Water Reuse Research

Peter Grevatt, PhD, CEO
The Water Research Foundation

advancing the science of water®

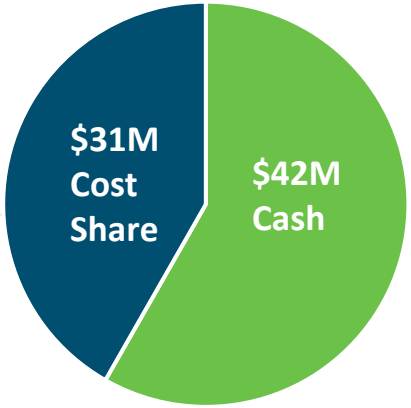
The Water Research Foundation
AT A GLANCE*

Funded Research

$73M

Contractually Funded Research

Managed by 53 Staff



Research Portfolio

1 Federal Contracts

2 Private Grants

3 Federal/State Grants

77 Co-funded Projects

200 Co-funders

210 Active Projects

Subscribers

1040 UTILITIES

88 CONSULTANTS

40 MANUFACTURERS

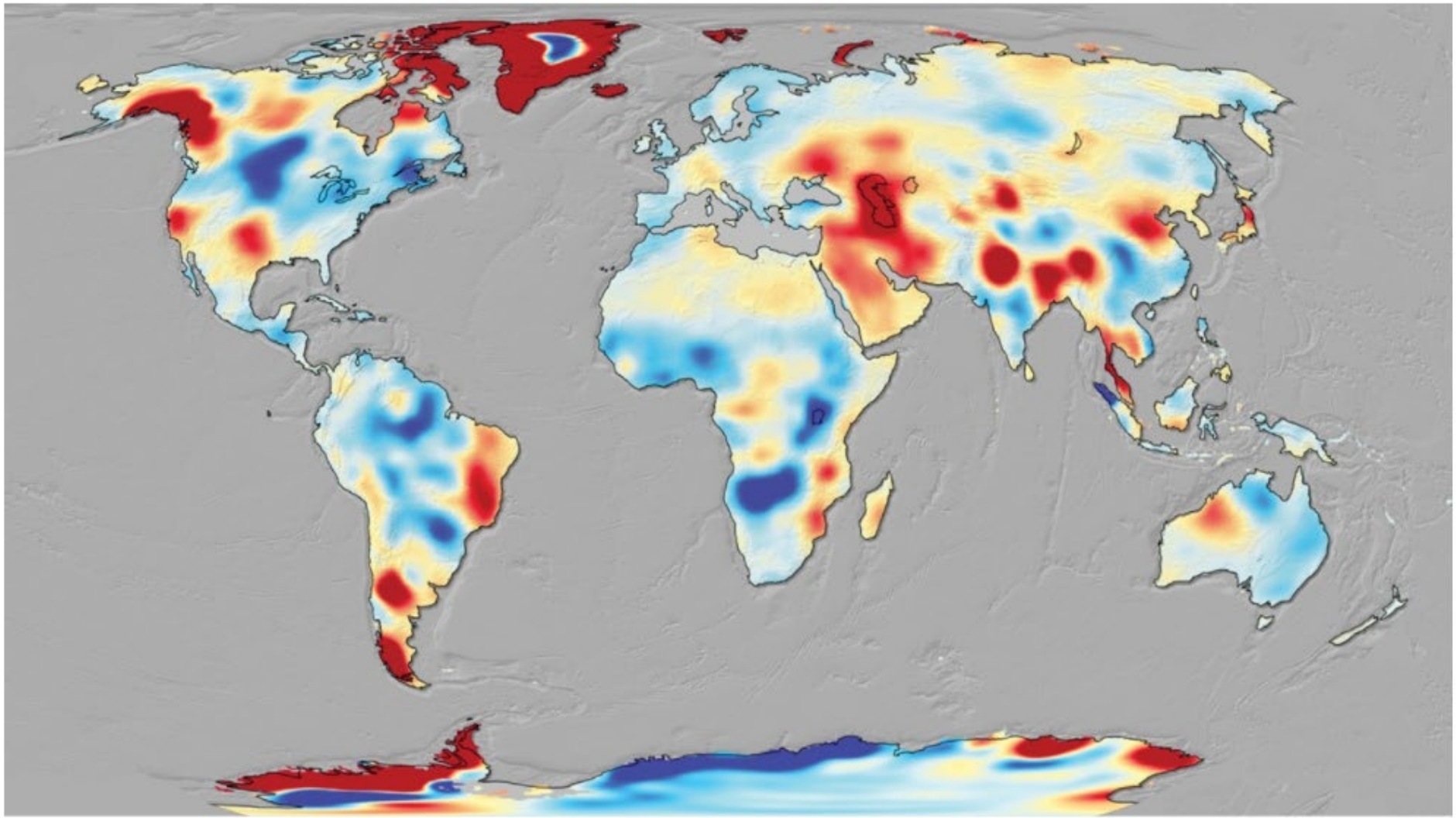
Research & Innovation Programs

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

$.84 OF EVERY DOLLAR supports program services

* As of March 31, 2021

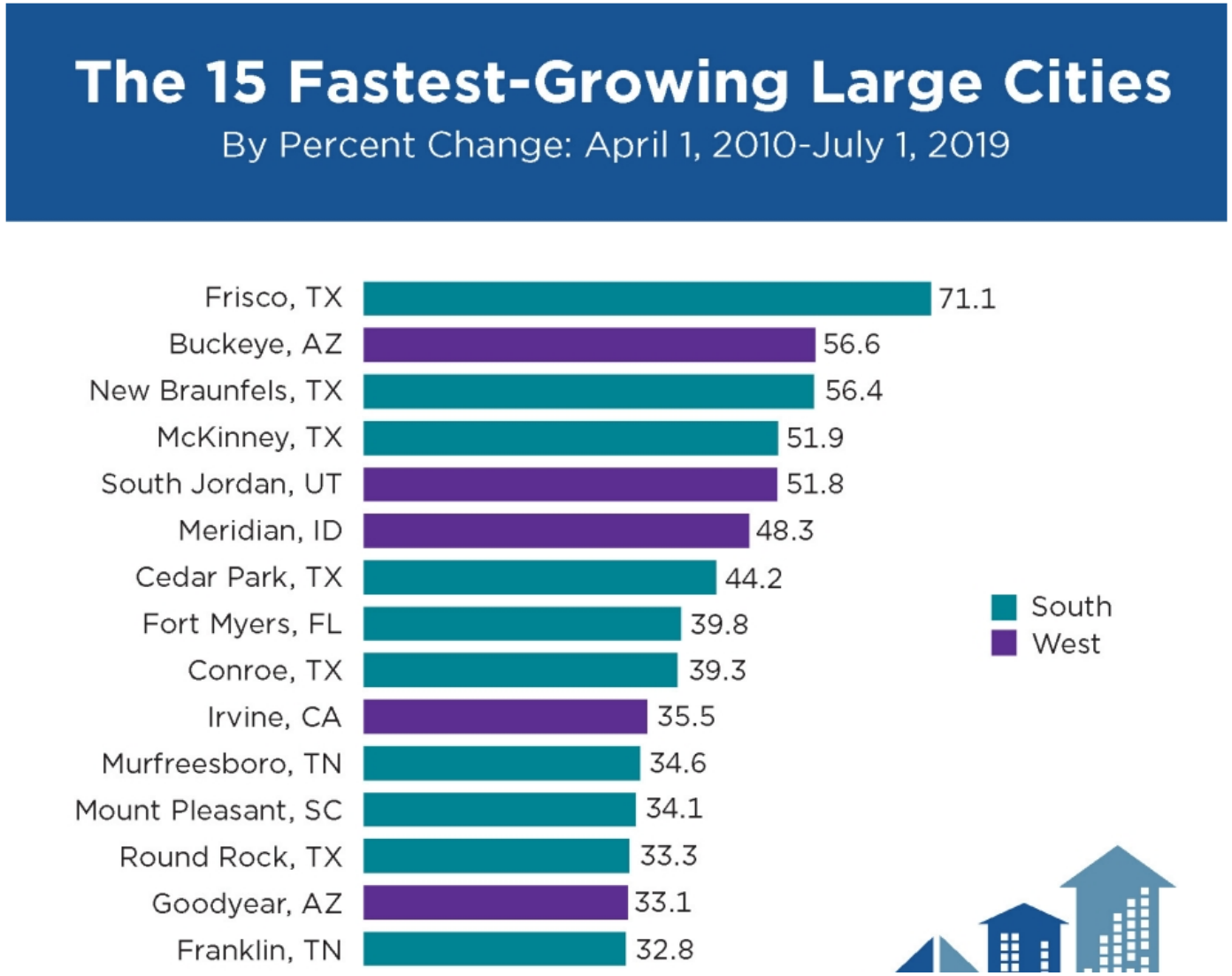
GRACE: A map of the future of water



Source: Jay Famiglietti,
A Map of the Future of Water | The Pew Charitable Trusts (pewtrusts.org)

The 15 Fastest-Growing Large Cities - By Percent Change: 2010-2019

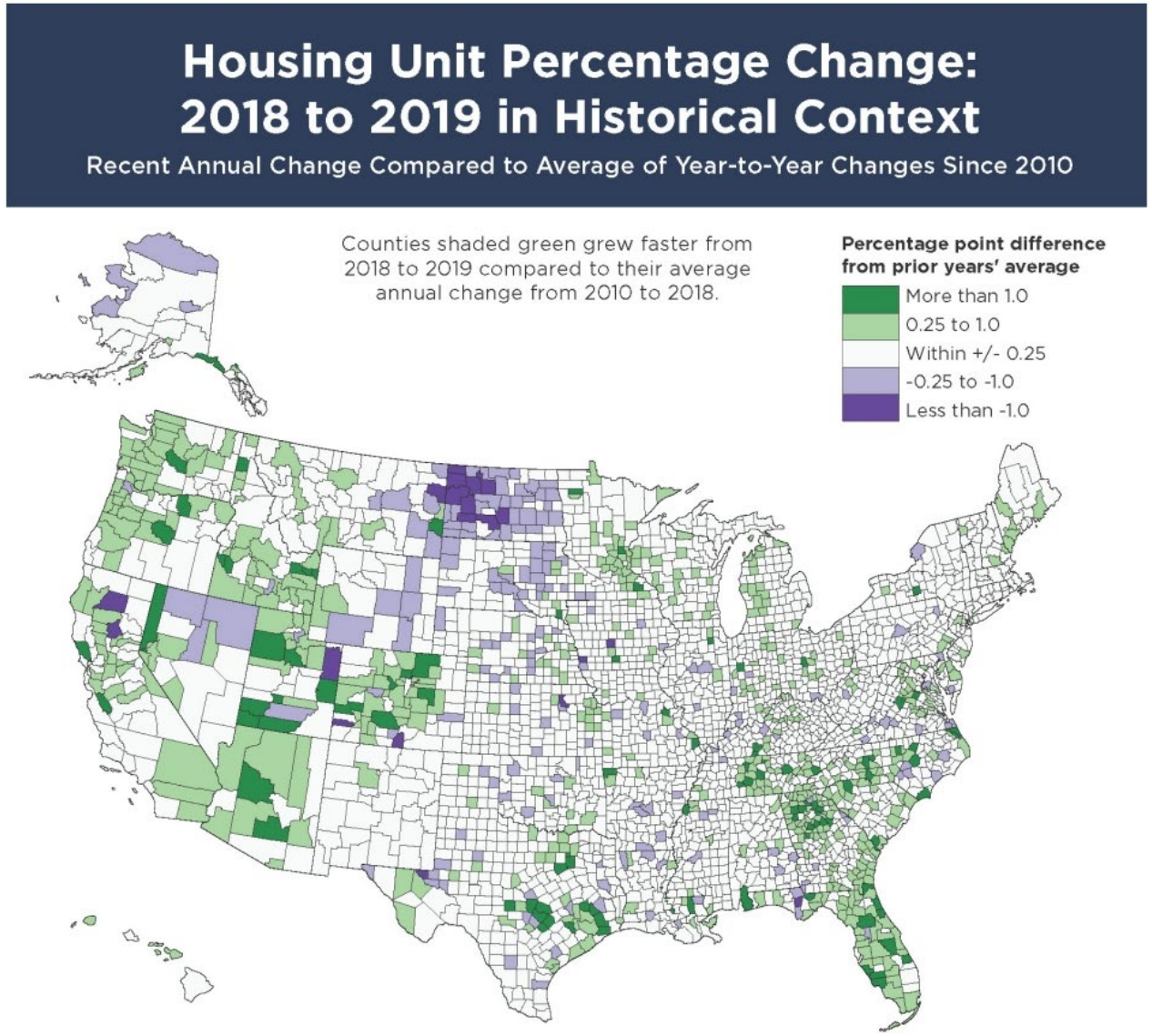
MAY 21, 2020



Source: [The 15 Fastest-Growing Large Cities - By Percent Change: 2010-2019 (census.gov)]

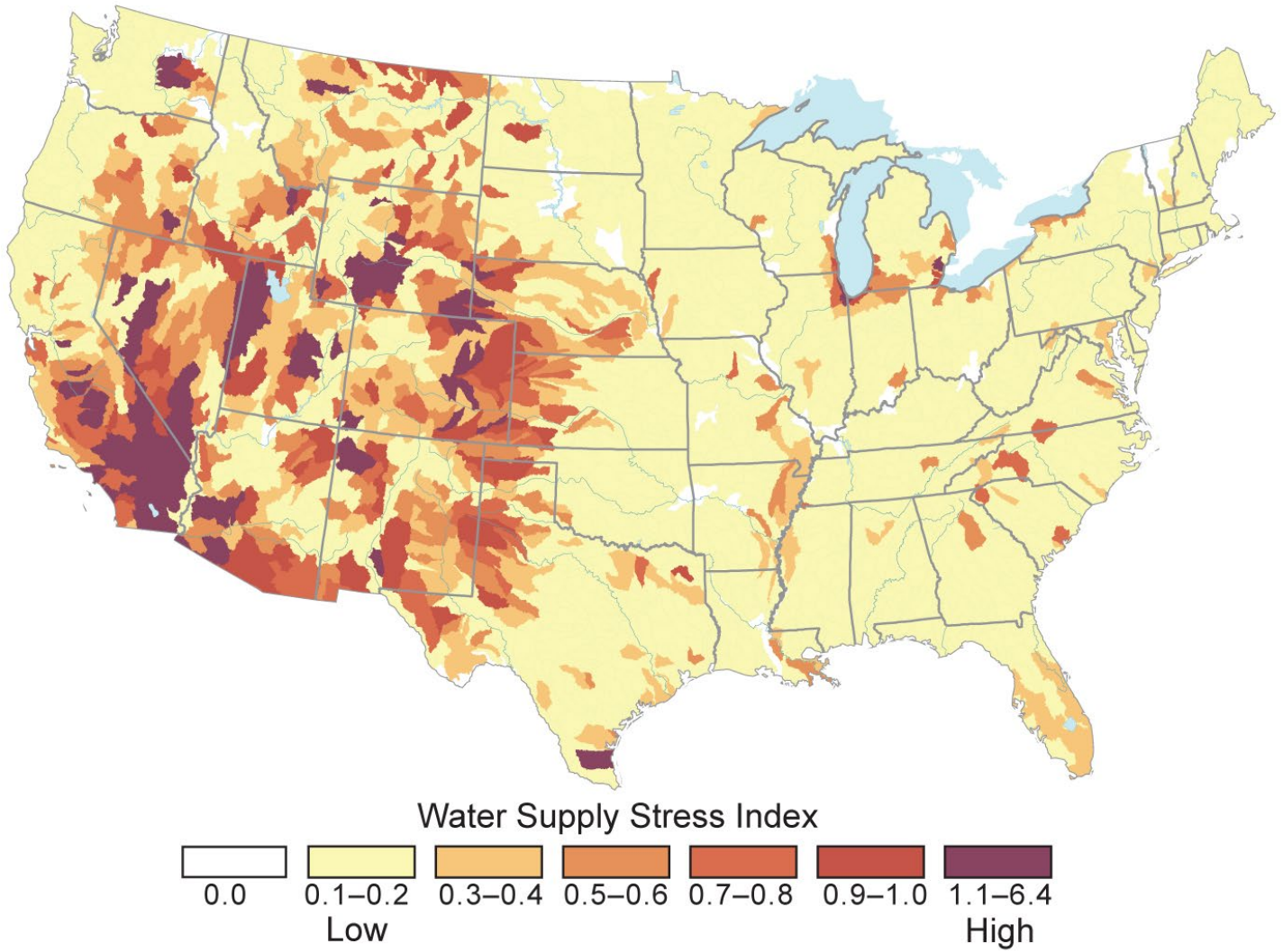
Housing Unit Percentage Change: 2018 to 2019 in Historical Context

MAY 21, 2020



Source: [Housing Unit Percentage Change: 2018 to 2019 in Historical Context (census.gov)]

Water Stress in the U.S.



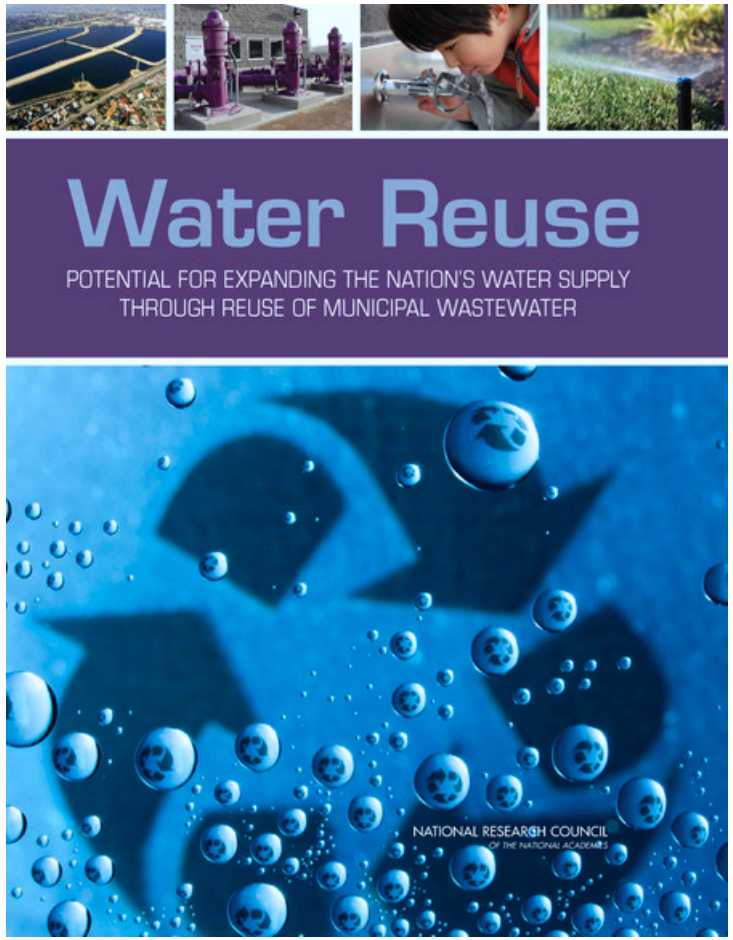
Source: [Water Supply | National Climate Assessment (globalchange.gov)]

National Academy of Sciences Report

Importance to Potable Reuse

"…the use of treated wastewater for beneficial purposes including irrigation, industrial uses, and drinking water augmentation – could significantly increase the nation's total available water resources."

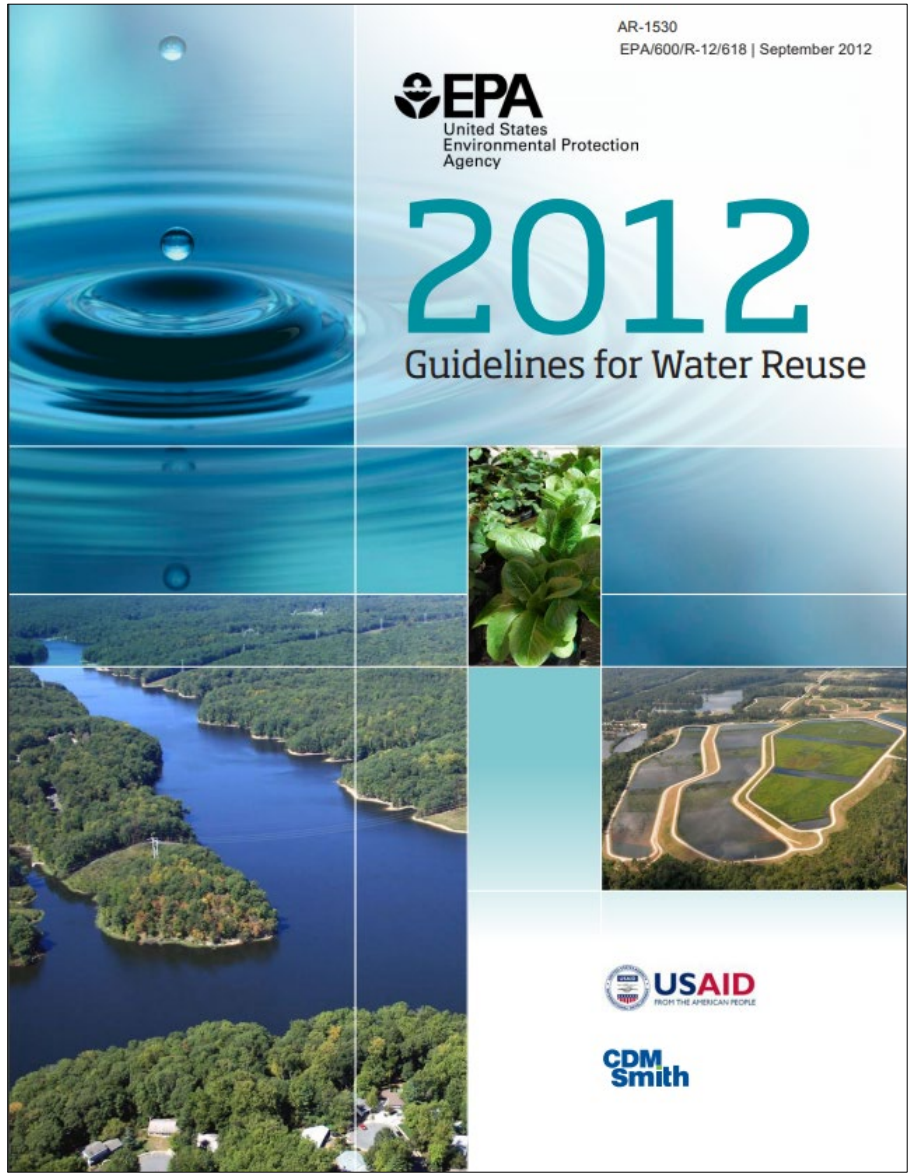
-NAS, 2012



Assessment of Water Reuse as an Approach for Meeting Future Water Supply Needs | National Academies

EPA Guidelines for Reuse

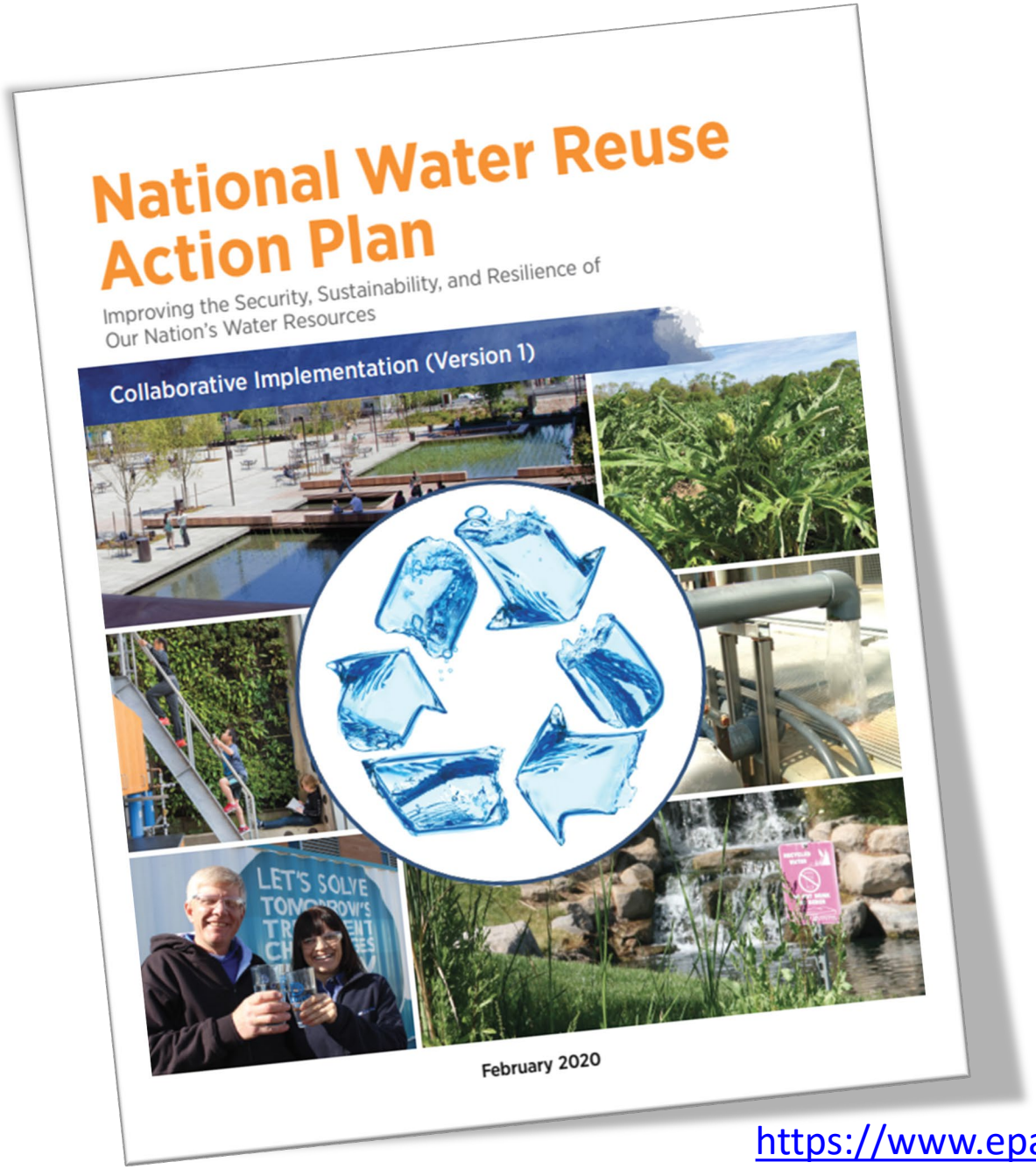
- There are no federal reuse regulations
- EPA has relied on framework of the CWA and SDWA and reuse guidelines
- Reuse is implemented state-by-state; rules are set to be protective of end use



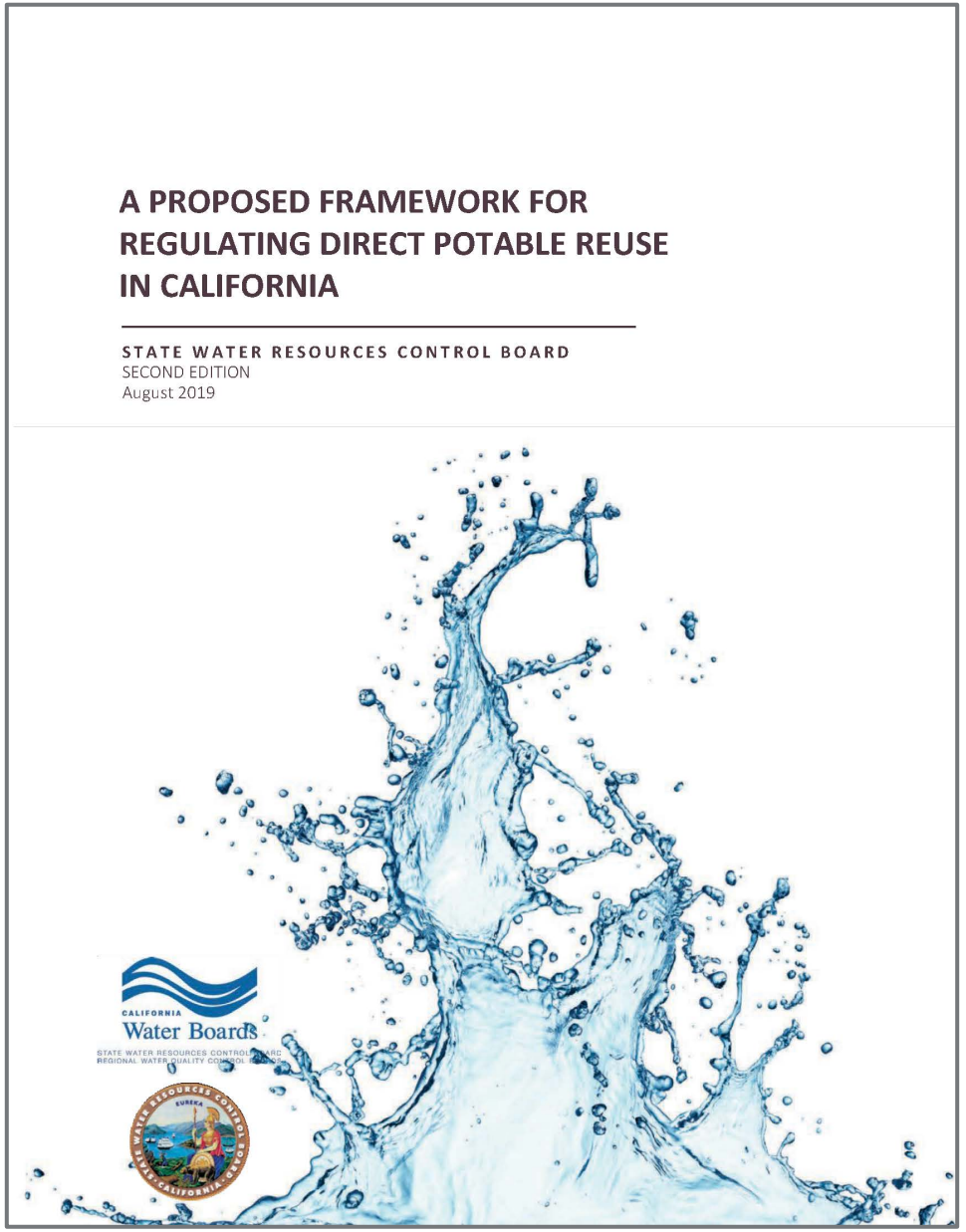
[2012 Guidelines for Water Reuse (epa.gov)]

Potable Reuse Compendium

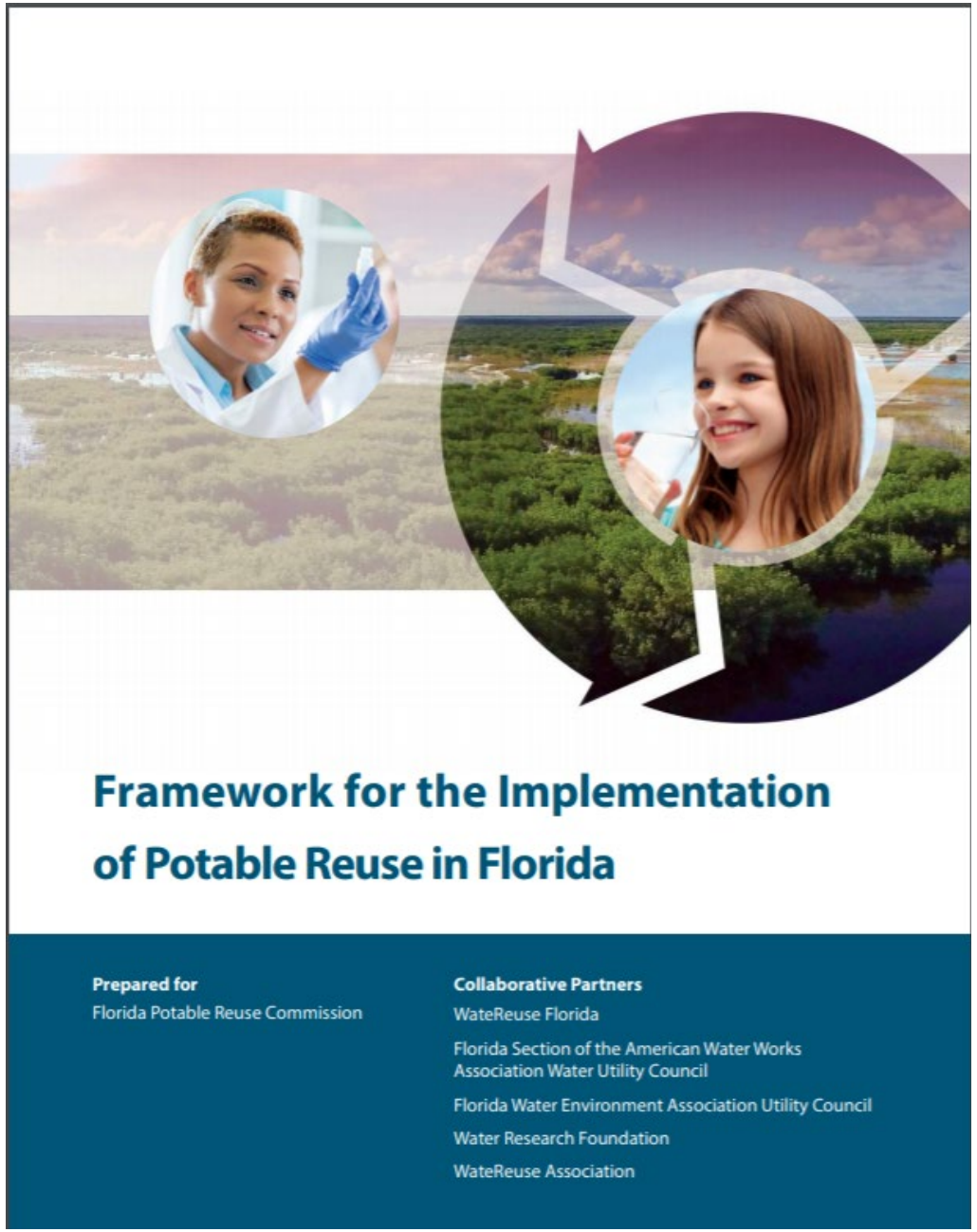
- EPA **supports water reuse** as part of an integrated water resources management approach developed at the state and local level to meet the water needs of multiple sectors including agriculture, industry, **drinking water**, and ecosystem protection.
- EPA **acknowledges the importance of potable water reuse** and looks forward to **working with our stakeholders as the practice continues to be developed and deployed** as an important approach to ensure a clean, safe, and sustainable water supply for the nation.



https://www.epa.gov/waterreuse/water-reuse-action-plan



[A Proposed Framework for Regulating Potable Reuse in California, Second Edition]



[Florida | WateReuse Association]

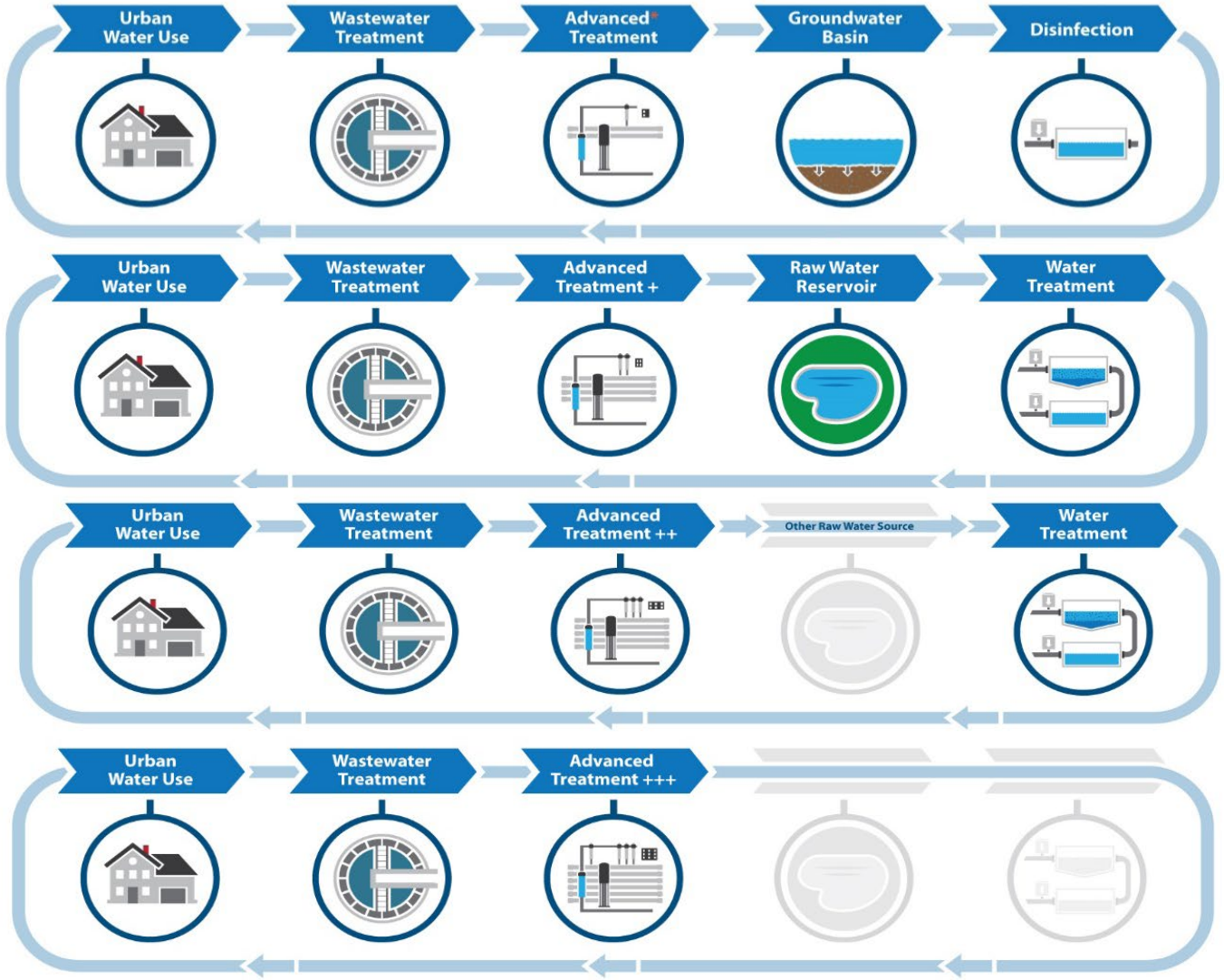
Potable Reuse Continuum

Groundwater Augmentation
Indirect

Reservoir Water Augmentation
Indirect

Raw Water Augmentation
Direct

Drinking Water Augmentation
Direct

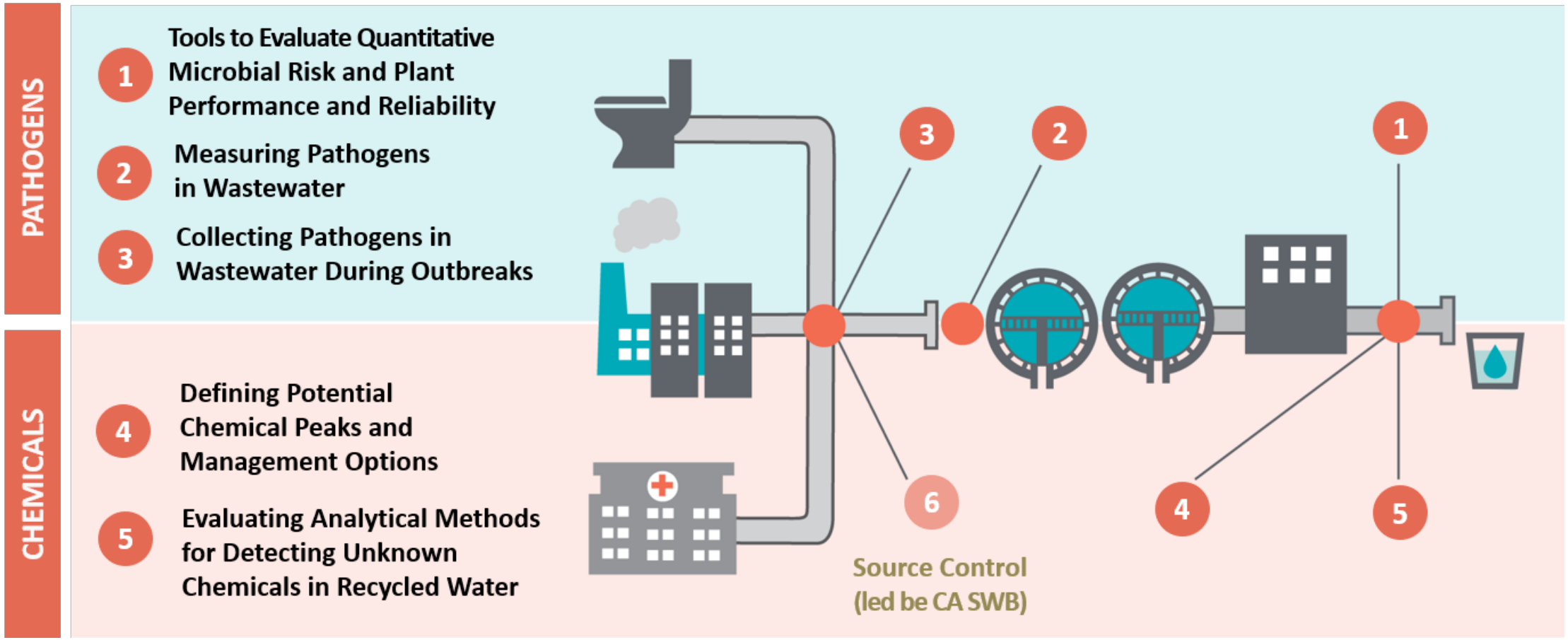


Partnership with CA State Water Board -$4.5M

- The first grant ($1.4M) funded 5 projects which were recommended by the SWB Expert Panel in their report on the feasibility of developing criteria for DPR. Each of these studies have been completed:
  - 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
- CA legislation SB 574 (2017) established a deadline for the DPR regulations of 2023
- Thanks to the Coordinating Committee (Adam Olivieri, Jim Crook, Robert Brownwood (DDW), Claire Waggoner), and the outstanding research teams

https://www.waterrf.org/research/topics/reuse

Projects to Inform the Development of DPR Regulations



California Draft Pathogen Control Criteria 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 in 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

DPR-2 Measure Pathogens in Wastewater

Develop recommendations for the collection and analysis of pathogen data in raw wastewater that may be used in future monitoring efforts

- Literature Review Pathogens & Methods
- Methods Optimization
- Pathogen Monitoring
- Data Analysis QC

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

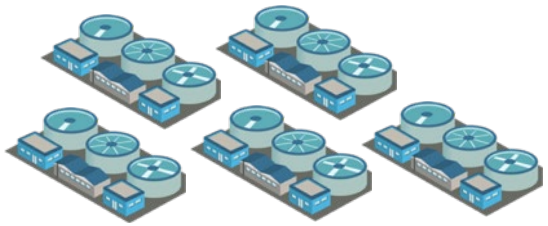
Extensive new dataset from 14-month campaign

San Francisco Water Power Sewer
Services of the San Francisco Public Utilities Commission

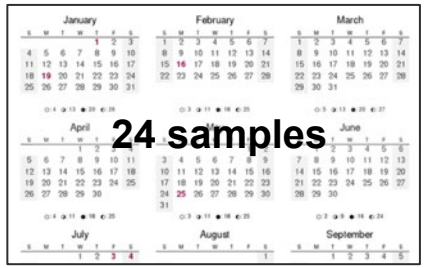
LOS ANGELES COUNTY SANITATION DISTRICTS
Converting Waste Into Resources

environment LA SANITATION
CITY OF LOS ANGELES

The City of SAN DIEGO



Five facilities



120 Samples of Pathogens & Indicators

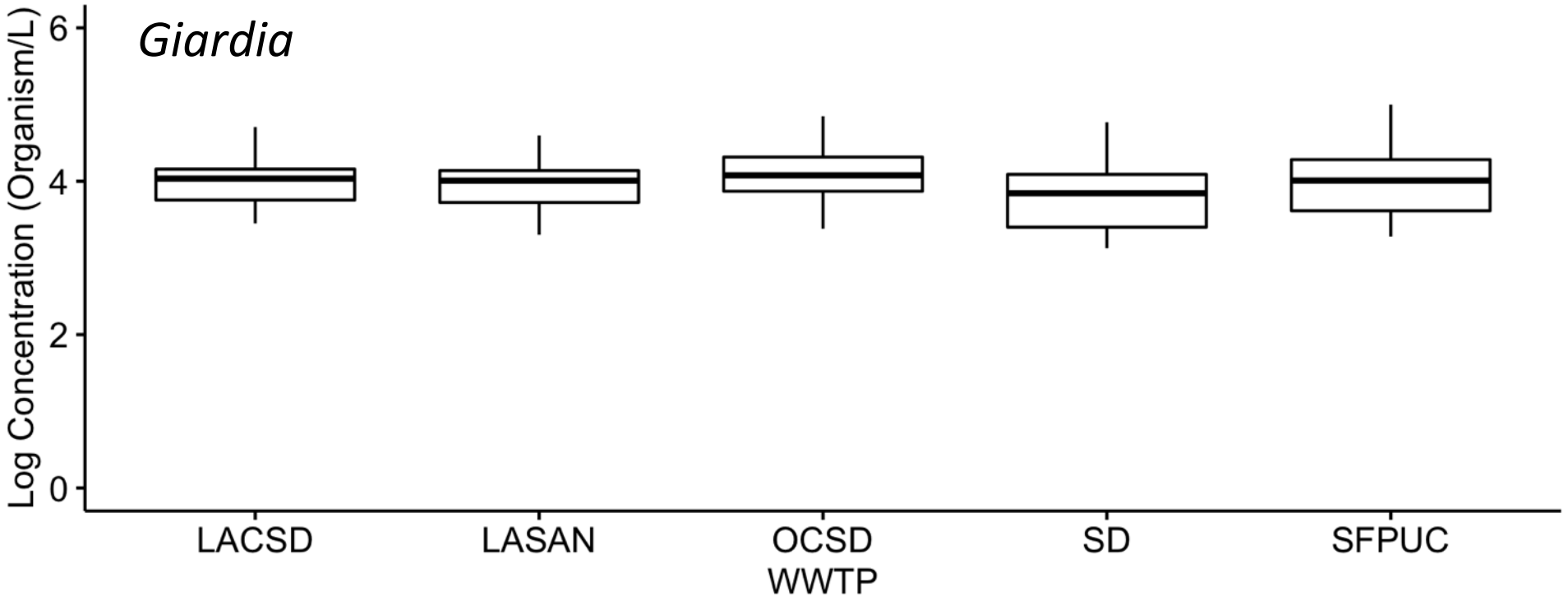
- Enterovirus (culture)
- Enterovirus (PCR)
- Adenovirus (culture)
- Adenovirus (PCR)
- Norovirus (PCR)
- SARS-CoV-2 (PCR)

- *Giardia*

- *Crypto*

[From SWB DPR Research Webcast Part 1: Pathogens](#) – recording available at www.waterrf.org

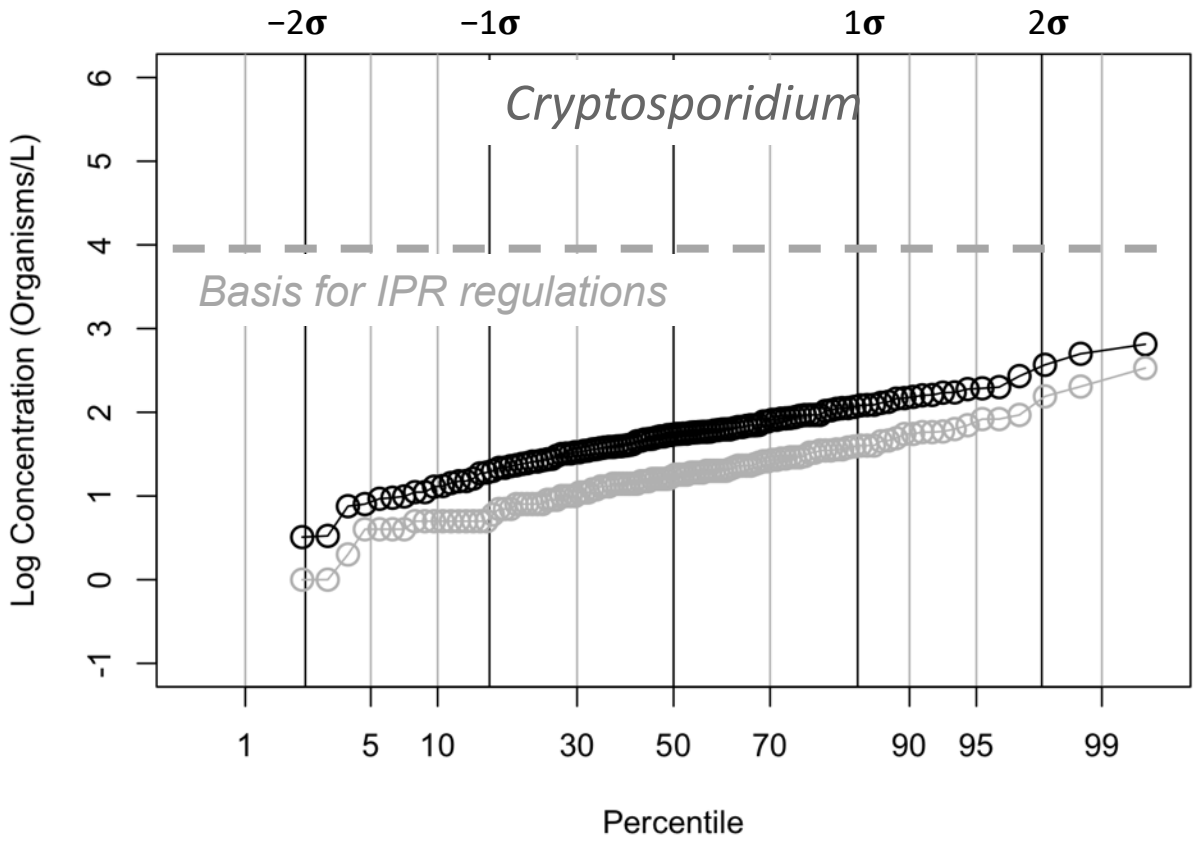
Applicability of findings across treatment plants

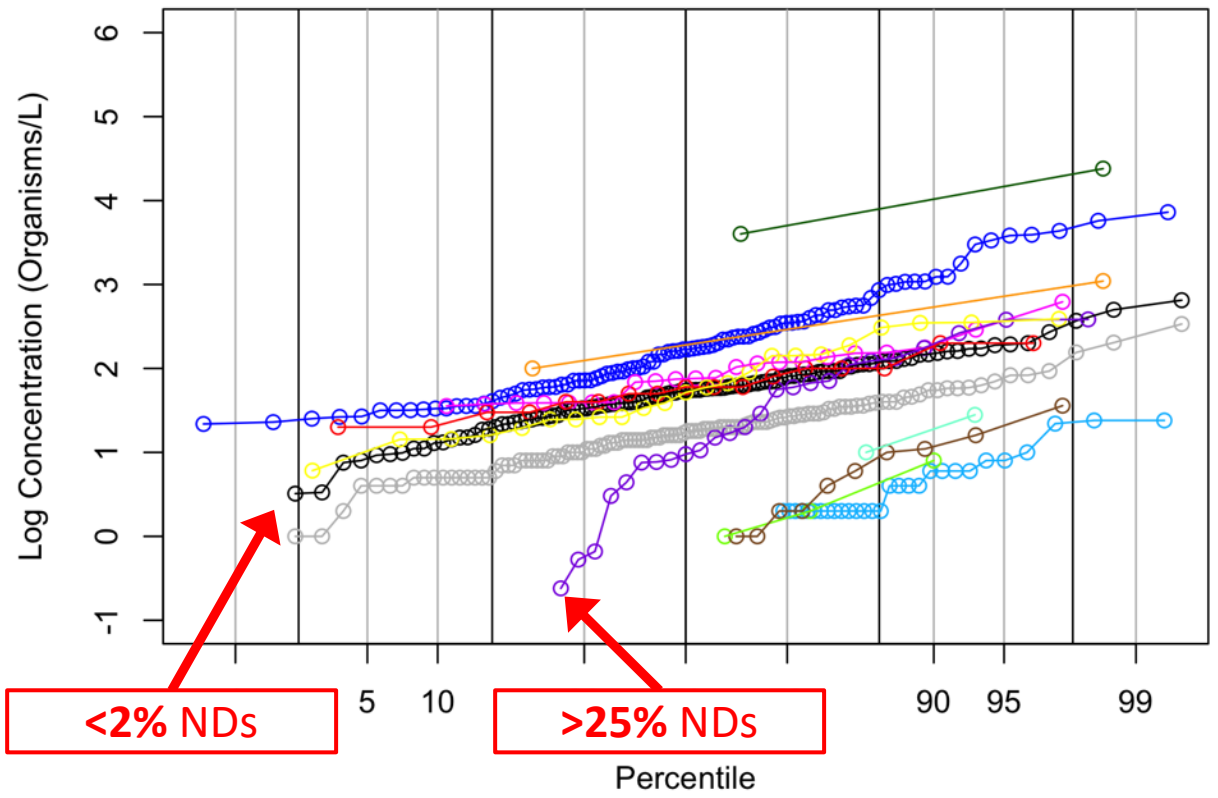


- Generally, no statistical difference in concentrations between facilities
- Findings are widely applicable for the California population

From SWB DPR Research Webcast Part 1: Pathogens – recording available at www.waterrf.org

A Closer Look: Pathogen Distributions



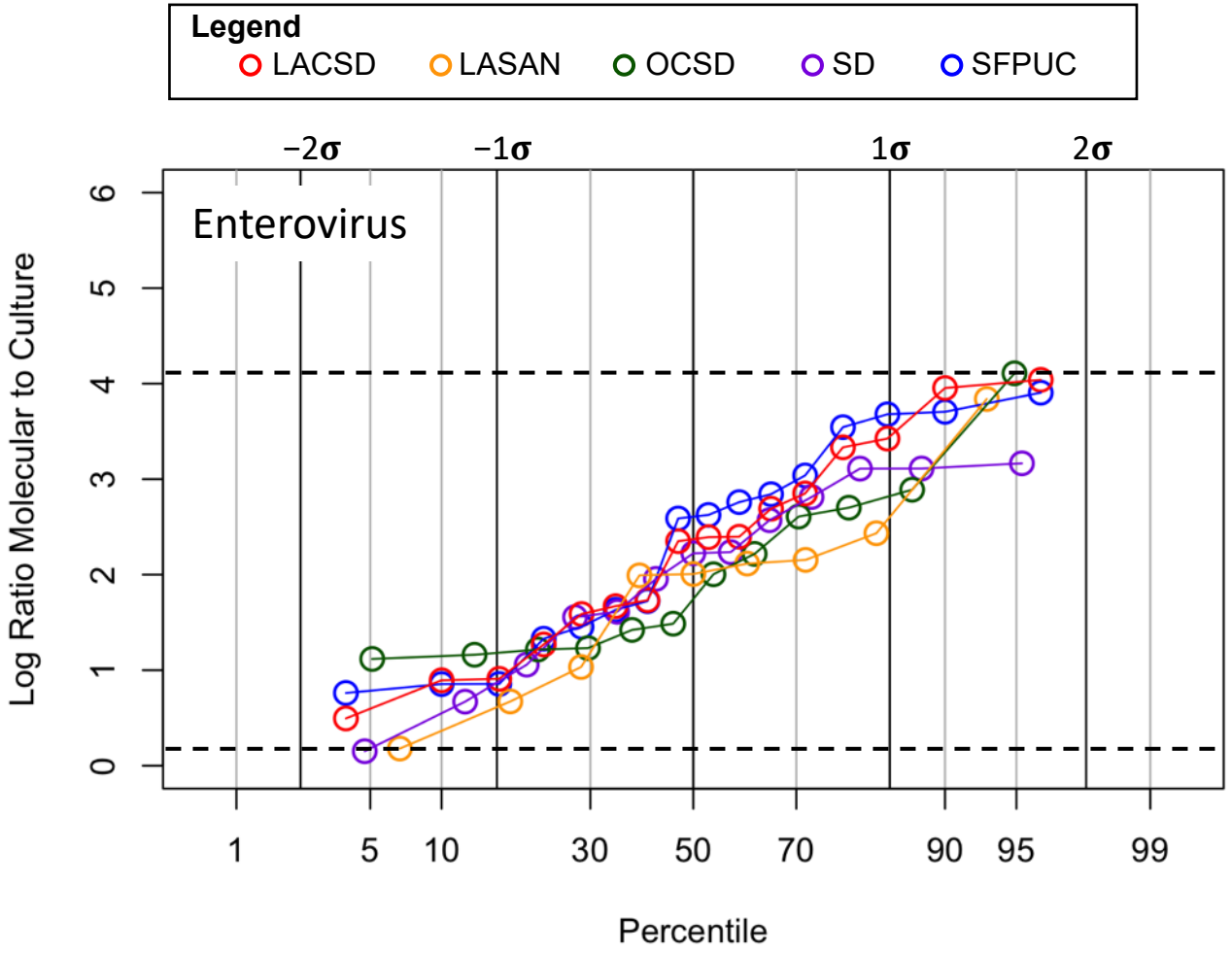


- Only two studies correct for recovery
- DPR-2 among highest rate of detects

From SWB DPR Research Webcast Part 1: Pathogens – recording available at www.waterrf.org

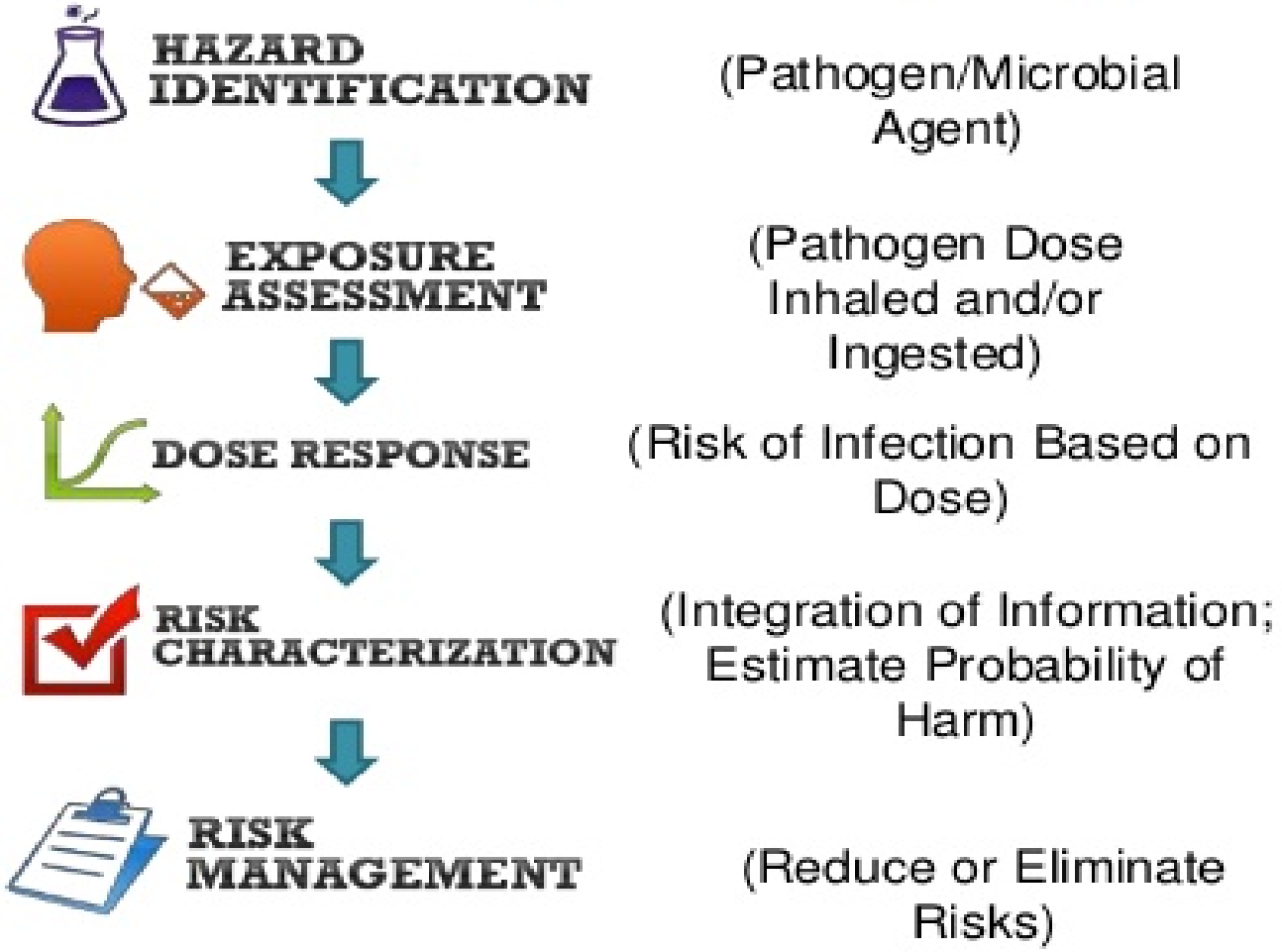
Culture vs. Molecular: What to use?

- 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)



From SWB DPR Research Webcast Part 1: Pathogens – recording available at www.waterrf.org

DPR-1 Develop QMRA tool to evaluate quantitative microbial risk and plant performance/reliability



Estimation of Infectious Risks in Residential Populations Near a Center Pivot Spraying Dairy Wastewater Robert S. Dungan, Ph.D. USDA-ARS

From SWB DPR Research Webcast Part 1: Pathogens – recording available at www.waterrf.org

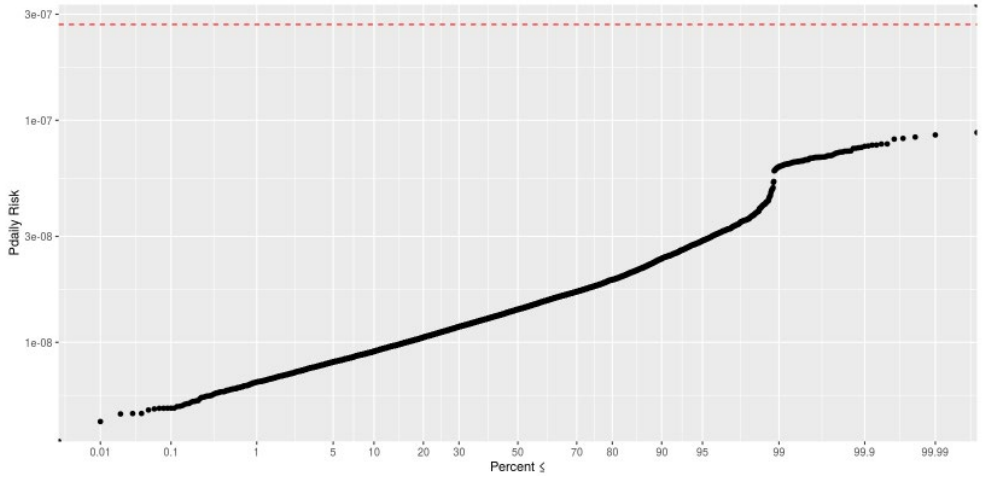
DPRisk Tool and Guidance Document

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
- **Exposure**
  - Volume, Frequency (1 to 96 per day)
- **Dose Response**
  - Default Models, User-Defined Parameters

OUTPUTS:

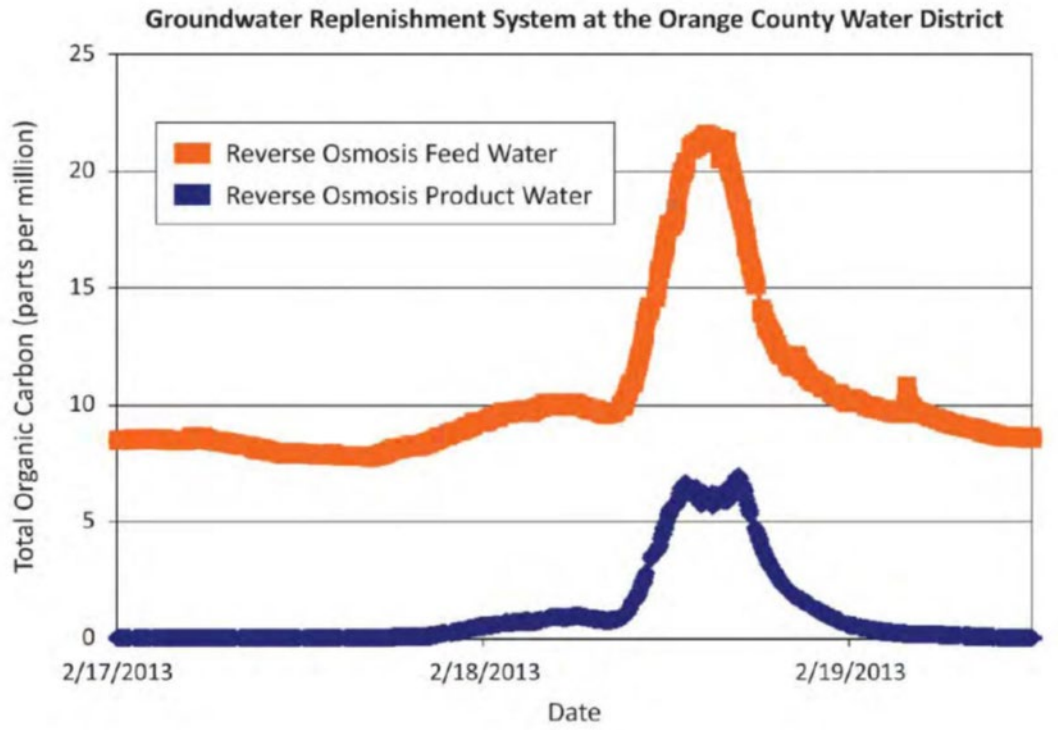
- **Probabilistic Assessment of Treatment Train Performance**
  - Simulated Treatment Train LRVs
  - Simulated Unit Process LRVs
  - Benchmark LRVs (exact LRV to achieve target risk)
- **Quantitative Microbial Risk Assessment**
  - Distributions for QMRA Inputs
  - Daily Risk
  - Annual Risk



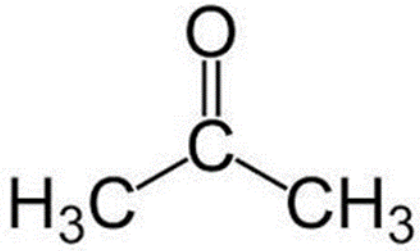
From SWB DPR Research Webcast Part 1: Pathogens – recording available at www.waterrf.org

DPR-4: Treatment for Averaging Potential Chemical Peaks

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



Acetone



From SWB DPR Research Webcast Part 2: Chemicals – recording available at www.waterrf.org

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The Water Research Foundation Reuse Research Update

July 2021

Partnership with CA State Water Board - $4.5M Grant

SWB Grant 1

The first grant ($1.4M, D1705002) funded 5 projects which were recommended by the SWB Expert Panel in their report on the feasibility of developing criteria for DPR. The SWB's Division of Drinking Water will use these research findings to develop regulations for DPR, driven by the CA legislation SB 574 (2017), which established a deadline for the DPR regulations of 2023.

The DPR projects under this grant have been completed. Two have been published, the others are undergoing final copyediting, and a webtool has been developed:

- DPR1: A copy of QMRA DPRisk is available at cawaterdatadive.shinyapps.io/DPRisk with an approved shinyapps.io account. To obtain authorization, send an email to DDWrecycledwater@waterboards.ca.gov, including your name, phone number, organization, and project (if any). Include "DPRisk" in the subject of your email. DDW will review all requests after WRF posts the guidance document for the DPRisk tool.
- DPR4: Defining Potential Chemical Peaks and Management Options (4991-Kennedy/Jenks)
- DPR5: Evaluating Analytical Methods for Detecting Unknown Chemicals in Recycled Water (4992-SCCWRP)

Over the past few months, WRF has shared the findings and conclusions of this research through numerous outreach activities, including a press release, CWEA article, social media, Advances in Water Research article, Symposium Roundtable, special DPR Flyer, and two webcasts with the State Water Board and the Metropolitan Water District of Southern California (Webcast Part 1: Pathogens; Webcast Part 2: Chemicals). Great thanks to the members of the Coordinating Committee for their participation and oversight (Adam Olivieri, Jim Crook, Robert Brownwood (DDW), Claire Waggoner (DWQ)), and to each of the researchers who contributed to this outstanding work.

SWB Grant 2

Grant 2 ($3.1M, D1705003) uses the WRF Research Priority program process for research on potable and non-potable reuse. The SWB agreement has been modified to extend the end date to mid-2024. SWB Project list with objectives.

1. **Phase 1 – 2 Projects approved in 2017:** All projects are contracted and are underway.
   - Evaluation of Constituents of Emerging Concern Removal by Ozone/Biological Activated Filtration Treatment (4832-Trussell Technologies)
   - Understanding Wastewater Treatment Performance on Advanced Water Treatment Processes and Finished Water Quality (4833-Carollo Engineers)
2. **Phase 2 – 12 Projects approved in 2018: All 12 projects are underway.**
   - Considerations and Blending Strategies for Drinking Water System Integration with Alternative Water Supplies (4953-Hazen and Sawyer)
   - Integration of High-Frequency Performance Data for Microbial and Chemical Compounds Control in Potable Reuse Treatment Systems (4954-Trussell Technologies)
   - Indicator Viruses to Confirm Performance of Advanced Physical Treatment (4955-U of Arizona)
   - Compiling Evidence of Pathogen Reduction through Managed Aquifer Recharge and Recovery (4957-Carollo Engineers)
   - New Techniques, Tools, and Validation Protocols for Achieving Log Removal Credit across NF and RO Membranes (4958-Carollo Engineers)
   - Evaluation of Tier 3 Validation Protocol for Membrane Bioreactors to Achieve Higher Pathogen Credit for Potable Reuse (4959- Carollo Engineers)
   - Review of Industrial Contaminants Associated with Water Quality or Adverse Performance Impacts for Potable Reuse Treatment (4960-Virginia Tech)
   - The Use of Next Generation Sequencing (NGS) Technologies and Metagenomics Approaches to Evaluate Water and Wastewater Quality Monitoring and Treatment Technologies (4961-Virginia Tech)

- Identifying the Amount of Wastewater that is Available and Feasible to Recycle in California (4962-UC Davis)
- Developing a New Foundational Understanding of SAR-Soil Structure Interactions to Provide Management Options for Recycled Water Use in Agriculture (4963-UC Davis)
- Assessing the State of Knowledge and Impacts of Recycled Water Irrigation on Agricultural Crops (4964-UC Davis)
- Potential of Oilfield Produced Water for Irrigation in California (4993-Pacific Institute)

3. **Phase 3 – 6 Projects approved in 2019: All 6 projects are underway.**
   - Guidelines for the Demonstration of Pathogen Log Removal Credits in Wastewater Treatment (5047-San Diego State)
   - Integrating Real-Time Collection System Monitoring Approaches into Enhanced Source Control Programs for Potable Reuse (5048-Carollo Engineers)
   - Public Health Benefits and Challenges for Blending of Advanced Treated Water with Raw Water Upstream of a Surface Water Treatment Plant in DPR (5049-Carollo Engineers)
   - Applicability of the UV/Chlorine AOP: Assessment of Applicability, Operational Issues, and Potential By-Products (5050-U of Toronto)
   - Geochemical Considerations for Managed Aquifer Recharge (MAR) Implementation in Potable Reuse (5051-Jacobs Engineering)
   - Standardizing Methods with QA/QC Standards for Investigating the Occurrence and Removal of ARB/ARGs in Wastewater and Advanced Treated Water (5052-Virginia Tech)

Additional Reuse Projects

- WRF recently awarded William Becker, CU Boulder (also Hazen and Sawyer) in response to the RFP for *Assessing Water Quality Monitoring Needs, Tools, Gaps, and Opportunities for Potable Water Reuse* (5079).
- Partnership with SWB and SCCWRP: A LOA has been finalized with SCCWRP to partner on SWB Prop 1 funded Project D1905006, *Research to Develop and Standardize Bioanalytical Screening Tools.* WRF is funding $245,000 for one out of 5 tasks – *Develop Standard Operating Procedures for the Collection, Storage and Extraction of Aqueous Samples for IVB Screening* (4828). Louisiana State University is leading this work.
- In the Unsolicited Research program, *Use of DNA Nanostructures as Viral Surrogates in Potable Reuse Applications* (5104) was selected. Dan Gerrity from Southern Nevada Water Authority is the PI.
- In the fall of 2021, WRF will release an RFP, *Demonstration of Innovation to Improve Pathogen Removal, Validation, and/or Monitoring in Carbon Based Advanced Treatment for Potable Reuse*.

National Water Reuse Action Plan

WRF is lead on WRAP Action No. 7.2: *Develop a Coordinated National Research Strategy on Water Reuse*. The Steering Committee and partners EPA, WRA, AWWA, and WEF, have held several calls and recorded a 90-minute session for the WRA Symposium in September 2020. WRF has developed a multi-step scope of work, completing the WRF-led tasks. To keep the project moving, as part of Phase 1, we are developing a research strategy for stormwater capture and use. This will incorporate *Assessing the State of Knowledge and Research Needs for Stormwater Harvesting* (4841) results and is in partnership with Action 3.3 led by EPA's Dave Smith.

Additionally, WRF is lead on WRAP Action No. 3.2: *Identify Monitoring Practices for Reuse Applications.* This action leverages research to share specific and actionable information on monitoring practices with the water reuse community with a focus on current and novel monitoring practices and techniques.

Other Reuse Research Activities

WRF submitted a proposal with University of Arizona in January 2021 in response to EPA's STAR RFA *Viral Pathogen and Surrogate Approaches for Assessing Treatment Performance in Water Reuse*. We are currently awaiting the final funding decision.