

ROLE OF WATER REUSE IN INTEGRATED WATER RESOURCES MANAGEMENT

Takashi Asano

Professor Emeritus

Department of Civil and Environmental Engineering
University of California, Davis

1

Acknowledgements

■ CREDITS

California Department of Water Resources

City of San Diego

Orange County Water District, CA

Du Pont PERMASEP Permeators

2

Presentation Outline

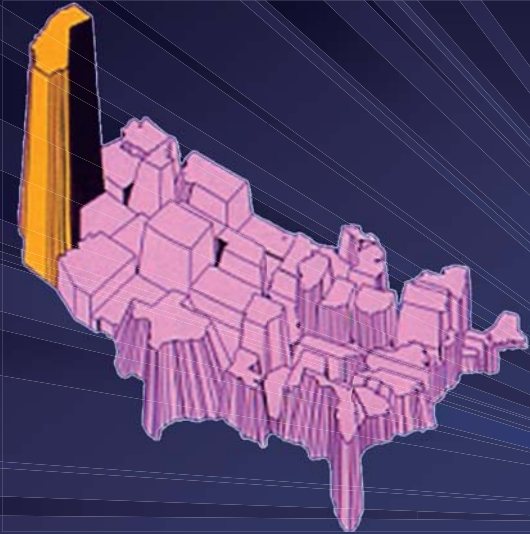
- Water Resources in California
- Current Water Supply Situation/Problems
- New Source of Water Supply – Reclaimed Water and Water Reuse
- Necessity and Opportunities
- Implementing Indirect Potable Reuse (IPR) and Direct Potable Reuse (DPR)

Key Concepts

Water Supply Challenges

- Population Growth
- Urbanization
- Climate Change
- Environmental Protection
- Economics

Comparison of Water Withdrawals, by State



The total national rate of withdrawal of ground and surface water is approx. 450 billion gallons per day ($1.7 \times 10^9 \text{ m}^3/\text{d}$)

5

Increasing water demand in California (Water Plan Update 160-98)

	1995	2020 Forecast	% Change
Population (million)	32.1	47.5	+48
Irrigated crops (km ²)	38,445	37,231	-3.2
Urban water use (Mm ³)	10,855	14,802	+36
Agricultural water use (Mm ³)	41,691	38,854	-6.8
Environmental use (Mm ³)	45,515	45,638	+0.3

The present world population of 7 billion is expected to reach 9.5 billion by 2050 (U.S. Census Bureau, 2011)

6



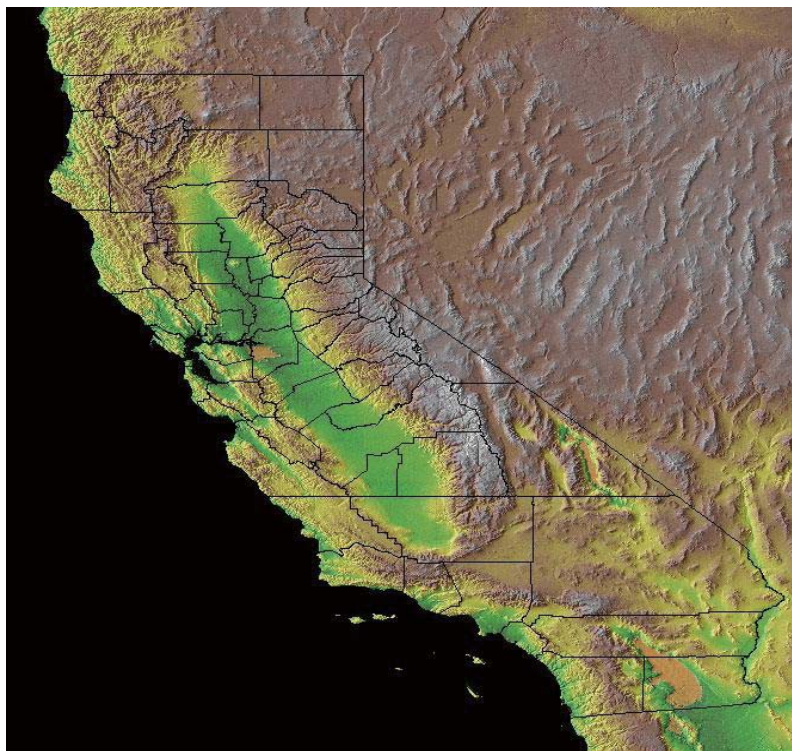
7



2-2



9



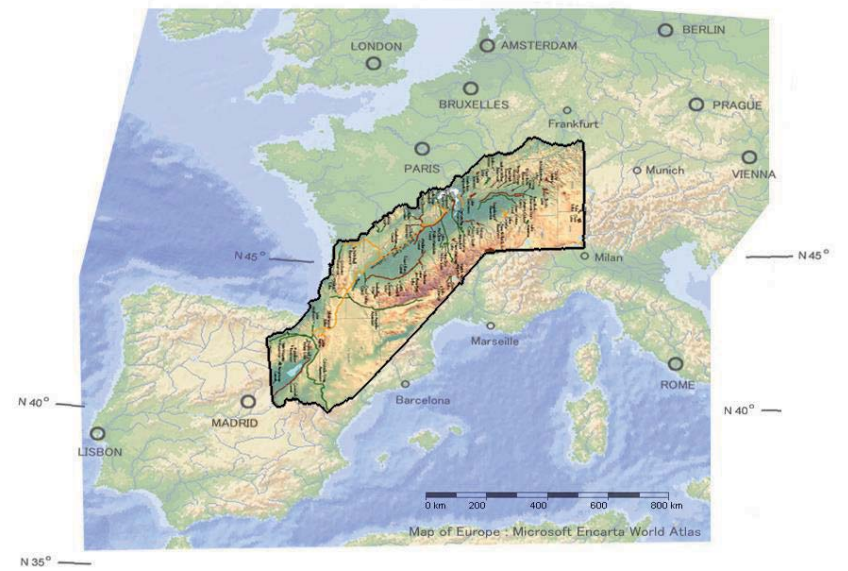
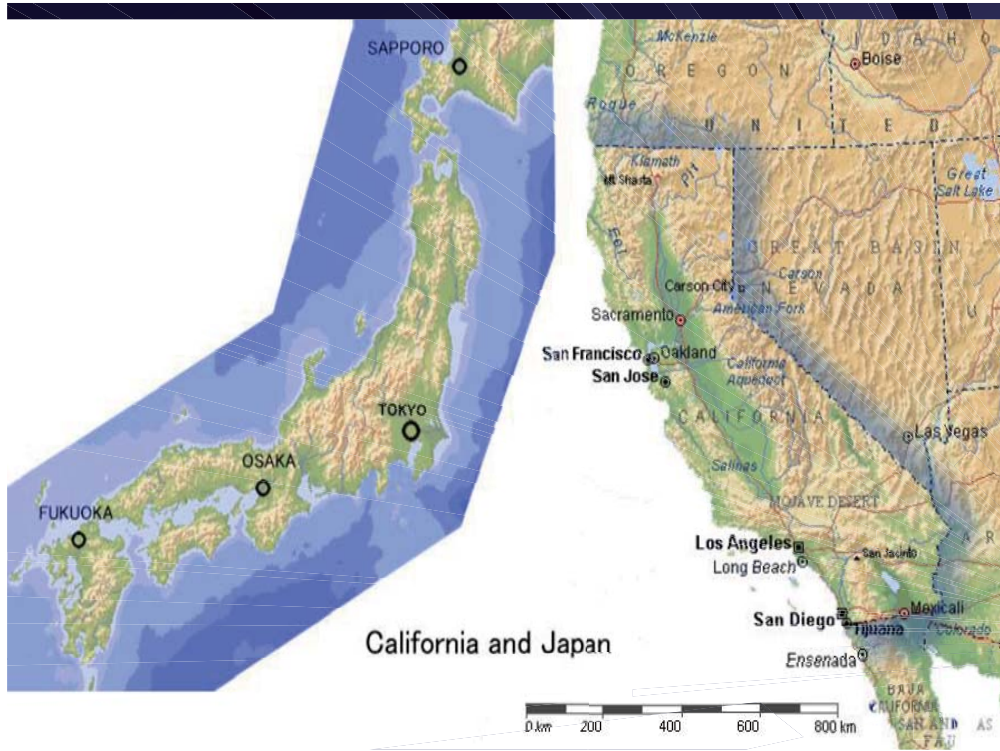
11



California Water Plan Update 2005, Bulletin 160-05, December 2005. State of California

2-3

12



Map of California Source : California Water Plan Update 2005, Bulletin 160-05, December 2005 State of California

Comparative Map of Europe and California

(approx. same scale) T. Hamaguchi Jan. 2007

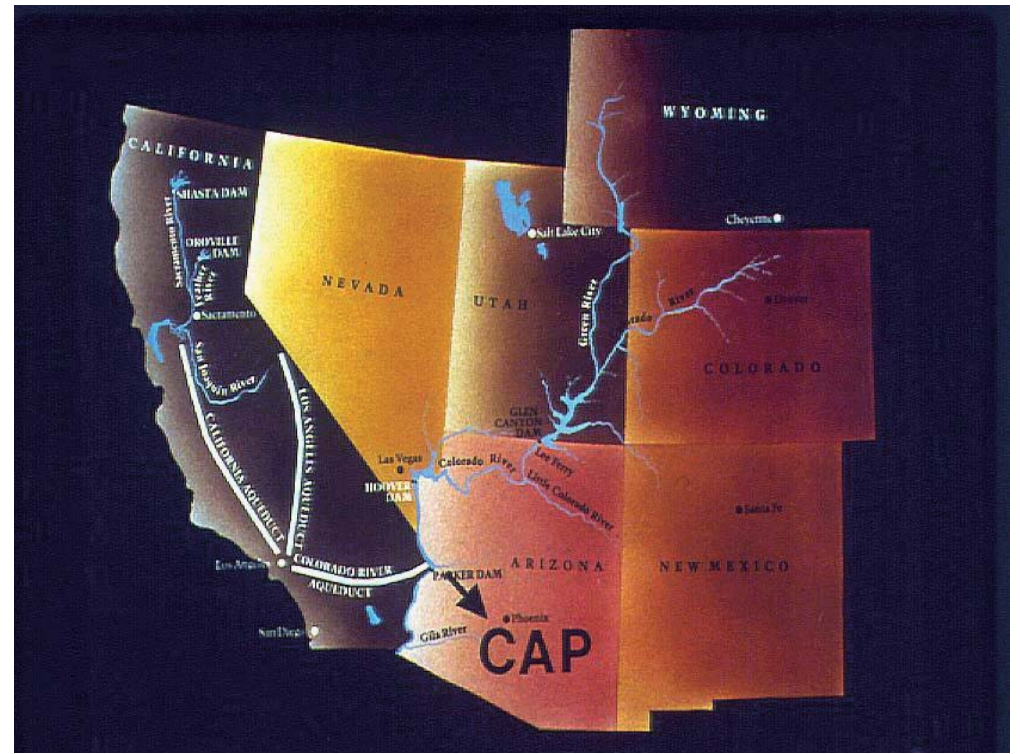


2-4

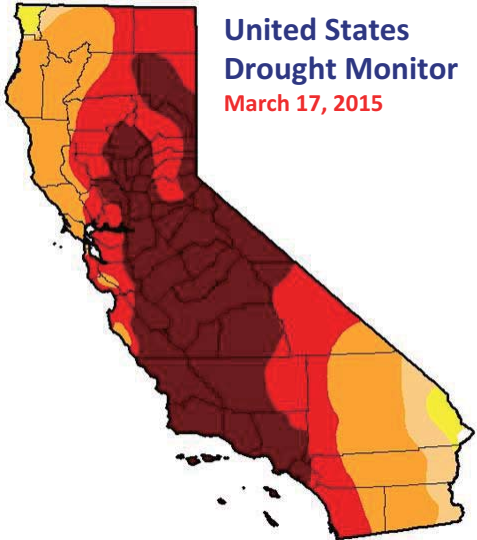


200 commercial crops, $\frac{1}{4}$ of the nation's table foods, and $\frac{1}{2}$ of fruits and vegetables





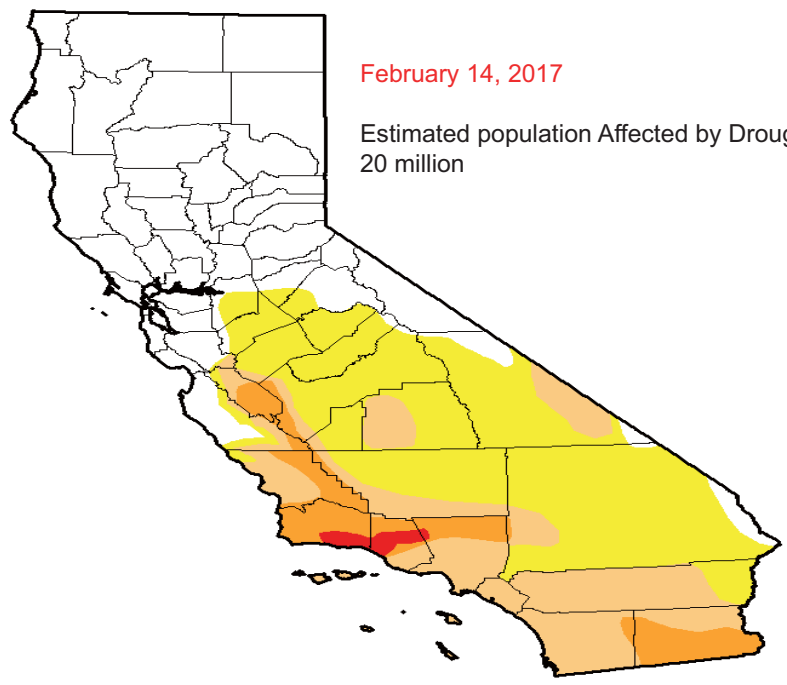
Statewide Drought Conditions



United States Drought Monitor
March 17, 2015

Severe Drought	26%
Extreme Drought	27%
Exceptional Drought	40%

Over 37 million Californians affected by drought



February 14, 2017
 Estimated population Affected by Drought
 20 million

Take Home Messages

- Future schemes for inter-basin water transfers have become prohibitive, because of environmental concerns, water rights, and economics
- Growth of urban areas is resulting in increased pressure on local water supplies, particularly groundwater
- Municipal wastewater is right at the doorstep of the metropolis and has become a dependable local source of new water

REUSE

Recovering Sustainable Water from Wastewater

26

With current technology, source water quality no longer dictates finished water quality



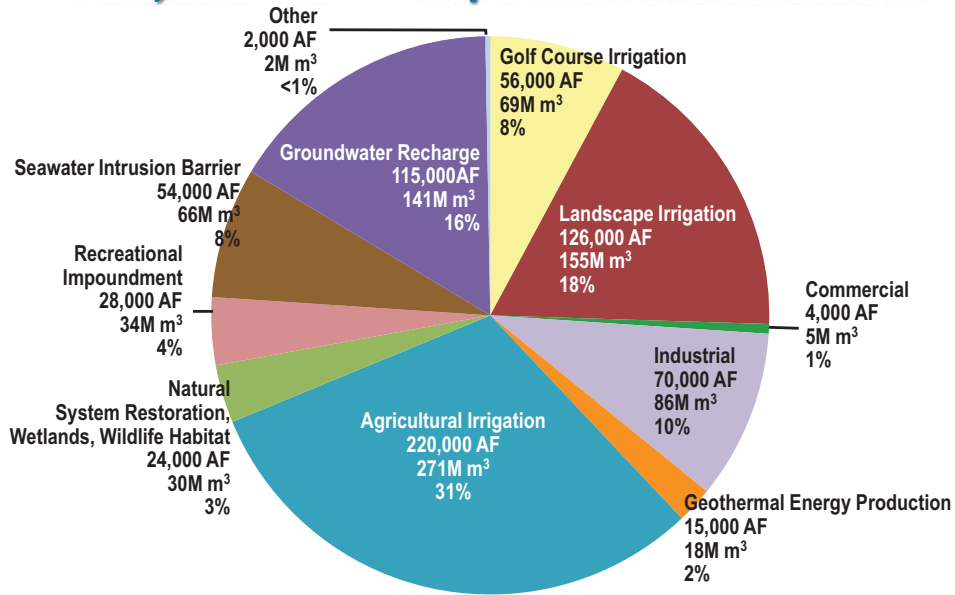
Adapted from the work of Takashi Asano in "Water from (Waste) Water—the Dependable Water Resource" written for the 2001 Stockholm Water Prize Laureate Lecture, August 13, 2001, Stockholm, Sweden

Categories of Reuse

1. Agricultural Irrigation
2. Landscape Irrigation
3. Industrial Reuse
4. Recreational and Environmental
5. Non-potable Urban Uses
6. Groundwater Recharge
7. Potable Reuse

2-7

2015 Recycled Water Use: 714,000 acre-feet/881M cubic meters



\$44 Million, 1.6% of USA's Crop, 2 900 ha



Non-potable Urban Reuse – Toilet Flushing



Tokyo Metropolitan Area in 1984



33

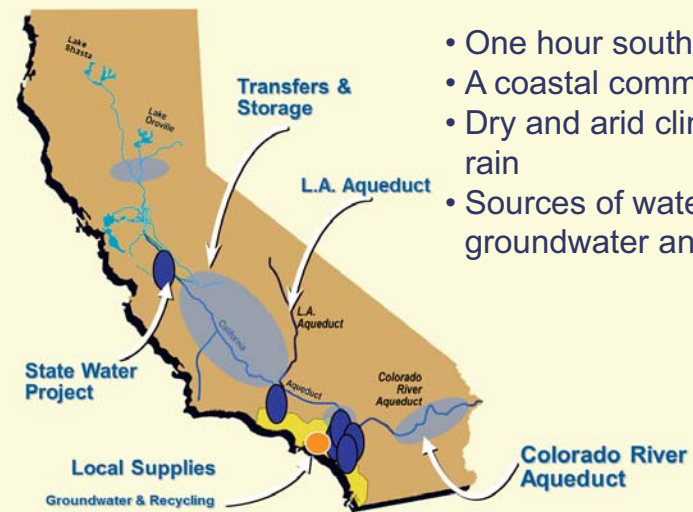


Necessity and Opportunities

- Indirect potable reuse (IPR) through groundwater recharge and surface water augmentation is inevitable and growing
- Direct potable reuse (DPR) will be also inevitable in Southern California in the near future, to ensure water resources sustainability

2-9

Orange County, CA



- One hour south of Los Angeles
- A coastal community
- Dry and arid climate with little rain
- Sources of water include: local groundwater and imported water

Aerial view of GWRS facility and adjacent OCSD plant 1

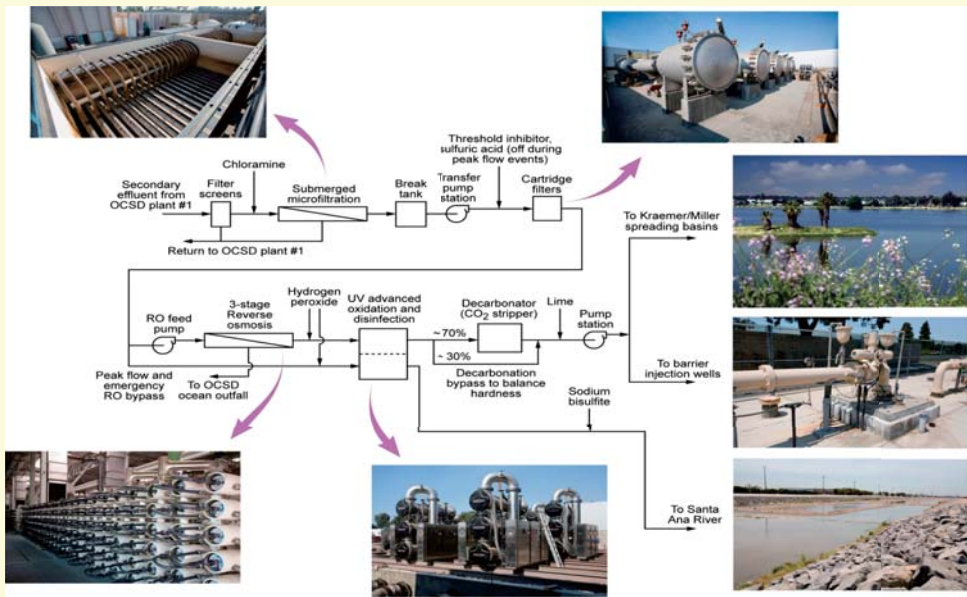


Orange County Water District's Groundwater Replenishment System - 2008

- Built on the experience of world-famous Water Factory 21
- 378,000 m³/d (100 mgd) production capacity (since 2015)
- Advanced purification technology
 - Microfiltration (MF)
 - Reverse Osmosis (RO)
 - Ultraviolet light (UV) with hydrogen peroxide



Orange County GWR System



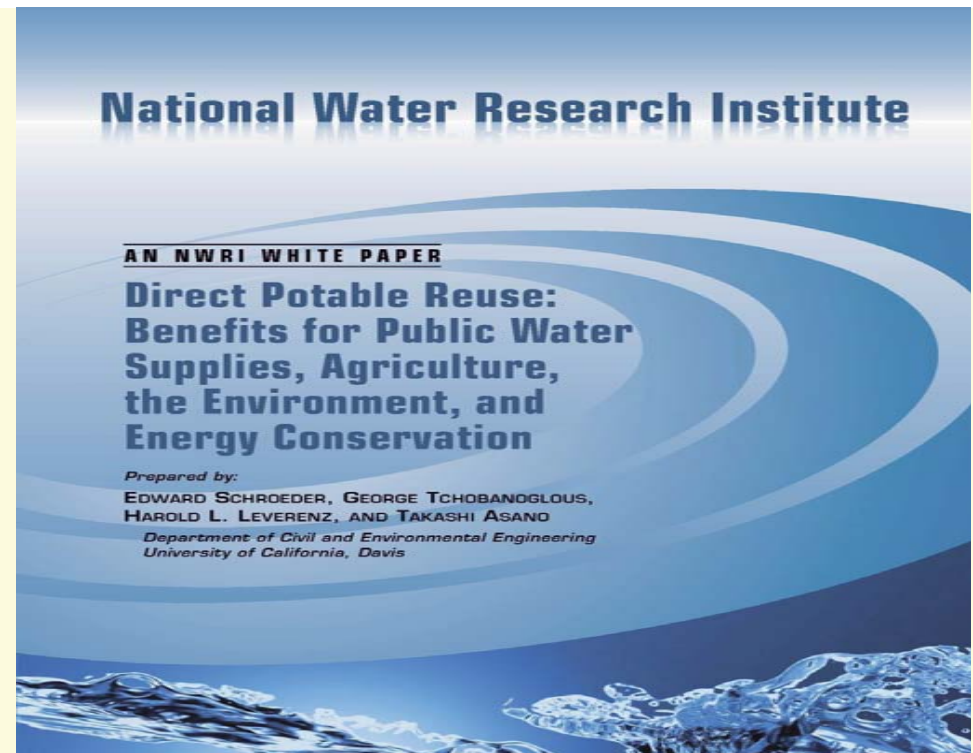
Energy Requirement for water delivery to Orange County, California

Various water sources	Energy requirement kWh/m ³
Desalination	3.5 – 4.0
State water project	2.6
Colorado River	1.8
Groundwater Replenishment System (GWRS)	1.2

Adapted from Orange County Water District, 2006.

Looking at next 20 years

- The value of water will increase significantly
- The cost of dual distribution systems has become prohibitive in most urban areas and thus has limited implementation
- Existing and new technologies can meet the new water quality challenge
- Potable Reuse is considered inevitable
- It is important that water agencies begin to develop the necessary information as to allow direct potable reuse to become a reality



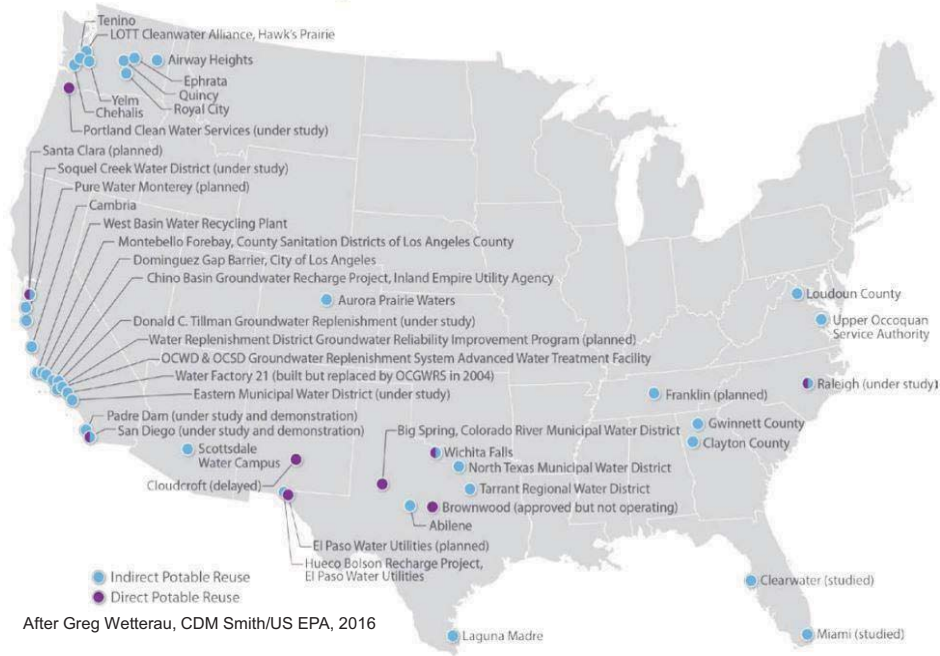
Direct Potable Reuse - Strategic Solution for Future Water Supply

- Benefit Public Water Supplies
- Benefit Agriculture
- Benefit the Environment
- Benefit Energy Conservation

Potential for DPR in Southern California

- Ocean discharge, representing the most available source water for DPR in the four Southern California counties, averages 4.8×10^6 m³/d (1 752 hm³/y)
- Treating a significant fraction of the wastewater now being discharged to the ocean, up to drinking water quality standards, and introducing DPR will stabilize the water supply in Southern California

PLANNED potable reuse in U.S.



**A PARADIGM SHIFT IN VIEW OF WASTEWATER
FOR THE 21ST CENTURY
(ALSO, TAKE HOME MESSAGE)**

Wastewater is a renewable recoverable source of **drinking water, resources, and energy.**

After George Tchobanoglous, 2017

Integrated Water Resources Management Silo Mentality?



2-12

Thank you



Adapted from Du Pont PERMASEP Permeators