Citizens Water Advocacy Group

National Trends in Potable Water Reuse

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May 9, 2015

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Engineers...Working Wonders With Water®

Today's Agenda

- Introduction
- Reuse 101
  - Reuse in the Water Resources Context
  - The Ways Water can be Reused
  - Arizona's Regulatory Framework
  - Trends in Water Reuse
- Direct Potable Reuse
  - Water Quality Criteria
  - Treatment Technologies
- Resources
- Wrap up, Q&A

Carollo's Background and History

- Founded in 1933
- Professional services corporation
- 34 offices
- 650 employees
- 325 professional engineers

WATER

OUR FOCUS
OUR BUSINESS
OUR PASSION

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Engineers...Working Wonders With Water®

Reuse 101

Much like with your Retirement Planning, A Diverse Portfolio is a Prudent Response

- Integrated Water Resource Planning
  - Surface Water
  - Groundwater
  - Reclaimed Water
  - Stormwater
  - Conservation
  - Drought Response Measures

Graphic credit: www.wef.org

Reuse in the Water Resources Context

Graphic credit: www.healthywaterways.org

- All water is recycled
  - De facto
  - Intentional
- "New" supply
- Efficiency of existing supply
- One time or continuous
- In the gap between CWA and SDWA

The four ways water can be reused…



Non-Potable Reuse (NPR) or
"Direct Reuse" (Purple Pipe)

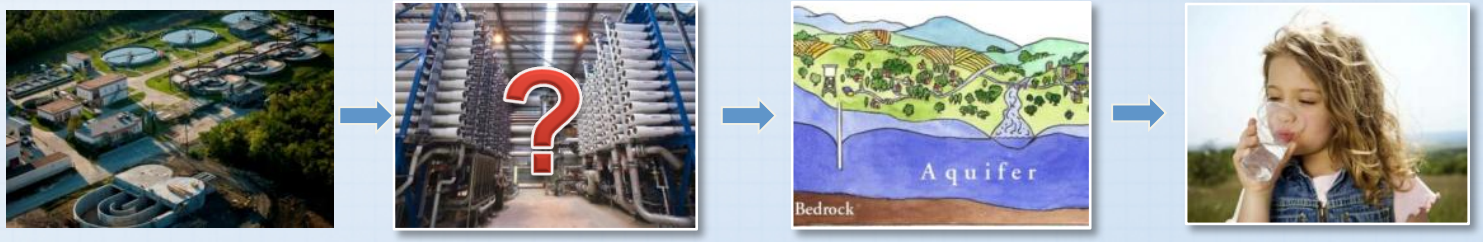



"De Facto"
Potable Reuse

The four ways water can be reused…

Non-Potable Reuse (NPR) or "Direct Reuse" (Purple Pipe)

Indirect Potable Reuse - Surface Water Augmentation



Indirect Potable Reuse - Groundwater Recharge

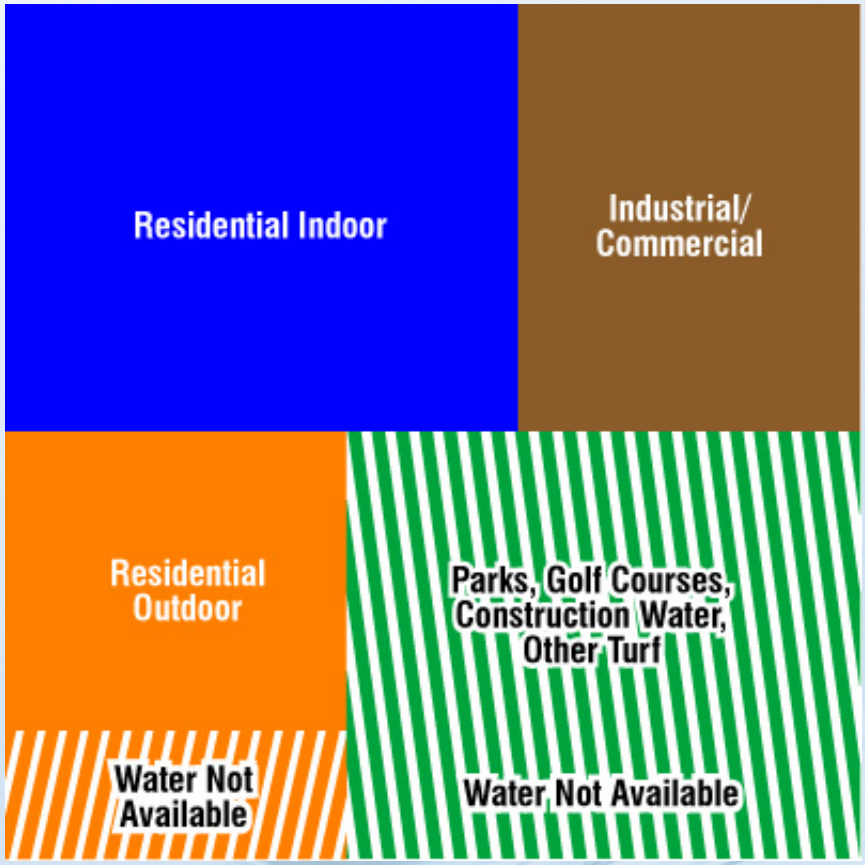
Direct Potable Reuse

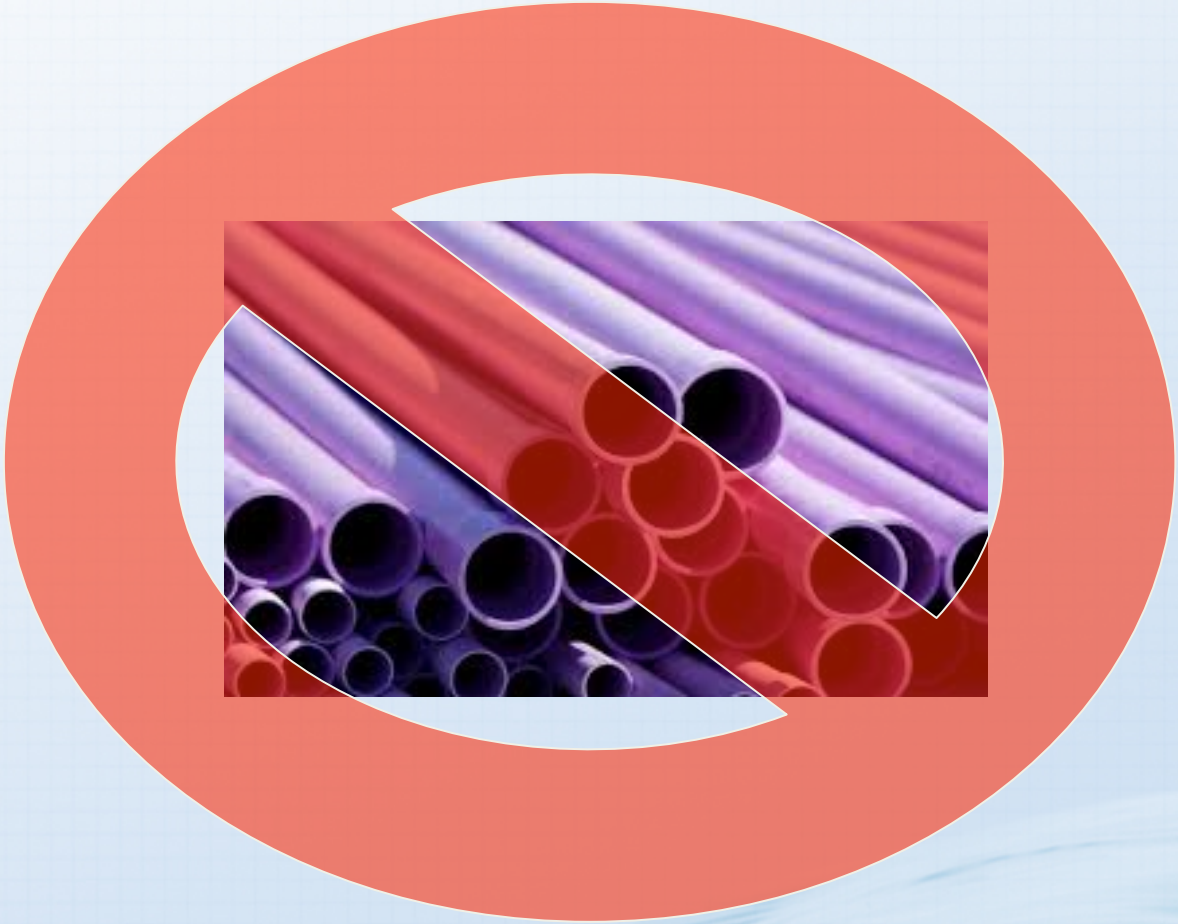
From Ratatouille…

In a good water year, everyone gets what they need, and purple pipe system meets non-potable demands

But when a drought occurs, purple pipe still meeting non-potable demands, but everyone has to cut back on potable demand

So maybe hybrid approach of some NPR and some IPR makes more sense?





Arizona's Regulatory Framework

Possibilities shaped by regulations

	A+	A	B+	B	C
Allowable Uses	Irrigation of food crops, open-access irrigation, fire protection systems, vehicle washing, snowmaking		Surface irrigation of orchards, golf course irrigation, restricted access landscape irrigation, dust control, livestock watering (dairy), street cleaning		Livestock watering (non-dairy), irrigation of sod farms, silviculture
Treatment Require-ment	Secondary Treatment, Filtration w/ Coagulant Addition, Nitrogen Removal, & Disinfection	Secondary Treatment, Filtration Coagulant Addition, & Disinfection	Secondary Treatment, Nitrogen Removal, & Disinfection	Secondary Treatment & Disinfection	Secondary Treatment
Turbidity Limits	2 NTU (24-hr avg) 5 NTU (max)	2 NTU (24-hr avg) 5 NTU (max)	--	--	--
Total Nitro-gen Limits	10 mg/L 5-sample mean	--	10 mg/L 5-sample mean	--	
Fecal Coli-form Limits	Non-detectable in 4 out of 7 daily samples 23 MPN or cfu/100 mL max	Non-detectable in 4 out of 7 daily samples 23/100 mL max	200/100 mL in 4 out of 7 daily samples 800/100 mL max	200/100 mL in 4 out of 7 daily samples 800/100 mL max	1000/100 mL in 4 out of 7 daily samples 4000/100 mL max

Source:
A.A.C. R18-11-Article 3, December 31, 2008

Note that B and B+ do not require filtration

But do require fairly significant reductions on pathogens

Even though B+, B, and C are classifications, BADCT for APP requires achieving A or A+ for new or modified plants

BADCT Criteria	Treatment Requirement
Setbacks	350 ft (For facilities over 1 mgd, with full noise, odor and aesthetic controls) 150 ft with an ordinance or waiver
Treatment Requirement	Secondary Treatment meeting BOD_5 < 30 mg/L (30-day avg) Or $CBOD_5$ < 25 mg/L (30-day avg)
Total Suspended Solids	< 30 mg/L (30-day avg)
pH	Between 6.0 – 9.0
Removal Efficiency	85% of BOD_5, $CBOD_5$, and TSS
Total Nitrogen	<10 mg/L 5-month rolling mean
Fecal Coliform Limits	Non-detectable in 4 out of 7 daily samples 23 MPN or cfu/100 mL max
Disinfection	Use chlorination-dechlorination, ultraviolet light and/or ozone to achieve pathogen removal and minimize trihalomethane generation
Source: A.A.C. R18-9-part B, September 30, 2005	

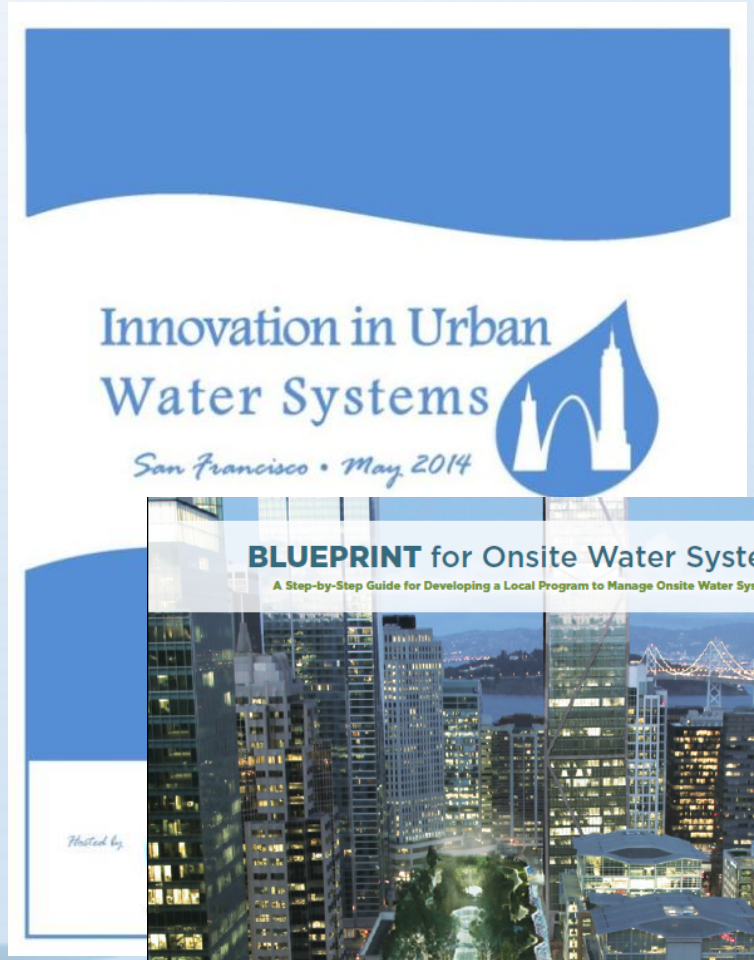
Potable Reuse in Arizona

- APP and USF / WS permits allow for “Indirect Potable Reuse”
- Direct Reuse for Human Consumption is Prohibited
- Steering Committee on Arizona Potable Reuse
  - Regulation
  - Technology
  - Public Perception
  - Emerging Contaminants

Trends in Water Reuse

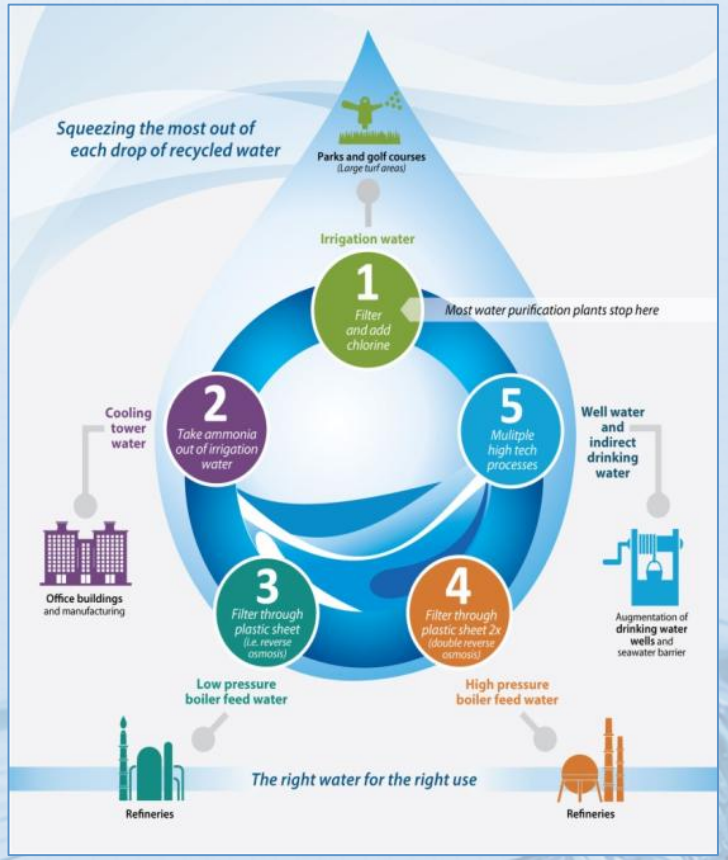
Trend Toward Decentralized & On-site Water Management

Living Machine in San Francisco Public Utilities Commission Cafeteria Area



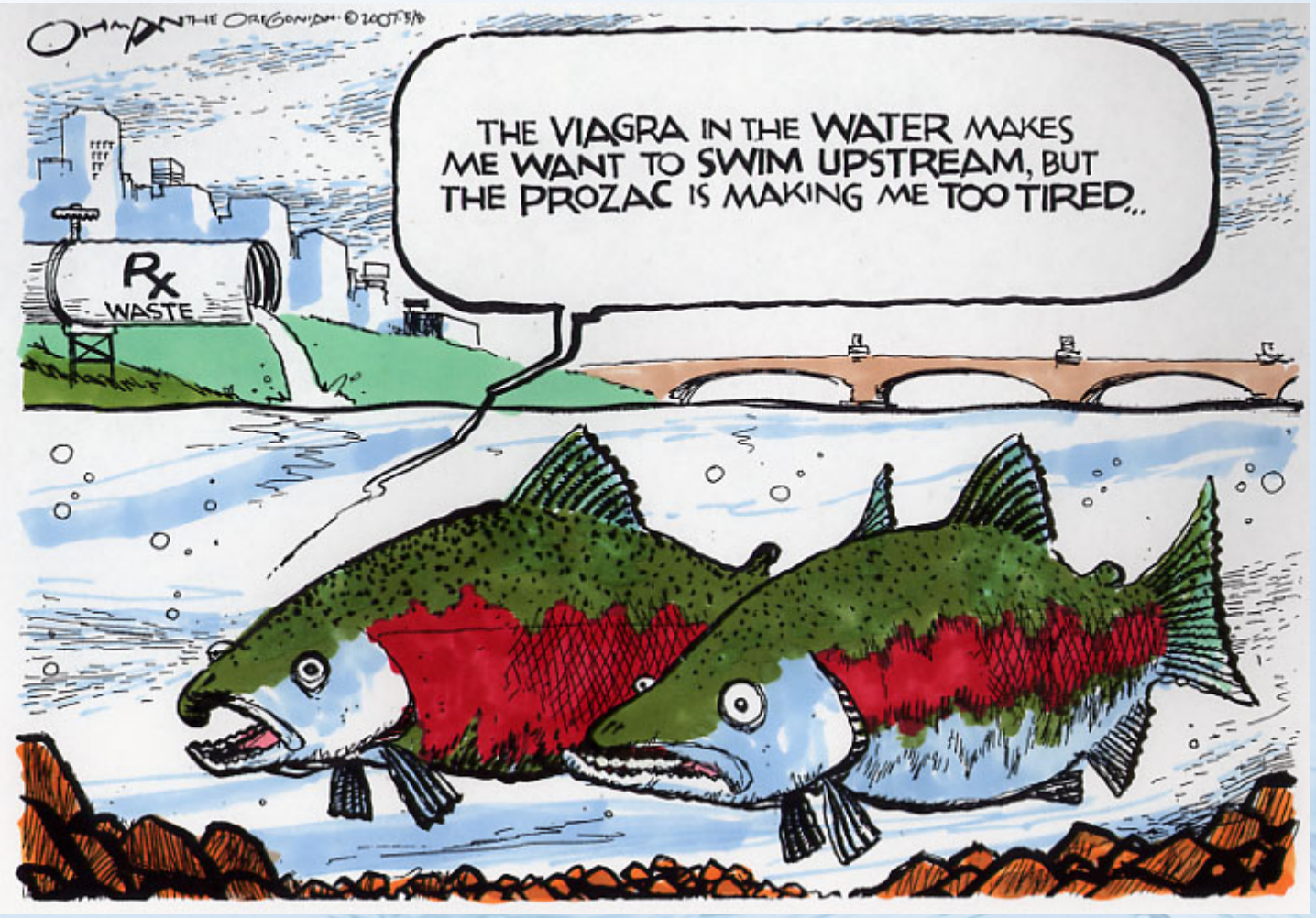
NSF Center: Stanford, Berkeley, Colorado School of Mines


Ocean Mist


Squeezing the most out of each drop of recycled water
Parks and golf courses
(Large turf areas)
Irrigation water
1
Filter and add chlorine
Most water purification plants stop here
2
Take ammonia out of irrigation water
5
Mulitple high tech processes
Cooling tower water
Well water and indirect drinking water
Office buildings and manufacturing
3
Filter through plastic sheet (i.e. reverse osmosis)
4
Filter through plastic sheet 2x (double reverse osmosis)
Augmentation of drinking water wells and seawater barrier
Low pressure boiler feed water
High pressure boiler feed water
The right water for the right use
Refineries
Refineries

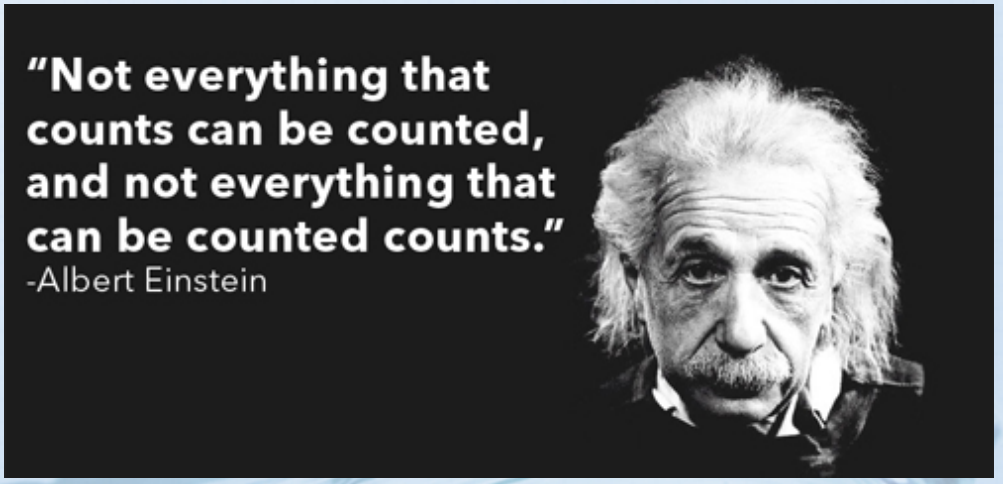
Direct Potable Reuse (DPR)

Pharmaceutically Active Compounds



People generally have difficulty with the concept of relative concentrations and risk

- There is a concern that “presence” in any amount is a problem
- Adverse health effects are presumed if anything can be detected.
- There is no “zero” of anything… including risk.



Amount of Water to Meet Acceptable Daily Intake (for Humans) - Pharmaceuticals

	ADI-DWEL	Maximum Water Conc. Finished	Amount of water to meet ADI		
	µg/L	µg/L	8 oz Glasses/d	Gallons/d	55-Gallon drums/d
Atenolol	70	0.026	22,800	1,400	25
Carbamazepine	12	0.018	5,500	340	6.2
Diazepam	35	0.00033	890,000	55,000	1,000
Fluoxetine	35	0.00082	360,000	22,000	400
Gemfibrozil	45	0.0021	180,000	11,000	200
Meprobamate	260	0.043	51,000	3,200	58
Phenytoin	6.8	0.032	1,800	110	2.0
Risperidone	0.49	0.00034	12,000	770	14
Sulfamethoxazole	18,000	0.0030	51,000,000	3,200,000	58,000
Triclosan	2,600	0.0012	19,000,000	1,200,000	22,000

Credit: Shane Snyder, University of Arizona

Cost Implications of Deciding to Reduce Trace Organic Compound Concentrations for a 10 MGD Treatment Plant (add to end of existing process)

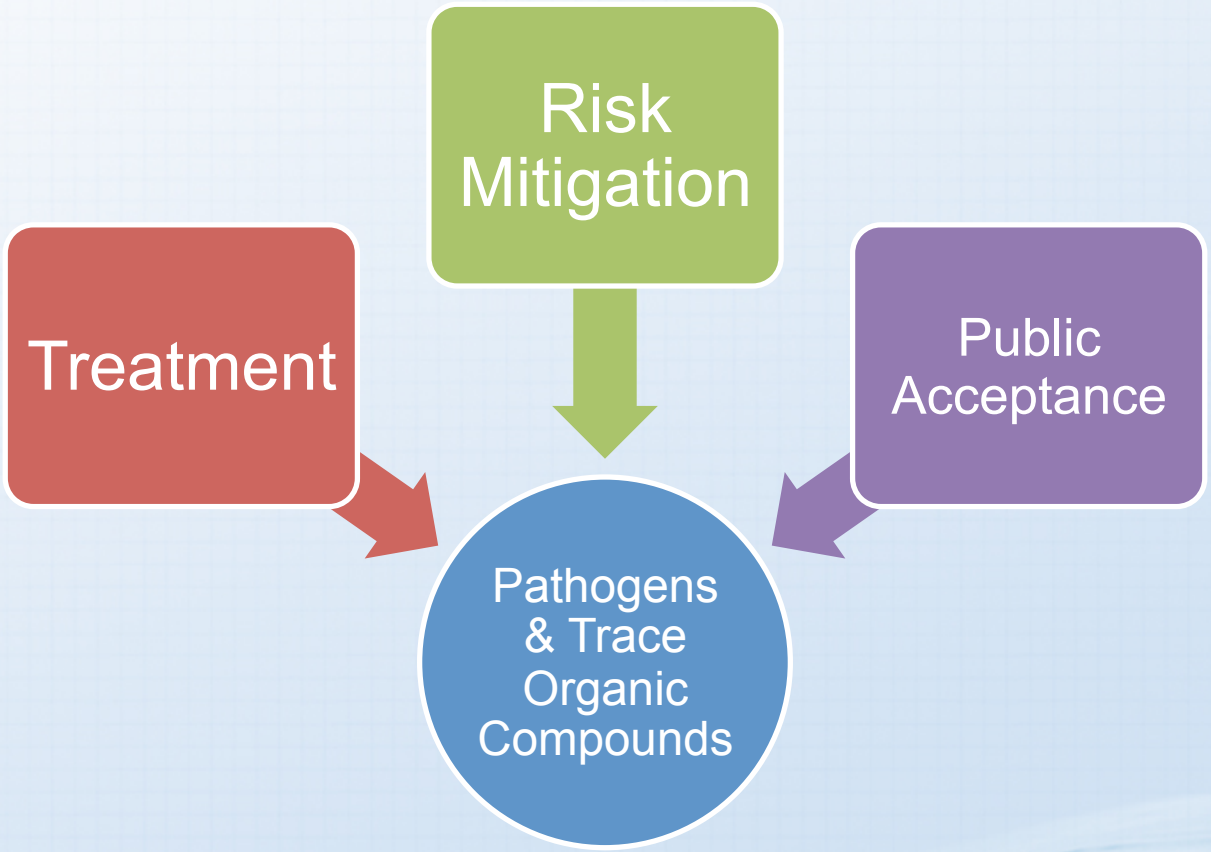
Treatment Technology	Capital Cost	Annual O&M	EEq Destruction
NaOCl (free chlorine residual)	$7,532,000	$219,000	~75%
Medium Pressure UV + Hydrogen Peroxide	$8,923,000	$509,000	>90%
Medium Pressure UV + Peracetic Acid	$9,563,000	$1,645,000	60%
Ozone	$8,828,000	$217,000	>90%
Titanium Dioxide with UV	$15,941,000	$311,000	>90%
MF/RO + UV & H_2O_2	$45,601,000	$2,470,000	>95%

EEq is Estradiol Equivalent; a measure of hormonal activity

But What Keeps Public Health Officials, Engineers, and Operators up at Night?

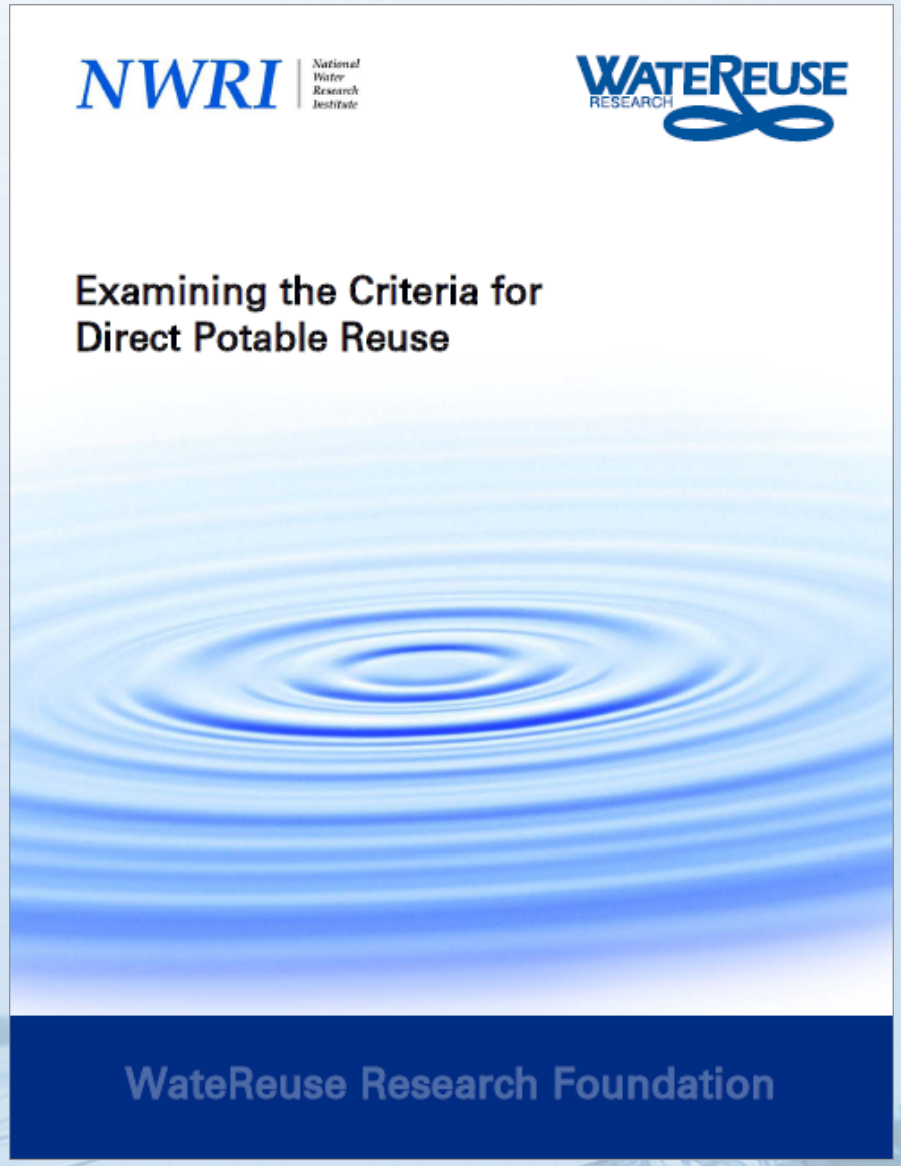
- Viruses
- Cryptosporidium
- Giardia
- Bacteria

What do you need to do to make drinking water out of sewage?



WRRF 11-02 Panel Report specifies treatment goals

- From Raw Wastewater to Potable Water
  - 12-log virus
  - 10-log protozoa (crypto & giardia)
  - 9-log bacteria



NWRI Panel – Chemical Criteria

DBPs	Criterion
THMs	
HAA5	
NDMA	
Bromate	
Chlorate	

Pharmaceuticals	Criterion[a]/If Applicable
Cotinine/Primido Phenyltoin	
Meprobamate/At	
Carbamazepine	
Estrone	

Chemicals Relevant to Public Health	Criterion/ If Applicable
PFOA	0.4 µg/L
PFOS	
Perchlorate	
1,4-Dioxane	

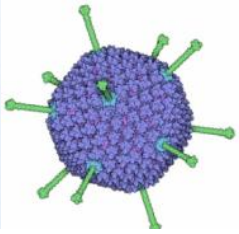
Steroid Hormones	Criterion/ If Applicable
Ethinyl Estradiol	None, but if established, it will
17-β-E	

Other Chemicals	
Sucralose	150 mg/L[c]
TCEP	5 µg/L
DEET	200 µg/L
Triclosan	2,100 µg/L

Overall Goal: How do we make DPR safe?

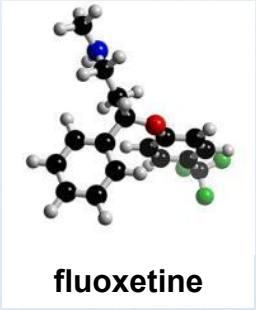
WRRF Project 11-02 Addresses Two Key Questions:

1. What level of treatment must we achieve?

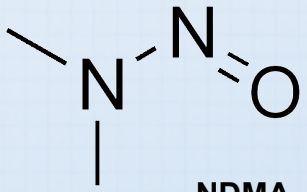


Adenovirus

Cryptosporidium

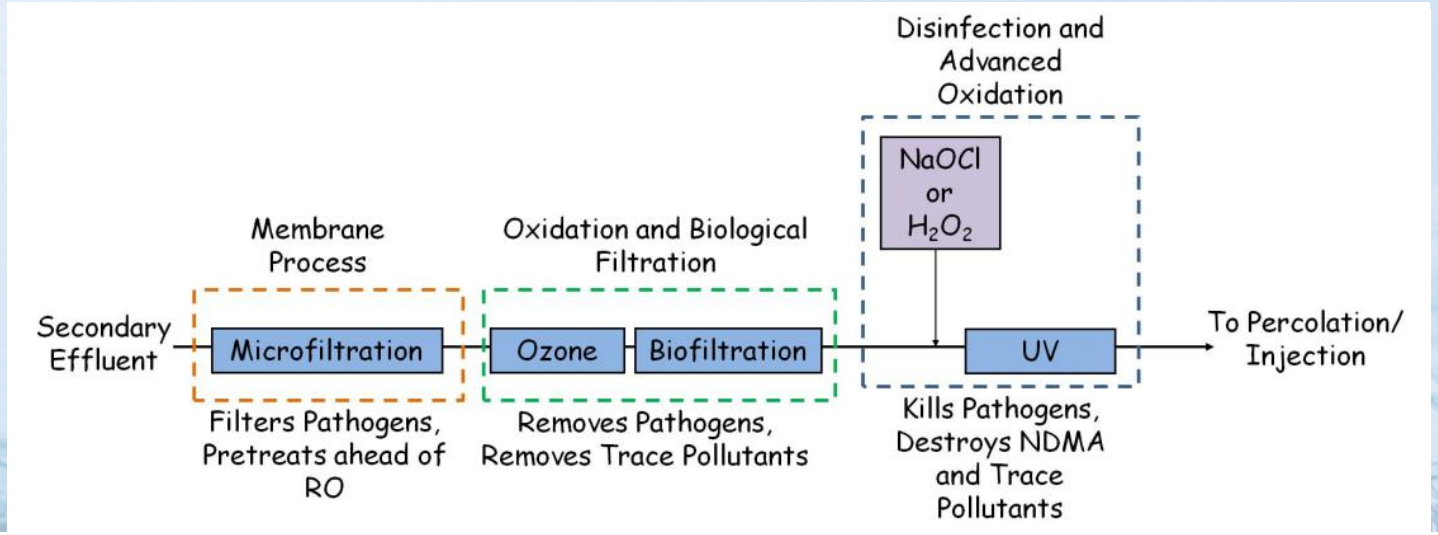


fluoxetine



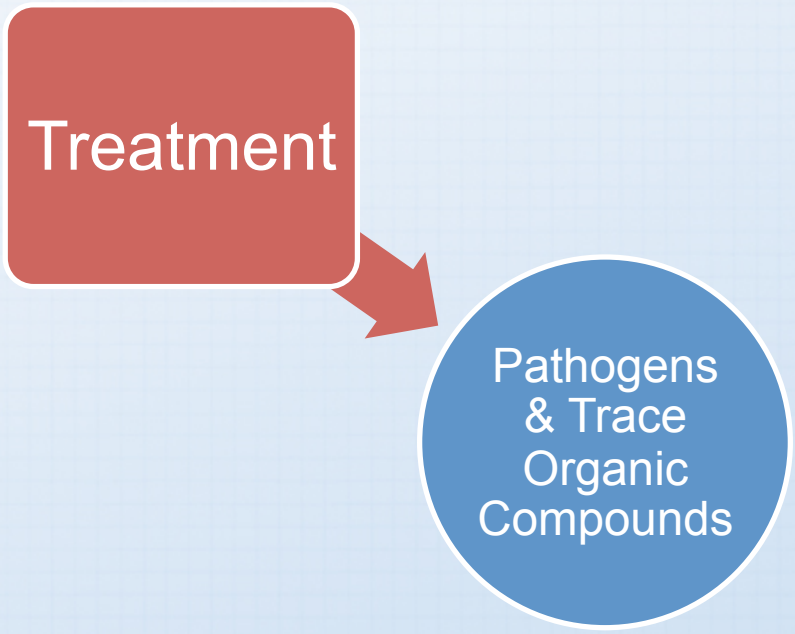
NDMA

2. How can we achieve that level of treatment?



Treatment Technologies

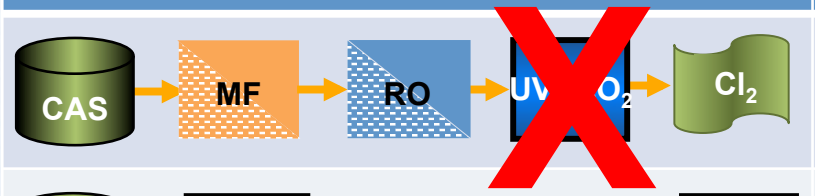
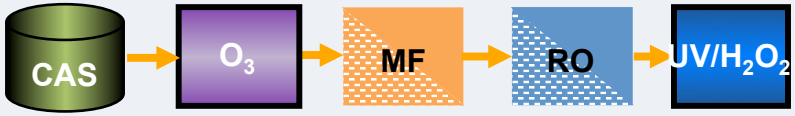
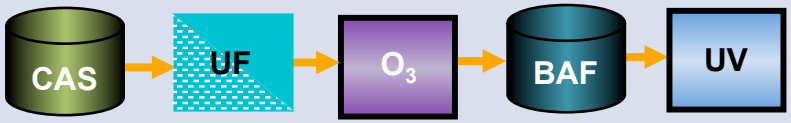
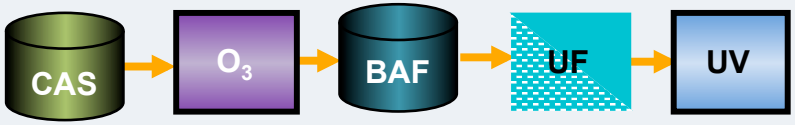
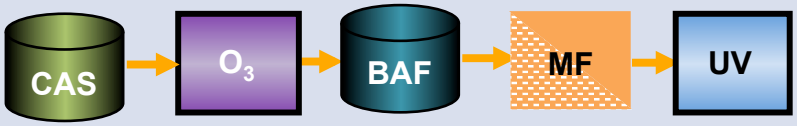
What do you need to do to make drinking water out of sewage?



If you address the pathogens, you will address the trace organic chemicals (WRRF-11-02)

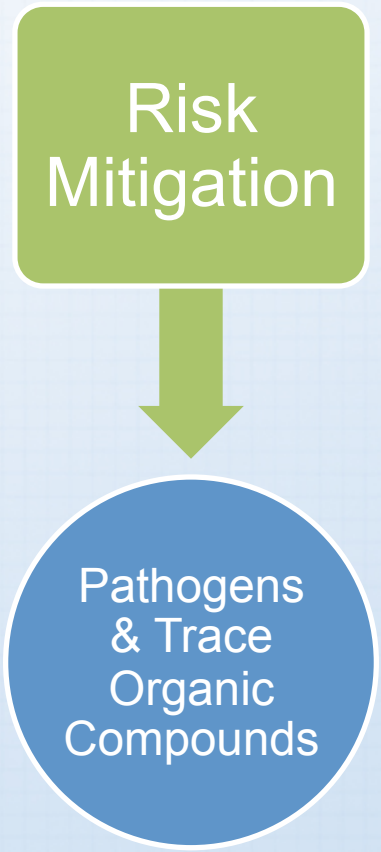
Treatment Train	Virus	Crypto	Total Coliform
GOALS From raw wastewater to potable water	**12**	**10**	**9**

But what if a process fails?

Treatment Train	Virus	Crypto	Total Coliform
	X 9	X 6	X 12
	15	13	18
	14	11	16
	14	11	16
	13	11	16
GOALS	**12**	**10**	**9**

Risk Mitigation

What do you need to do to make drinking water out of sewage?

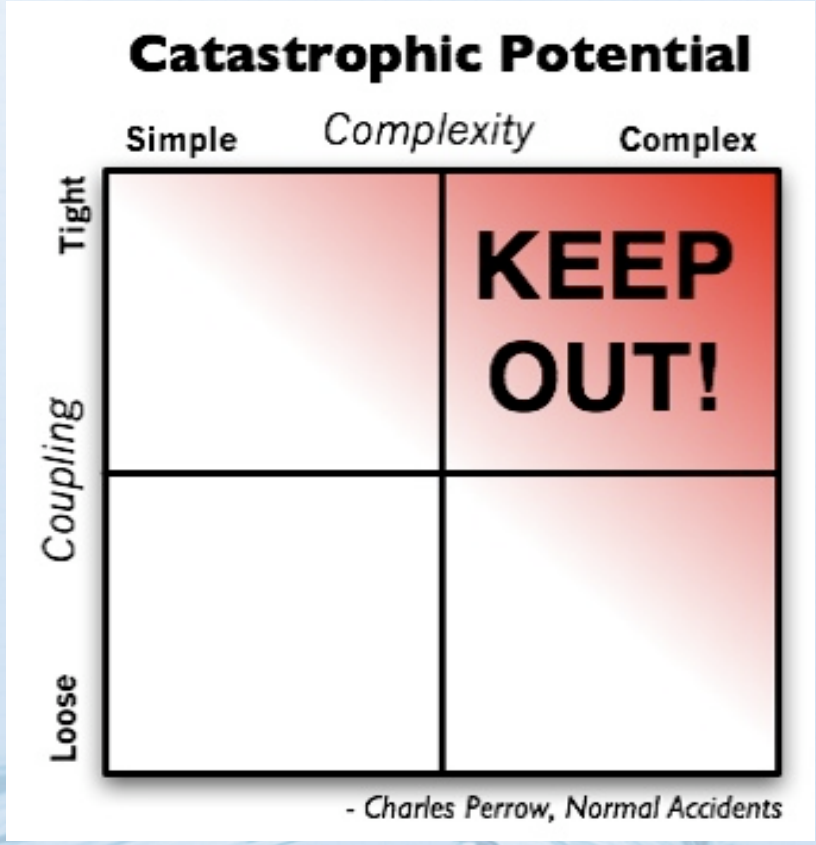


For Failsafe Design - Look to NASA! (WRRF 11-10)

Lessons learned from other fail-safe industries

- Space exploration (NASA)
- Bridge building

1. Decouple & simplify
2. Control potential failure points relative to their risk
3. Monitoring is key
4. For personnel:
   - Training
   - SOPs for critical failure events.

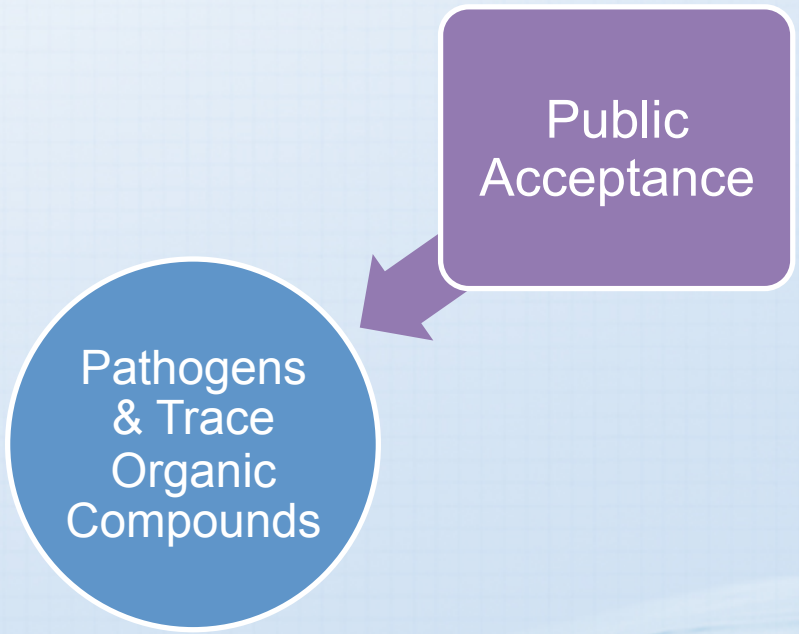


The bottom line:

Processes WILL fail.

- Process failure cannot reduce delivered water quality below target goals; so…
  - We must know when the failure has occurred and divert flow from the potable stream; or
  - We must have sufficient redundancy of treatment, storage, and monitoring to know that water quality goals are being met.

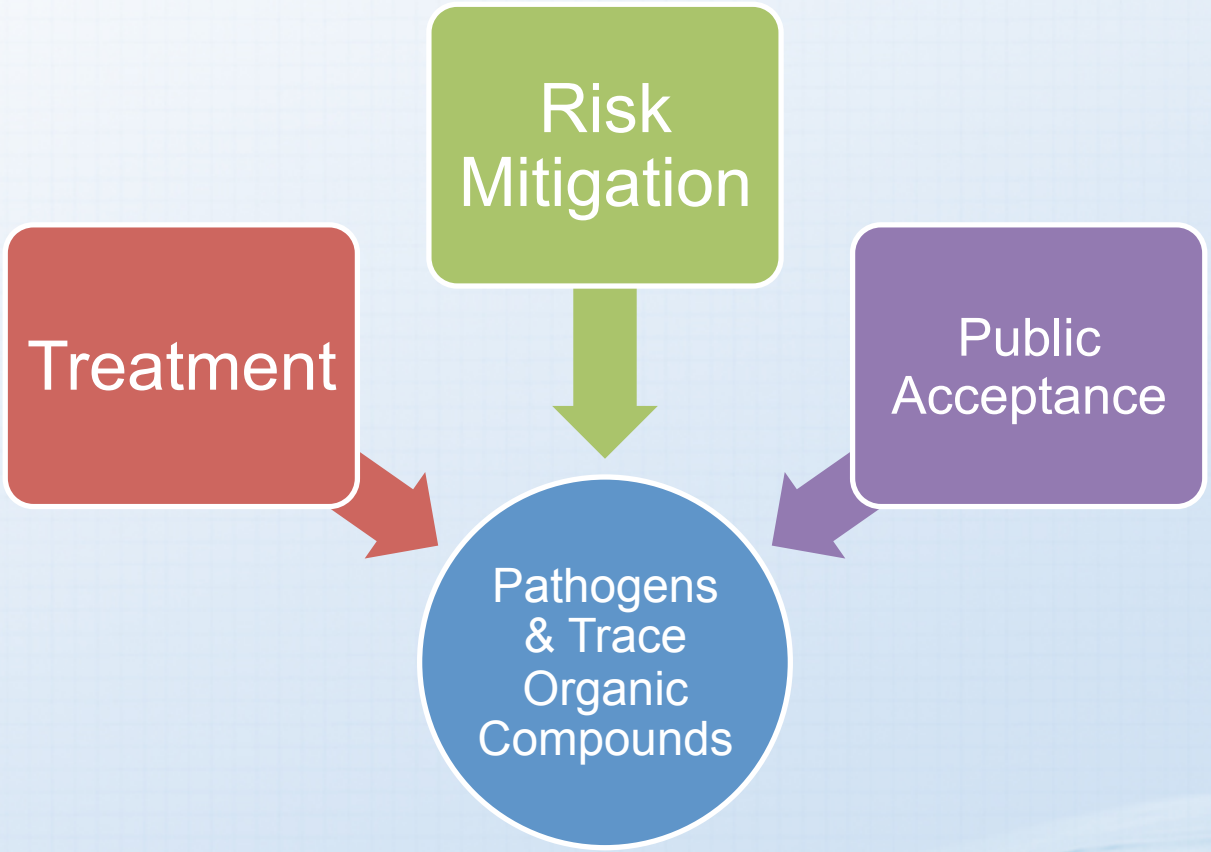
What do you need to do to make drinking water out of sewage?



Public Acceptance of Water Reuse

- Strongly supports nonpotable uses
- Favors minimal contact (e.g., irrigation)
- More knowledge = more acceptance
  - Inform; don't convince
  - Reuse is one option among many
  - Portfolio = Resiliency = Stable Economy
- Engage public involvement specialists early

What do you need to do to make drinking water out of sewage?



Colorado River Municipal Water District's

Raw Water Production Facility

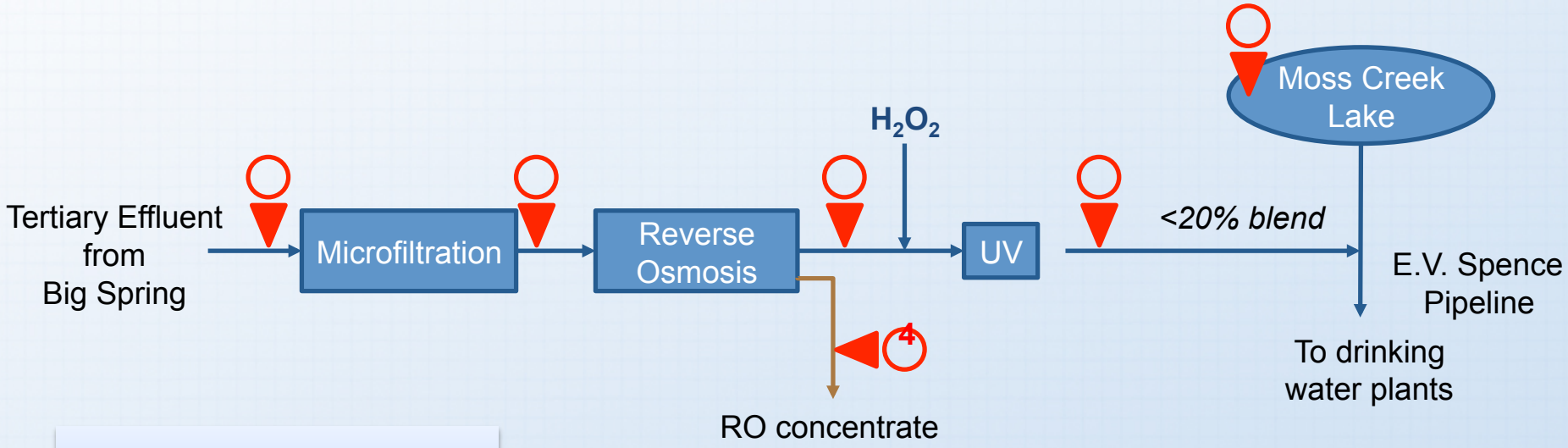
at Big Spring

Colorado River Municipal Water District is No Stranger to Drought

- Raw Water Provider
- Serves over 500,000 people in 25 counties
- Relies mainly on surface water reservoirs:
  - Lake J.B. Thomas (44% full)
  - E.V. Spence (<2% full)
  - O.H. Ivie (<15% full)
- Five well fields (peaking)

Lake O.H. Ivie, April 2011

Raw Water Production Facility in Big Spring Provides Supply Diversification



Facility Designed by Freese & Nichols

Sample locations

Study Sponsored by:

Texas Water Development Board

WATEREUSE RESEARCH

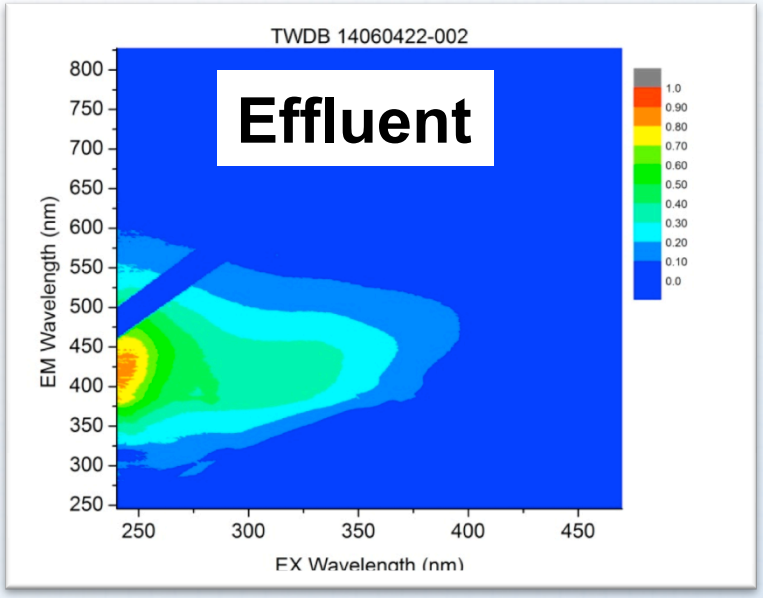
NWRI

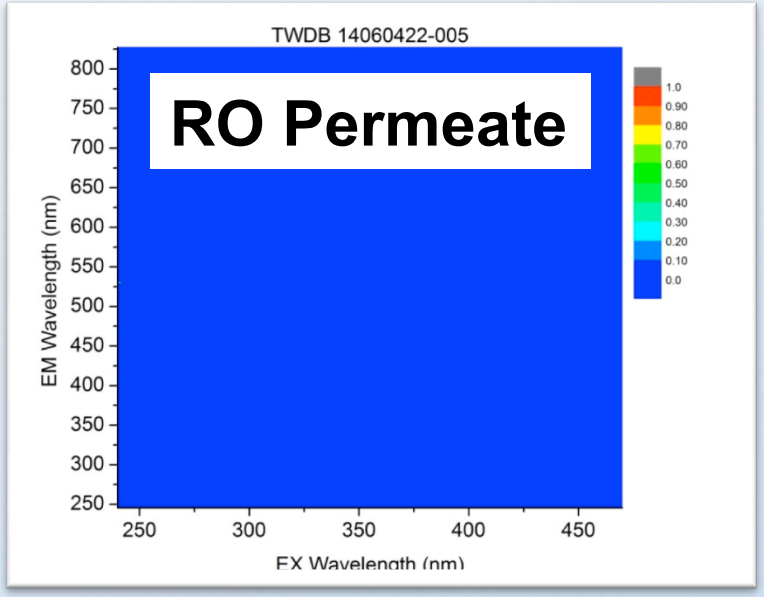
Research Partners:

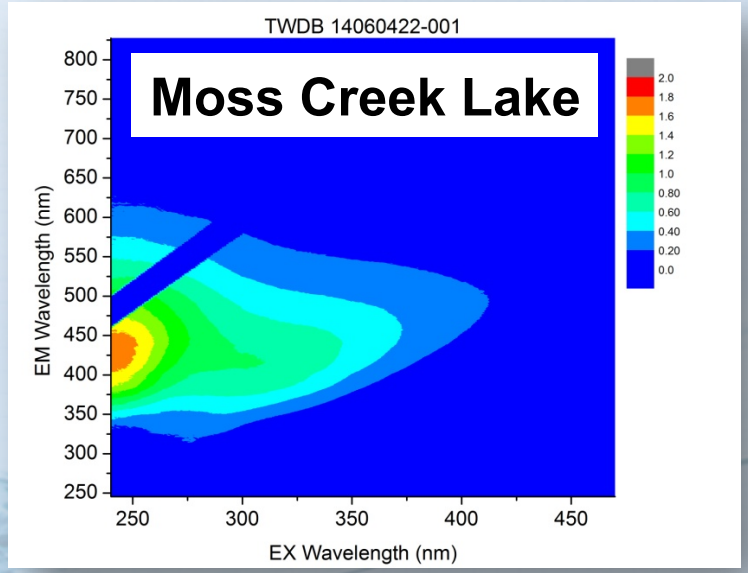
- *Carollo Engineers*
- *Trussell Technologies*
- *University of Texas*
- *Southern Nevada Water Authority*
- *Nalco Company*
- *Hazen & Sawyer*

INITIAL WATER QUALITY RESULTS (JULY 2014 & FEB 2015)

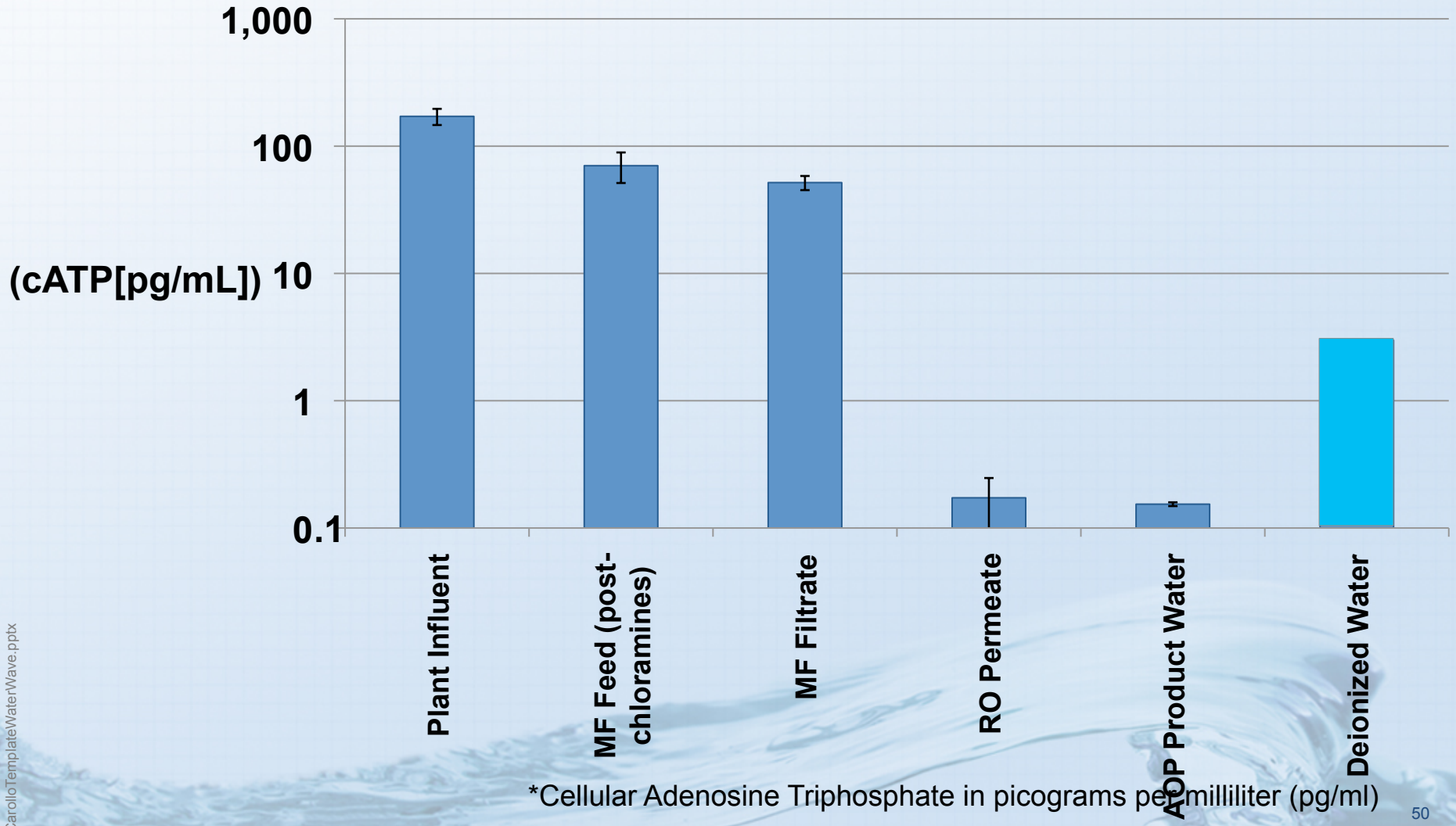
Fluorescence Images Tell a Good Story







ATP Tests Confirm Significant Removal of Bacterial Activity



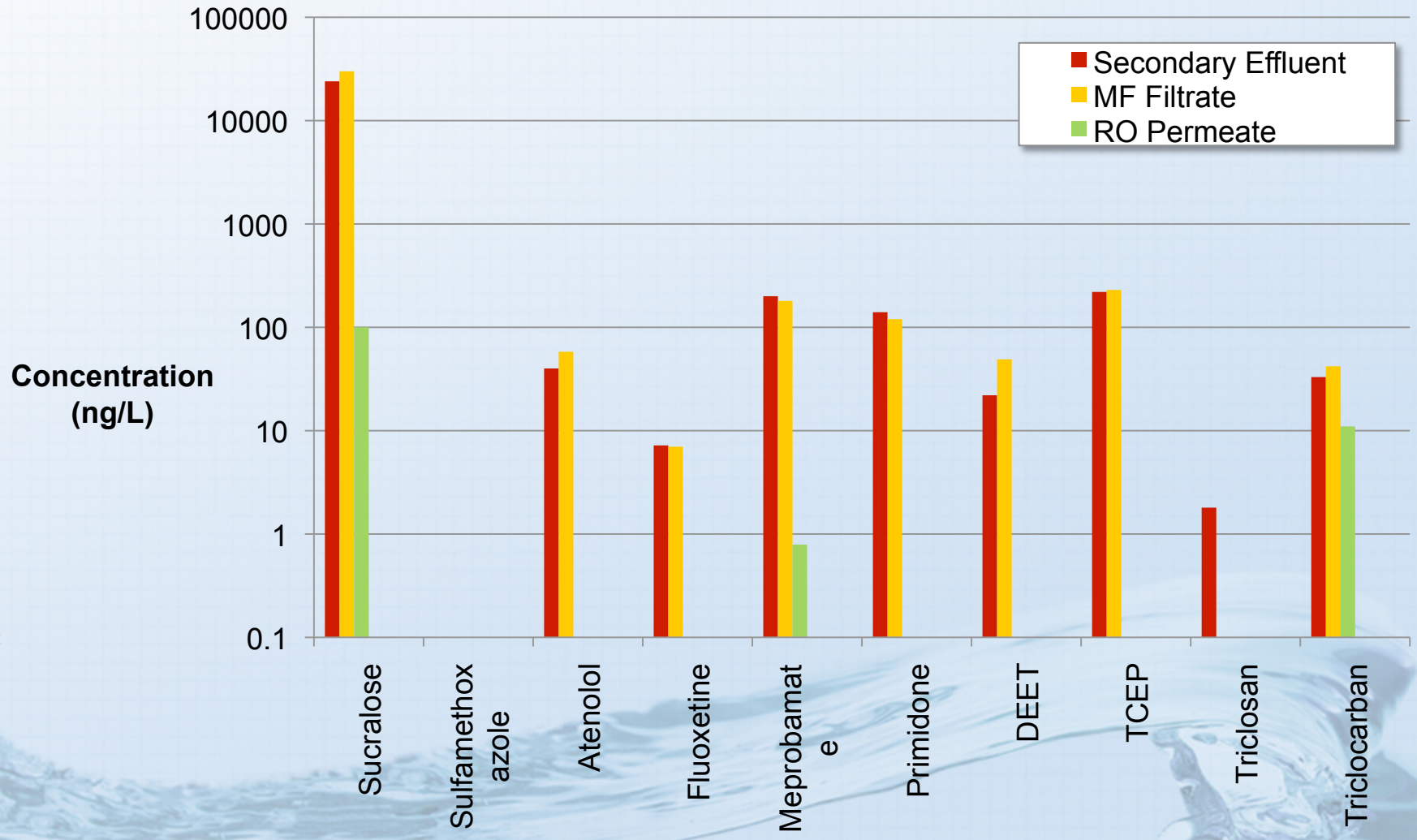
*Cellular Adenosine Triphosphate in picograms per milliliter (pg/ml)

Pathogen Results: DPR vs. Conventional

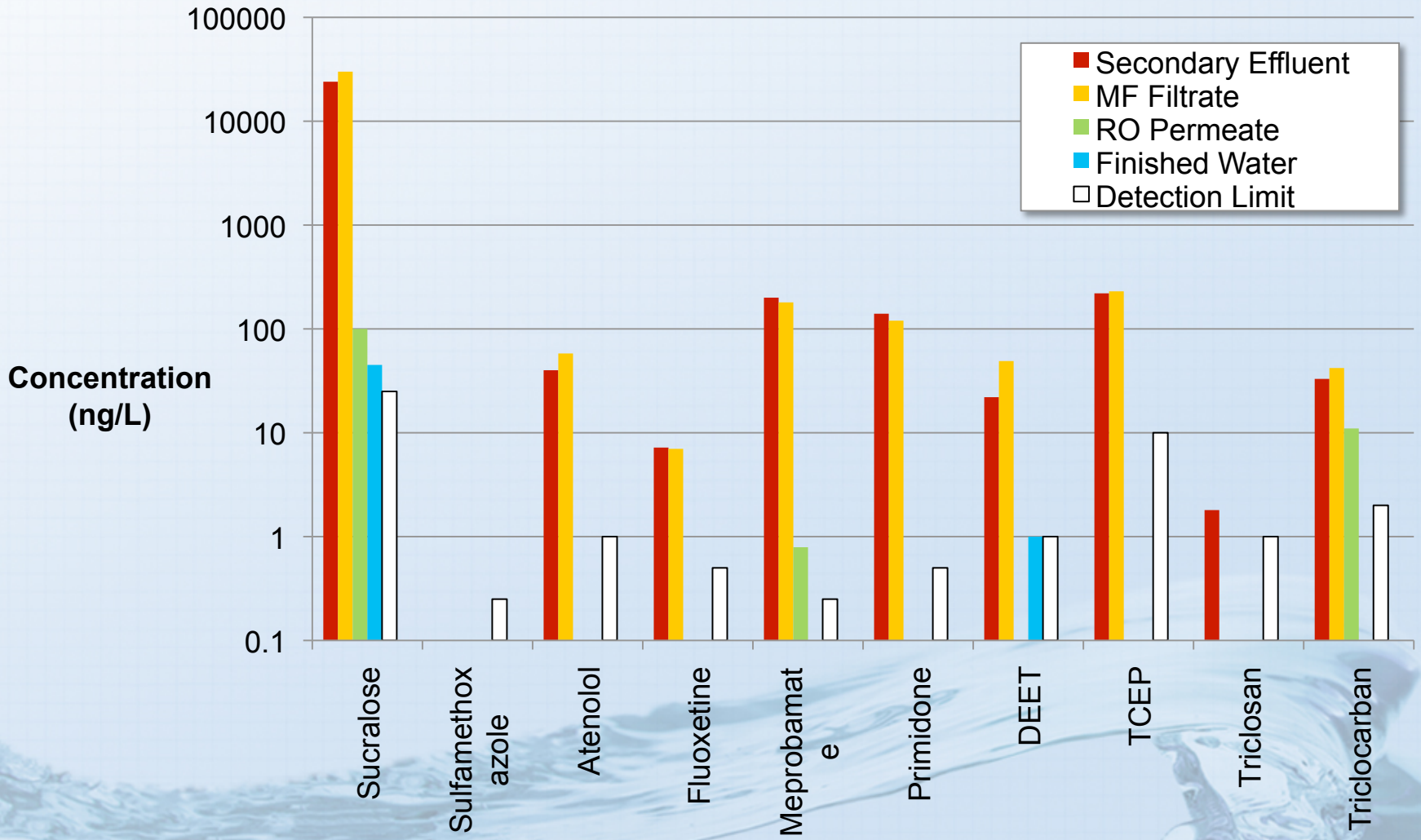
Pathogen	RWPF Influent	RWPF Product Water	Moss Creek Lake
Enteric Virus	ND (1)	ND (4)*	ND (2)
Giardia	8 positive (16)	ND (10)	ND (4)
Cryptosporidium	4 positive (16)	ND (10)	ND (4)
E. Coli	6 positive (9)	ND (6)	7 positive (9)

**Samples Collected from RO permeate, before UV/AOP*

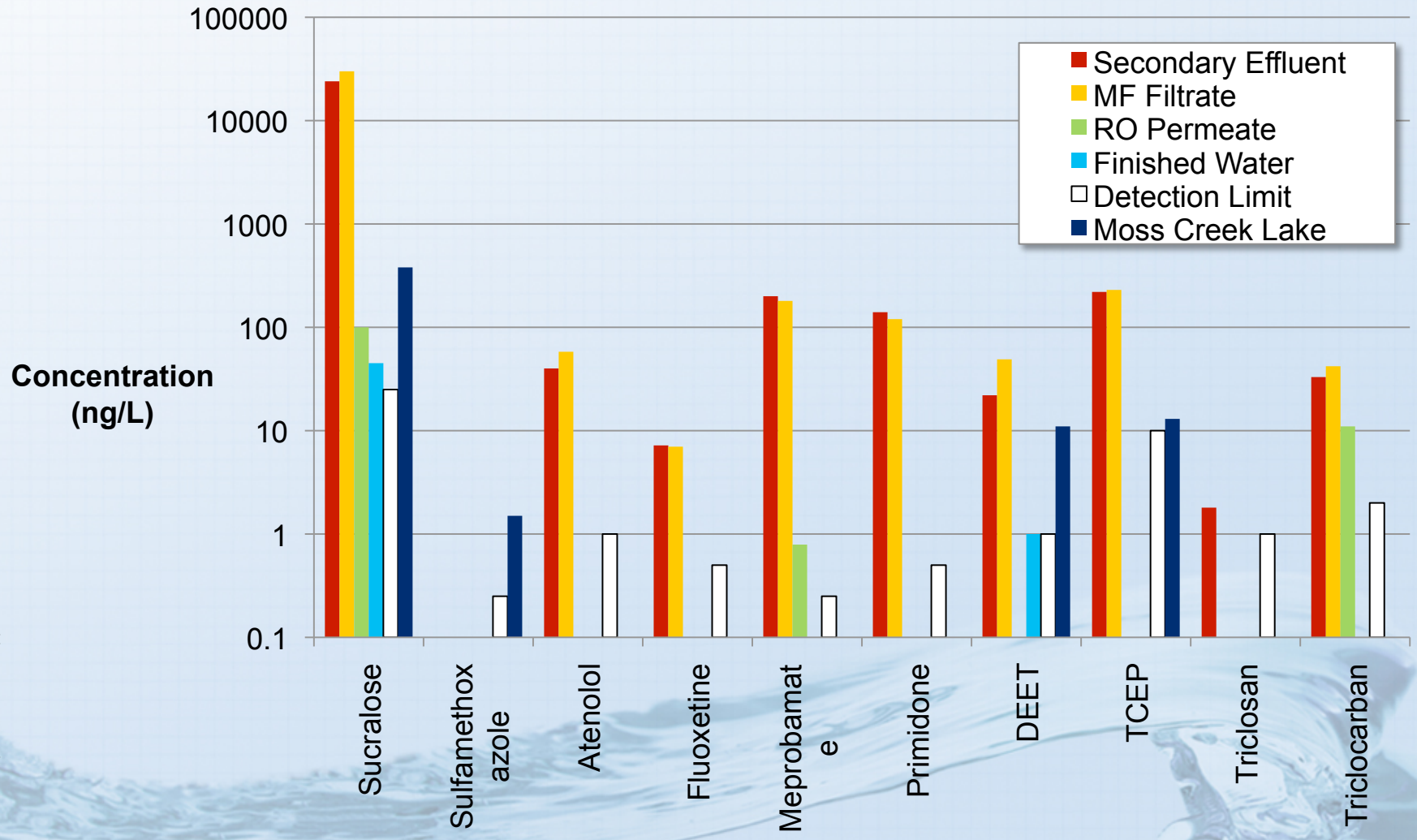
RO Achieves Robust Removal of Trace Organics (Pharmaceuticals etc.)



AOP Finishes the Job



DPR Product Water Improves Blended Water Quality with regard to Trace Organics



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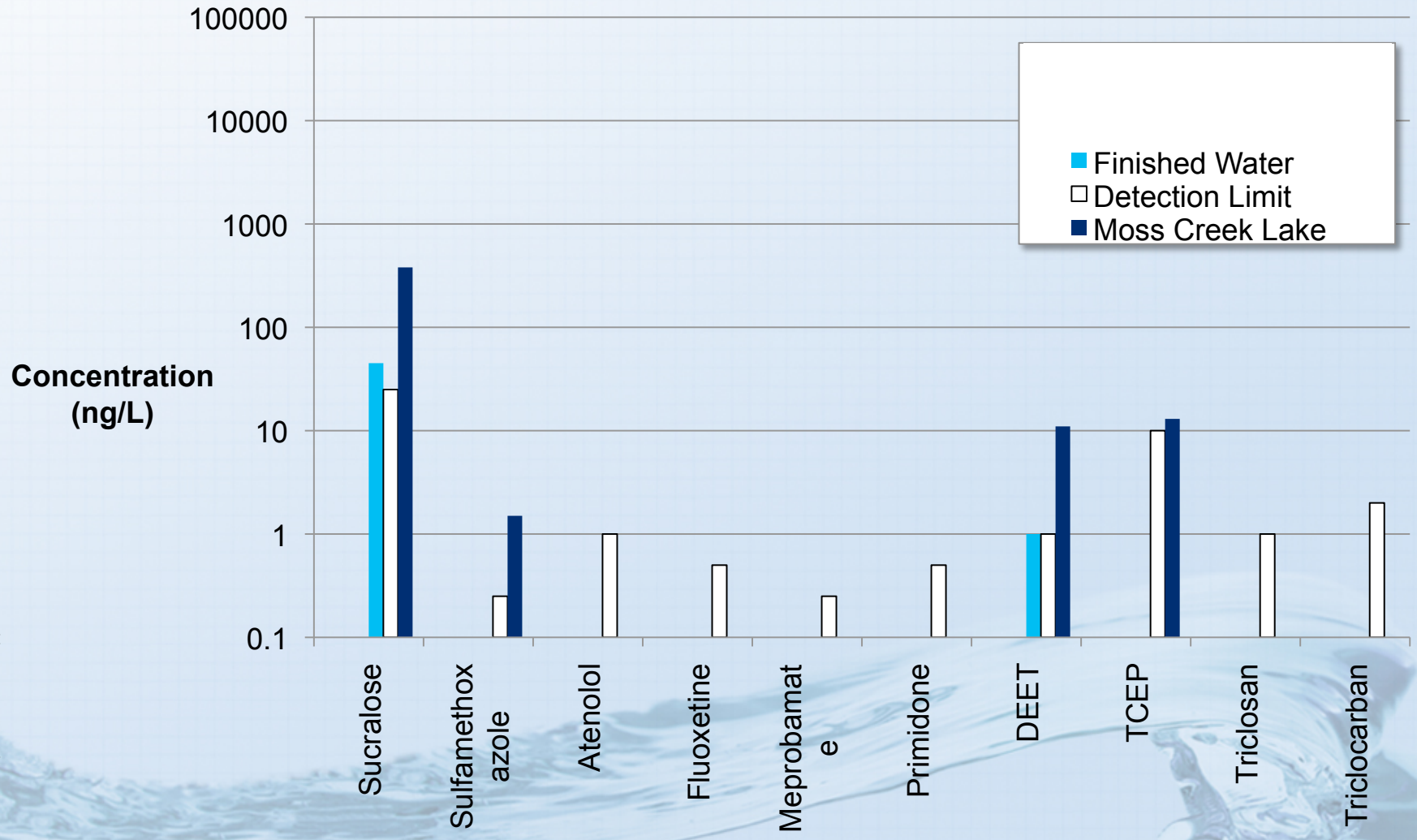
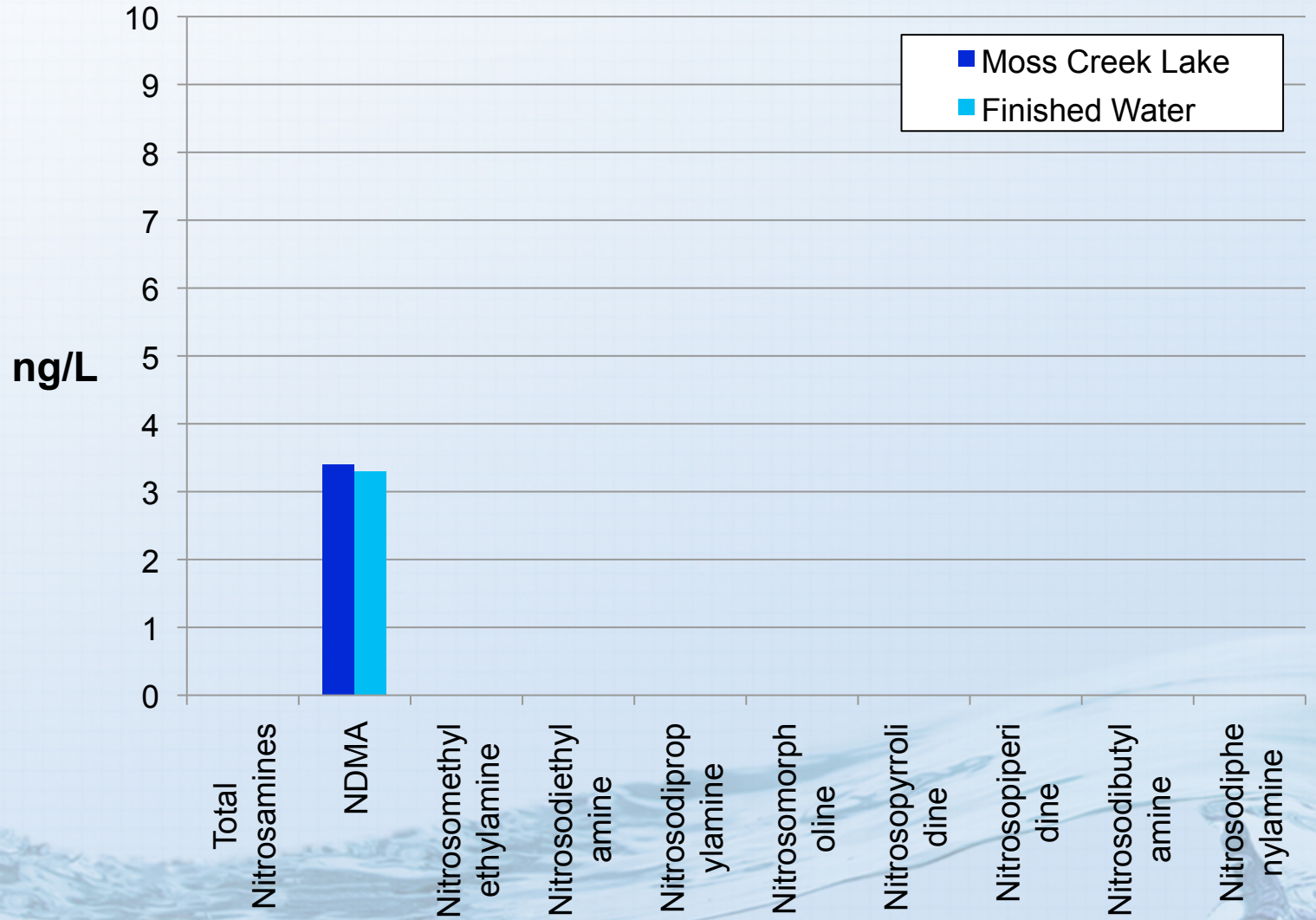
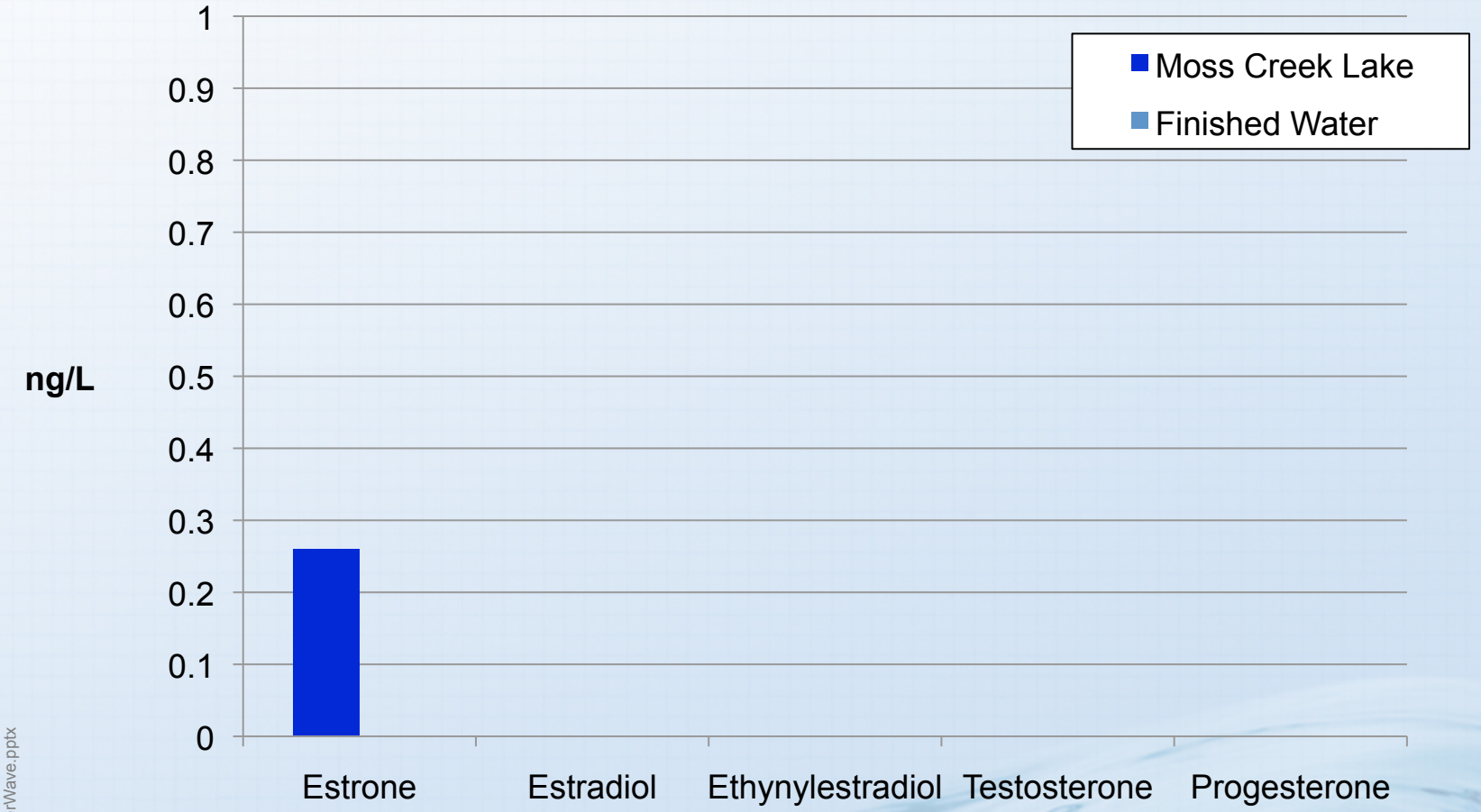


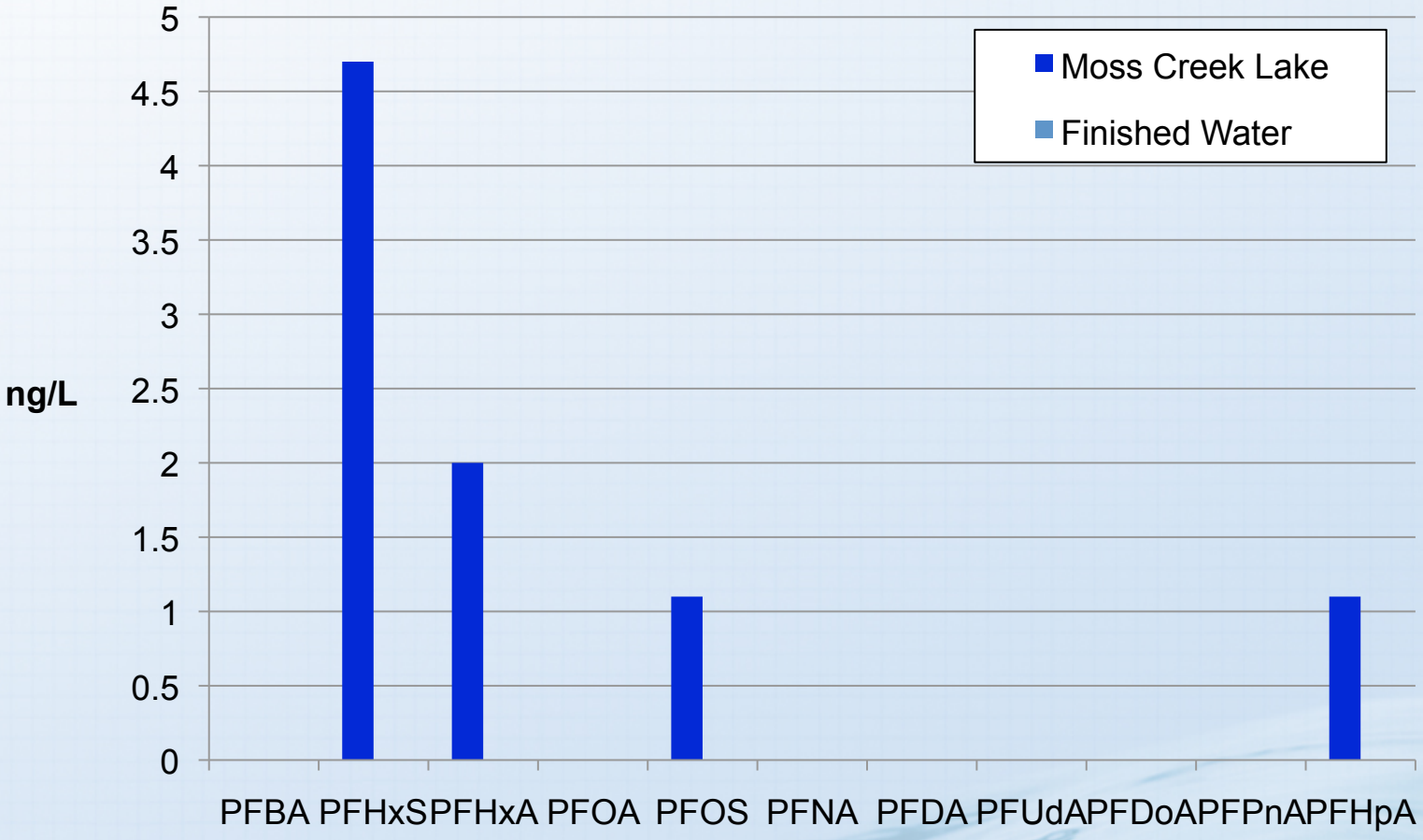
The Story is similar for Nitrosamines…



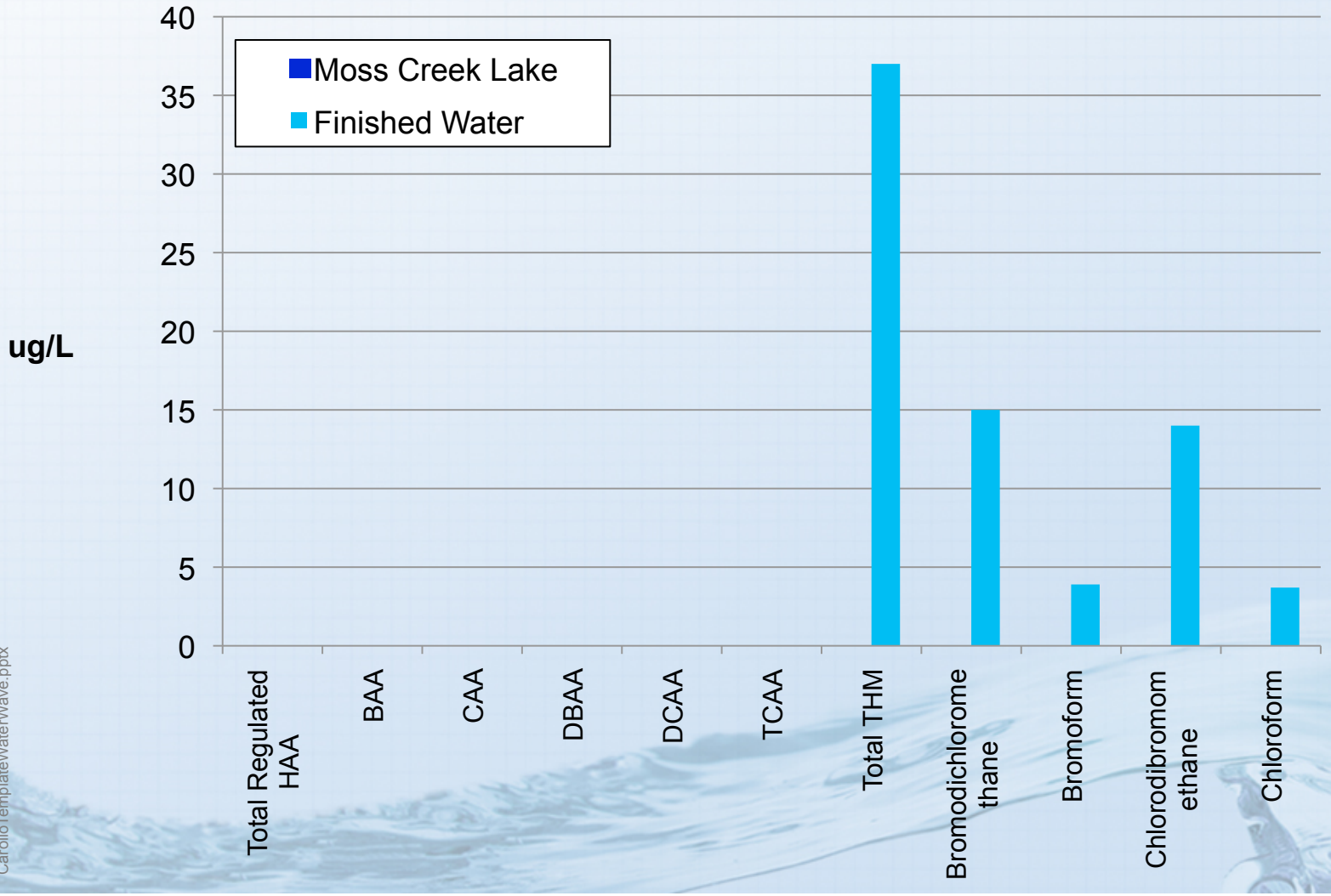
… and Estrogens…



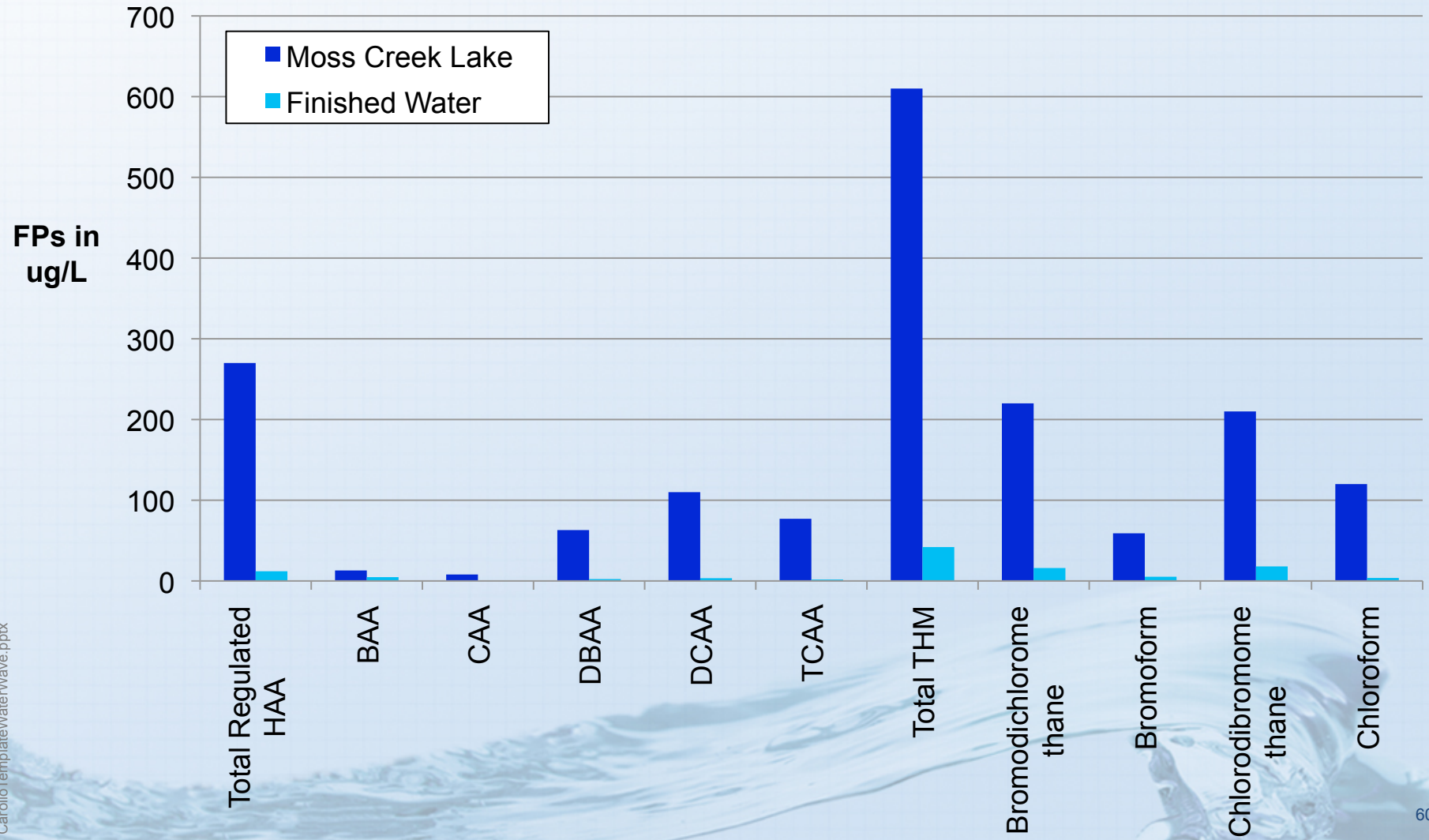
… and Perfluorinated Chemicals…



… but not for Trihalomethanes (THMs)



Formation Potential Tests Illustrate the DBP Advantage of RWPF Water



Initial Observations from Big Spring

- The “bar” for DPR is higher than for conventional water treatment.
- RWPF water quality is (much!) better than that of the conventional raw water with which it is blended.
- Conventional water treatment concerns (conventional DBPs, e.g.) are important for DPR, too!

Resources

Communicating Risk of PPCPs (Pharmaceuticals and Personal Care Products)

User & Public Friendly Document

Includes a CD with printable materials

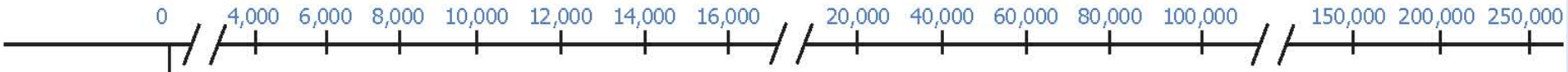
http://www.watereuse.org/catalog/toolkit

WHAT'S THE RISK?

A Comparison of Exposure to PPCPs from Recycled Water vs. Conventional Uses

This chart compares typical exposures to three Pharmaceuticals and Personal Care Products (PPCPs) — antidepressant, ibuprofen, hormone — with exposure to the same chemicals in recycled water under four different scenarios in which a person may come into contact with the water. For each scenario — child at play, agricultural worker, landscaper, and golfer — the chart shows how many years one could participate in that activity before reaching a single daily dose of the chemical from typical exposures.

Number of years of exposure to recycled water to equal conventional dose.



Fluoxetine =
One Dose Prozac


26,000 Years


83,000 Years


91,000 Years


220,000 Years

Ibuprofen =
One Advil Tablet


8,600 Years


26,000 Years


28,000 Years


67,000 Years

17-beta estradiol =
One Dose Hormone Replacement


5,000 Years


13,000 Years


16,000 Years


160,000 Years

KEY: Four common scenarios where people may come into contact with recycled water.


Child at Play


Ag Worker


Land-scaper


Golfer

Helpful Resources

- EPA Guidelines for Water Reuse
  - 2012 Version: http://www.waterreuseguidelines.org/
- For the Public:
  - www.athirstyplanet.com
  - Ways of Water
- For Technical Info:
  - http://www.watereuse.org/information-resources/reuse/resources
  - http://www.watereuse.org/catalog/foundation-research-reports

Questions/Discussion?

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