Overview of the Texas Direct Potable Reuse Resource Document

Introduction

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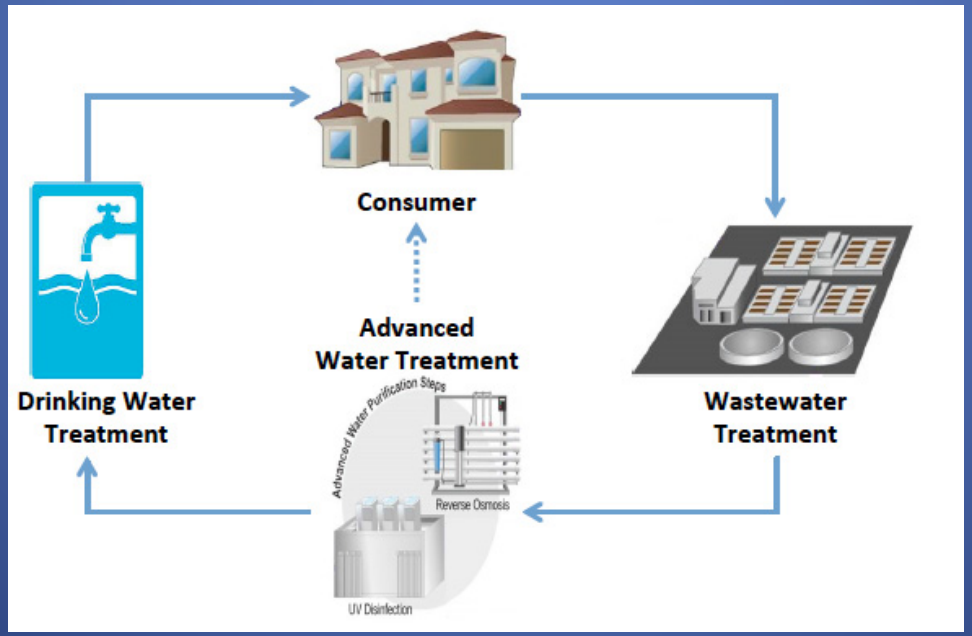
Agenda

- Background
  - Definition of DPR
  - Project goals and participants
  - Overview of project scope
- Chapter-by-chapter highlights

Definition of Direct Potable Reuse

"The introduction of advanced-treated reclaimed water either directly into the potable water system or into the raw water supply entering a water treatment plant."



Project Goals

- Develop a resource document for DPR that can be used by
  - Public Water Systems
  - Agencies
  - Consultants
  - Anyone who wants to know!
- Provide information that is technically sound and promotes safe and practical implementation of DPR in Texas

Project Sponsors

City of College Station

San Antonio Water System

Brazos Valley Groundwater Conservation District

City of Houston Texas

Upper Trinity Water Quality Compact

El Paso Water Utilities Public Service Board

Irving Texas

Fort Worth

City of Lewisville

City of Lubbock Texas

WateReuse Texas

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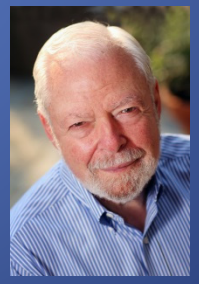

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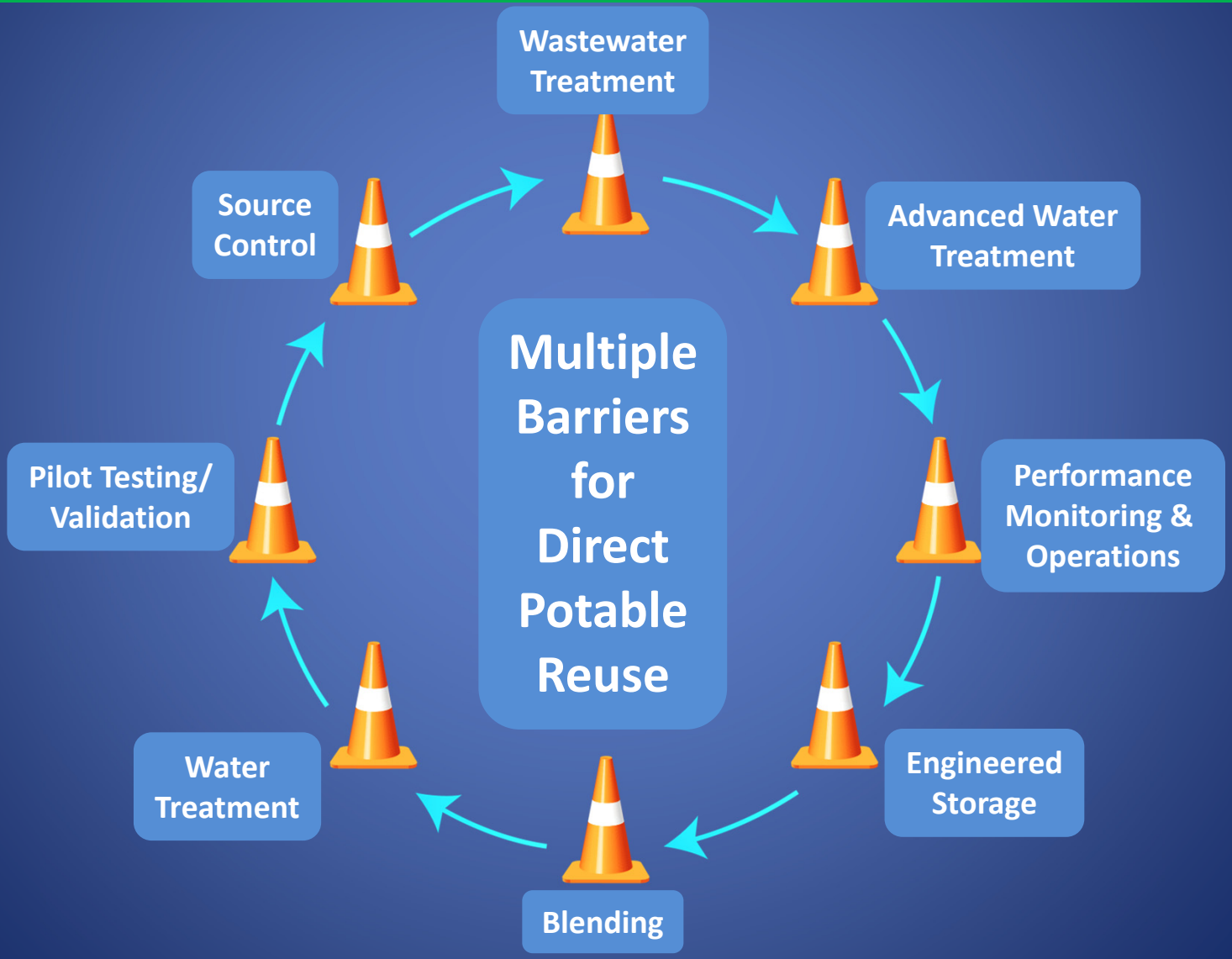
Planned or Implemented DPR Projects in Texas

- Colorado River Municipal Water District at Big Spring
- Wichita Falls*
- El Paso
- Laguna Madre Water District
- San Angelo
- Brownwood**

*No longer in operation

**Currently on hold

Multiple Barriers for DPR



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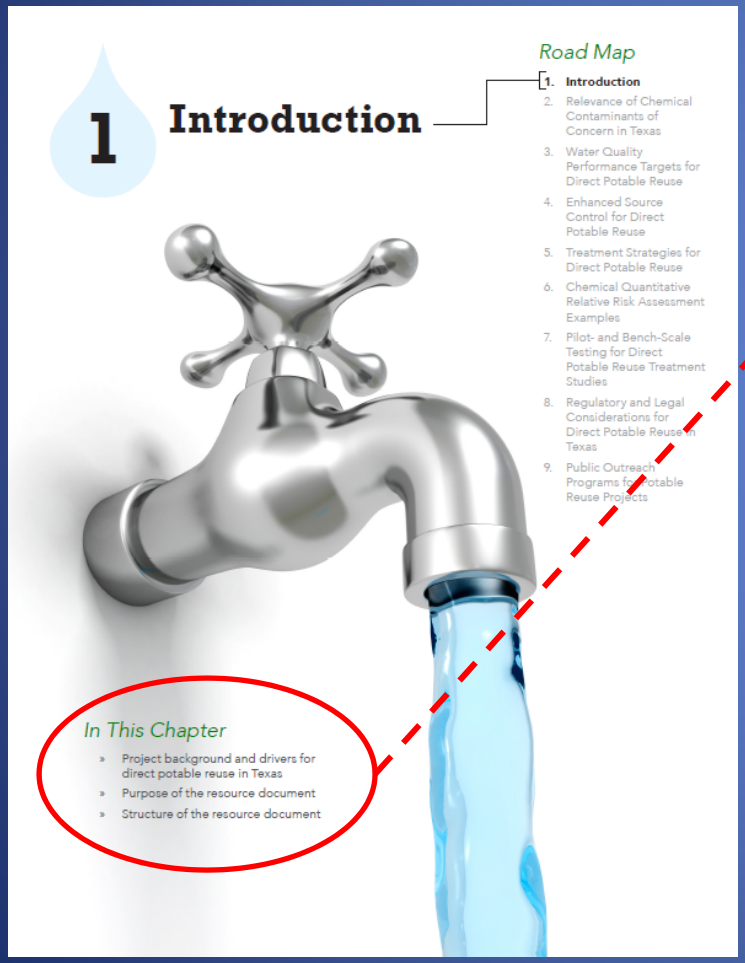
Chapter 7	Pilot- and Bench-Scale Testing for DPR Treatment Studies
Chapter 8	Regulatory and Legal Considerations for DPR in Texas
Chapter 9	Public Outreach Programs for Potable Reuse Projects

Chapter 1: Introduction



- Project background and drivers for DPR in Texas
- Purpose of document
- Structure of document

Chapter 2: Relevance of Chemical Contaminants of Concern in Texas

- What are COCs and CECs?
- Summary of statewide water quality trends
  - Comparison to standards and advisory levels
- Review of state of analytical technology
- Suggested monitoring framework for utilities interested in pursuing DPR
  - Indicators and surrogates

Ch. 2 Introduction

2.1 Introduction

Water quality and the safety of drinking water is a primary focus for any direct potable reuse (DPR) project. For this document, a number of terms are used to discuss water quality, including chemical, compound, contaminant, and constituent, which are defined in the glossary. Two terms will primarily be used throughout the document: (1) constituent, which is used to describe a chemical or compound, and (2) contaminant, which is any physical, chemical, biological, or radiological substance that has an adverse effect on air, water, or soil substance (often also called pollutants).

When considering DPR projects, pathogens, contaminants of concern (COCs) and constituents of emerging concern (CECs) present in the originating wastewater (source water for DPR treatment schemes) and treated reclaimed water should be evaluated.[2] The objective would be to determine if and what treatment or management strategies may be required to produce a raw source water for further treatment at a water

[2] In Chapter 6, as part of the Quantitative Relative Risk Assessment (QRRA), COCs and CECs are further differentiated. Contaminants of Concern that (1) are detected in the waters used for the example QRRAs, (2) are regulated or are currently under consider for regulation, and (3) have published toxicity information are referred to as Constituents of Potential Concern (CPCs). For the example QRRAs, CECs are defined as unregulated detected constituents with published toxicity information to evaluate their health significance.

What are COCs and CECs?

Contaminants of Concern (COCs) are:

- *Any substance that has an adverse effect on human health that is regulated in drinking water or under consideration for regulation in Texas or at the national level.*
- *A substance that may not pose a health risk, but that can inform treatment process effectiveness and maintenance.*

Constituents of Emerging Concern (CECs) are:

- *Chemicals or compounds not regulated in drinking water or reclaimed water and /or not routinely monitored. They may be candidates for future regulation depending on their ecological toxicity, potential human health effects, public perception, and frequency of occurrence in environmental media (Lazorchak and others, 2008).*
- *Constituents that have been present in the environment for a long time, but for which analytical or health data have only recently become available (NRC, 2012).*

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State Water Quality Trends

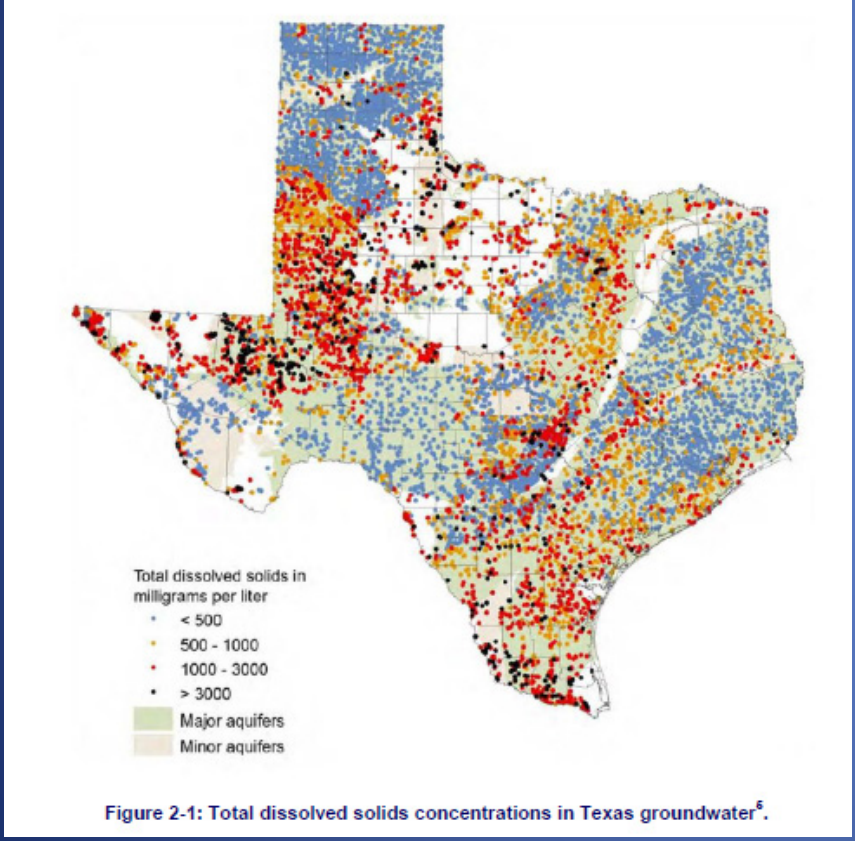


Figure 2-1: Total dissolved solids concentrations in Texas groundwater[6].

Secondary Drinking Water Standards		
Constituent	SMCL	SCL
TDS (mg/L)	500	1000

SMCL = secondary maximum contaminant level (EPA)
SCL = secondary contaminant level (Texas)

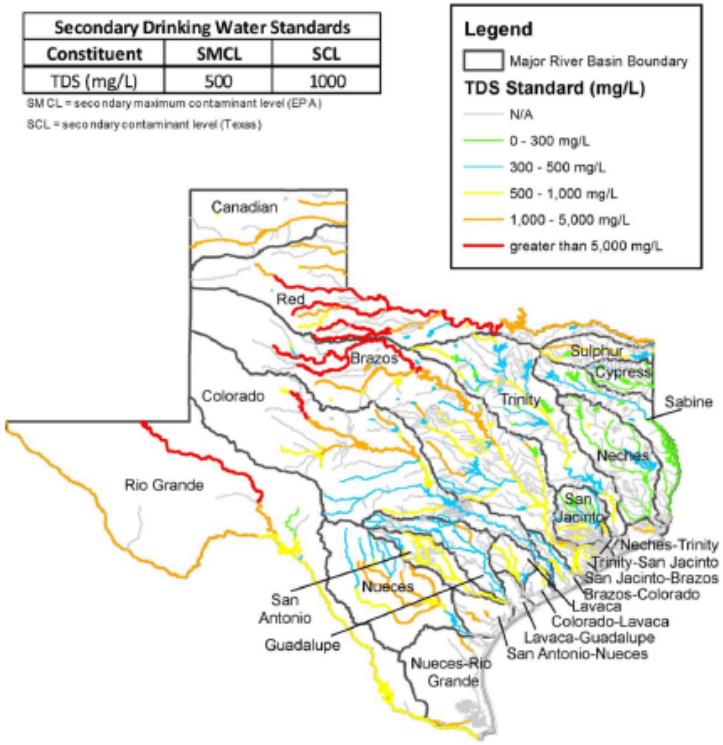


Figure 2-2: Texas total dissolved solids (TDS) surface water quality standards and secondary drinking water standards[7].

Key Questions to Ask when Developing a Monitoring Program

- Has TCEQ approved the monitoring program?
- Is sample size large enough to provide adequate statistical relevance?
- Does program properly capture spatial and temporal variability?
- Are grab or composite samples more appropriate?

Indicator and Surrogate Concept

- Indicators

  Individual constituents that represent specific physicochemical and biodegradable characteristics of a family of constituents.

  Examples: caffeine, sucralose, N,N-Diethyl-meta-toluamide (DEET)

- Surrogates

  Bulk constituents used to evaluate the performance of individual treatment processes.

  Examples: total organic carbon, ultraviolet irradiation (UV)

Suggested Indicator Chemical Monitoring List

Constituent	Rationale	Monitoring Trigger Threshold (ng/L)	Reporting limit (ng/L)
Total trihalomethanes (THMs)	Health	80,000	1,000
Haloacetic acids (HAA5)	Health	60,000	1,000
N-Nitrosodimethylamine (NDMA)	Health	10	2
Perfluorooctanoic acid (PFOA)	Health	400	10
Perfluorooctane Sulfonate (PFOS)	Health	200	10
Bromate	Health	10,000	1,000
Perchlorate	Health	15,000	1,000
1,4-Dioxane	Health	1,000	100
17b-Estradiol	Health	<1	0.9
Atenolol	Health/ Performance	4,000	100
Tris(2-chloroethyl)phosphate (TCEP)	Health/Performance	5,000	100
Caffeine	Performance		50
Gemfibrozil	Performance	800,000	10
Iopromide	Performance	750,000	50
Meprobamate	Health/Performance	200,000	100
N,N-Diethyl-meta-toluamide (DEET)	Performance	200,000	50
Primidone	Performance	10,000	10
Sucralose	Performance	150,000,000	100
Triclosan	Performance	2,100,000	50

Suggested Surrogate Parameters for Advanced Water Treatment

Surrogate Parameter	Unit processes
Total organic carbon (TOC) or dissolved organic carbon (DOC)	RO, NF, GAC, PAC, ozone, AOP
UV absorbance (254 nm)	RO, NF, GAC, PAC, ozone, AOP
Fluorescence indices/ratios	RO, NF, GAC, PAC, ozone, AOP
Total dissolved solids (TDS)/electrical conductivity	RO, NF
Boron (surrogate for NDMA)	RO, NF
Aesthetics	
Temperature	RO, NF, GAC, PAC, ozone, AOP
Color (436 nm)	RO, NF, GAC, PAC, ozone, AOP
Odor	RO, NF, GAC, PAC, ozone, AOP
Hardness	RO, NF

Suggested Monitoring Framework

Phase 1: Initial Assessment

- Begins prior to or during piloting and continues through initial startup
- Meet with the TCEQ to discuss project goals and monitoring requirements
- Identify occurrence of key indicators and surrogates in reclaimed water (can begin prior to piloting)
- Determine treatment effectiveness (during pilot phase)
- Define initial project-specific performance indicators and surrogates to monitor in subsequent phases.

Phase 2: Baseline Monitoring Program

- Begins following initial setup and continues for 3 years
- Assess and refine selection of indicators and surrogates

Phase 3: Standard Operating Monitoring Program

- Begins following baseline monitoring and continues through the life of the project
- Includes monitoring of indicators and surrogates identified during previous monitoring phases
- May be adusted as project conditions are changed

Chapter 3: Water Quality Performance Targets

- Discussion of constituents of concern
  - Pathogens and chemicals
- Approaches to development of pathogen targets

Basis of Pathogen Targets

- WateReuse Research Foundation Project 11-02
  - Use EPA 10^{-4} risk level in drinking water

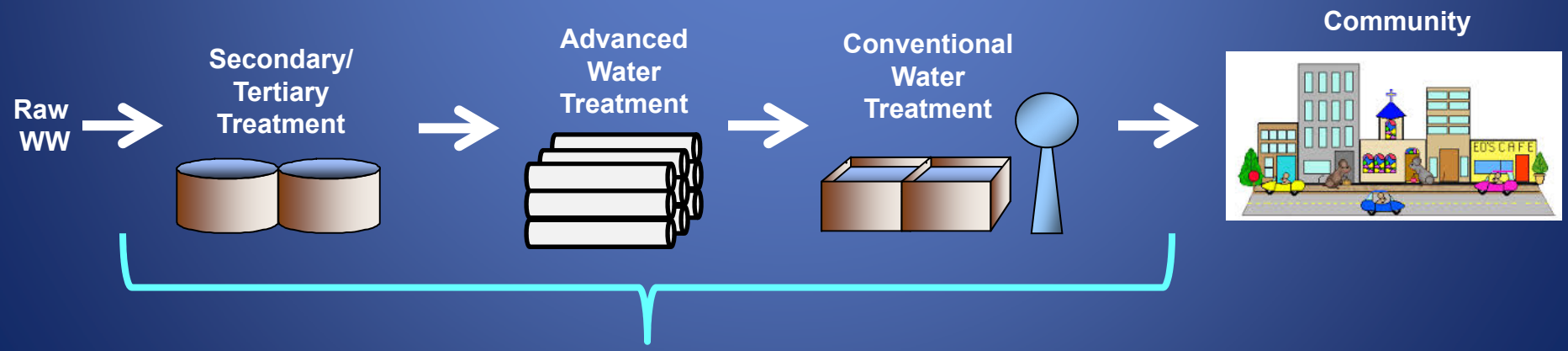
Parameter	Units	Pathogens		
		Virus	*Cryptosporidium*	*Giardia*
Raw wastewater	IU/L[a]	10^5	10^5	10^5
Drinking water goal	IU/L	2×10^{-7}	3×10^{-5}	6.8×10^{-6}
Ratio	-	5×10^{11}	3×10^9	1.5×10^{10}
Log removal	**-**	**12**	**10**	**10**

[a] IU/L = infectious units per liter

Pathogen Targets

- Technical Team Recommendations
  - Base on WRRF Project 11-02

	Cryptosporidium	Giardia	Virus	Total Coliform
$\log_{10}$ removal	10	10	12	9

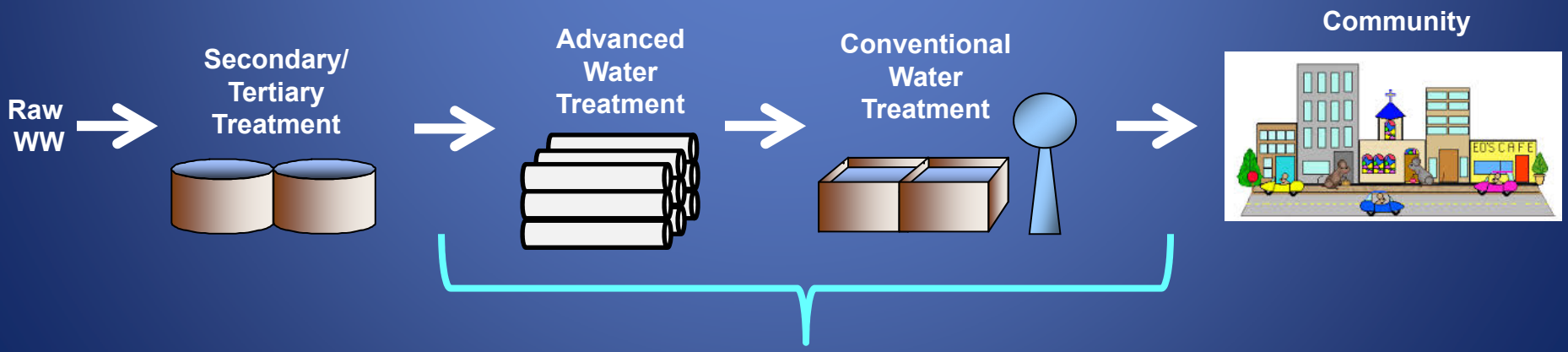


$\log_{10}$ removal between **RAW** wastewater and treated drinking water

Pathogen Targets

TCEQ Baseline Pathogen Targets

	Cryptosporidium	Giardia	Virus	Total Coliform
log_{10} removal	5.5	6	8	--



log_{10} removal between **TREATED** wastewater and treated drinking water

Chemical Targets and Aesthetics

- Chemical targets
  - MCLs
  - Indicators and Surrogates from Chapter 2
- Aesthetics
  - Color, odor, etc.
  - Consistency with existing supplies

Chapter 4: Enhanced Source Control

- Summary of federal pretreatment requirements
- Suggested enhanced program elements

Source Control (SC) vs. Pretreatment (PT)

- **MORE** than Federal or State PT Programs

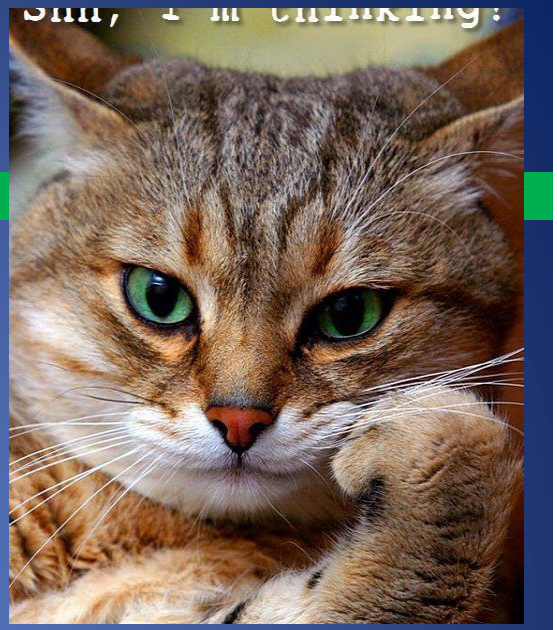
+ Enhancements

- Managerial and operational barriers to:
  - Eliminate or control the discharge of POCs to wastewater that can be difficult to treat and may impair the final quality of the treated water intended for DPR

Not Every POTW is Required to Have a PT Program

- TPDES Permit
  - Approved program if flow > 5 mgd, IUs that could cause pass through or interference, one or more CIUs, other criteria
- Non-TPDES permit (TLAP)
  - Case-by case (only certain PT program elements)
- **Program gaps or no program ⟶ be proactive!**

Keep in Mind Effectiveness



- You can measure pollutant in POTW's influent and collection system and . . .
- Can
  - Identify a source or group of sources that account for a majority of the loading
  - The identified loading is controllable
  - The loading is > pollutant reduction needed
- Is the source within the jurisdiction of the POTW to control?
  - Yes: Industries and businesses
  - No: residential sources (address thru outreach and voluntary behavior changes)
  - No: commercial products (restricted on a local, regional, statewide, or national basis), low level radioactive wastes (voluntary)

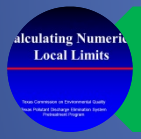
What Does Enhanced SC Look Like?

The Basics

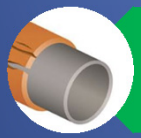
Legal Authority

Procedures

Funding



Local Limits



Enforcement Response Plan

IU List

All Federal Prohibitions, Standards, etc.

Enhanced SC Recommendations - Consider

- **Tailoring** the program to your service area and treatment system
- Ensuring you have **sufficient legal authority** to take whatever actions are needed to protect your DPR project
- Developing and maintaining a frequently updated **comprehensive inventory** – IUs and POCs
- Developing **comprehensive local limits** that consider a broader spectrum of regulated (MCLs) and non-regulated constituents

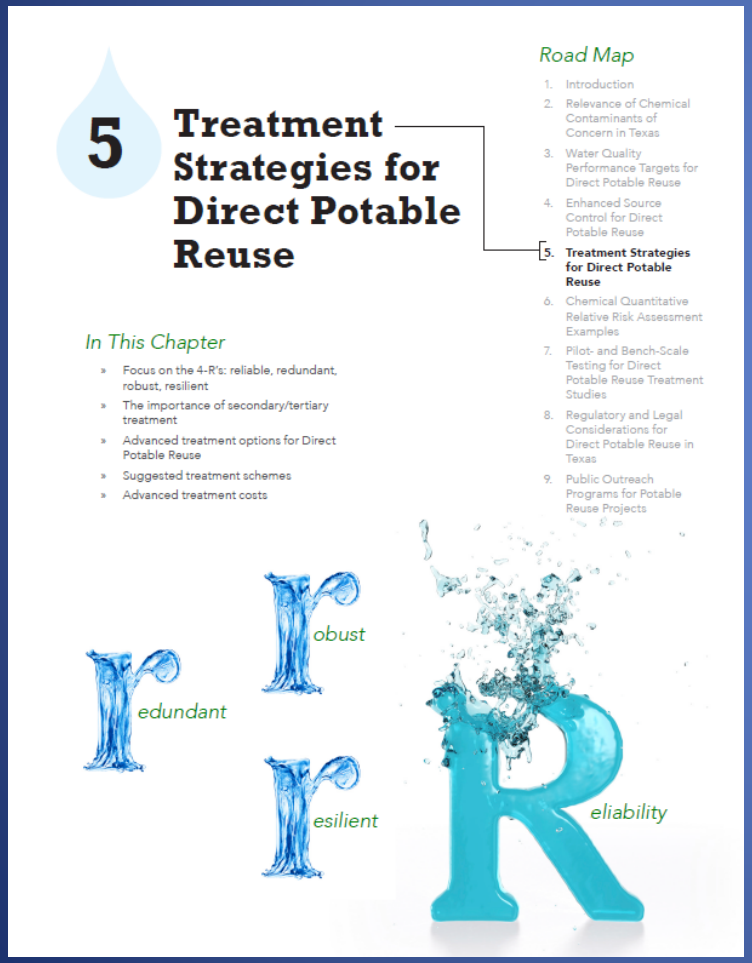
Enhanced SC Recommendations - Consider

- Ensuring that you have **effective IU permits** that regulate and reduce the discharge of POCs
- Using **alternative control mechanisms** such as BMPs or self-certification for zero discharge of pollutants (radiator shops, dry cleaners, etc.)
- Creating **comprehensive monitoring programs** that address POCs for DPR
- Developing **rapid response plans** that can identify and respond to discharges of POCs

Enhanced SC Recommendations - Consider

- Conducting **outreach to industries and public** (stewardship programs, compliance assistance, proper disposal)
- Developing a **communication plan** between the wastewater & AWT operations and source control to respond to industrial “incidents” and changes in water quality
- Developing **MOAs between POTW and RW producer** so that appropriate source control actions can be taken if necessary to protect DPR water quality

Chapter 5: Treatment Strategies



- Importance of secondary/tertiary treatment
- Summary of available advanced treatment technologies and log removal capabilities
- Potential treatment schemes

The 4 “R’s” of Treatment for DPR

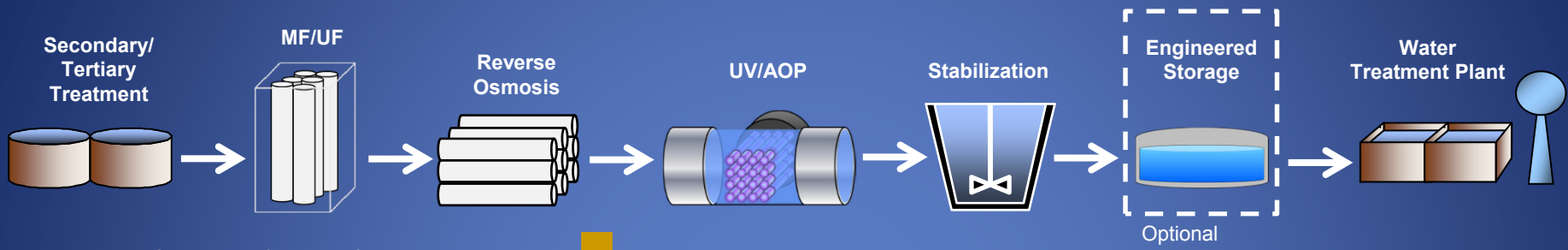
Redundancy
f(# of barriers targeting a contaminant)

Robustness
f(treatment process diversity)

Resilience
f(failure response protocols)

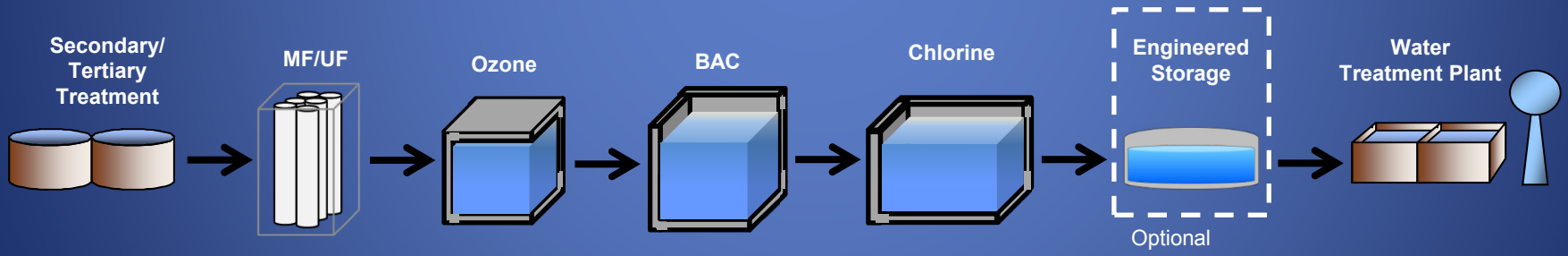
RELIABILITY

Sample Treatment Schemes



Membrane-based treatment
(17/17/13/20)
(11/11/8)

Brine concentrate- can be expensive!



Ozone/BAC- based treatment (12/14/13/17)
(10/11/12)

Targets: Crypto/giardia/virus/total coliform
10/10/12/9 (WRRF 11-02)
5.5/6/8/-- (TCEQ)

What is Engineered Storage?

- A constructed storage facility that provides a safety factor in the form of response time to address acute risks from pathogens should a treatment system fail or operate below desired performance targets.
- See Project WRRF 12-06, *Guidelines for Engineered Storage for Direct Potable Reuse*

Other Treatment Issues

- DBP Management
  - THMs, HAAs
  - Bromate
  - NDMA
- Residuals Management
- Conventional treatment optimization and control

Treatment Scheme Comparative Costs

Capacity (MGD)	Treatment Scheme[2]	Capital Cost ($M/MGD)	O&M Cost ($M/MGD)
1	1	$ 9.43	$ 1.000
	2	$ 7.54	$ 0.992
	3	$ 7.89	$ 1.048
	4	$ 7.18	$ 0.537
	5	$ 6.93	$ 0.499
	6	$ 4.75	$ 0.153
5	1	$ 6.27	$ 0.778
	2	$ 5.38	$ 0.771
	3	$ 5.63	$ 0.810
	4	$ 4.04	$ 0.398
	5	$ 3.81	$ 0.362
	6	$ 2.32	$ 0.125
10	1	$ 5.30	$ 0.700
	2	$ 4.66	$ 0.693
	3	$ 4.88	$ 0.727
	4	$ 3.21	$ 0.350
	5	$ 2.98	$ 0.315
	6	$ 1.72	$ 0.115
25	1	$ 5.13	$ 0.610
	2	$ 4.63	$ 0.603
	3	$ 4.84	$ 0.631
	4	$ 2.89	$ 0.297
	5	$ 2.63	$ 0.263
	6	$ 1.42	$ 0.103

Source: Stanford, B. and others , "A Cost-Benefit Analysis of the Energy Requirements for UV/Peroxide and Ozone Pre-Oxidation for Organic Fouling Control in RO Membranes", Annual Water Reuse & Desalination Research Conference, WateReuse Research Foundation, 2012

Chapter 6: Quantitative Relative Risk Assessment Examples

- Overview of risk assessment process
  - Carcinogenic and non-carcinogenic risk
  - Focus on chemicals (not pathogens)
- Benefits of QRRAs
- Summary of 2 case study examples

QRRA

- Identify detected chemicals
- Toxicity assessment
- Exposure assessment
  - Relative – not absolute risk since absolute exposure problematic
- Characterize health risks

WHY do a QRRA?

1. MCL Comparisons: Varying risk levels, technical & cost considerations

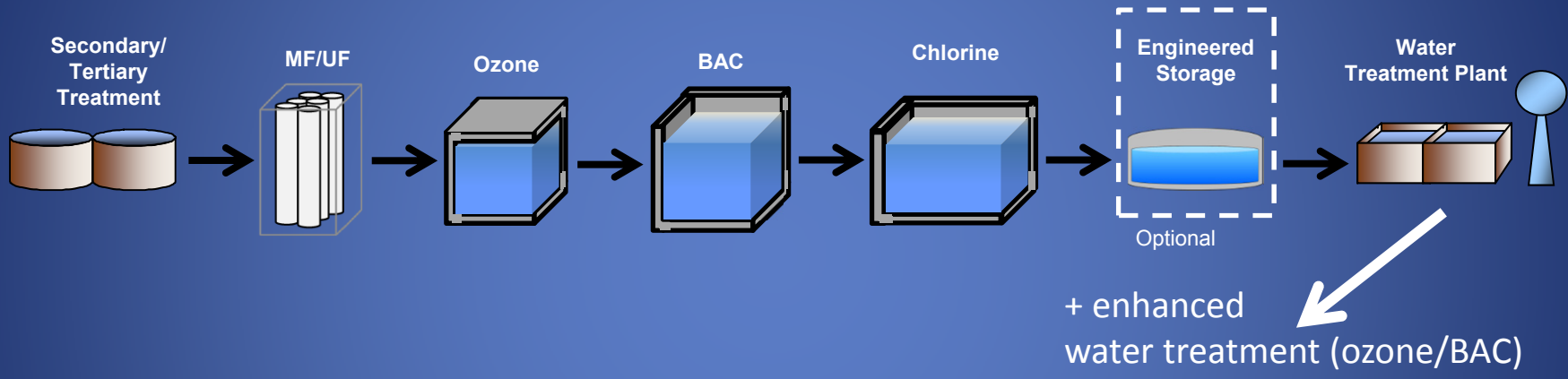
2. Epidemiology Studies: Cost, sensitivity, confounding factors, exposure

3. Conventional Risk Assessments: Issues w/ exposure

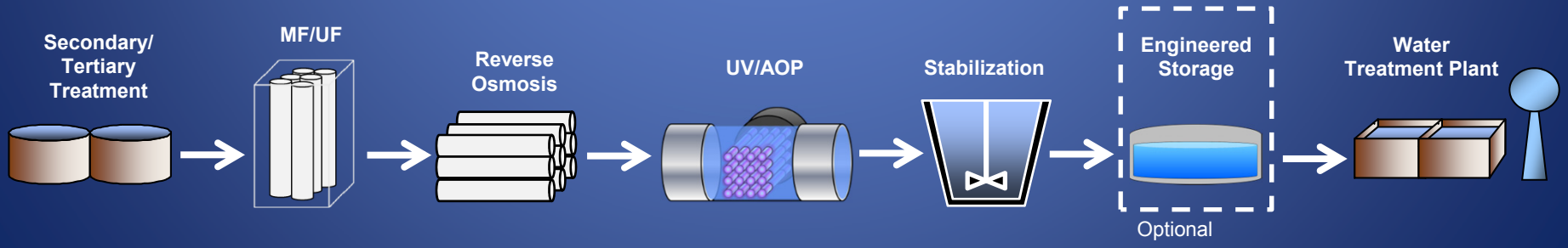
Relative Risk

Case Study Treatment Schemes

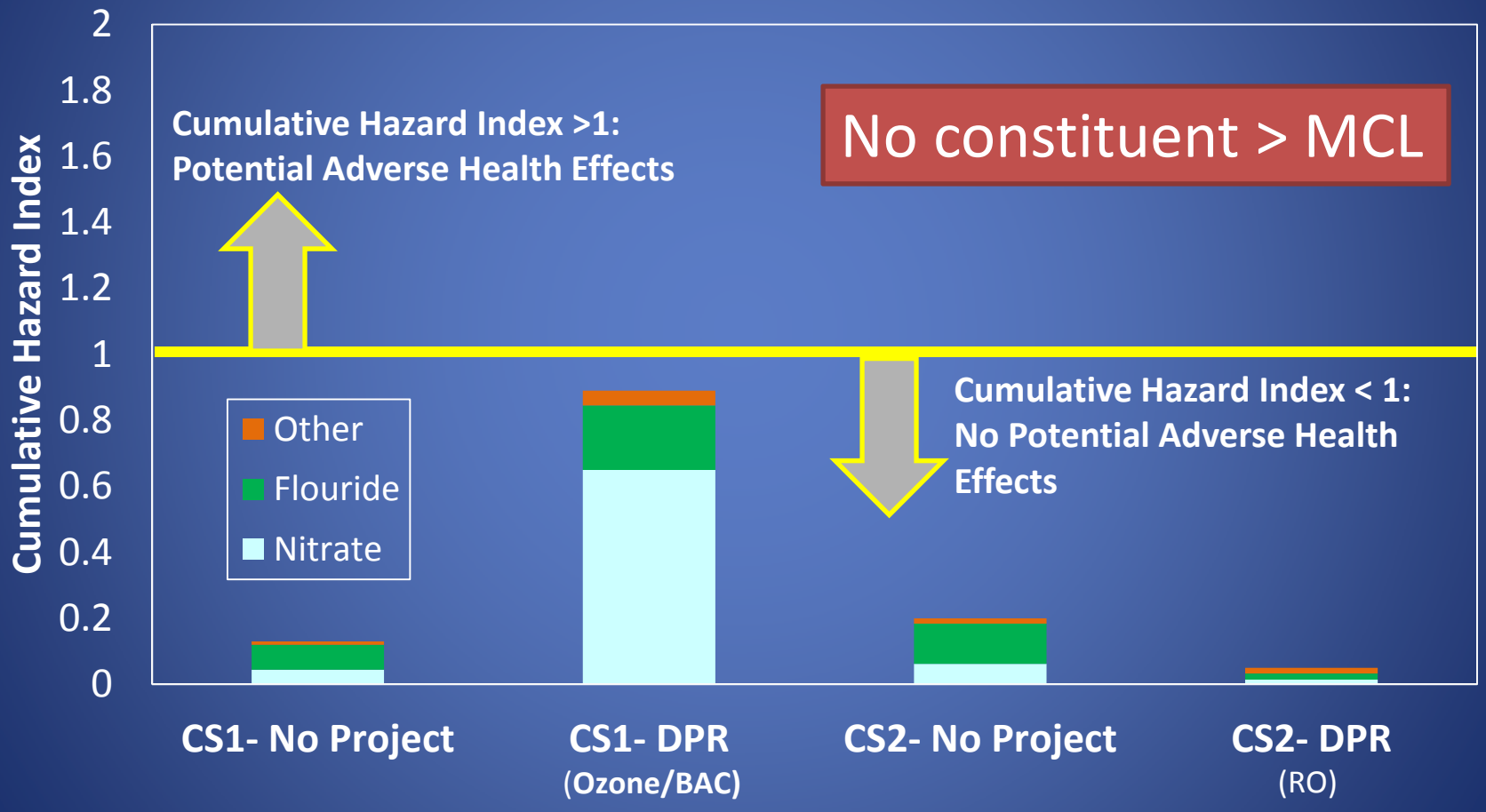
Case Study #1: Non-RO AWTF/enhanced WTP



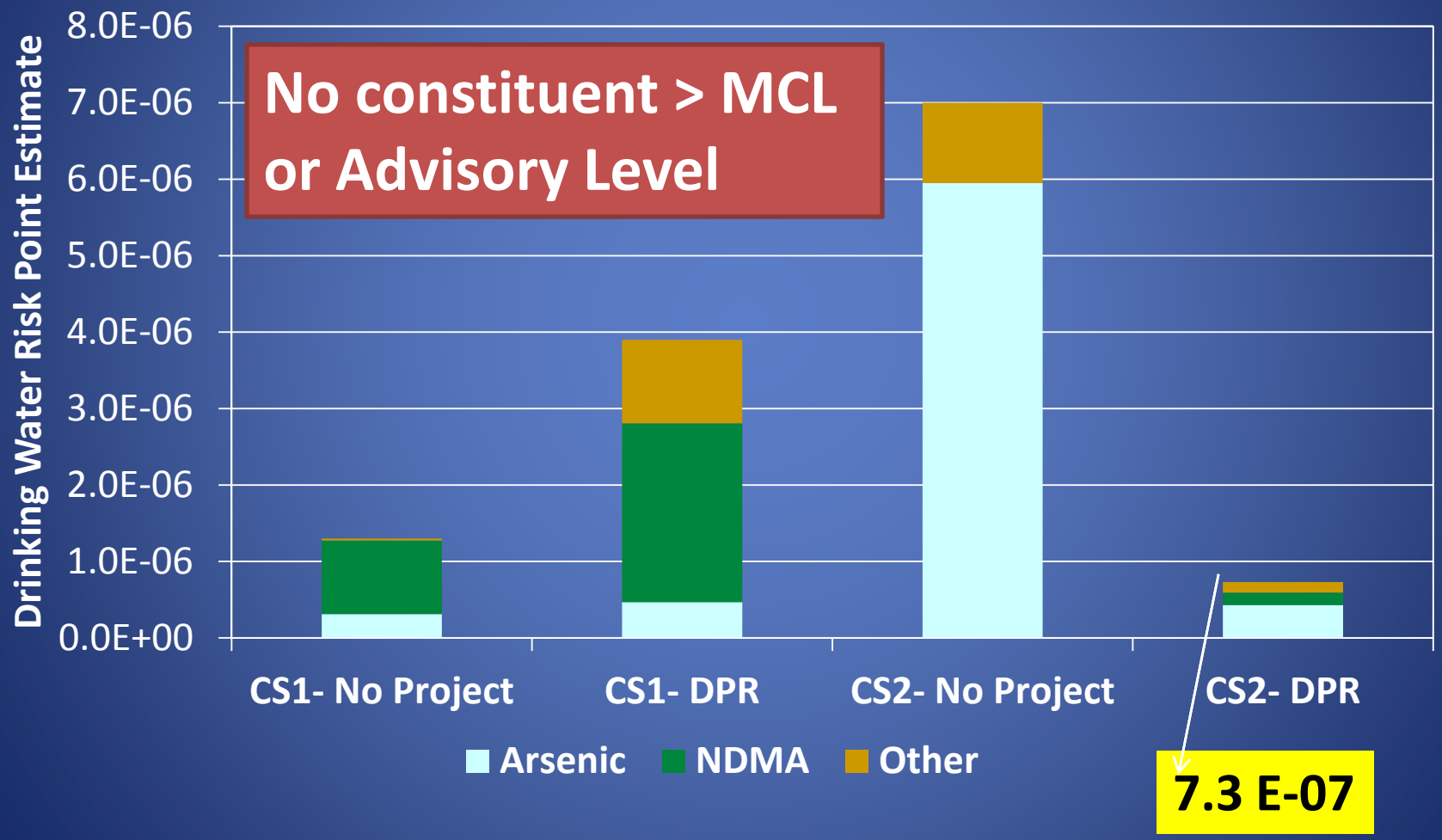
Case Study #2: RO AWTF/Conventional WTP



Non-Carcinogenic Risk Results



Carcinogenic Risk Results



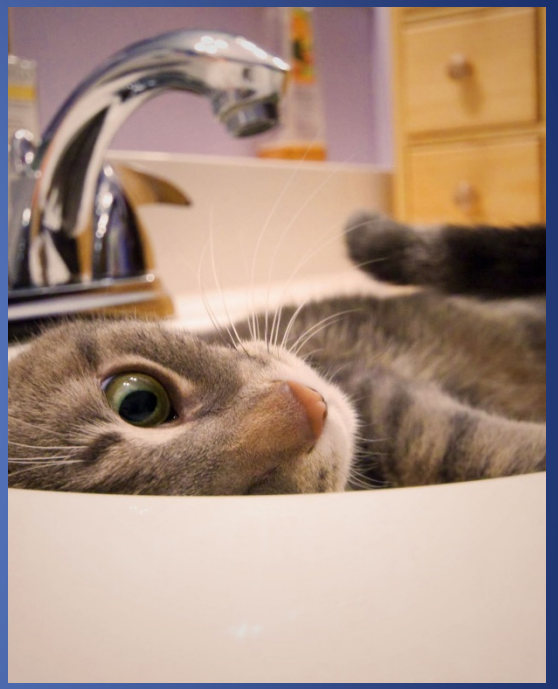
CEC Risk Exemplar Results

	Case Study 1		Case Study 2	
	No Project Alternative	DPR Alternative	No Project Alternative	DPR Alternative
# CECs present > MRL	32	46	5	53
MOS Range	1.6 – 1.0E10	0.9 – 5.9E10	3,600 – 1.6E07	13 – 6.0E09
# CECs with MOS 1-10	1	1	0	0
CECs with MOS 1-10	Quinoline	Quinoline	---[a]	0[a]

[a] Not detected in source water; found in secondary effluent but removed by RO

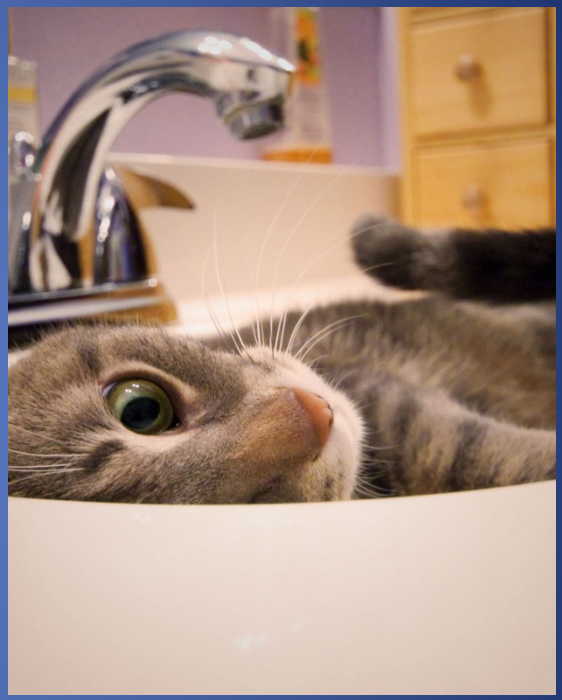
QRRA Practical Applications for DPR

- Assess short-term drought mitigation vs. long-term water supply
- Assist with decisions on the need for pilot testing
- Assist with decisions on DPR treatment components
- Modify/tailor monitoring to collect data for most relevant contaminants



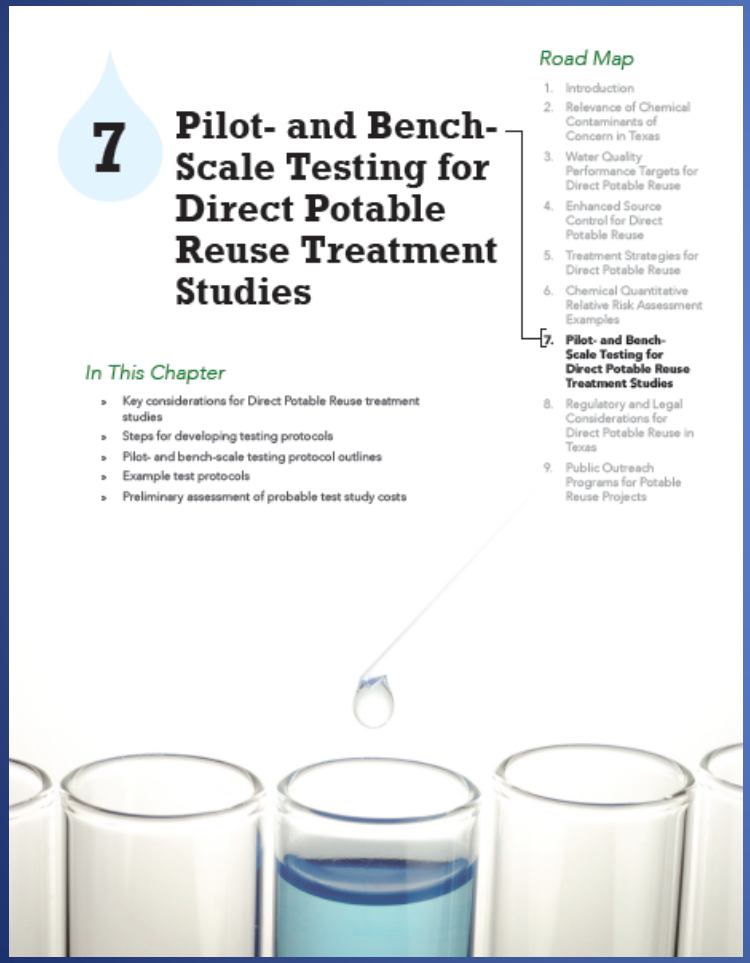
QRRA Practical Applications for DPR

- Specific source control and/or treatment options:
  - Where the relative risk may increase over time or
  - Reaches a level of potential concern



- Inform the public about the safety of DPR as part of public outreach

Chapter 7: Pilot and Bench-Scale Testing



7

Pilot- and Bench-Scale Testing for Direct Potable Reuse Treatment Studies

In This Chapter

- Key considerations for Direct Potable Reuse treatment studies
- Steps for developing testing protocols
- Pilot- and bench-scale testing protocol outlines
- Example test protocols
- Preliminary assessment of probable test study costs

Road Map

1. Introduction
2. Relevance of Chemical Contaminants of Concern in Texas
3. Water Quality Performance Targets for Direct Potable Reuse
4. Enhanced Source Control for Direct Potable Reuse
5. Treatment Strategies for Direct Potable Reuse
6. Chemical Quantitative Relative Risk Assessment Examples
7. **Pilot- and Bench-Scale Testing for Direct Potable Reuse Treatment Studies**
8. Regulatory and Legal Considerations for Direct Potable Reuse in Texas
9. Public Outreach Programs for Potable Reuse Projects

Alan Davis, P.E.

Chris Boyd, Ph.D., P.E.

Chapter 7: Pilot and Bench-Scale Testing

- Reasons for performing testing studies
- Treatment study considerations
- Treatment study tasks
- Pilot- and bench-scale testing protocol outlines and sample protocols
  - Sample protocols for RO-based treatment and ozone/BAC-based treatment
- Probable costs for treatment testing

Bench & Pilot Testing

- ***Pilot-scale treatment studies:***
  - Smaller than full-scale
  - Large enough to behave like full-scale
  - Often use portable treatment units that can be located near the source water.
  - Continuous testing over longer period
  - Used to evaluate different treatment processes or different vendors of the same process.

Bench & Pilot Testing

- ***Bench testing:***
  - Typically performed in a laboratory
  - Used to evaluate performance characteristics of treatment processes that can be represented adequately at a laboratory scale.
  - Discrete samples of the water to be treated are typically transported to the laboratory for testing.

Why are we testing?

Regulatory

- Satisfy state and federal pilot- and bench-scale testing requirements

Design

- Establish design criteria and operating procedures
- Evaluate equipment performance
- Optimize treatment
- Determine the influence of a unit process on downstream unit processes
- Evaluate opportunities to reduce operation and maintenance costs
- Provide input to utility's source control program to identify contaminants that are not effectively treated or that negatively impact treatment performance

Why are we testing?

Treatment Efficiency

- Assess treatment performance relative to established water quality goals

Procurement

- Obtain test data on multiple manufacturers and/or process variations for the equipment selection and bid phases of the full-scale project

Other

- Provide hands-on training to plant operators and staff
- Provide an opportunity for research and development
- Provide an opportunity for public outreach to demonstrate the technology

Treatment Schemes and Testing Requirements

Treatment Scheme No.	AWT Process	Example Test Plan	Feed Source	Typical Testing Consideration[1]
2	Secondary/Tertiary	---	---	---
	MF/UF	Pilot-Scale	Secondary/Tertiary	R,D,T,P,O
	RO	Pilot-Scale	MF/UF	R,D,T,P,O
	UV/AOP	Bench-Scale	RO	D,T,P
	Stabilization	Bench-Scale	RO	D
	WTP	---	---	---

R = Regulatory D = Design T = Treatment Efficiency O = Other

Treatment Schemes and Testing Requirements

Treatment Scheme No.	AWT Process	Example Test Plan	Feed Source	Typical Testing Consideration[1]
6	Secondary/Tertiary	---	---	---
	Ozone	Pilot-Scale	Secondary/Tertiary	R,D,T,O
	BAC[3]	Pilot-Scale	Ozone	D,T,O
	UV	Bench-Scale	BAC	D,T,P

R = Regulatory D = Design T = Treatment Efficiency O = Other

Costs

- Typical Treatment Study Cost Items
  - Site preparation
  - Equipment shipping
  - Equipment rental
  - Vendor services
  - Engineering fees
  - Water quality sampling
  - Internal operating costs

Costs

Process	Test Scale	Minimum Test Duration[1]	Assumed No. of Vendors/ OEMs	Preliminary Budgetary Planning Cost[2]
BAC	Pilot-scale*	3 months	---	$100,000 - $150,000
MBR	Pilot-scale	3 months	3	$400,000 - $550,000[4]
MF/UF	Pilot-scale	3 months	3	$350,000 - $500,000
Ozone	Pilot-scale*	3 months	1	$150,000 - $250,000
RO	Pilot-scale	3 months	3	$400,000 - $550,000
UV			Bench-scale	Single study	$25,000 - $45,000
UV/AOP			Bench-scale	Single study	$25,000 - $45,000

Chapter 8: Legal and Regulatory Considerations

- Current regulatory framework for DPR
  - Chapter 290
    - Source water approval
    - Innovative/alternative treatment process approval
      - Addressed on case-by-case basis
  - Chapter 210
    - Used to authorize delivery of reclaimed water to advanced treatment facility

Suggested Steps for Obtaining Regulatory Approval

Initial meeting with TCEQ (Water Supply , Water Quality and Water Availability Divisions)

- Discuss conceptual alternatives
- Obtain information about subsequent regulatory process
- Define anticipated pilot-testing and monitoring requirements

Residuals management (Water Quality Division or Office of Waste)

- Evaluate disposal requirements for treatment residuals
- Submit application for discharge permit, deep well injection, or alternative disposal methodology to TCEQ (as needed)
- TCEQ reviews application and requests additional information (as needed)
- TCEQ issues draft permit and public notice (as needed)
- TCEQ issues final permit

Chapter 210 reclaimed water authorization (Water Quality Division)

- Submit application for authorization to TCEQ (as needed)
- TCEQ reviews application and requests additional information (as needed)
- TCEQ issues reclaimed water authorization

Exception request (Water Supply Division)

- Submit exception request to TCEQ
- TCEQ reviews application and requests additional information (as needed)
- TCEQ establishes specific conditions pertaining to sampling, treatment, public notice and other activities associated with the request.
- TCEQ issues approval of the exception.

Pilot testing (Water Supply Division)

- Develop pilot/bench testing plan
- Submit testing plan to TCEQ
- TCEQ reviews plan and requests additional information (as needed)
- TCEQ issues approval of testing plan
- Perform testing
- Coordinate with TCEQ on approval of testing results and selection of treatment elements

Construction approval (Water Supply Division)

- Utility to submit plans and specifications prepared by a registered professional engineer
- TCEQ reviews submittal and requests additional information (as needed)
- TCEQ issues construction approval

Startup approval (Water Supply Division)

- Perform required testing at full scale facility and submit to TCEQ
- TCEQ reviews submittal and requests additional information (as needed)
- TCEQ issues approval to begin operation

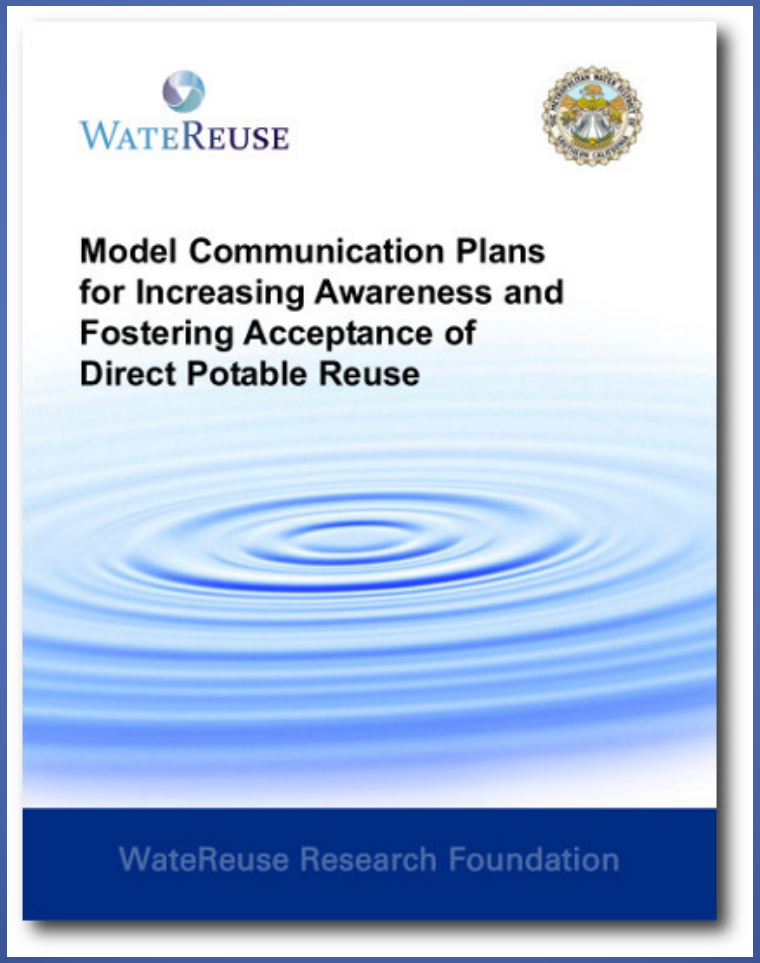
Chapter 9: Public Outreach Programs

- Lessons learned from existing DPR/IPR projects
- Available tools
- Suggested best practices

Key Tips for Public Outreach and Participation

- Provide compelling and accurate information on the water cycle
- Try to avoid technical jargon
- Proactively work with the media, educational institutions and others to broaden understanding about water
- Focus on creating trust with the community
- … and more

WateReuse Research Foundation Outreach Tools



Ongoing DPR Research Focus Areas

- Alternative treatment schemes
- Blending and storage needs
- Treatment operations and reliability
- Monitoring strategies
- Quality assurance
- Public education and communication

Questions?