From Indirect to Direct Potable Reuse: Regulatory Frameworks, Risk Management, and Technology Implications

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Board of Directors, The Water Research Foundation

WateReuse Arizona
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Acknowledgements

• City of San Diego Pure Water Program

• Julie Minton, The Water Research Foundation

• Shane Trussell and Brian Pecson, Trussell Technologies, Inc.
Agenda

- The Eras of Water Supply
- The Imperative for Potable Reuse
- Regulatory Definitions & Developments
- Risk Management
- Technology Implications
- Our Role
Agenda

- The Eras of Water Supply
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First Era

Find and Deliver Water Supplies
Second Era

Find and Deliver Water Supplies

Public Health
Third Era

Find and Deliver Water Supplies
Public Health

Flood Protection and more “useable” land
Fourth Era

Find and Deliver Water Supplies
Public Health
Flood Protection and More "Usable" Land
Environmental Health/Source Water Protection
Fifth Era
Find and Deliver Water Supplies
Public Health
Flood Protection and More “Usable” Land
Environmental Health/Source Water Protection

Sustainable Water Supplies

- Diverse
- Fit for purpose sources
- Conservation
- Promoting waterway protection
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Development of World Cities

1950

World Cities exceeding
5 million residents

Data source:
U.N. Population Division

Courtesy, Paul Reiter, former Exec Director, IWA
Development of World Cities

2000

World Cities exceeding 5 million residents

Data source: U.N. Population Division

Courtesy, Paul Reiter, former Exec Director, IWA
Development of World Cities

2015

World Cities exceeding
5 million residents

Data source:
U.N. Population Division

Courtesy, Paul Reiter, former Exec Director, IWA
Water covers 70% of the earth’s surface, but…

Source: USGS, 2012
Global Gap Between Existing Accessible, Reliable Supply and Water Withdrawal*

- **Municipal & Domestic Industry**
  - Existing withdrawals: 4,500
  - Basins w/ deficits: 1,500
  - Basins w/ surplus: 2,800
  - CAGR: 2%

- **Agriculture**
  - Existing withdrawals: 3,100
  - 2030 withdrawals: 4,500
  - Relevant supply quantity is much lower than the absolute renewable water availability in nature

- **Groundwater**
  - Existing accessible, reliable, sustainable supply: 700

- **Surface Water**
  - 2030 withdrawals: 6,900

* assuming no efficiency gains

SOURCE: Water 2030 Global Water Supply and Demand model, agricultural production based on IFPRI IMPACT-WATER base case
We have reached the point of “how” – not “if”
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“Recycled water should no longer be considered a water of ‘last resort’. In the U.S., up to one-third of the water used nationally each day can be recycled back into water supplies.”

“Additional research could enhance the performance and quality assurance of existing processes and help address public concerns over the safety of reuse to human health and the environment.”

“The committee did not identify any technological hurdles holding back the application of reuse to address local water supply needs.”
Indirect Potable Reuse (IPR)

Source Control
WWTP / WRP
Advanced Water Treatment

Groundwater Injection / Spreading

Surface Water Augmentation

WTP / Distribution

Courtesy; Shane Trussell, Trussell Technologies, Inc.
Direct Potable Reuse (DPR)

Existing raw water supply

Raw Water Augmentation

Treated Water Augmentation

Source Control

WWTP

Advanced Water Treatment

WTP / Distribution

Courtesy; Shane Trussell, Trussell Technologies, Inc.
It isn’t just about California  ... Ellen McDonald, APAI
## Potable Reuse Regulatory Development

<table>
<thead>
<tr>
<th>State</th>
<th>Regulatory Construct</th>
<th>Guidance / Framework</th>
<th>Case-by-case</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arizona</td>
<td>Developing</td>
<td>✓ (DPR)</td>
<td></td>
</tr>
<tr>
<td>California</td>
<td>✓ (IPR)</td>
<td>✓ (DPR)</td>
<td></td>
</tr>
<tr>
<td>Colorado</td>
<td>Developing</td>
<td>Developing</td>
<td></td>
</tr>
<tr>
<td>Florida</td>
<td>Developing</td>
<td>Developing</td>
<td></td>
</tr>
<tr>
<td>Nevada</td>
<td>✓ (IPR)</td>
<td>Developing</td>
<td>✓</td>
</tr>
<tr>
<td>New Mexico</td>
<td>Developing</td>
<td>Developing</td>
<td>✓</td>
</tr>
<tr>
<td>Oklahoma</td>
<td>✓ (Sep 2018)</td>
<td>Developing</td>
<td>✓</td>
</tr>
<tr>
<td>Texas</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Virginia</td>
<td>Developing</td>
<td>Developing</td>
<td>✓</td>
</tr>
</tbody>
</table>
Guidance Framework for DPR in Arizona

The DPR recommendations provided in this Guidance Framework are intended to:

• Be protective of **public health** based on available technical and scientific information

• Incorporate a level of **public health protection** as good as or better than provided by conventional drinking water supplies.
Proposed Framework for Regulating DPR in California

Developing DPR criteria will require a deliberate and phased approach to ensure public health protection and continued consumer confidence in the public water supply.
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• Our Role
Role of environmental buffer in IPR

- Dilution / blending
- Natural attenuation/treatment
- Time to detect & respond to failures

The SB-918 Expert Panel suggests that the benefits of the environmental buffer can be substituted with enhanced reliability provided by mechanical systems and treatment plant performance.

A proposed Framework for Regulating Direct Potable Reuse in California
State Water Resources Control Board, April 2018
The Transition From IPR to DPR

Groundwater Spreading
GW Injection/SW Augmentation
Direct Potable Reuse

0%
25%
50%
75%
100%

Treatment
Monitoring
Retention Time

Courtesy; Shane Trussell, Trussell Technologies, Inc.
## DPR Guiding Principles

<table>
<thead>
<tr>
<th>Principle</th>
<th>Approaches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Necessary pathogen removal</td>
<td>• Meet $\leq 10^{-4}$ annual risk of infection</td>
</tr>
<tr>
<td></td>
<td>• Apply multi-barrier approach</td>
</tr>
<tr>
<td></td>
<td>• Utilize process redundancy</td>
</tr>
<tr>
<td></td>
<td>• Consider reference pathogens beyond <em>Giardia, Cryptosporidium</em> and enteric virus</td>
</tr>
<tr>
<td>Appropriate chemical control</td>
<td>• Meet SDWA requirements</td>
</tr>
<tr>
<td></td>
<td>• Address unregulated CECs</td>
</tr>
<tr>
<td></td>
<td>• Monitor CECs to determine treatment effectiveness</td>
</tr>
<tr>
<td>Established source control program</td>
<td>• Minimum requirements that include drinking water chemicals</td>
</tr>
<tr>
<td></td>
<td>• Aggressive education program</td>
</tr>
<tr>
<td>Performance requirements for WRPs</td>
<td>• Control nitrogen and nitrate</td>
</tr>
<tr>
<td></td>
<td>• Establish pathogen log credit reduction</td>
</tr>
</tbody>
</table>
## DPR Guiding Principles

<table>
<thead>
<tr>
<th>Principle</th>
<th>Approaches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defined failure response measures</td>
<td>• Bypass non-compliant water to sewer&lt;br&gt;• “De-couple” from water supply</td>
</tr>
<tr>
<td>Appropriate instrumentation and monitoring systems</td>
<td>• Rapid surrogate measures for pathogen reduction&lt;br&gt;• Representative real-time monitoring for chemical surrogates</td>
</tr>
<tr>
<td>Successful Operation and Maintenance Culture</td>
<td>• Appropriate operator certification with quality control&lt;br&gt;• Clear and detailed O &amp; M plan with treatment failure analysis&lt;br&gt;• Meaningful emergency response plan&lt;br&gt;• Supportive instrumentation and alarm systems</td>
</tr>
<tr>
<td>Adequate Technical, Management and Financial Capability</td>
<td>• Appropriate existing water sources, operations, monitoring and strong compliance culture&lt;br&gt;• Clear roles and responsibilities for management&lt;br&gt;• Well developed policies&lt;br&gt;• Strong and sustainable financial platform</td>
</tr>
</tbody>
</table>
The Four “Rs”

- Robustness
- Redundancy
- Reliability
- Resilience

Failure Prevention

Failure Response

Courtesy; Brian Pecson, Trussell Technologies, Inc.
The multi-barrier concept can be enhanced for DPR by increasing the number of effective barriers required and requiring diversity of organism reduction mechanisms.

A proposed Framework for Regulating Direct Potable Reuse in California
State Water Resources Control Board, April 2018
Robustness: Pathogen Control

Source: Title 22 Engineering Report; North City Pure Water Project
Robustness: Chemical Control

Source: Title 22 Engineering Report; North City Pure Water Project
DPR Risk Management for Chemicals

- Lab results can take days or weeks to return results
- Routine sampling of treatment influent and effluent
- Source control takes on a renewed emphasis

- Need treatment surrogates and indicators
  - Diverse, multi-barrier treatment
  - Surrogates such as TOC with daily peak not-to-exceed (short duration discharge)

- Determine percent removals of known chemicals
  - Characterization of effluent
  - New group of chemical that can persist through RO/AOP
  - Upstream monitoring to characterize peaks (high concentration spills)

- Enhanced source control program
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To minimize the chance that the LRVs necessary to meet the health objective are not consistently met, DPR projects must provide log reduction capacity in excess of the basic LRVs (redundant LRV treatment).

A proposed Framework for Regulating Direct Potable Reuse in California
State Water Resources Control Board, April 2018
Determining Failure Probability Across Treatment

Courtesy; Brian Pecson, Trussell Technologies, Inc.
Comparing Levels of Treatment Redundancy

![Graph showing annual risk of enterovirus infection per year compared to percent equal to or less than. Two lines represent FAT + Cl2 and O3 + FAT + Cl2 treatments.](image)

Courtesy: Brian Pecson, Trussell Technologies, Inc.
Comparing Levels of Treatment Redundancy

 Courtesy; Brian Pecson, Trussell Technologies, Inc.
The urgency for action in response to a treatment deficiency increases with proximity and severity ... A critical control point (CCP) program, where a treatment process loses LRV credit when monitoring no longer indicates effective treatment, is likely to be a requirement of DPR.  

*A proposed Framework for Regulating Direct Potable Reuse in California*  
State Water Resources Control Board, April 2018

*There can be no response without detection...*
## Monitoring Recommendations for Critical Control Points

<table>
<thead>
<tr>
<th>Process</th>
<th>Critical Control Point Monitoring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Secondary treatment</td>
<td>SRT, ammonia, turbidity (for tertiary)</td>
</tr>
<tr>
<td>Ozone</td>
<td>Ozone residual, ozone/TOC, CT tables</td>
</tr>
<tr>
<td>Biologically active filtration (BAF)</td>
<td>On-line TOC, turbidity</td>
</tr>
<tr>
<td>Microfiltration/Ultrafiltration</td>
<td>Pressure decay test</td>
</tr>
<tr>
<td>Reverse Osmosis</td>
<td>Electrical conductivity, TOC, strontium</td>
</tr>
<tr>
<td>Granular activated carbon</td>
<td>On-line TOC, UVT</td>
</tr>
<tr>
<td>UV/AOP</td>
<td>UV intensity, UVT, oxidant weighted dose, UVDGM</td>
</tr>
<tr>
<td>Free chlorine</td>
<td>Chlorine residual, CT tables</td>
</tr>
</tbody>
</table>

**Sources:**
- Title 22 Engineering Report, San Diego North City Facilities
“Technology to Market” is Getting Faster

Installed UV Capacity in US and Canada

- **Capacity, mgd**
The next technology leaps will come by “borrowing” from other fields.
Operators Are A Critical Line of Defense (as always)

This isn’t your grandparent’s water treatment technology

The control system also allows for the calculation of total pathogen log reduction credits...with automated warning systems and, if needed, system shutdown and diversion.

Guidance Framework for Direct Potable Reuse in Arizona
WateReuse_AZ and NWRI, January 2018

On-line monitoring should include critical control points, alarm set points and automatic shutdown.

A proposed Framework for Regulating Direct Potable Reuse in California
State Water Resources Control Board, April 2018
AWT Certification

Producing Pure Water
We monitor systems to ensure pure water

SIGN UP FOR THE AWT OPERATOR CERTIFICATION EMAIL LIST
Operator-Implemented “Technology Management”

- O & M Practices
  - Integration of HACCP protocol
  - Defined O & M SOPs
  - Operator training and certification
  - Technology training – process/controls/data

- Emergency Response
  - Emergency response plan
  - Clear roles and responsibilities
  - Supportive instrumentation and alarm protocols

- Communications Protocols
  - Intra-agency
  - Interagency
  - Public
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# Growth of Information

<table>
<thead>
<tr>
<th>Days</th>
<th>Doubling Time</th>
<th>Multiplier</th>
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<tbody>
<tr>
<td>400</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>800</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>1200</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>1600</td>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td>3200</td>
<td>8</td>
<td>256</td>
</tr>
<tr>
<td>6400</td>
<td>16</td>
<td>65,500</td>
</tr>
<tr>
<td>12,800 (35 years)</td>
<td>32</td>
<td>4.3 billion</td>
</tr>
</tbody>
</table>
There are a lot of data and information “out there”
We Are Guardians Of This Legacy:

Find and Deliver Water Supplies

Public Health

Flood Protection and More “Usable” Land

Environmental Health/Source Water Protection
Our Responsibility is to Forge the Next Era:

Find and Deliver Water Supplies
Public Health
Flood Protection and More “Usable” Land
Environmental Health/Source Water Protection

Sustainable Water Supplies

• Diverse
• Fit for purpose sources
• Conservation
• Promoting waterway protection
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