distributions for QMRA Inputs
  - Daily Risk
  - Annual Risk
- **Comparison of Risk Curves**
  - Up to 3 scenarios simultaneously

DPRisk: Hypothetical Failure Analysis

Question: What **duration** of failure can be tolerated before daily risk benchmark is exceeded?

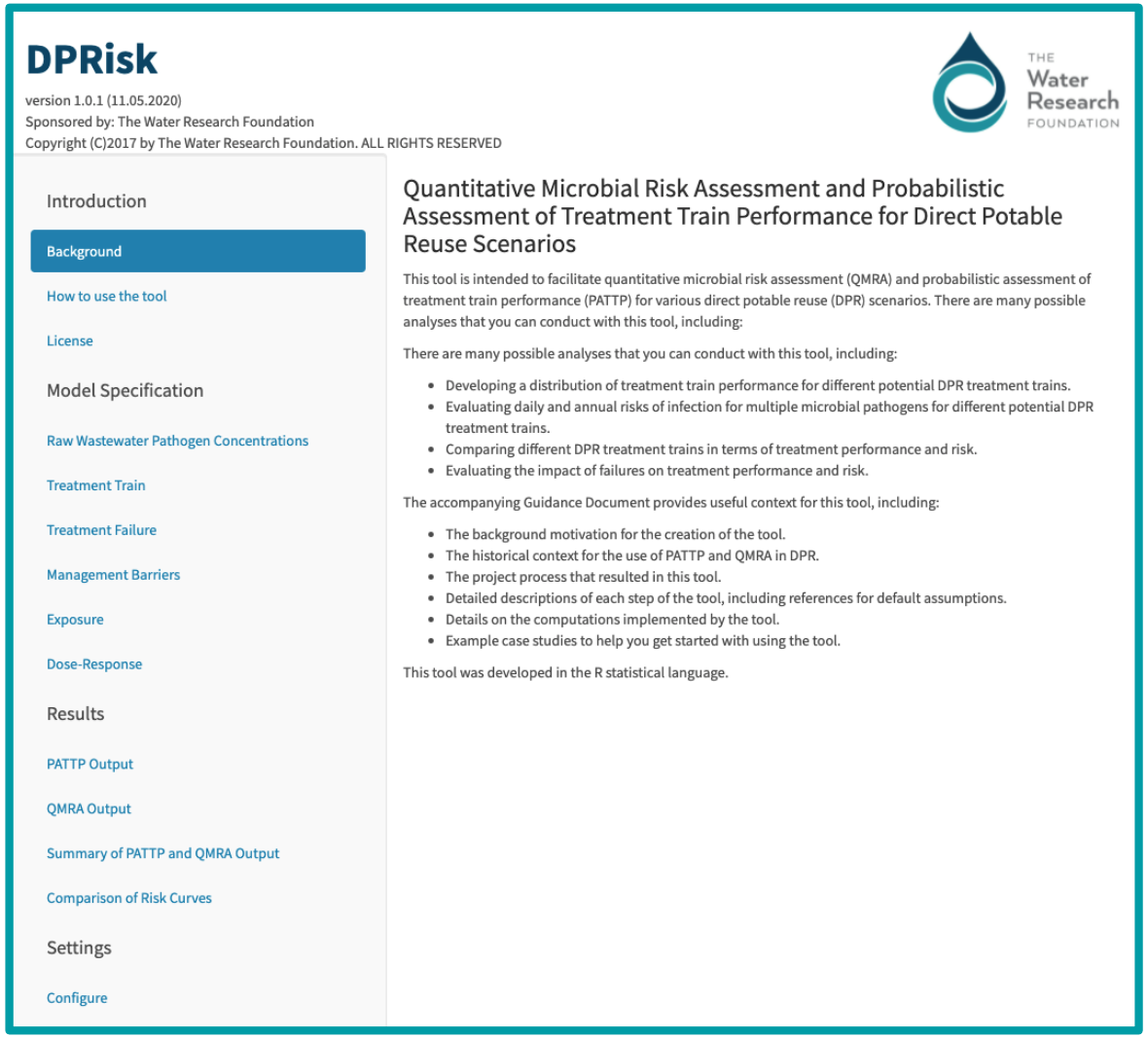
Implication: Minimum **monitoring frequency** for a critical control point



Using DPRisk

Anya Kaufmann, PE, Trussell Technologies, Inc.

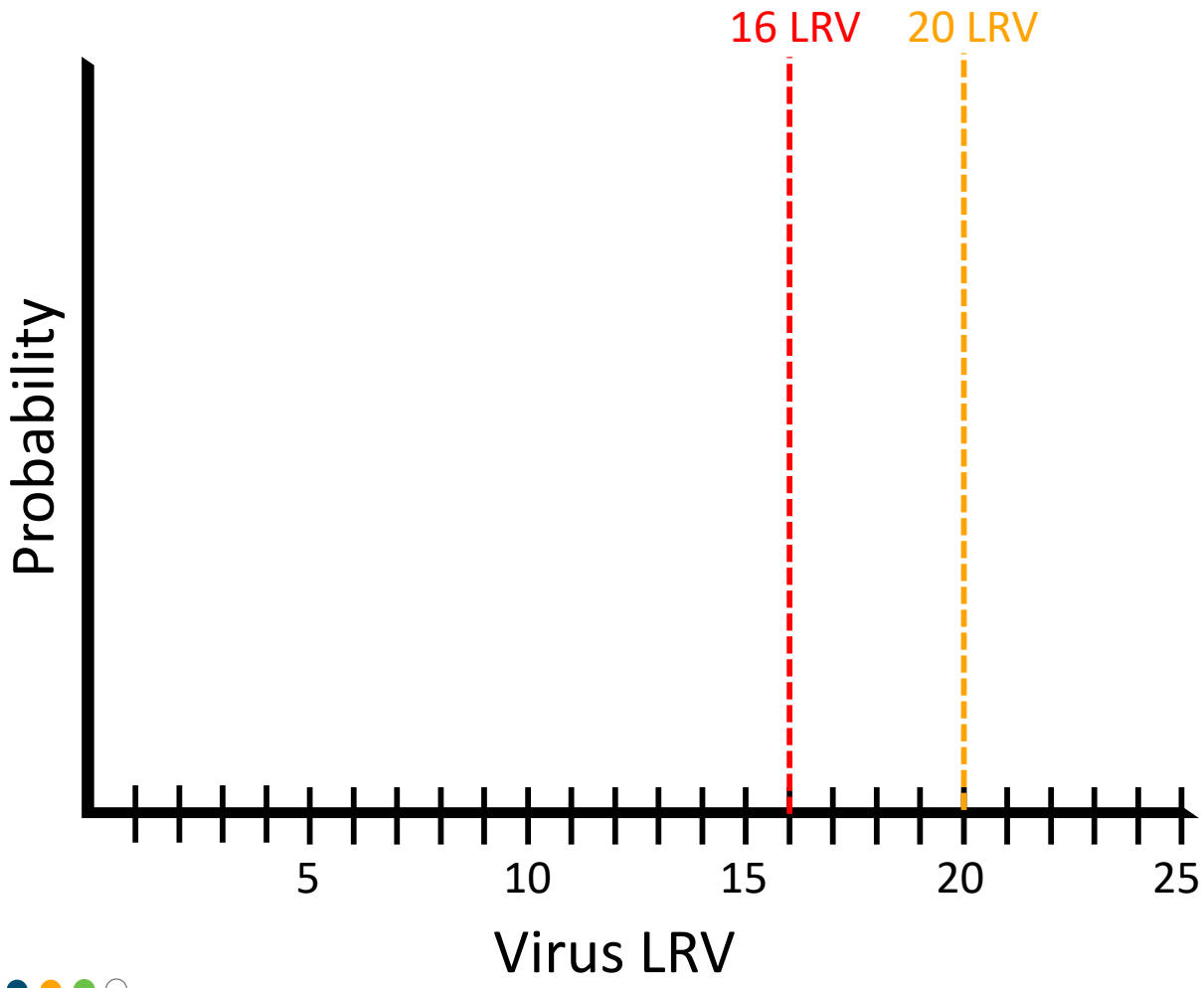
Why should you use DPRisk?



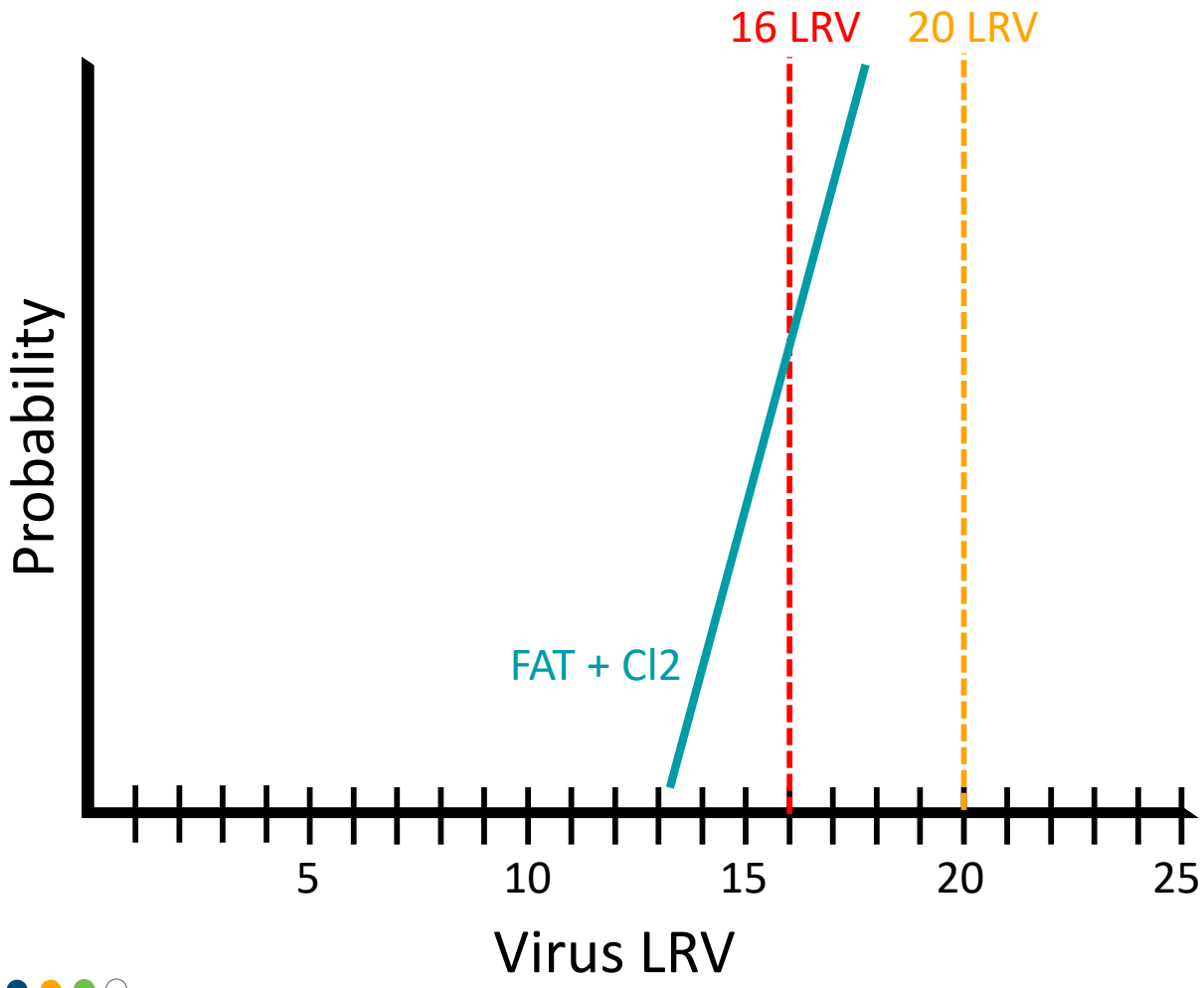
- DPRisk is:
  - Accessible (easy to use)
  - Flexible (model diverse scenarios)
  - Transparent (consistency in methods)

- Use DPRisk to evaluate the performance and risk of a project:
  - Different treatment trains
  - Inclusion of management barriers
  - Site-specific data

Assessing Treatment Performance

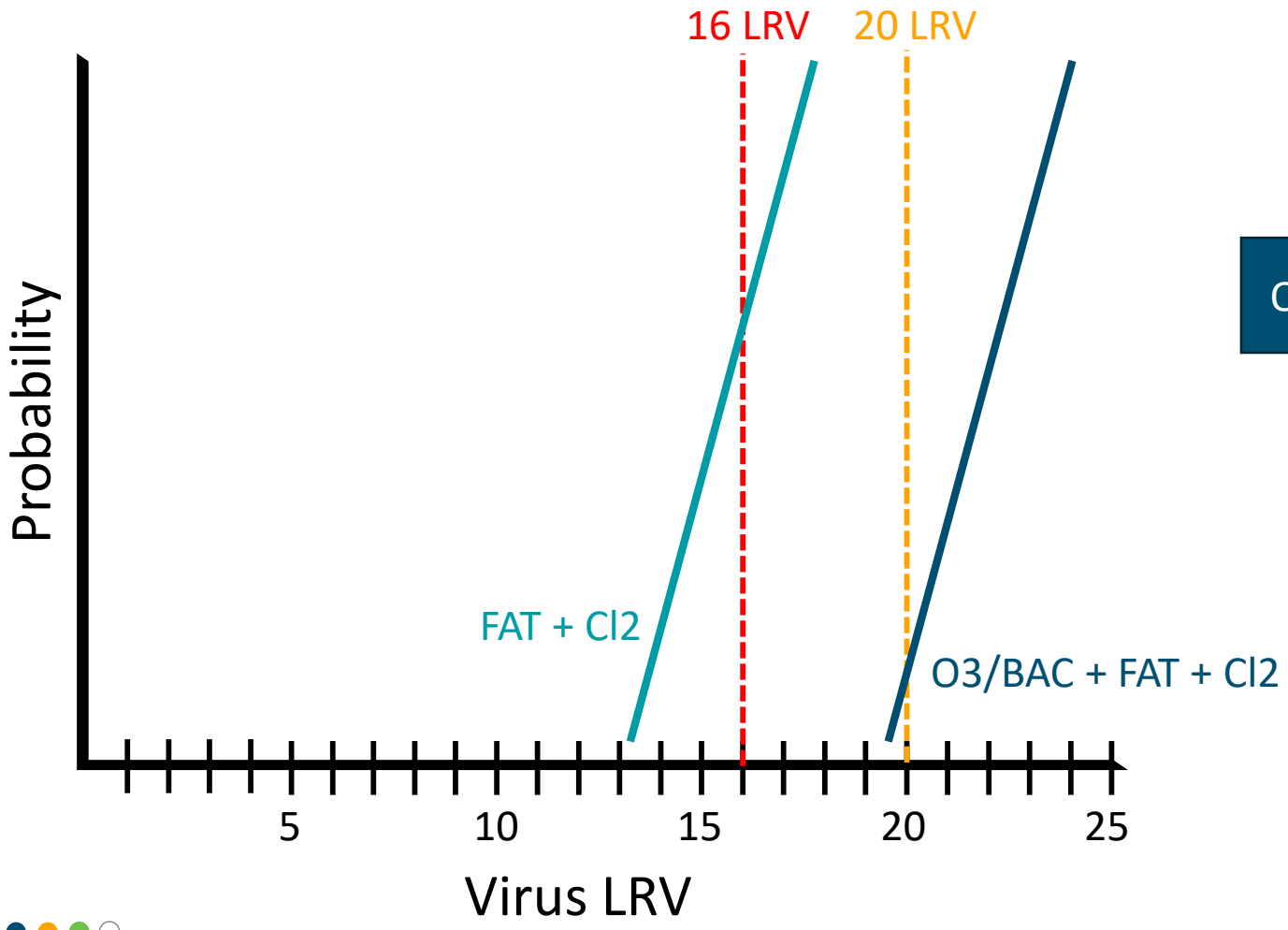


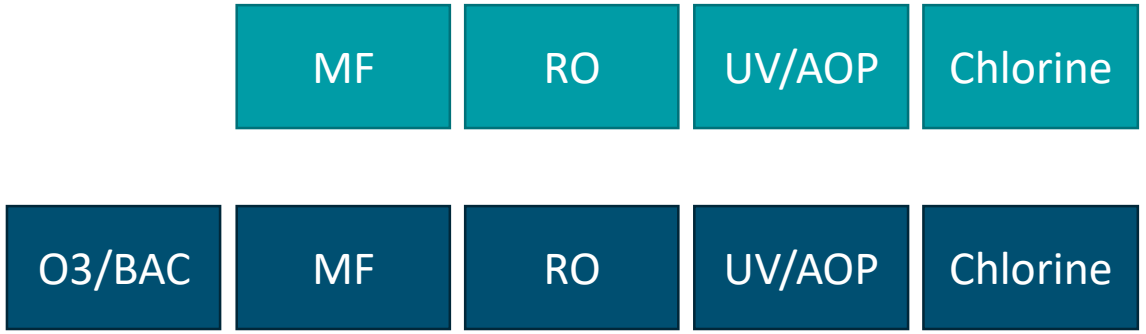
Assessing Treatment Performance



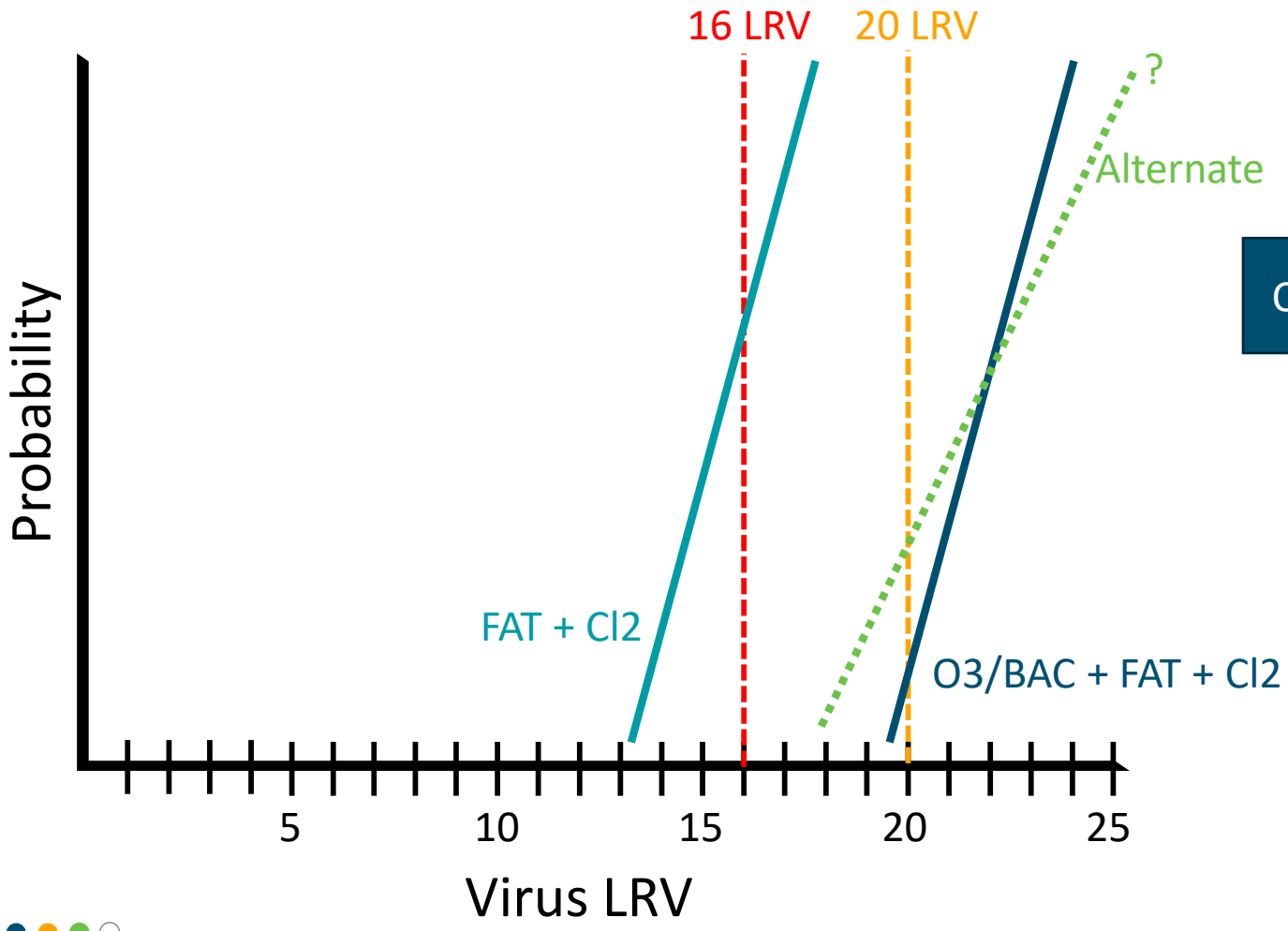
MF | RO | UV/AOP | Chlorine

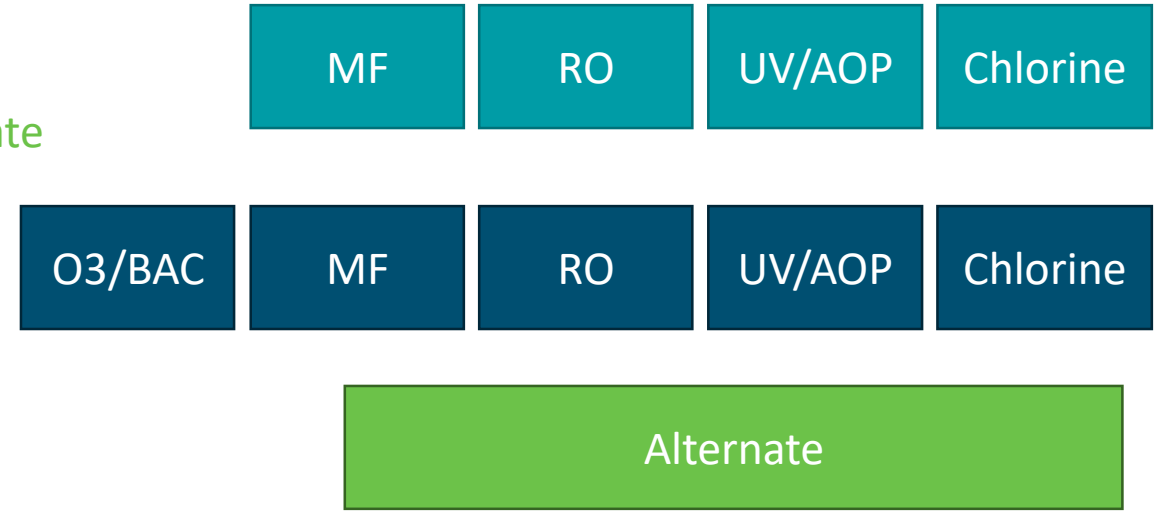
Assessing Treatment Performance



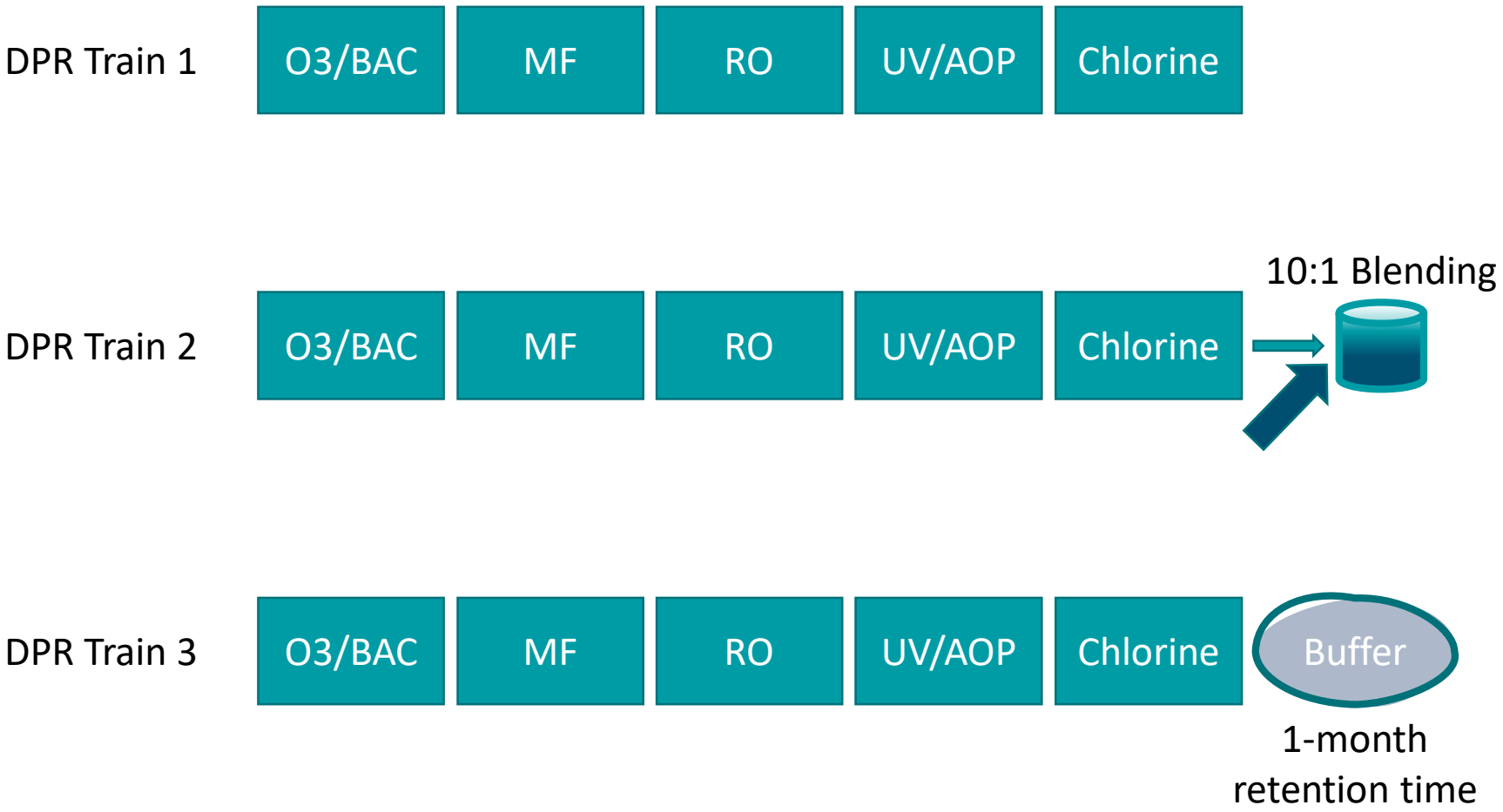


Assessing Treatment Performance

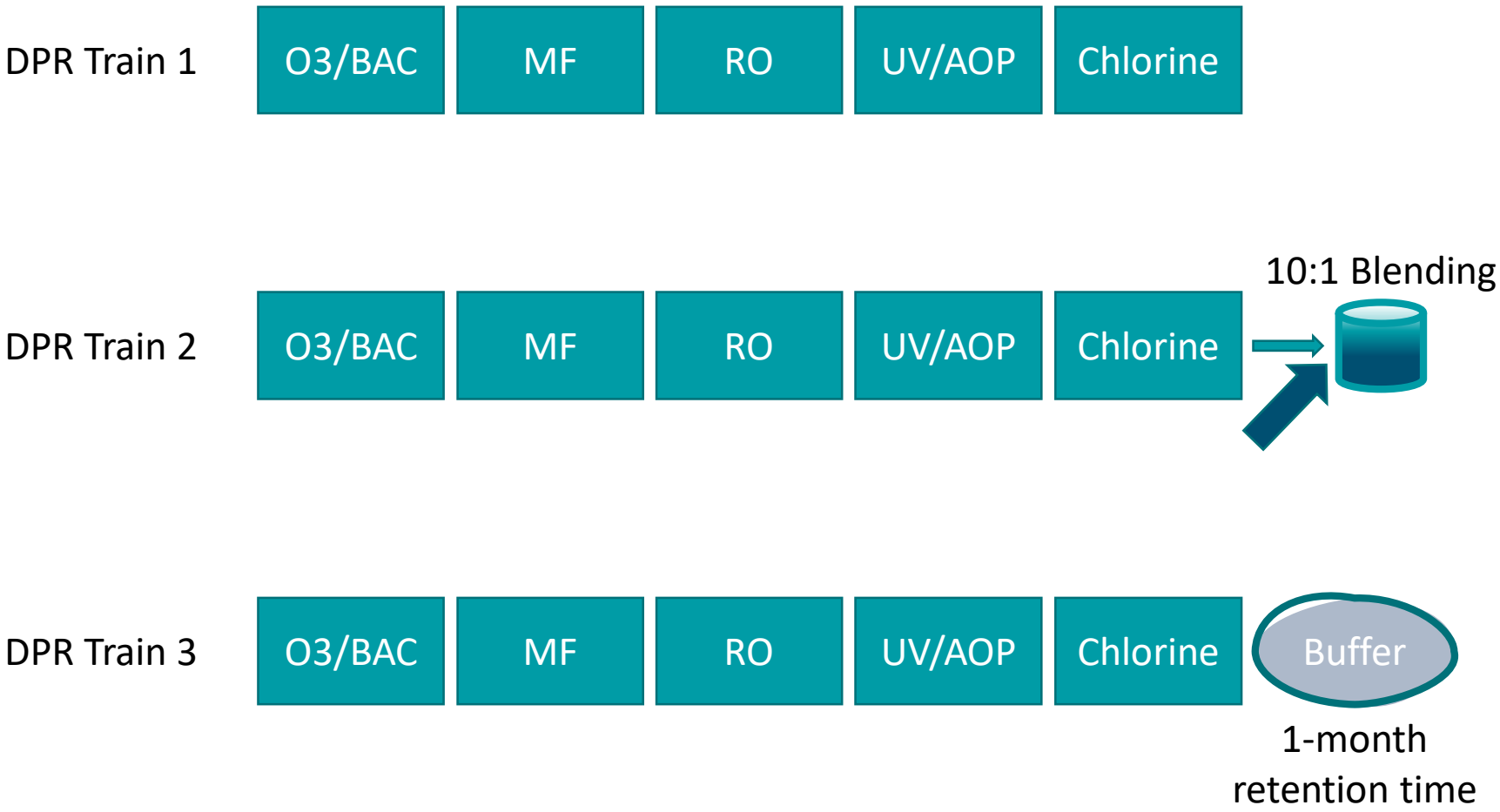




DPR Projects May Include Different Elements

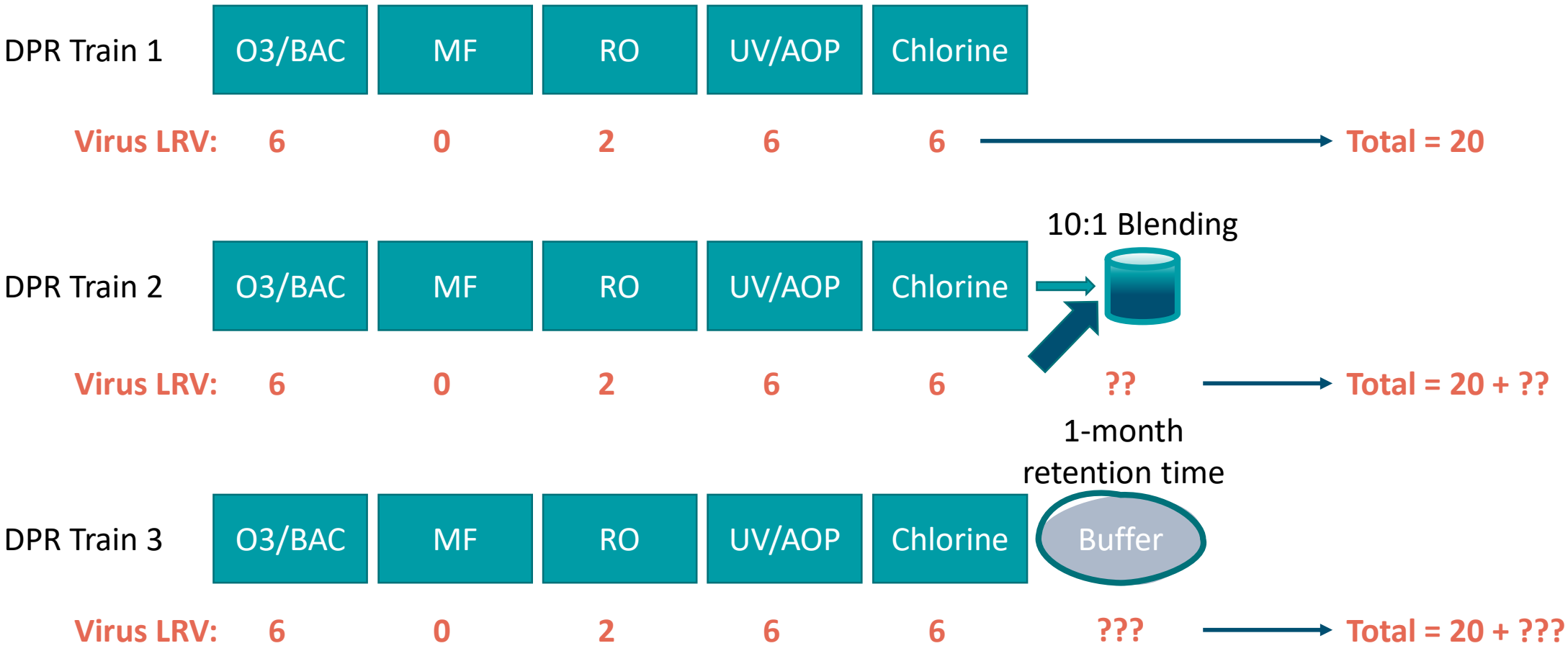


DPR Projects May Include Different Elements



Do these projects have different risk profiles?

DPRisk – Evaluate Inclusion of Different Elements



DPRisk – Evaluate Inclusion of Different Elements

DPR

DPR

DPR

Blending

Specify the log removal associated with blending. Please see Guidance Document on estimating log removals for blending.

Specify log removal for blending as:

Point estimate

Log Removal:

0

Dilution

Specify the log removal associated with dilution. Please see Guidance Document on estimating log removals for dilution.

Specify log removal for dilution as:

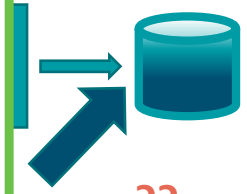
Point estimate

Log Removal:

0

Total = 20

10:1 Blending



??

Total = 20 + ??

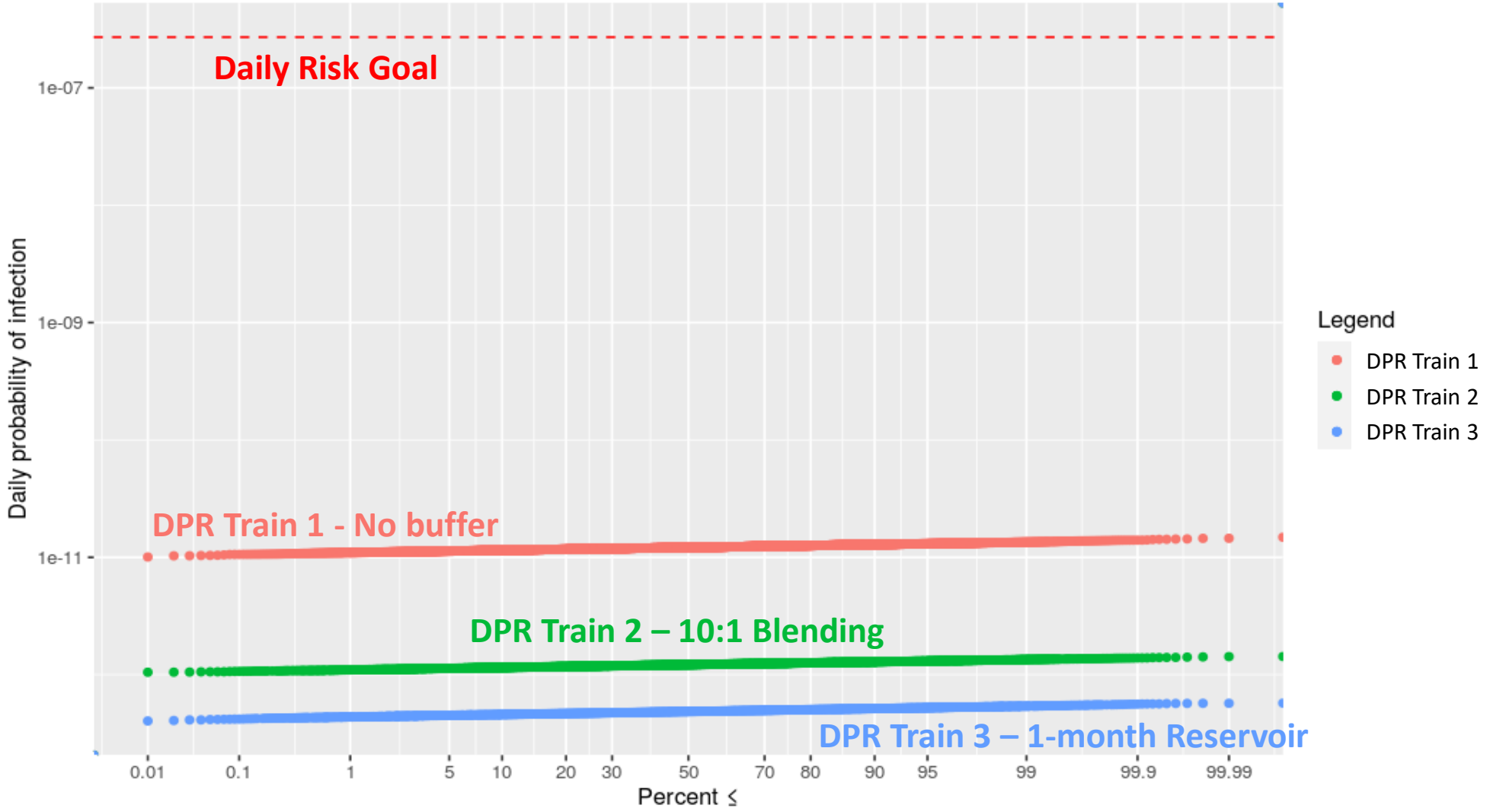
1-month retention time

Buffer

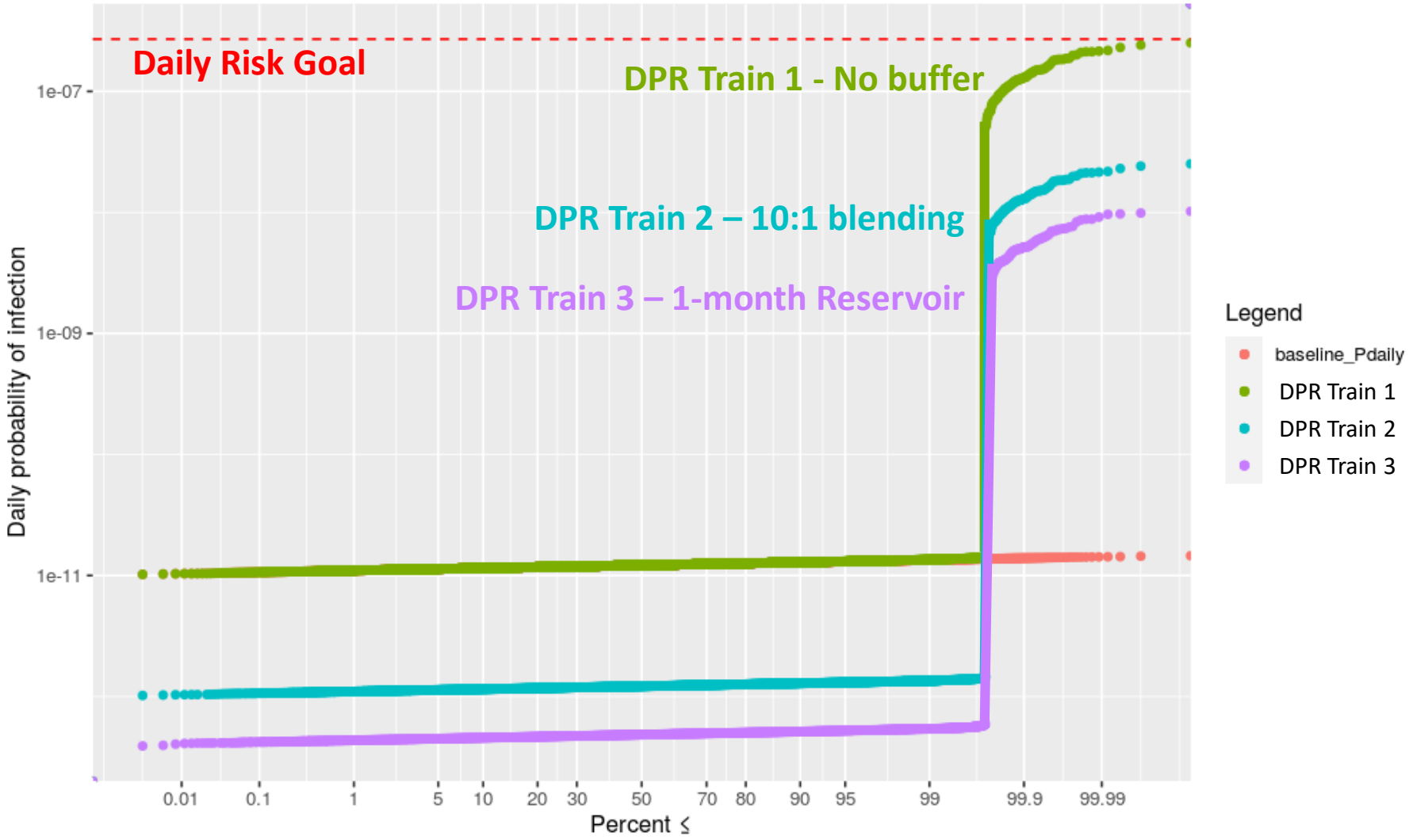
???

Total = 20 + ???

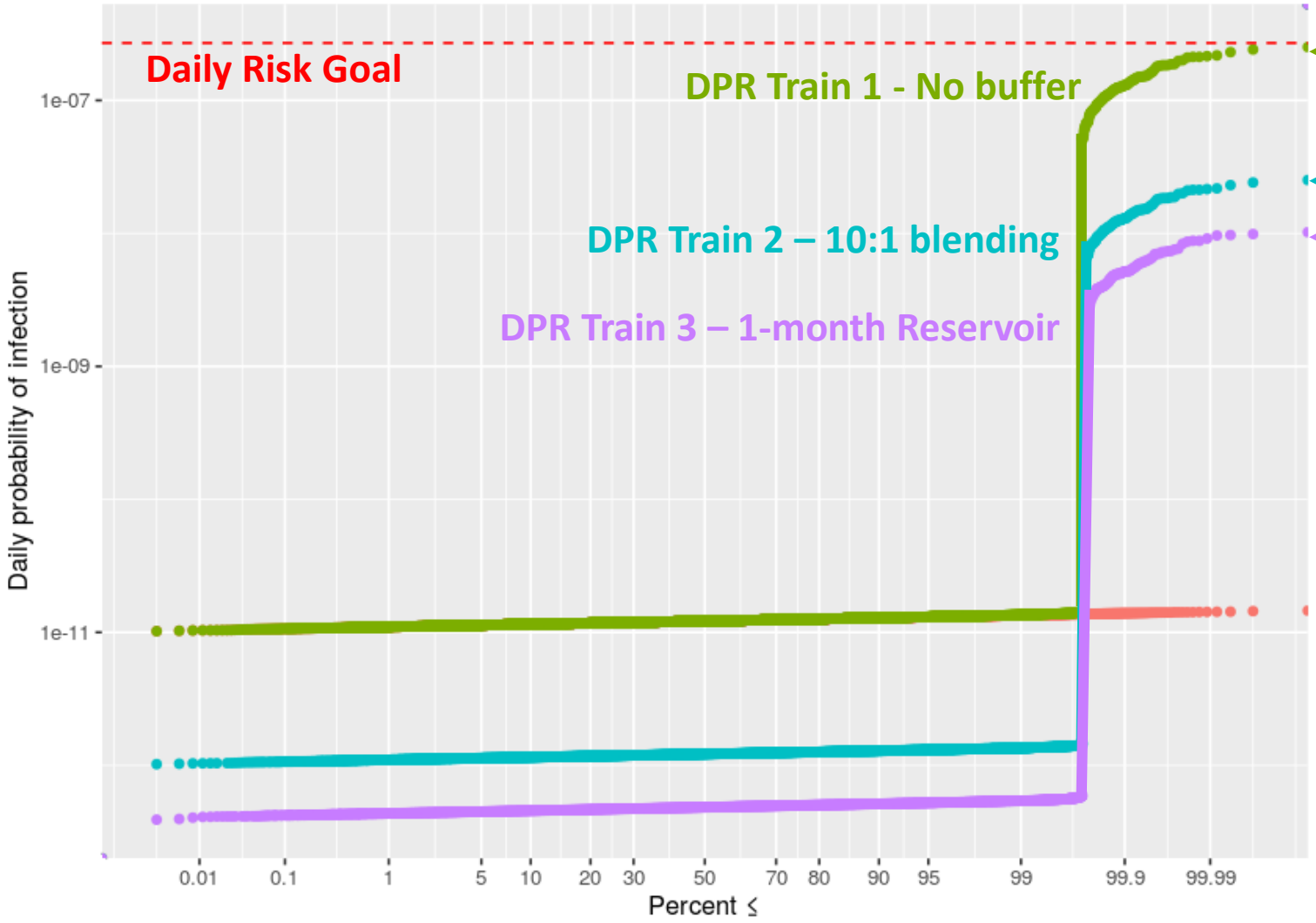
DPRisk – Risk Profiles of Projects with Different Elements



DPRisk – Risk Profiles of Projects with Failure Analysis



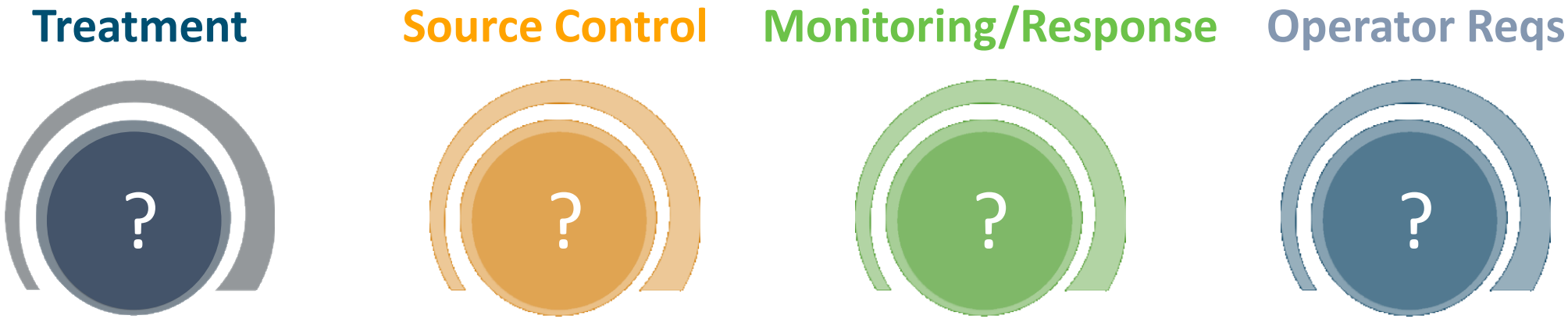
DPRisk – Risk Profiles of Projects with Failure Analysis



These projects have different risk profiles…

…should they have the same requirements?

Evaluate Your Project as a Whole

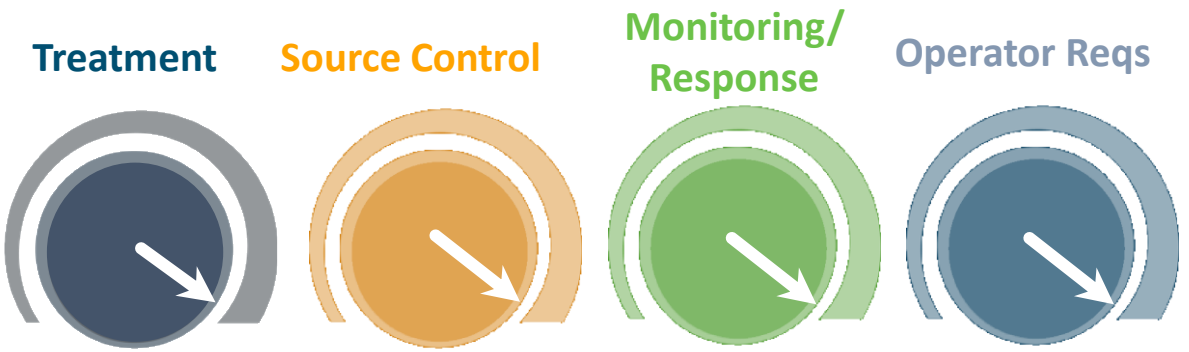


- How can I determine if my balance of project elements provides sufficient public health protection?

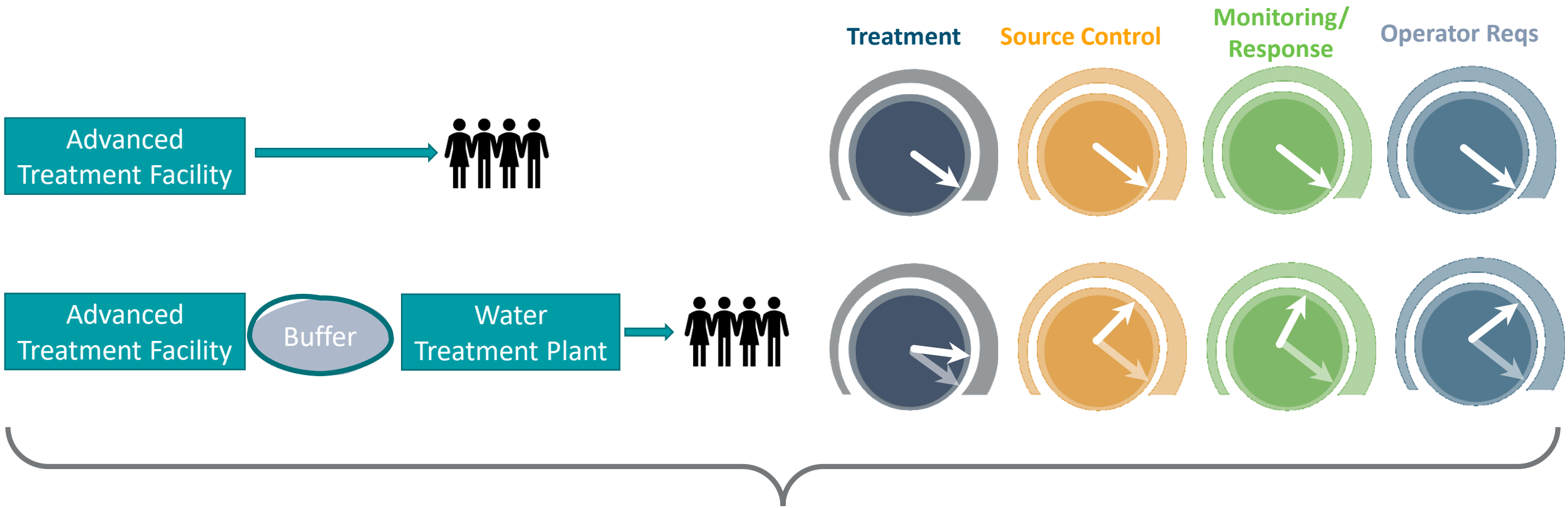
- DPRisk allows you to quantify the benefits of certain project elements

Requirements for DPR

Advanced Treatment Facility

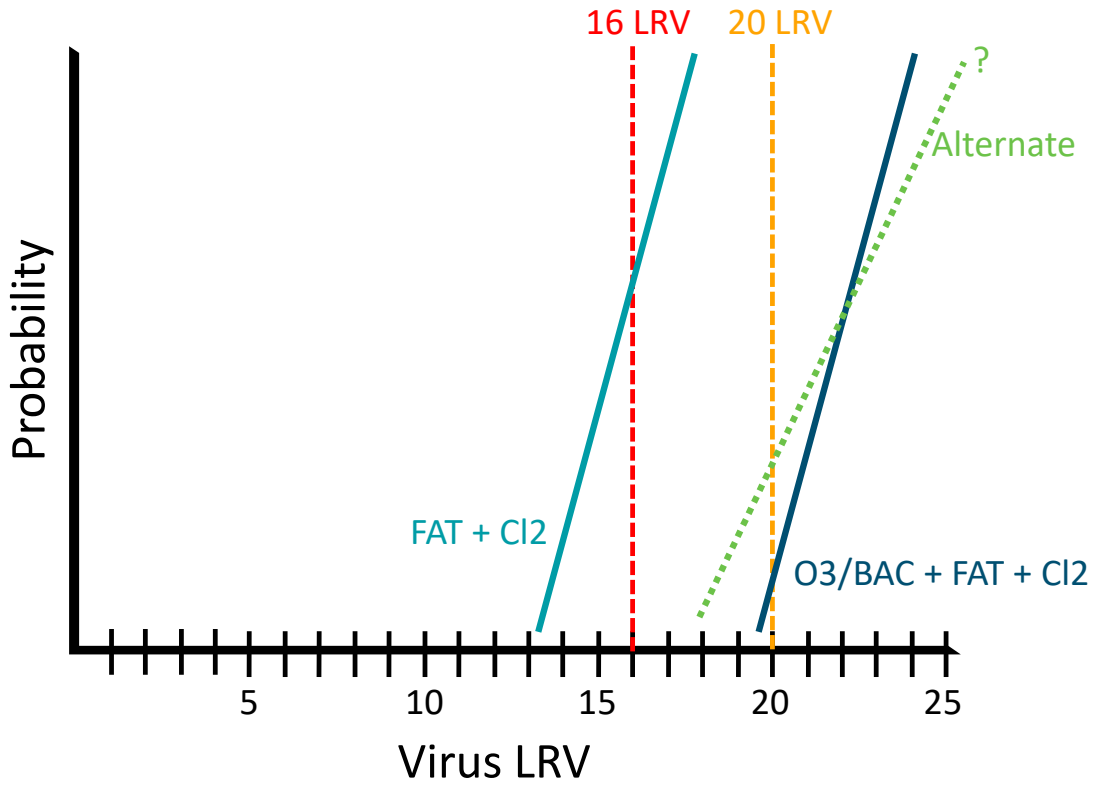


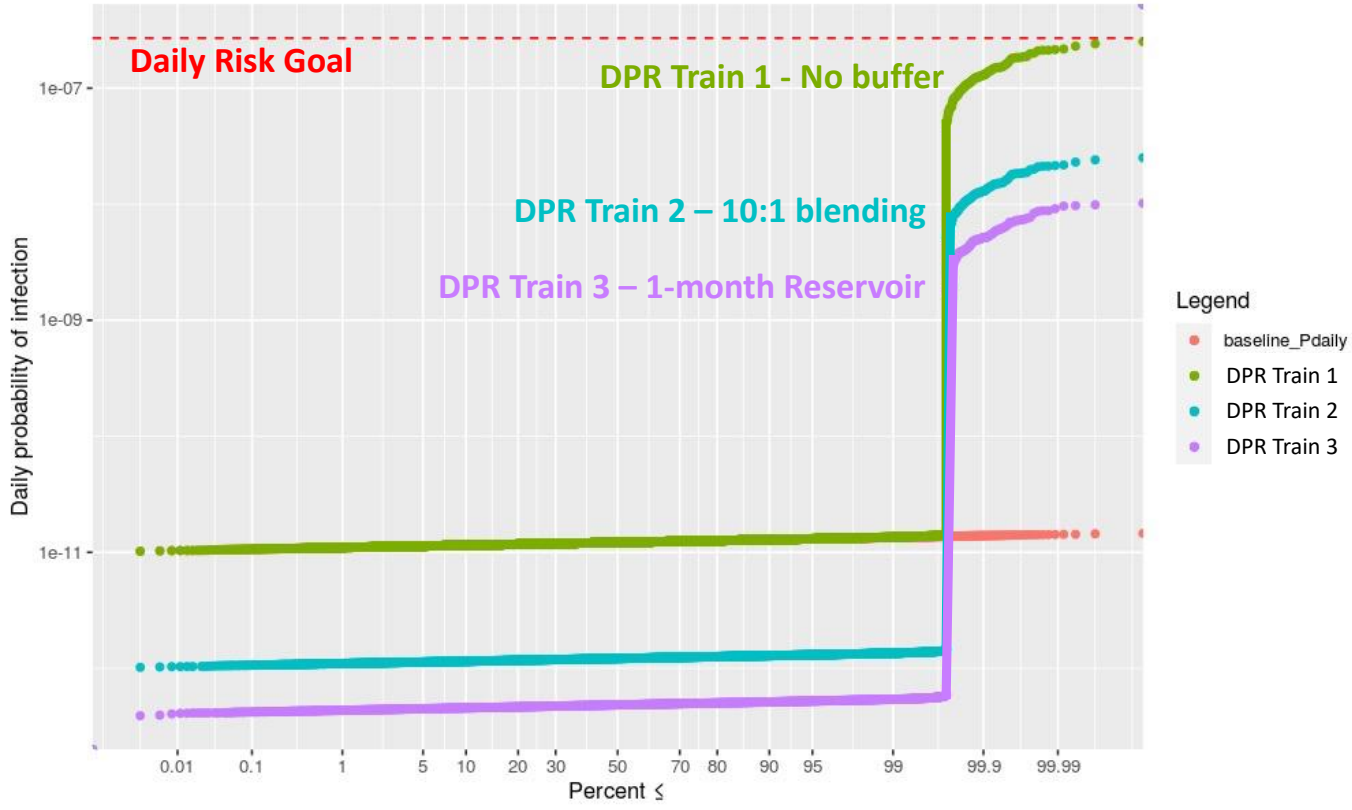
Requirements for DPR – Rebalanced



The combination of project elements and requirements should provide equivalent/reasonable public health protection

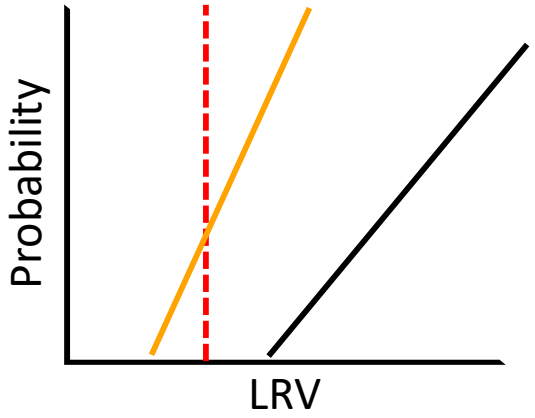
DPRisk – Quantify the Elements of Your Project





DPRisk – Evaluate Treatment and Risk of Your Project

- Use DPRisk to evaluate compliance with treatment and risk goals



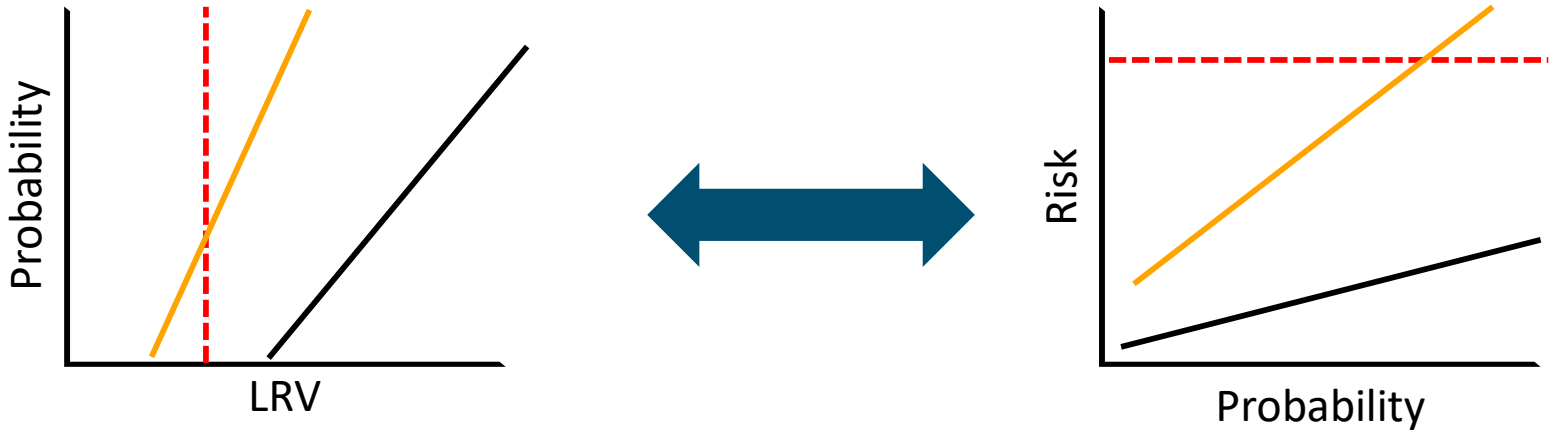
Is my project always complying with the treatment requirements?

How often might my project have to shutdown?

How do failures impact compliance with treatment goals?

DPRisk – Evaluate Treatment and Risk of Your Project

- Use DPRisk to evaluate compliance with treatment and risk goals



Is my project always complying with the treatment requirements?

How often might my project have to shutdown?

How do failures impact compliance with treatment goals?

Does my project always meet the risk thresholds?

How do failures in treatment impact the risk profile?

Is my project protective of public health?

Pathogen Control Criteria Overview

Bob Hultquist

Pathogen Control Criteria Overview

- Pathogen reduction targets to achieve specific health risk goals
- Reliability - multi-barrier treatment, diverse treatment mechanisms, and redundant treatment
- Validate treatment trains to ensure effective pathogen removal
- On-line monitoring
- Pathogen control point critical limits
- Control system that responds appropriately

Pathogen Reduction - Achieve Risk Goal

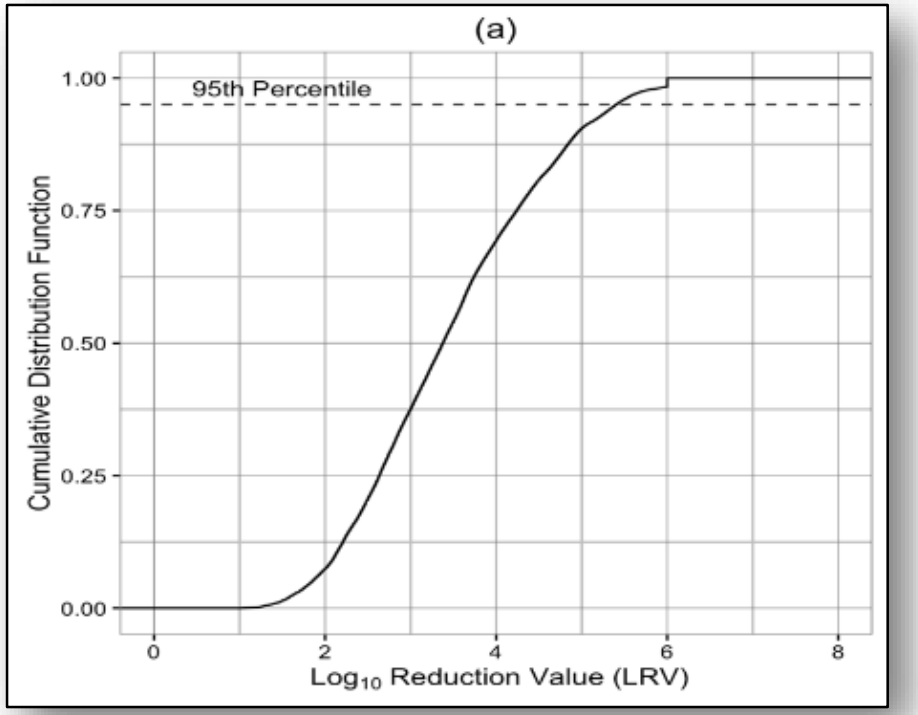
- Risk goal – daily risk of infection for consistent quality
- Reference pathogens - virus , Giardia, and Cryptosporidium
- Wastewater pathogen density - literature review & DPR-2 data
- Worst case wastewater pathogen density
  - NoV gene copies for virus
- Log reduction calculated from ratio of safe density to worst case wastewater density - 16/10/11 for virus , Giardia, and Cryptosporidium respectively

Pathogen Reduction – Treatment Reliability

- For each reference pathogen:
  - At least 4 pathogen treatment processes,
  - At least 3 treatment mechanisms (physical separation, chemical disinfection, UV disinfection)
- Extra (redundant) log reduction capacity (Expert Panel)
  - Quantitative microbial risk assessment (QMRA) used to evaluate failure scenarios – DPR-1: QMRA "DPRisk" tool
  - Critical failure scenario is UV power disruption
  - 4 log LRV deficiency for achieve daily risk goal
  - Hence treatment train must be designed to provide 20/14/15

Pathogen Treatment Validation

- Validate processes and trains
- Determine the LRV a treatment will achieve most of the time (5th percentile LRV)
- Correlate performance with a measurable parameter and identify limits indicating failure



Validation Process

- Identify the mechanism(s) of pathogen reduction by process
- Identify the pathogens addressed or appropriate surrogates for pathogens for validation study
- Identify influencing factors that affect efficacy of process
- Describe method to collect and analyze data: the lower 5th percentile LRV demonstrated is the LRV credited for process
- Determine critical limit(s)

Validation Opportunities

- The treatment required for CEC removal (O3/BAC – RO – AOP) can be validated for pathogen reduction and used to meet the bulk of the required LRTs
- Features of a raw water augmentation project, such as transport time and the “drinking water treatment plant” can be validated for pathogen LRVs

Pathogen Treatment LRVs

- The treatment train LRV for virus, Giardia, and Cryptosporidium is the sum of the treatment process validated 5th percentile LRVs for each pathogen.
- Any pathogen control point parameter that is not meeting the critical limit means that treatment process is not allowed the validated LRV.
- The sum of the treatment process validated log reductions for the treatment train must be at least 20 log for enteric virus, 14 log for Giardia cysts, and 15 log for Cryptosporidium oocysts.

Pathogen Treatment Operation Limits

- Discontinue delivery of water to the distribution system if the treatment train is not achieving LRVs of 16/10/11
- Discontinue delivery if the minimum # of treatment processes or treatment mechanisms are not provided.
- Discontinue delivery within 24 hours if the treatment train is not achieving minimum design LRVs of 20/14/15.

Pathogen Treatment Monitoring & Control

- Treatment LRVs must be tracked continuously with a SCADA system utilizing on-line monitoring for each process that was approved to receive credit for pathogen reduction.
- Control system must have associated alarms that indicate when the process is not operating as designed.
- Control system must be designed to identify a failure of a process to meet its critical limit.
- Control system must be designed to automatically stop the flow of inadequately treated water to the drinking water system before unsafe water reaches the system.

Review of California Draft DPR Regulations: Expert Panel

Adam Olivieri, Dr.PH, PE
Principal and Founder, EOA, Inc.
DDW Expert Panel Co-Chair

Background: California Water Code Requirements

- California Water Code §13561 defines DPR as “the planned introduction of recycled water either directly into a public water system, or into a raw water supply immediately upstream of a water treatment plant.”
- DPR is defined to include, but is not limited to, the following: (1) “raw water augmentation,” which means the planned placement of recycled water into a system of pipelines or aqueducts that deliver raw water to a drinking water treatment plant that provides water to a public water system, and (2) “treated drinking water augmentation” which means the planned placement of recycled water into the water distribution system of a public water system.
- California Water Code (CWC) §13561.2(a) requires the SWB (DDW) to adopt proposed regulations on or before December 31, 2023. (pursuant to AB 574)

Enabling Legislation for Inclusion of Expert Panel

- Prior to adopting the proposed regulations, DDW must submit the proposed criteria to an expert review panel convened pursuant to CWC §13561.2(c). (pursuant to AB 574).
- In addition, the statutory mandate for external scientific peer review (Health and Safety Code §57004) states that the reviewer's responsibility is to determine whether the scientific portion of the proposed rule is based upon sound scientific knowledge, judgment, methods and practices.

Expert Panel Expertise Requirements

- **Microbial Risk Assessment**
- **Chemistry**
- **Microbiology**
- **Water Treatment Engineering**
- **Wastewater Treatment Engineering**
- **Toxicology**
- **Multi-barrier System Reliability**
- **Public Health**
- **Potable Reuse Operations**

Expert Panel Members

James Crook, PhD, PE, Panel Co-Chair

Environmental Engineering Consultant, (Boston, MA)

Adam Olivieri, DrPH, PE, Panel Co-Chair

Principal/Founder, Vice President of EOA, Inc. (Oakland, CA)

Richard Bull, PhD

Toxicologist, MoBull Consulting, (Richland, WA)

Jörg Drewes, Dr-Ing.

Professor, Chair of Urban Water Systems Engineering, Technical University, (Munich, Germany)

Charles Haas, PhD, F AEESP, BCEEM, F ASCE, F AAAS, F AAM, Dist. F IWA, F SRA, NAE

LD Betz Professor of Environmental Engineering
Head of Civil, Architectural, & Environmental Engineering, Drexel University, (Philadelphia, PA)

Joan B. Rose, PhD, NAE

Homer Nowlin Endowed Chair for Water Research Professor, Michigan State University, (East Lansing, MI)

George Tchobanoglous, PhD, PE, NAE, BCEE

Professor Emeritus, University of California (Davis, CA)

Expert Panel Members

Michael P. Wehner

Assistant General Manager, (Retired), Orange County Water District, (Fountain Valley, CA)

Charles Gerba, PhD

Professor, Microbiology & Environmental Sciences, Professor of Public Health, University of Arizona (Tucson, AZ)

Amy Pruden, PhD

W. Thomas Rice Professor, College of Civil and Environmental Engineering, Virginia Polytechnic Institute and State University, (Blacksburg, VA)

Shane Snyder, PhD

Professor of Civil and Environmental Engineering, Nanyang Technological University, (Singapore); Director, Nanyang Environment & Water Research Institute (Singapore)

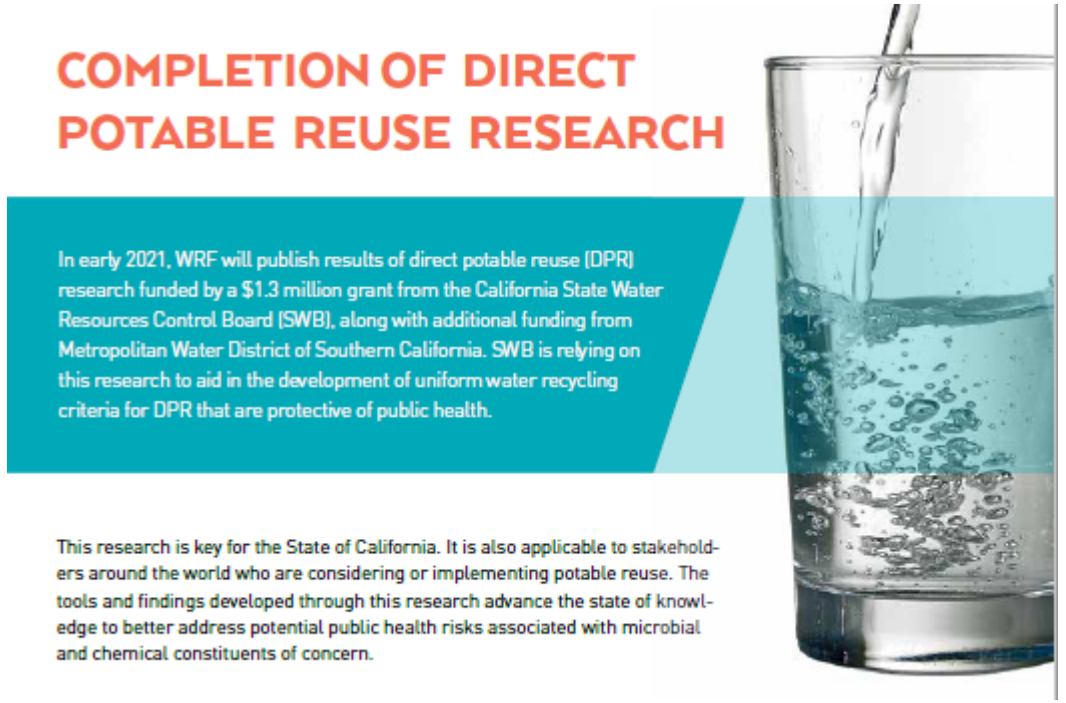
Jacqueline E. Taylor, MPA, REHS

Director, Bureau of Environmental Protection, County of Los Angeles Department of Public Health (Los Angeles, CA)

Proposed Schedule

- Four to Five Full Panel Meetings
  - August 2021 (tentative)
  - Quarterly thereafter though mid-2022
- Technical Work Groups and Support
  - Through December 2023

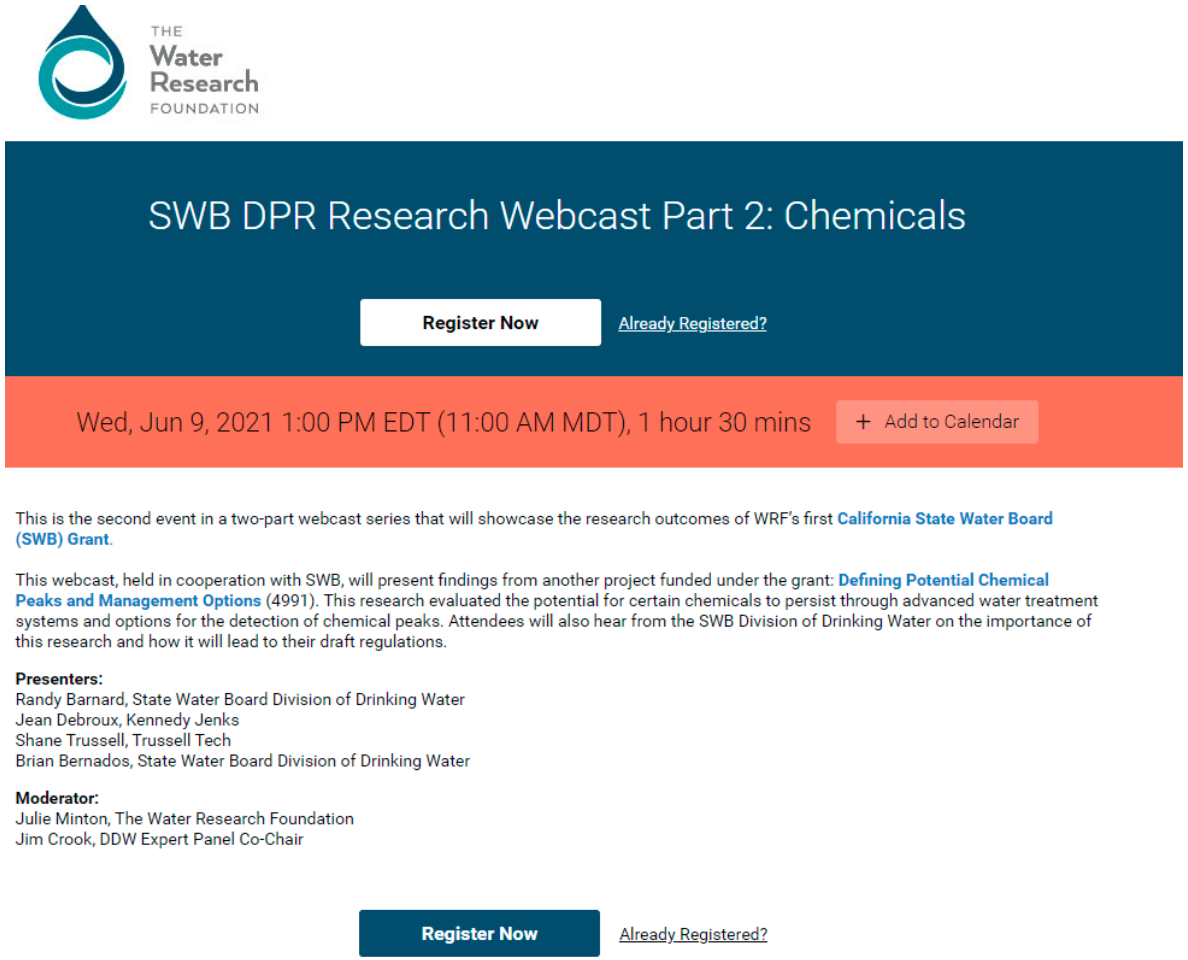
THE Water Research FOUNDATION



Summary flyer available on
https://www.waterrf.org/california-state-water-board-grant

Q&A

SWB DPR Research Webcast Part 2: Chemicals



Register: https://event.webcasts.com/starthere.jsp?ei=1464221&tp_key=cb1efb774c

Thank you

Comments or questions, please contact:

Julie Minton: jminton@waterrf.org

For more information, visit www.waterrf.org