Committee on Water

Advancements in Water Reuse

NARUC Policy Summit

July 16, 2018

Presentation Overview

About the Foundation

Reuse and Alternative Water Supplies

Water reuse in agricultural applications

Real-time monitoring systems

THE
Water
Research
FOUNDATION

The integrated organization represents the evolution of water research issues, the overlap between water and wastewater, and efficiencies to be gained through a consolidated research program.

Learn more at www.waterrf.org and www.werf.org

$700 Million in Research

2,300 Projects

1,200 Subscribers

WE&RF and WRF Integration

- A more interconnected research and innovation agenda
- Access to an expanded collection of water research
- Leverages funding
- Communicates more effectively with government partners
- Strengthens relationships with water partners
- Creates a model for collaboration across the water community

The evolution of water research

- 1,200 subscribers
- 2,300 research studies
- $700M integrated research portfolio

Reuse and Alternative Water Supplies

Cost of Water Supply Options

Supply Option	Cost ($/AF)	Opportunities and Value
Direct Potable Reuse (DPR)	820–2000	High-quality potable water with reliable and drought-resistant yields. Relies on proven technologies using existing water distribution infrastructure.
Indirect Potable Reuse (IPR)	820–2000	
Seawater Desalination	1500–2330	High-quality supply with climate-resistant yields. Source waters are virtually unlimited in availability along coastal areas.
Brackish Groundwater Desalination	930–1290	High-quality potable supply with climate resistant yields in locations with access to brackish groundwater.
Imported Water	850–1300	Existing infrastructure and institutions are in place to govern and deliver water.
Nonpotable Reuse	310–1960	Reduces demand on potable systems with reliable, drought-resistant yields matching water quality to a variety of uses.
Demand Side Management	465–980	Reduces water demand and energy used to treat and pump water. Additional energy savings where less hot water is needed.

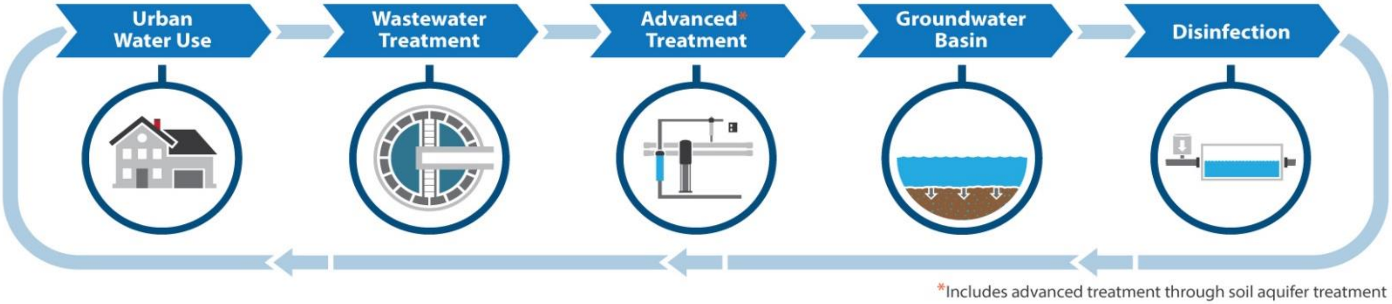
Source: The Opportunities and Economics of Direct Potable Reuse (Raucher and Tchobanoglous)

Drivers for Potable Reuse

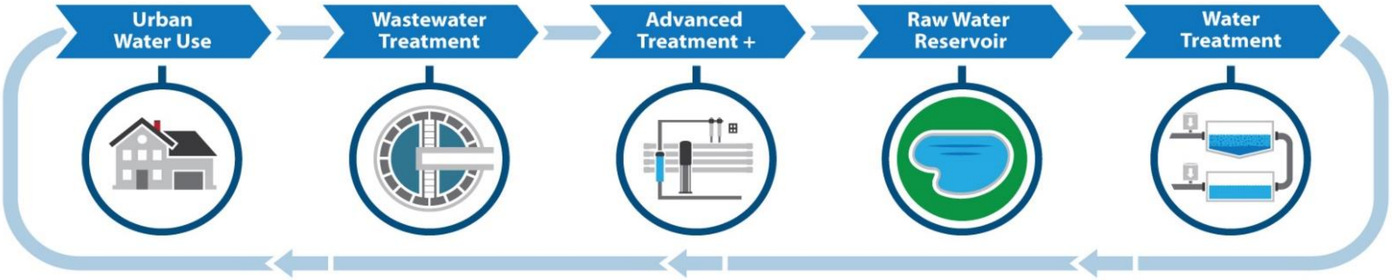
- Drought and extreme weather
  - Water at a desired quality is not necessarily where and when it is needed
  - Wastewater sources are located where demand for potable water is highest
- Decreased energy use compared to pumping and/or overtreating water
  - Water treated to potable standards is not needed for all uses
  - Cost considerations – less expensive than desalination
- Community considerations
  - Greater desire for “green” cities and communities
  - Public health protection
- Additional environmental considerations

Indirect Potable Reuse

Groundwater Augmentation

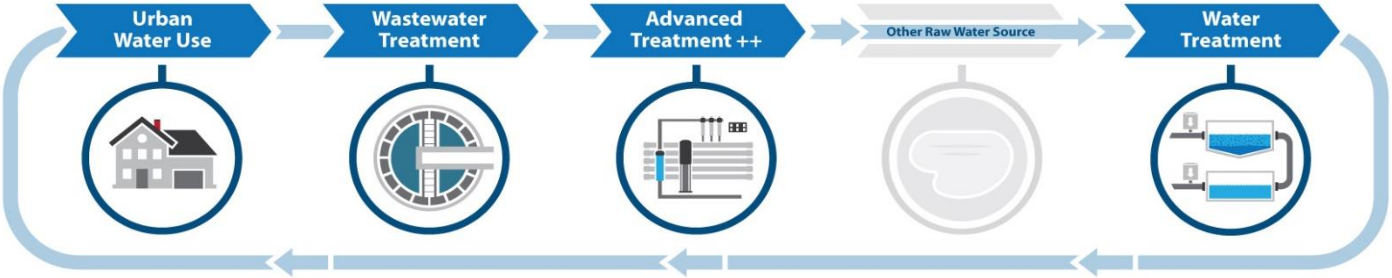


Surface Water Augmentation

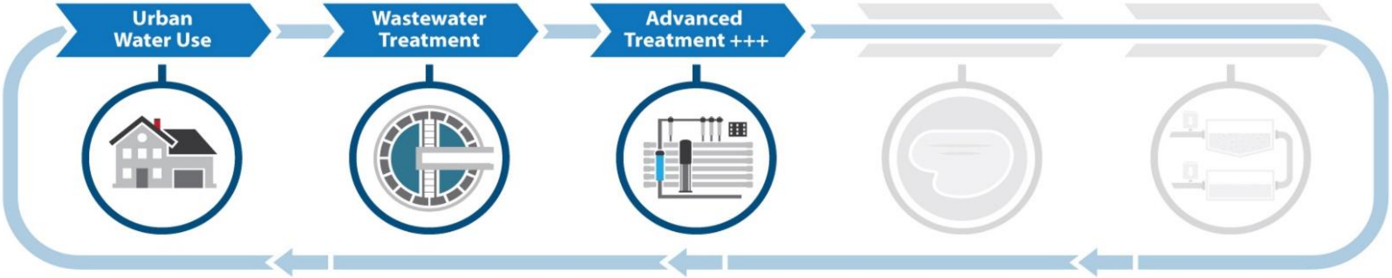


Direct Potable Reuse

Raw Water Augmentation

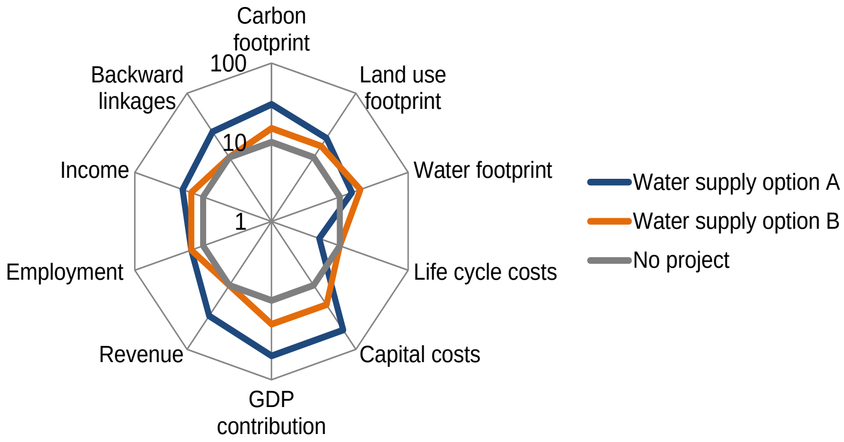


Drinking Water Augmentation



Comprehensive Analysis of Alternative Water Supply Projects Compared to Direct Potable Reuse

- Decision tool to facilitate water supply planning
- Combined lifecycle analysis, triple bottom line (TBL), and multi-criteria decision making tool
- Workshops, tool development, beta tests, case studies



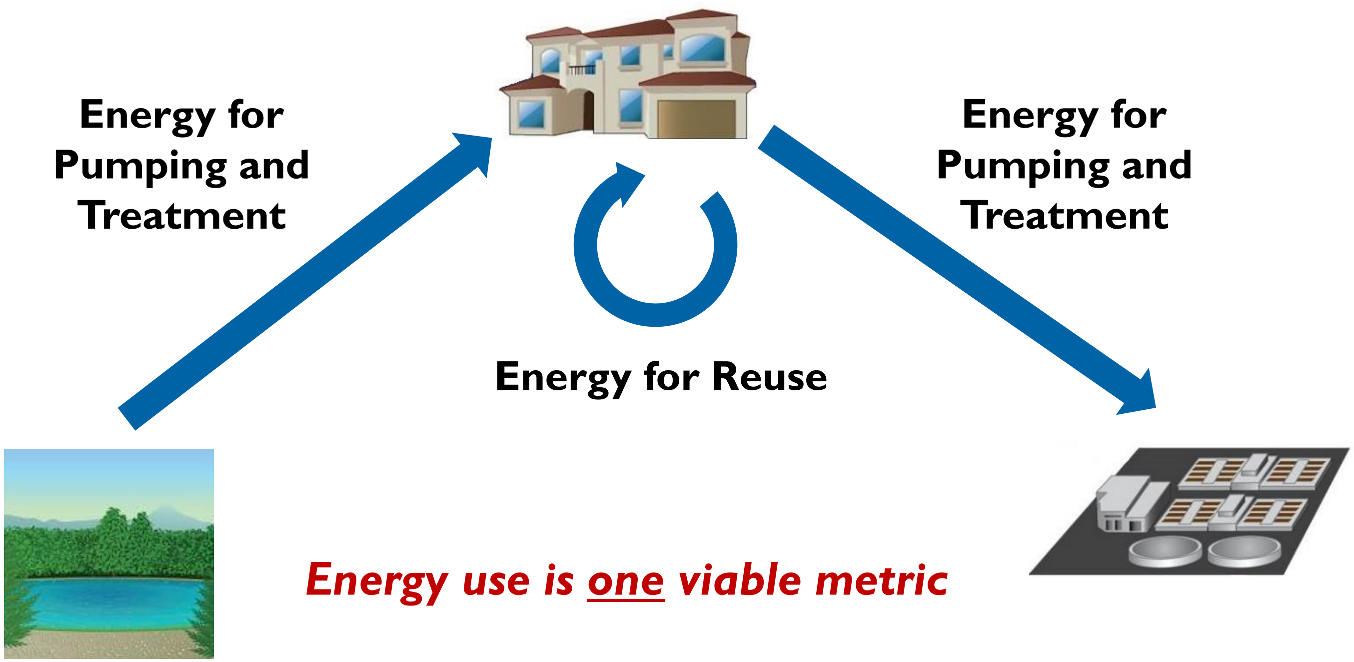
Case studies from utilities in the U.S. and Australia

Water Water Supply Options

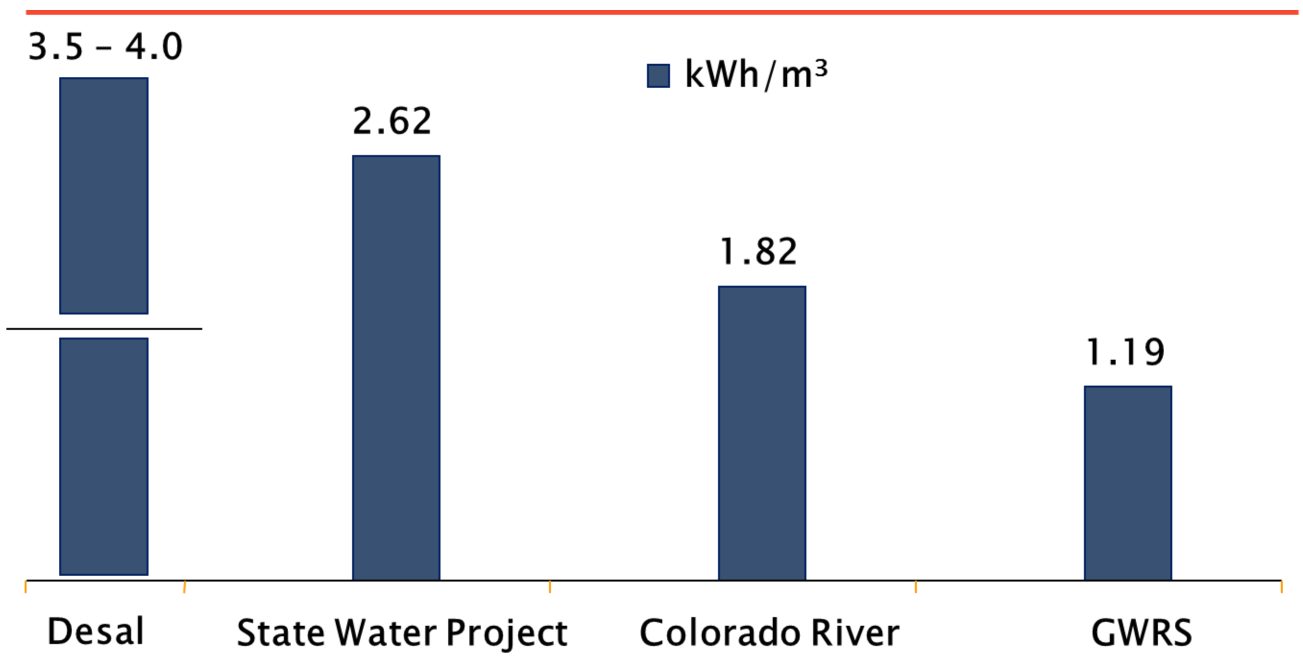
- IPR/DPR
- Brackish and Seawater Desalination
- New Dam (reservoir)
- Groundwater Pumping
- Rainwater Tanks

- Stormwater Capture
- Extension of Existing Supply
- Demand Management and Leak Reduction
- Nonpotable Reuse
- Water Imports

How Do We Define Sustainability?

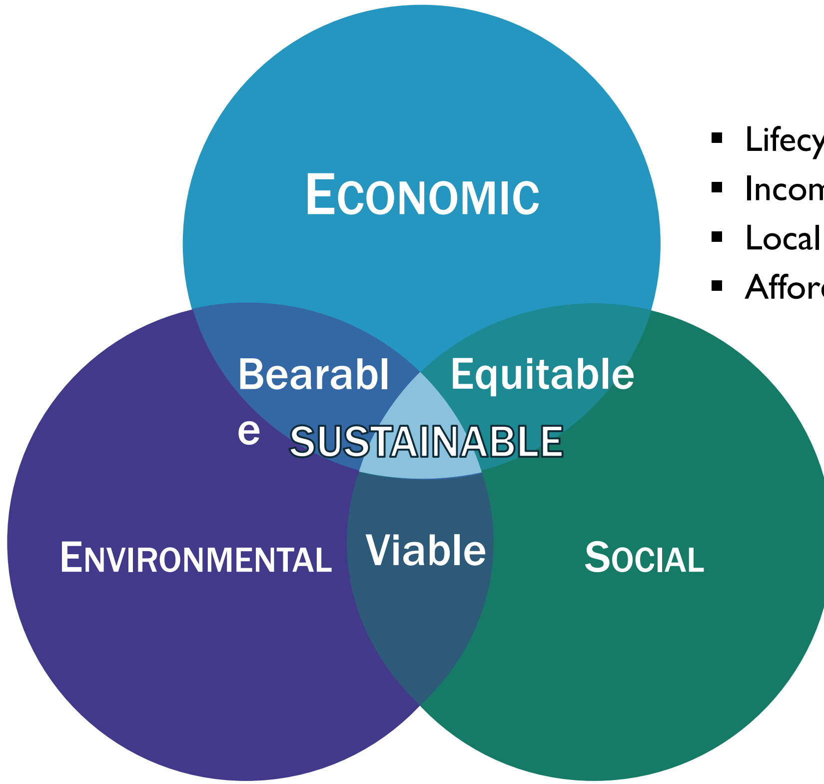


Energy Required for Water Delivery and Treatment in Orange County, CA



Triple-Bottom Line Concept

- Lifecycle cost
- Income
- Local tax revenue
- Affordability



- Water quality
- Air quality
- Carbon footprint
- Land footprint
- Eutrophication and ecosystem impact

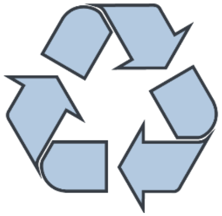
- Recreation
- Property Values
- Job growth
- Public health
- Water shortage impact
- Public perception

Limitations of Current TBL Methods

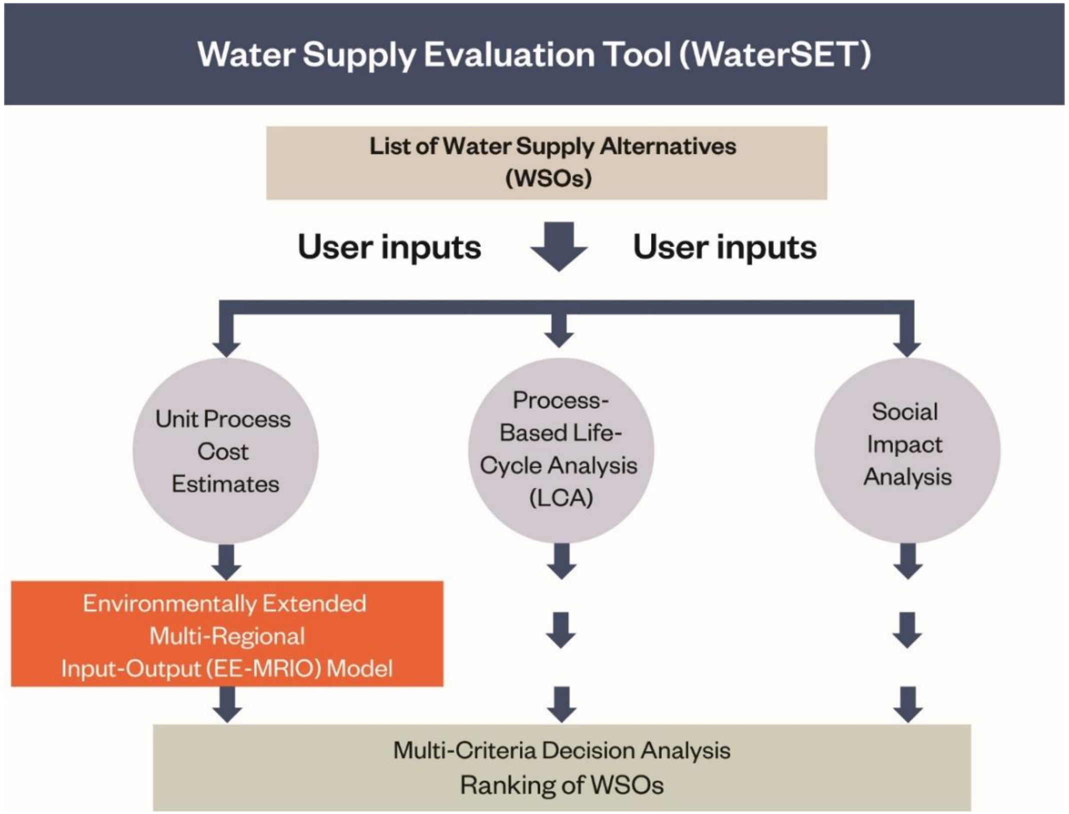
- Integrating Economic, Social, and Environmental Criteria into a Common Decision Framework
  - Metrics are different (e.g. dollars versus pollutant loadings)
  - Some Social and Environmental Criteria are Difficult to Monetize
- Comprehensive TBL still quite rare
- Supply chain impacts are not typically evaluated
  - Impacts Assessed for WSO facility only, not impacts from "upstream activities"

Water Supply Evaluation Tool (WaterSET)

- TBL modeling framework and spreadsheet tool:
  - Hybrid LCA
  - Social impact assessment
  - Multi-criteria decision analysis
- Water supply comparison at the treatment process level
- US and Australian context



Conceptual View of the Model



WaterSET Criteria

Category	Indicator	Origin
Economy	Lifecycle cost	LCC
	Income generation	LCA
	Outside capital cost	User input (UI)
	Variable cost	LCC or UI
	Cost of imported inputs	LCA or UI

Category	Indicator	Origin
Environment	Carbon footprint	LCA
	Water footprint	LCA
	Eutrophication	LCA
	Ecotoxicity	LCA
	Land/space required	UI
	Residuals / brine	UI

Category	Indicator	Origin
Society	National jobs created	LCA
	Human health	LCA
	Drought resilience	UI
	Public acceptance	UI
	Social benefits	UI

Category	Indicator	Origin
Other	Implementation risk	UI
	Pollution impacts	UI
	Waste disposal impacts	UI
	Construction impacts	UI
	Operational impacts	UI

Multi-Criteria Decision Analysis Concept

- Not all criteria are treated the same in every location
- Community A may value drought resilience or additional water supply highest
- Community B may value eutrophication the highest

MCDA gives the user flexibility to rank criteria while supporting the integrity of the tool

Community A

Community B

Example Applications

Comparison of Different Water Supplies

↓

Seawater (New Desalination Facility)

vs.

Groundwater (via GW Augmentation)

Comparison of Different Treatment Approaches

↓

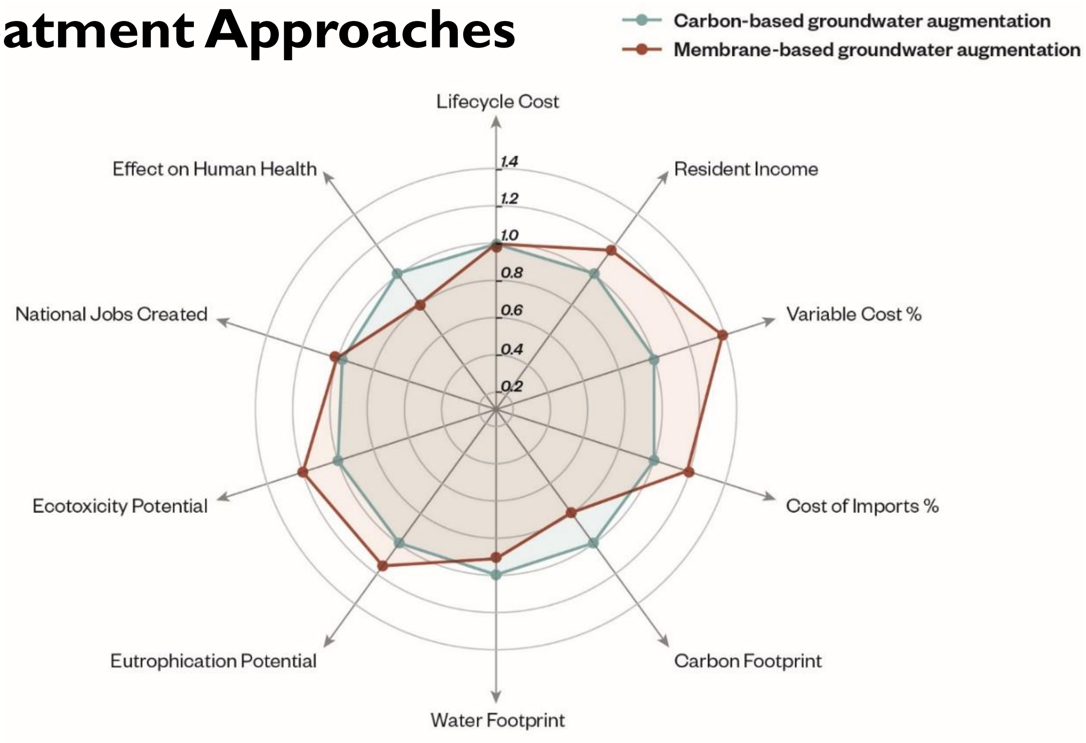
Membrane-Based Treatment for GW Augmentation

vs.

GAC-Based Treatment for GW Augmentation

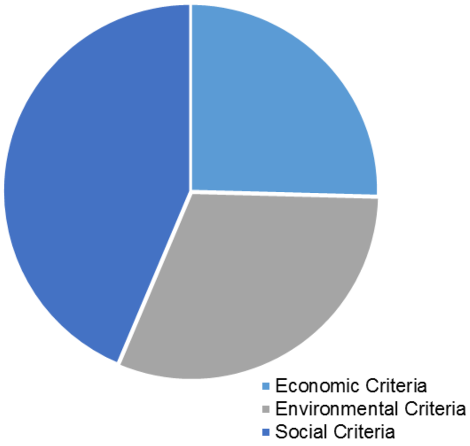
Unweighted TBL Outputs

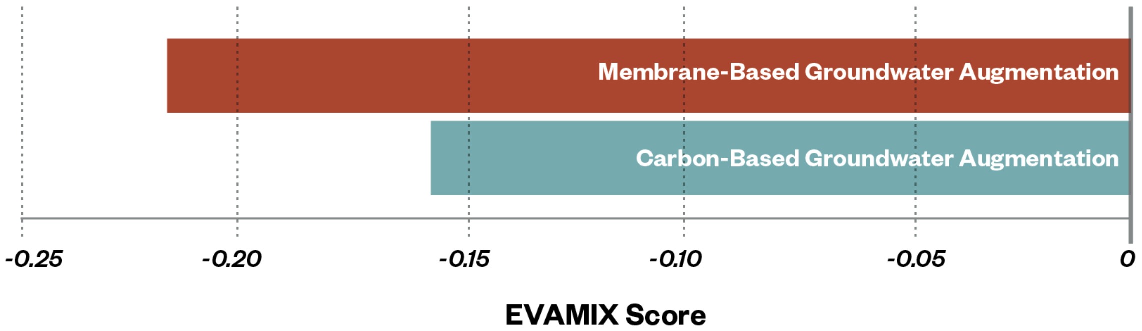
Compare Treatment Approaches



Multi-Criteria Decision Analysis

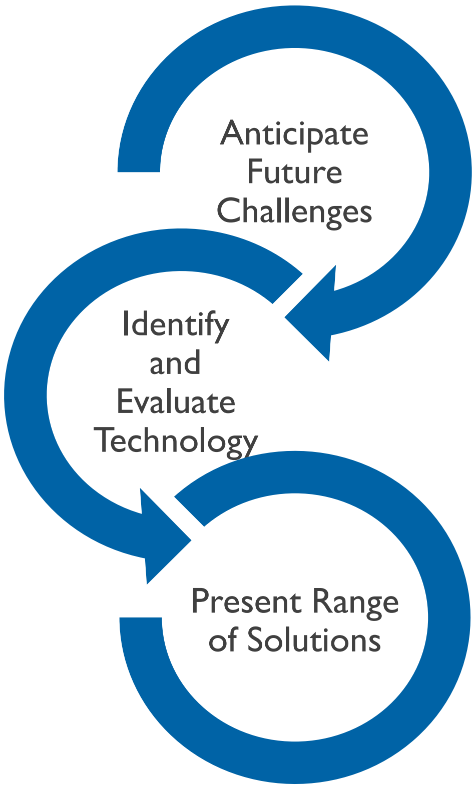
- User defined weightings
- Evaluate sensitivity to different valuation structures





Identify and Engage Stakeholders at Each Step in the Process

- Transparent
- Interactive
- Solution-Based Process



Water reuse in Agricultural Applications

Water Reuse for Agriculture

- Irrigation quality reuse is the most common use with the majority of water being used for common space, park and public property.

- Agricultural reuse for food crops is gaining momentum as a traditional water supply alternative.
    - This practice is common in California, occurs in Florida and is the topic of rule making in Colorado and Hawaii

    - Additional monitoring, mainly for pathogens, is generally required.

WRF Agricultural Water Reuse Research

- Economics and Policy
- Sustainable Practices
- Management

Four ongoing projects:

- State of Irrigated Agricultural Water Reuse - Impediments and Incentives (Reuse-15-08)
- White Paper on Groundwater Replenishment with Recycled Water on Agricultural Lands (Reuse-16-03)
- Evaluating Economic and Environmental Benefits of Water Reuse for Agriculture (Reuse-16-06)
- FDA Food Safety Modernization Act (FSMA) Produce Safety rule: Opportunities and Impact on Water Reuse for Agricultural Irrigation (Reuse-16-07)

State of Irrigated Agricultural Water Reuse – Impediments and Incentives

- Dr. Bahman Sheikh (Water Reuse Consultant)
- Global inventory of successes, delays, and set-backs in the process of switching from various traditional sources of irrigation water to recycled water
- Provide guidance that facilitates removal of impediments and implementation of effective incentives for use of recycled water for agricultural irrigation

State of Irrigated Agricultural Water Reuse: Project Workshop

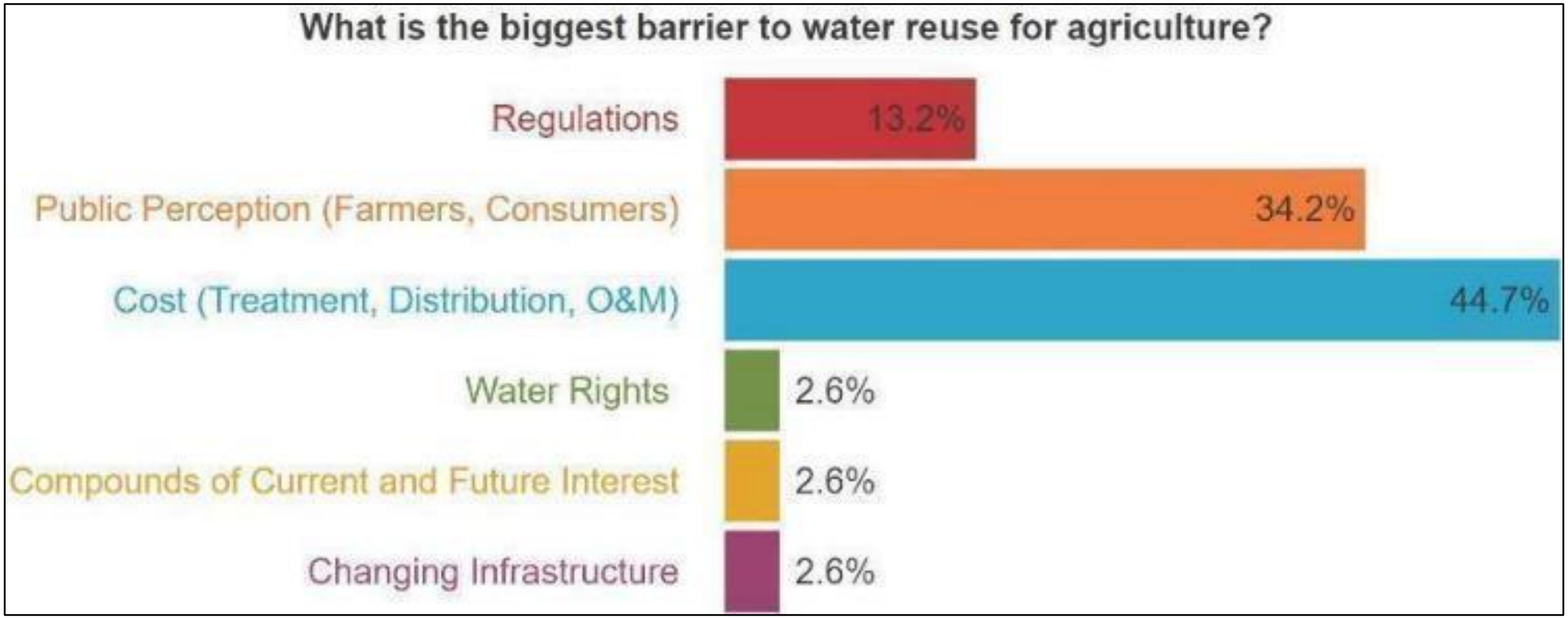
January 19, 2017 in Sacramento, California

Hosted by the CA State Water Resources Control Board

Workshop objectives:

- Identify additional impediments to using recycled water in the agricultural sector
- Identify potential solutions to increase the use of recycled water for agricultural purposes

WRF Agricultural Water Reuse Workshop

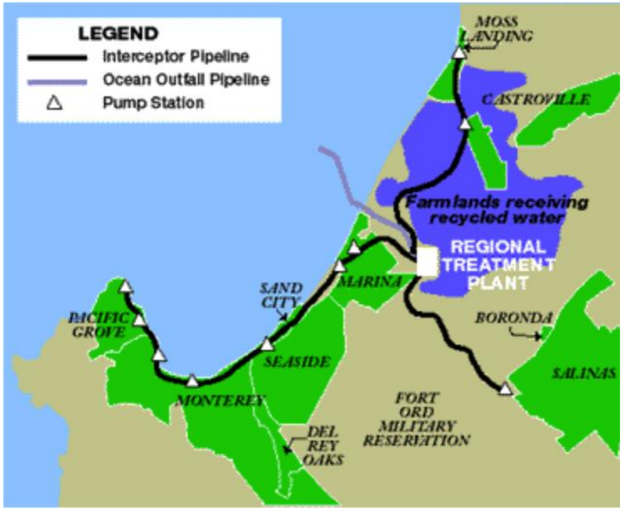


The WRF Priority Topics for 2018-2019

- **Salinity** issues related to agricultural water reuse (4 projects)
- Enhancing **energy** efficiency for water transport, treatment, and distribution for ag reuse
- Identify where water resources conditions would support reuse to help match **supply and demand** locations
- Critical review of **existing regulations** for production of recycled water in agriculture using risk assessment tools
- **QMRA** for agricultural reuse applications
- Evaluation of existing agricultural irrigation water **conveyance and storage** systems and investigation of storage for water reuse that facilitates crop irrigation scheduling
- New reuse-related technologies and policy for **aquaculture**

Case study: Monterey, CA

- **Drivers:**
  - Overdrafted Groundwater
  - Seawater Intrusion
  - Saline Groundwater
- **Impediments:**
  - Safety Perceptions
  - Concerns about Soil/Crop Health
  - Potential Impact on Sales
- **Incentives:** Pilot Project, CWA Grant Funding
- **Treatment:** Tertiary filtration, chlorine disinfection (450 CT)
- **Crops:** Cauliflower, Broccoli**,** Lettuce, Celery, Artichokes, Strawberries

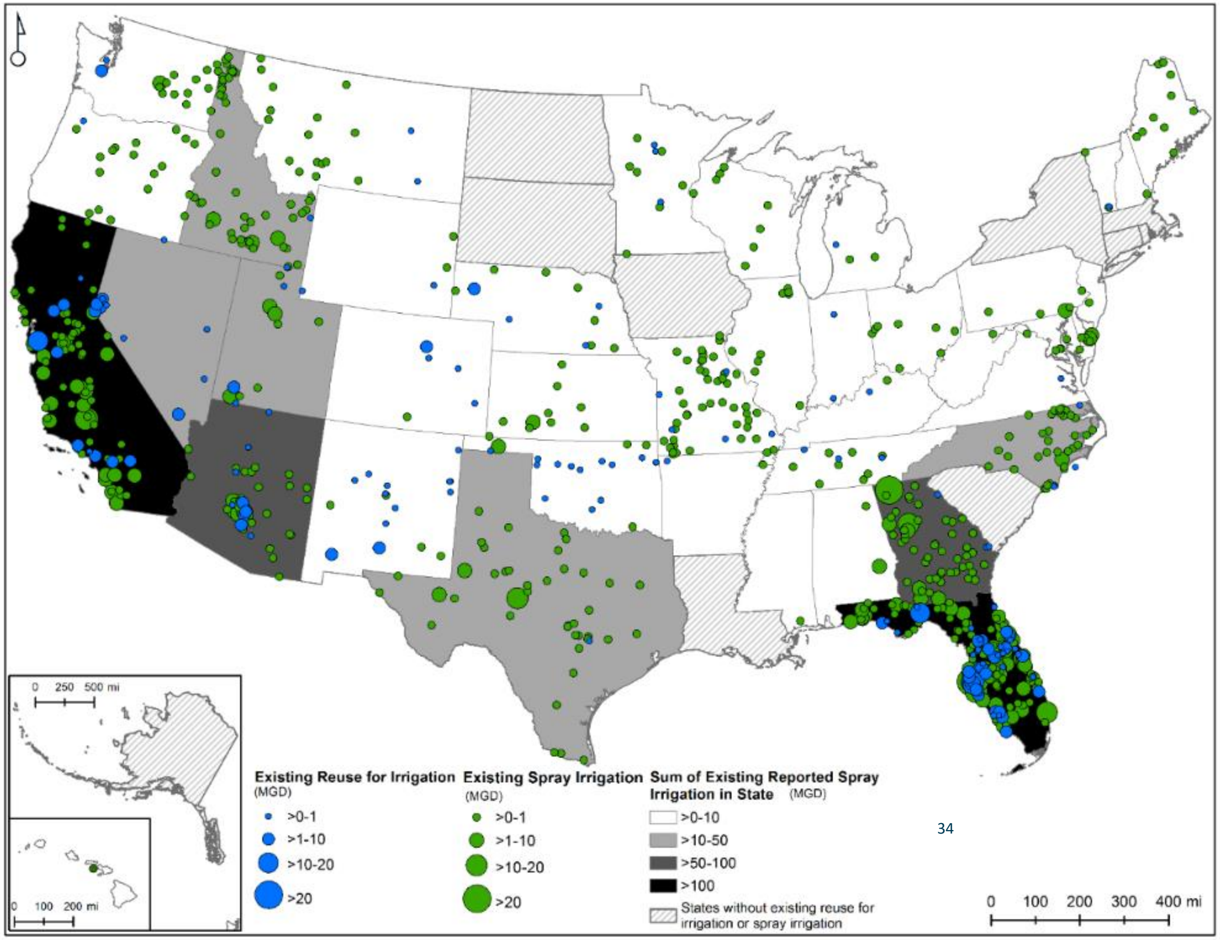


Dr. Bahman Sheikh, 2018

Where is current reuse for irrigation occurring?

41/50
states

Reuse for Irrigation	Existing (1-yr Avg)	Projected Design
Number	153	210
Flow (MGD)	234	652
Spray Irrigation	**Existing (1-yr Avg)**	**Projected Design**
Number	638	712
Flow (MGD)	587	1212



Slide courtesy of the 15-08 project team

Allowed Uses of Recycled Water in California, by Treatment Level

Food

Non-Food

Types of crops that can be irrigated

<table>
<tr><th rowspan="2">Agricultural Uses of Recycled Water</th><th colspan="4">Treatment Level</th></tr>
<tr><th>Disinfected Tertiary Recycled Water</th><th>Disinfected Secondary 2.2 Recycled Water</th><th>Disinfected Secondary 23 Recycled Water</th><th>Undisinfected Secondary Recycled Water</th></tr>
<tr><td>Food crops where recycled water contacts the edible portion of the crop, including all root crops</td><td rowspan="10">Allowed</td><td>Not Allowed</td><td rowspan="2">Not Allowed</td><td rowspan="4">Not Allowed</td></tr>
<tr><td>Food crops, surface-irrigated, above-ground edible portion, not contacted by recycled water</td><td rowspan="9">Allowed</td></tr>
<tr><td>Ornamental nursery stock and sod farms with unrestricted public access</td><td rowspan="8">Allowed</td></tr>
<tr><td>Pasture for milk animals for human consumption</td></tr>
<tr><td>Orchards and vineyards with no contact between edible portion and recycled water</td><td rowspan="6">Allowed</td></tr>
<tr><td>Non food-bearing trees, including Christmas trees not irrigated less than 14 days before harvest</td></tr>
<tr><td>Fodder and fiber crops and pasture for animals not producing milk for human consumption</td></tr>
<tr><td>Seed crops not eaten by humans</td></tr>
<tr><td>Food crops undergoing commercial pathogen-destroying processing before consumption by humans</td></tr>
<tr><td>Ornamental nursery stock, sod farms not irrigated less than 14 days before harvest</td></tr>
</table>

Increasing Levels of Treatment
(and Energy Requirements)

Source: SWRCB

Slide courtesy of the 15-08 project team

Impediments, Drivers, Incentives

- Water scarcity was a most frequently cited driver
- Costs are impediments; Grants and loans can be incentives
- Perception issues of safety were often cited as impediments
- Regulations:
  - Cited as Impediments, “Unclear”, “Inconsistent”, “Outdated”, “Which Water Quality Is Needed For Which Crops”, “Prohibitions”
  - Government Targets and Mandates to Increase Use of Recycled Water Are Significant Incentives
- Salinity of water source can be either driver or impediment
- Technical issues were not cited significant as driver or incentive

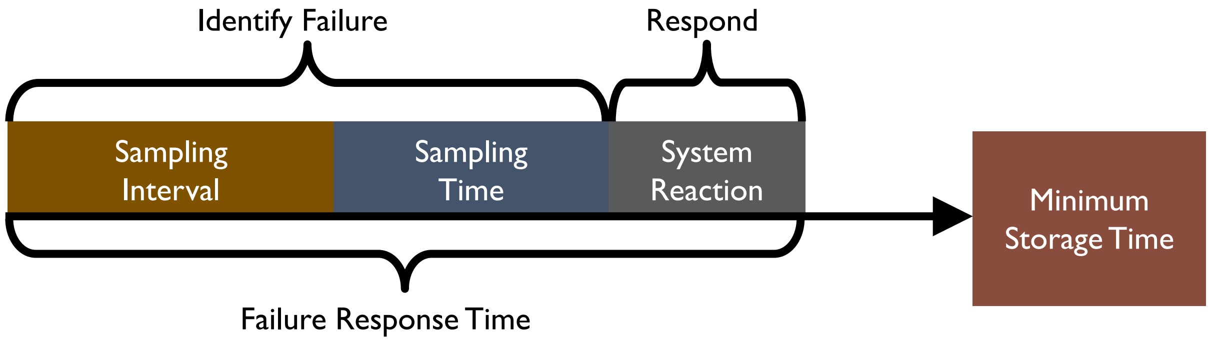
Summary Statistics

- 41/50 states report some reuse for irrigation
- 33,000 MG of wastewater produced daily
- ~2% of wastewater currently used for irrigation
- 80% of irrigated croplands within 10 mi of POTW
- 35 high potential POTWs
  - ~1000 MGD
  - 200,000 ac of irrigated croplands within 5 miles
- Existing unallocated flows in CA could meet RW targets several times over

Real-time monitoring systems

Monitoring in Potable Reuse

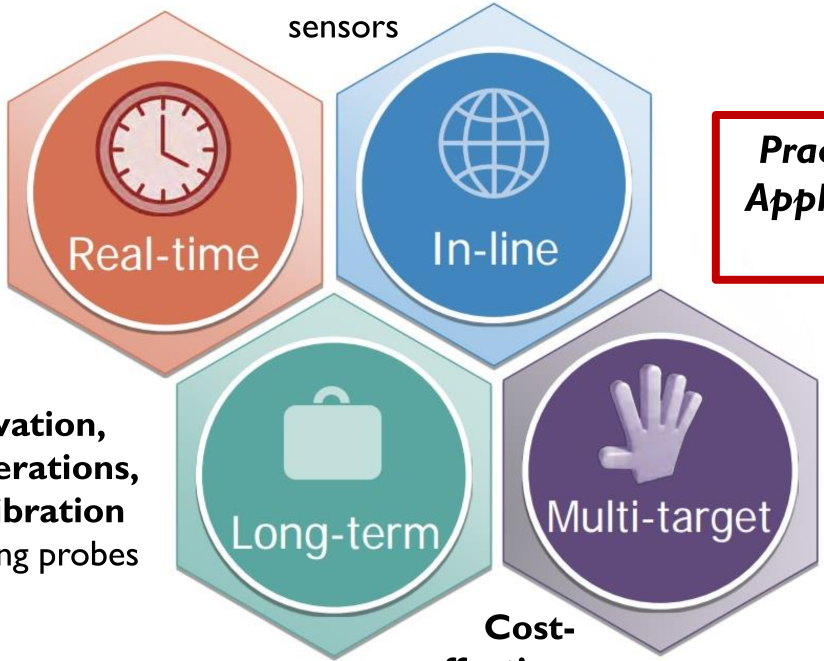
- Greater risks associated with using an impaired sourcewater
- Wastewater contains an array of chemical and microbial contaminants
- Engineered Storage Buffer (ESB) provides time to respond to treatment upsets



The Ideal Sensor

High-throughout
by distribution of
miniaturized
sensors

Integration
from sample
pretreatment and
concentration to
sensing system



Practical Application

Activation, Regenerations, & Calibration
of sensing probes

Cost-effectiveness

Sensor Issues

- False positives
- False negatives
- Detection of chemical and microbial contaminants via a real-time trigger
- Identification of treatment failures
- Integration of software data management
- Sensor maintenance and cost evaluation
- Self-monitoring

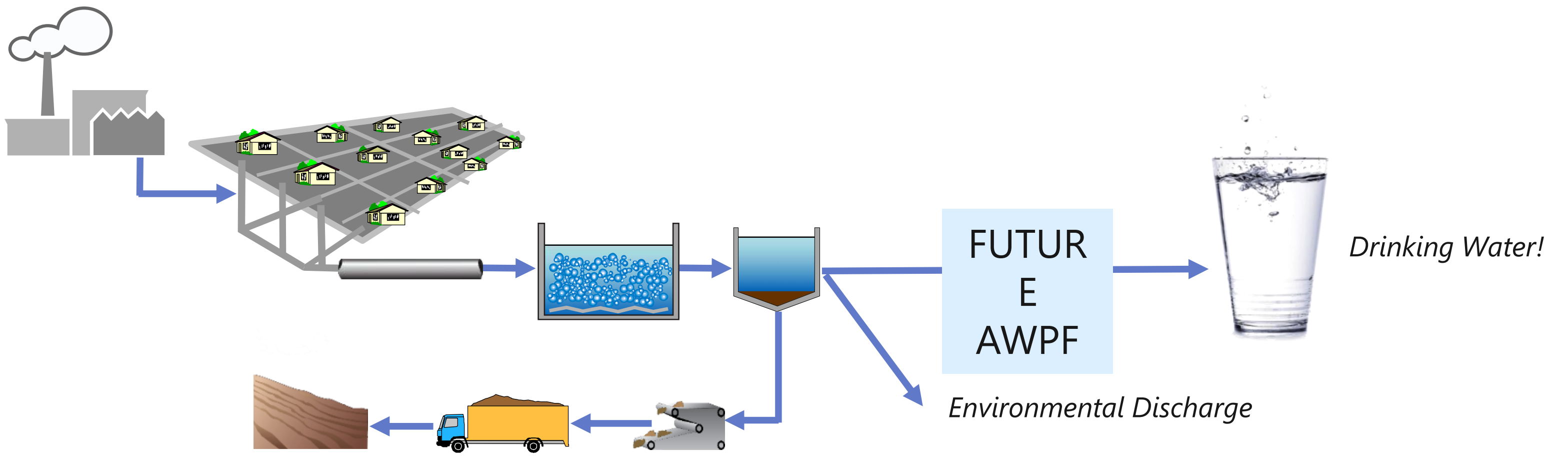
Data Management

- Real-time sensors generate large amounts of data
- Sensors are only effective if data can be understood and acted upon in a timely manner

Integrating Management of Sensor Data for a Real Time Decision Making and Response System

- Jeff Neeman, PhD – Black & Veatch
- Ian Pepper, PhD – University of Arizona
- Shane Snyder, PhD – University of Arizona

Demonstrating Real-Time Collection System Monitoring as part of Enhanced Source Control for Potable Reuse



Potable Reuse Expands the Traditional Goals of a Pretreatment Program (Carollo Engineers)

The National Pretreatment Program Provides the Legal Tools for Protecting Source Water Quality for IPR and DPR

- General Pretreatment Regulations established in 1983 (40 CFR 403)
- Requires *Publically Owned Treatment Works (POTWs)* to *control industrial and commercial discharges* into the collection system
- Resulted in successful reduction of pollutants to sewer systems and subsequently to waters of the U.S.

Six Main Pretreatment Program Elements

1	Legal Authority (sewer use ordinance)
2	Enforcement Response Plan
3	Local Limits
4	Industrial Waste Survey
5	Procedures (sampling, monitoring, compliance investigations, reporting, public notifications)
6	Funding and Other Resources (qualified personnel, sufficient budget, equipment, etc.)

POTWs with pretreatment programs already have in place the legal authority to implement enhanced source control.

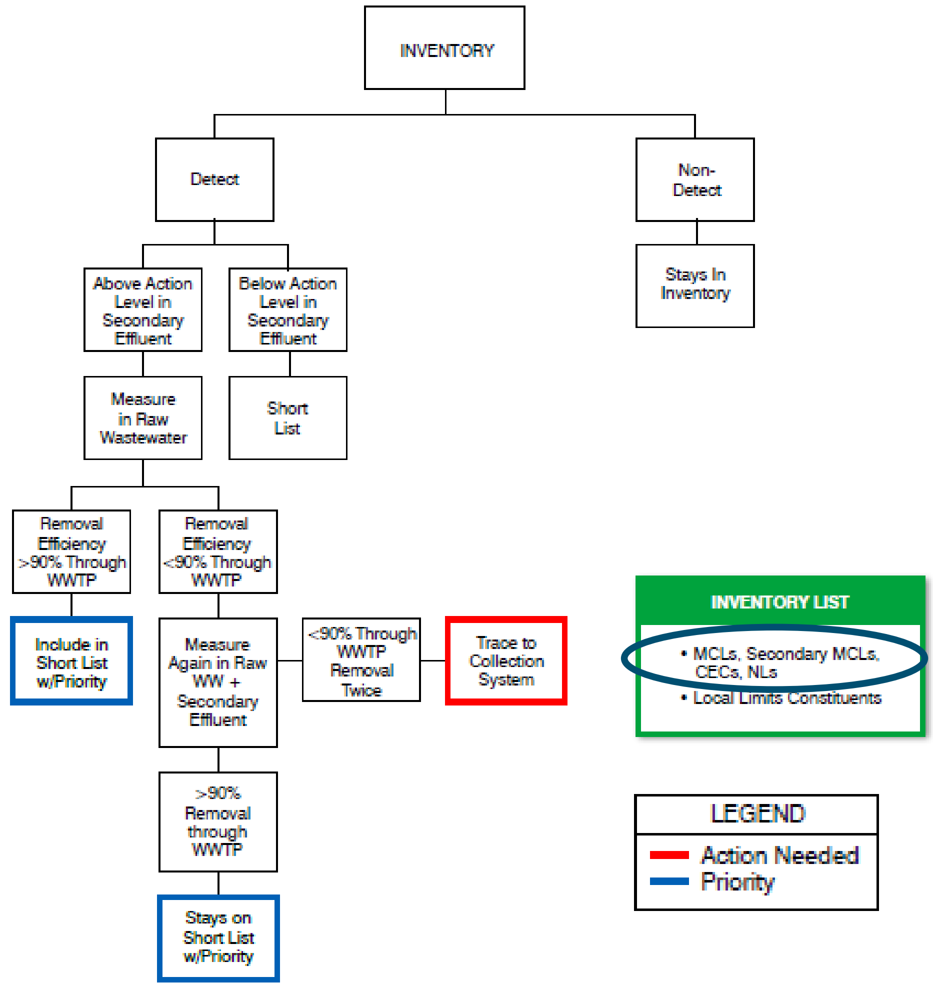
But *Enhanced* Source Control for Potable Re Means More…

…Local limits

…Routine Monitoring

…Action Plan Events

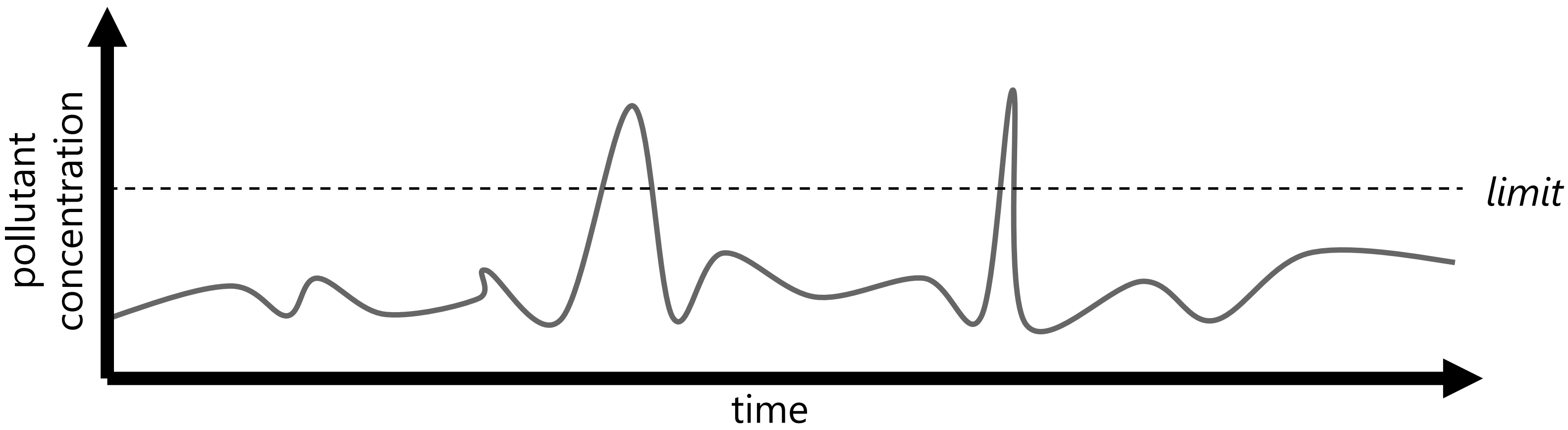
…Staff Time and Cost!



Example Secondary Effluent Inventory Action Plan for City of Oxnard, CA

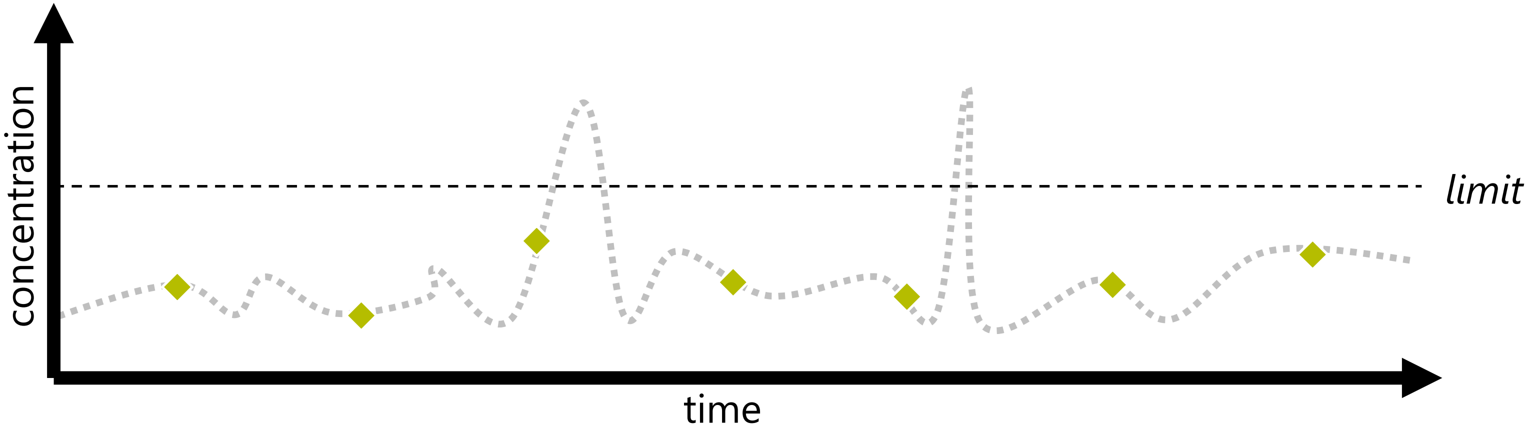
Demonstrate that Real-Time Monitoring is Better than a Traditional Sampling-Only Approach

Let’s walk through a thought experiment:



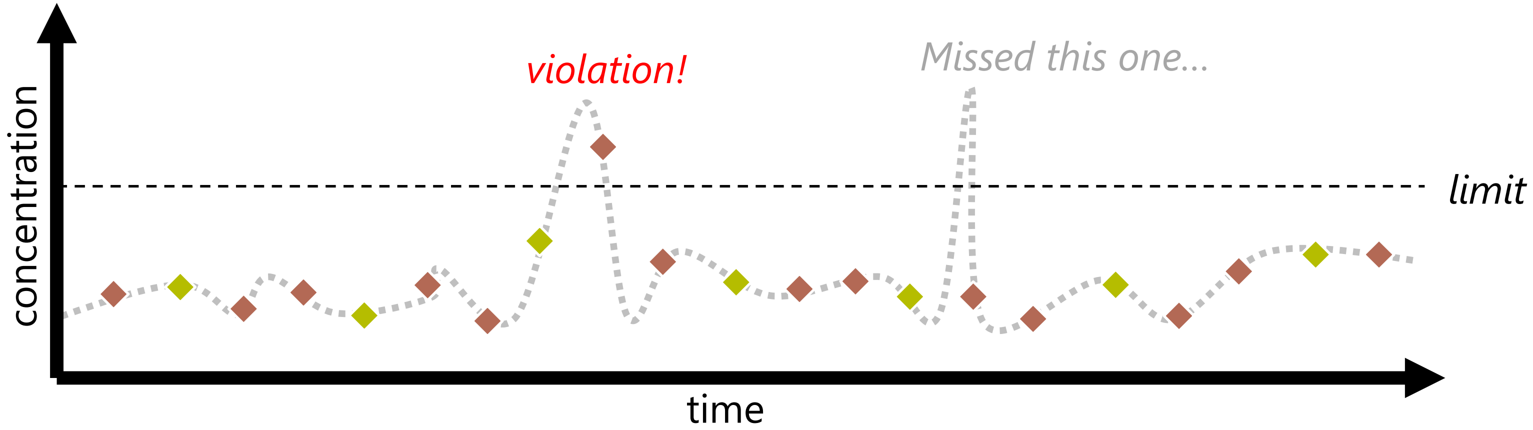
Demonstrate that Real-Time Monitoring is Better than a Traditional Sampling-Only Approach

Conventional sampling says "everything is ok."



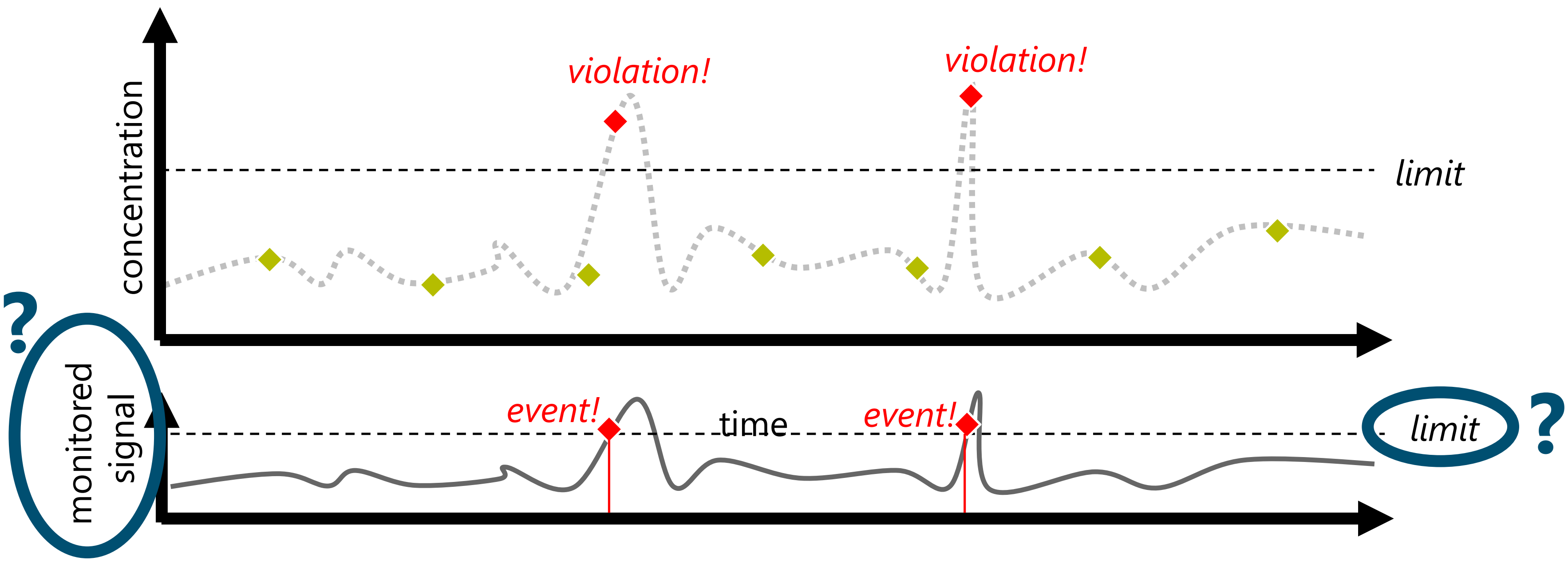
Demonstrate that Real-Time Monitoring is Better than a Traditional Sampling-Only Approach

Enhanced sampling helps, but costs 3x more and still misses violations.



Demonstrate that Real-Time Monitoring is Better than a Traditional Sampling-Only Approach

Real-time monitoring helps target sample collection:



Demonstrate that Real-Time Monitoring is Better than a Traditional Sampling-Only Approach

What does "better" mean?

We expect real-time monitoring to:

- *Catch more* discharge violations
- *Reduce* discharge violations (through deterrence)
- *Cost less* than enhanced manual sampling

Sampling Complements and Confirms Online Measurements

Analysis	Online	Routine	Baseline	Event-Based
pH (kando)	✓			
EC (kando)	✓			
ORP (kando)	✓			
Temperature (kando)	✓			
UV-vis (s::can)	✓*			
Vapor Phase PID (external)	✓*			
COD		✓		
TSS		✓		
Visual Inspections		✓	✓	✓
Chloride and Sulfides (EPA 300)			✓	✓
VOCs scan (EPA 624)			✓	✓
Total Petroleum Hydrocarbons (EPA 1664 SGT)				✓
Carbonyl Compounds (EPA 8315A)				✓
Additional POCs as Identified by Utility Partners			✓	✓

TBD, PAC input welcome!

Data Output Formats and Ease of Use are TBD

Open questions:

- What data remains in the “black box” versus available to users?
- How much can we do with data outside the “black box?”
- For identifying “events,” how much do we rely on:
    - Proprietary algorithms VS
    - Actual sensor measurements

Next Steps for the Demonstration in Ventura

1. Identify 3 Monitoring Locations
2. Install kando stations with s::can & PID sensors integrated
3. Collect baseline samples
4. Collect event-based samples
5. Review trends and events on ongoing basis
6. Feed findings into final report

Next Steps for the Demonstration in El Paso

1. Phase I monitoring
    a) Install s::can sensor equipment in one identified location
    b) Collect baseline samples
    c) Collect event-based samples
    d) Review trends and events on an ongoing basis

2. Phase II monitoring
    - Repeat steps a)-e), but with:
    - network of 3-4 kando sensors, augmented with s::can & PID probes

3. Feed findings into final report

Involves Partners from Utilities, Consulting, and Manufacturers

Thank you

Questions?

John Albert

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Committee on Water

NARUC Summer Policy Summit