Legacy of Windhoek Engineering: Successes and Implications for Potable Reuse in the US

50th Anniversary of Windhoek’s DPR Facility
Ben Stanford, PhD

AMERICAN WATER
American Water’s Footprint Is Unique in the US Water Community

• National water issues are also American Water’s issues
  • Extreme weather
  • Water quality
  • Water quantity
  • Urbanization
  • Infrastructure
U.S. Electric Utilities

Source: EIA detailed data files
https://www.eia.gov/electricity/data/eia861/
Created: 10/25/2017
Cartography by: Bill Carr & Steven Oliver
WATER COOPERATIVE, INC.
90% of these utilities serve less than 10,000 people (~3,000 homes)
The Footprint of Drought Changes But Impacts Many Areas of the US

U.S. Drought Monitor

October 7, 2008
(Released Thursday, Oct. 9, 2008)
Valid 7 a.m. EST

Drought Impact Types:
- O = Delineates dominant impacts
- A = Agricultural (rangelands, pastures, grasslands)
- H = Hydrological (water)

Intensity:
- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

The Drought Monitor focuses on broad scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

http://droughtmonitor.unl.edu/
The Footprint of Drought Changes But Impacts Many Areas of the US

U.S. Drought Monitor

October 6, 2009
(Released Thursday, Oct. 8, 2009)
Valid 7 a.m. EST

Drought Impact Types:

- A = Agricultural (crops, pastures, grasslands)
- H = Hydrological (water)

Intensity:

- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for additional statements.

http://droughtmonitor.unl.edu/
The Footprint of Drought Changes But Impacts Many Areas of the US

U.S. Drought Monitor

October 5, 2010
(Released Thursday, Oct. 7, 2010)
Valid 7 a.m. EST

Drought Impact Types:
- Delineates dominant impacts
- A = Agricultural (crops, pastures, grasslands)
- H = Hydrological (water)

Intensity:
- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Exceptional Drought
- D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

http://droughtmonitor.unl.edu/
The Footprint of Drought Changes But Impacts Many Areas of the US

U.S. Drought Monitor

October 4, 2011
(Released Thursday, Oct. 6, 2011)
Valid 7 a.m. EST

Drought Impact Types:
- Depletes domestic impacts
- S = Short-Term, typically less than 6 months (e.g., agriculture, grasslands)
- L = Long-Term, typically greater than 6 months (e.g., hydrology, ecology)

Intensity:
- 00 Abnormally Dry
- 01 Moderate Drought
- 02 Severe Drought
- 03 Extreme Drought
- 04 Exceptional Drought

Legend:
- Regulated
- Market-Based
- Both

http://droughtmonitor.unl.edu/
The Footprint of Drought Changes But Impacts Many Areas of the US

October 2, 2012
(Released Thursday, Oct. 4, 2012)
Valid 8 a.m., EDT

Drought Impact Types:
- D0: Abnormally Dry
- D1: Moderate Drought
- D2: Severe Drought
- D3: Exceptional Drought
- D4: Extreme Drought

Intensity:
- S = Short-Term, typically less than 6 months (e.g., agriculture, grasslands)
- L = Long-Term, typically greater than 6 months (e.g., hydrology, ecosystems)

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

http://droughtmonitor.unl.edu/
The Footprint of Drought Changes But Impacts Many Areas of the US

U.S. Drought Monitor

October 1, 2013
(Released Thursday, Oct 3, 2013)
Valid 7 a.m. EDT

Drought Impact Types:
- D = Dominant impacts
- S = Short-Term, typically less than 6 months (e.g., agriculture, grasslands)
- L = Long-Term, typically greater than 6 months (e.g., hydrology, ecology)

Intensity:
- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

The Drought Monitor focuses on broad scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

http://droughtmonitor.unl.edu/
The Footprint of Drought Changes But Impacts Many Areas of the US

October 7, 2014
(Released Thursday, Oct. 9, 2014)
Valid 8 a.m. EDT

U.S. Drought Monitor

Author:
Mark Svoboda
National Drought Mitigation Center

http://droughtmonitor.unl.edu/
The Footprint of Drought Changes But Impacts Many Areas of the US

U.S. Drought Monitor

October 6, 2015
(Released Thursday, Oct. 8, 2015)
Valid 8 a.m. EDT

Drought Impact Types:
P = Delivers significant impacts
S = Short-Term, typically less than 6 months (e.g. agriculture, grasslands)
L = Long-Term, typically greater than 6 months (e.g. hydrology, ecology)

Intensity:
00 Abnormally Dry
D1 Moderate Drought
D2 Severe Drought
D3 Extreme Drought
D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

http://droughtmonitor.unl.edu/
The Footprint of Drought Changes But Impacts Many Areas of the US
The Footprint of Drought Changes But Impacts Many Areas of the US

U.S. Drought Monitor

October 3, 2017
(Released Thursday, Oct. 5, 2017)
Valid 8 a.m. EDT

Drought Impact Types:
- ~ Delimits dominant impacts
- S = Short-Term, typically less than 6 months (e.g. agriculture, grasslands)
- L = Long-Term, typically greater than 6 months (e.g. hydrology, ecology)

Severity:
- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

http://droughtmonitor.unl.edu/
Over the Past 10 Years Alone, Most of the US Has Been Impacted by Drought or Other Extreme Weather
Over the Past 10 Years Alone, Most of the US Has Been Impacted by Drought or Other Extreme Weather

Ref: Higgins, AMWA, Wash D.C. Apr 2014; Data from National Climatic Data Center
Extreme Weather in the Context of Solving The Water Community’s Greatest Challenges

• Water Supply
• Water Quality
• Infrastructure
• Customer Expectations
Windhoek, Namibia Paved the Way for Many Innovations in the US

• Proactive approach to drought & water supply management
• Ozone-BAC for potable reuse
• Demonstrating to the world that “yes, it can be done!”
50+ Years of Water Reuse in the US (1968 – 2018)
Non-Potable Reuse Has Been in Use for Over 100 Years in the US

- (1912 – Irrigation of Golden Gate Park, San Francisco – activated sludge effluent)
- 1960’s – Landscape irrigation is major use of recycled water
- 1977 – St. Petersburg, FL, first large urban reuse system in US
- 1985 – Monterey County (CA) Water Resources Agency
- By 2000 – non-potable reuse for irrigation widely practiced (crops, landscape, golf courses, urban areas)
# Potable Reuse is More Recently Gaining Momentum

<table>
<thead>
<tr>
<th>Year</th>
<th>Project Name</th>
<th>Notes</th>
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</thead>
<tbody>
<tr>
<td>1962</td>
<td>Montebello Forebay Spreading Grounds, Los Angeles, CA</td>
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<tr>
<td>1968</td>
<td>Goreangab DPR Plant I, Windhoek, Namibia</td>
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<tr>
<td>1976</td>
<td>Water Factory 21, OCWD, CA</td>
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<tr>
<td>1978</td>
<td>UOSA, VA – Ozone and GAC</td>
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<tr>
<td>1985</td>
<td>Hueco Bolson Recharge Project, El Paso, TX &amp; Clayton County, GA</td>
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<tr>
<td>1993</td>
<td>West Basin Water Recycling Plant, CA</td>
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<tr>
<td>1999</td>
<td>Scottsdale Water Campus, AZ &amp; Gwinnett County, GA</td>
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<tr>
<td>2007</td>
<td>Chino Basin Recharge Project, CA</td>
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<tr>
<td>2008</td>
<td>Groundwater Replenishment Project, CA</td>
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<tr>
<td>2009</td>
<td>Arapahoe &amp; Cottonwood, CO</td>
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<tr>
<td>2010</td>
<td>Prairie Water, CO</td>
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<td>2011</td>
<td>Big Spring, TX</td>
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<td>2013</td>
<td>Wichita Falls, TX</td>
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<tr>
<td>2014</td>
<td>SWIFT Project @ Hampton Roads, VA</td>
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<tr>
<td>2017</td>
<td>Many More on the Horizon in MD, VA, FL, NC, AZ, TX, OK, NM, CO, CA,</td>
<td></td>
</tr>
</tbody>
</table>

☆ Indicates non-RO membrane approach to potable reuse
Conventional Drinking Water Treatment Was Not Designed for Potable Reuse

- Or was it?...
- Goreangab, 1968: DAF – Clarification – Filtration – GAC – Cl₂
- Challenging US source waters added ozone, GAC, DAF, and/or UV
Recent Research Shows Multiple Cities Have 100% Wastewater Dominance in Water Supply at Low Flow

Figure 4. De facto reuse under average flow and low-flow conditions (modeled by 7Q10). Cities marked with an asterisk are calculated on the basis of 7Q10 streamflow values from the EPA 1980 study. (The x-axis gives same site IDs as in Figure 2.)
Urbanization and Population Migration Impact Total Flow Into Water Supply

Cumulative Upstream Municipal Wastewater Flows (MGD)

- 2008 Increase
- 1980 Study

City A

City B

River

Assessment of De Facto Wastewater Reuse across the U.S.: Trends between 1980 and 2008

Jacelyn Rice, Amber Wutich, and Paul Westerhoff
Contamination of Water Threatens the Entire Water Community

- Chemical Spill in Water Supply
- Cross Connection Control Failure
- Abnormal Chemical Feed into Distribution
- Chemical Release from Facility
- Spill, Overflow from WWTP / Collection System
- New Guideline on Emerging Chemicals
- Movement of Groundwater Plume
- New Regulated Contaminant

Water Contamination
A Shifting Landscape of Regulation, Threats, and Perception Challenge All Water Utilities

Over 130,000,000 chemicals registered in CAS plus an additional 60,000,000 gene sequences
The “State” of Reuse

Potable Water Reuse Is Rapidly Expanding as a Realistic Option in the US

BUT…

Legislation ≠ Regulation
CA Regulatory Environment: “Let’s Study It”

• Title 22 Regulations
  • In place since 1978
  • Non-potable reuse
  • Indirect potable reuse (surface and subsurface)

• Three approved classes of recycled water

• Indirect Potable Reuse
  • Groundwater replenishment (GWR)
  • Surface water augmentation (SWA)

• Mostly membrane-based approaches
CA Regulatory Environment

• New rules for IPR emerged in 2016
• Expert panel recently decided DPR was “feasible”
• CA utilities piloting several alternative treatment to MF-RO-UV/AOP, including ozone and BAC
• Additional studies underway
TX Regulatory Environment: “Let’s do it”

- State permits DPR on a case-by-case basis
- Different requirements from CA
- Generally requires RO membrane approach
- Groundwater recharge in El Paso—since 1985
- El Paso developing long-term DPR
- Wichita Falls and Big Spring emergency DPR
FL Regulatory Environment: “Let’s Name it”

- IPR regulations in place since 1999
  - Non-potable since 1980s
  - Largest reclaim water volume of any state

- IPR requires full treatment and disinfection
- Lots of project acronyms:
  - CFWI, SHARP, AS2I, RIBS
FL Regulatory Environment: Some Recent Drivers

- Ocean Outfall Legislation driving IPR and non-potable reuse
  - SE Florida utilities required to reuse 60% of their WW
- Central Florida Water Initiative (CFWI)
  - 250 MGD in additional supply needed by 2035
- Potential implementation of DPR
  - Tampa, Orlando, Beach Communities
  - Assessing, piloting, demonstrating DPR
- State regulatory agency is evaluating DPR regulation now
VA Regulatory Environment: “Let’s stick with existing policy”

• IPR has been in place for many years (Occoquan Reservoir)
• Major drivers:
  • Climate Change, Sea Level Rise
  • Land Subsidence
  • Saltwater intrusion
  • Declining water surface profiles
• Chesapeake Bay / TMDL drivers
• Ozone-BAC precedent at UOSA
HRSD SWIFT Potable Reuse Demonstration
Coag/Flod/Sed – Ozone – BAC – GAC – UV Disinfection - Chlorine
North Carolina: “We don’t know but it has got to be better than what we have”

- DPR legislation passed in 2015
- Allows for DPR with:
  - Tertiary treatment + disinfection
  - 5 days of engineered storage

- Department of Public Health has no idea how to regulate this
- Ozone + GAC is used at many de facto reuse sites
Summary

- Long History of Reuse with Widening Acceptance of Potable Reuse
- Opportunity to Buffer Effects of Climate Change, Poor Water Quality, Planning for Resiliency
- Potable Reuse Is Becoming a Viable Option
- Namibia Has Been a Pioneer in Developing and Implementing Potable Reuse Solutions for the World
We Produce Innovations to Meet the Challenges of Now and the Future

Clean  Safe  Reliable  Affordable
Ben Stanford, PhD
Senior Director, Water Intelligence Technology and Innovation Division
American Water

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