TRENDS IN WATER RECLAMATION AND REUSE

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Topics

- Types of reuse accepted worldwide
- Satellite systems for water reuse
- Treatment technologies
- Regulatory framework
- Public education/acceptance
- Reuse: Projected worldwide growth
- Urine separation (Lunch)
- Energy recovery (Lunch)

TYPES OF REUSE ACCEPTED WORLDWIDE

Accepted Types of Reuse Worldwide

- Agricultural irrigation (seasonal demand)
- Landscape irrigation (seasonal demand)
- Industrial (constant demand, site specific)
- Non-potable urban uses (limited volumes)
- Recreation/environmental uses (site specific)
- *Indirect potable use through groundwater recharge (requires suitable aquifer)*
- *Indirect potable use through surface water augmentation (availability of reservoir sites)*
- *Direct potable use (public perception issues)*

Orange Groves, FL

Largo, FL

Cooling Towers, Tampa, FL

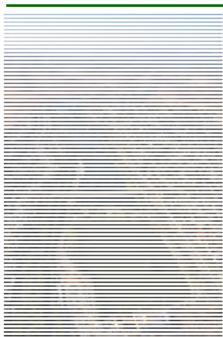
Commercial Car Wash, Tampa, FL

Snow Melting Facility, Sapporo, Japan

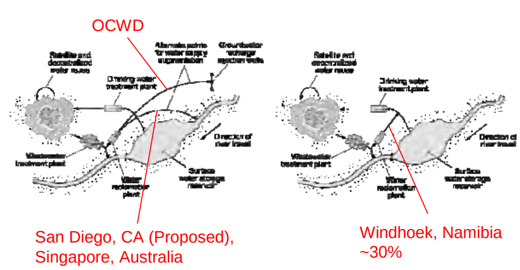
Urban Stream, Tokyo, Japan

Buildings with Dual Plumbing, Irvine, CA

Water Features, California, Florida



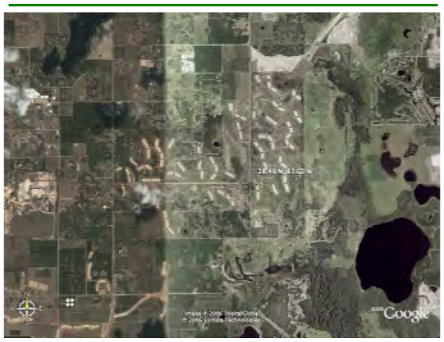
Indirect and Direct Potable Reuse, Along With New Approaches to Infrastructure, Represents the Future



Barrier Injection Wells, Orange County, CA

Infiltration Basins, Orlando, FL

Infiltration Basins, FL



Groundwater Recharge In Orange County, CA

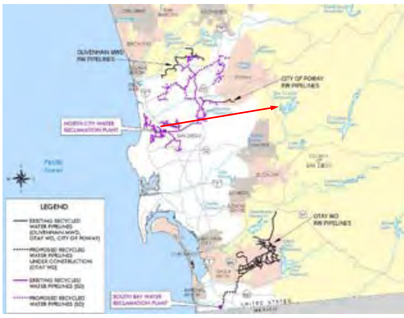
Driving Forces for Indirect Potable Reuse

- The value of water will increase significantly in the future (and dramatically in some locations)
- De facto indirect potable reuse is largely unregulated (e.g., secondary effluent, ag runoff, urban stormwater, highway runoff)
- Infrastructure requirements limit reuse opportunities
- Existing and new technologies can and will meet the water quality challenge
- Population growth and global warming will lead to severe water shortages in many locations. A reliable alternative supply should be developed
- More stringent environmental regulations

De Facto Indirect Potable Reuse

Courtesy City of San Diego

Infrastructure Requirements Limit Reuse Opportunities

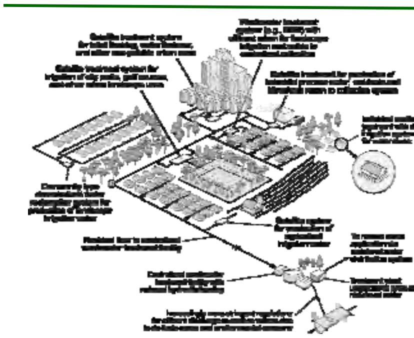


Courtesy City of San Diego

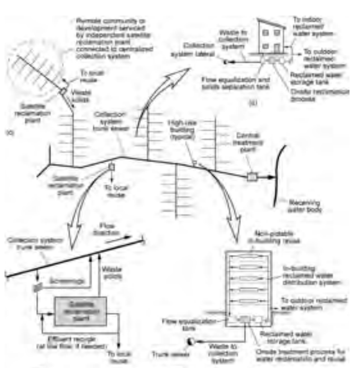
Direct Potable Reuse in Windhoek, Namibia

SATELLITE SYSTEMS FOR WATER REUSE

Satellite Systems For Water Reuse

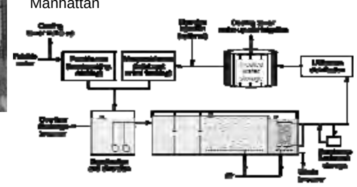


Offsetting Potable Water Demand Through Use of Satellite Treatment Systems and Reuse

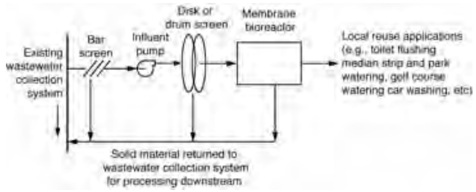


Offsetting Potable Water Demand with Intercepted In-Building Self-Contained Water Recycle System

- Onsite wastewater treatment and reuse system
- 27-story residential building
- 293 rental apartments
- Located in the Battery Park City in southwest Manhattan



Offsetting Potable Water Demand for Landscape Irrigation Through Sewer Mining

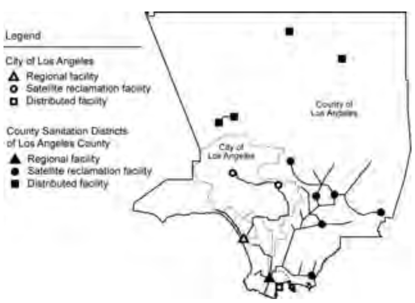


Offsetting Potable Water Demand for Irrigation

(System has been in Operation for 25 Years, Upland, CA)

Courtesy D. Ripley

Wastewater Management Infrastructure Employing Satellite Treatment and Reuse

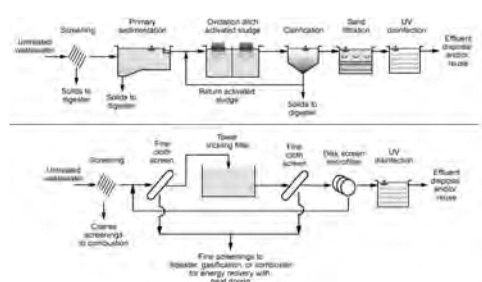


TREATMENT TECHNOLOGIES

Existing and New Treatment Technologies

- Technologies for the removal of BOD, TSS, nutrients, and pathogens
- Technologies for the removal of TDS, trace constituents, and unknowns
- Brine management for inland locations
- New technologies (even Silicon Valley is heavily involved)
- ***TREATMENT IS NOT THE ISSUE***

Technologies for the Removal of BOD, TSS, Nutrients, and Pathogens

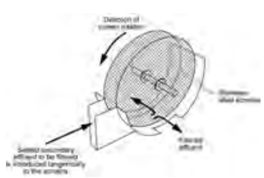


Fine Screen for Solids Removal

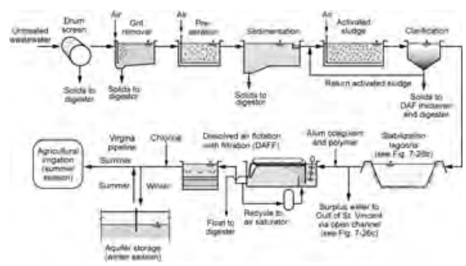
Advantages of Using Fine Screens in Place of Primary Sedimentation Tanks

- Treatment process flow diagram is simplified
- Particle size and size distribution is altered, leading to enhanced biological treatment kinetics whether with trickling filter or activated sludge

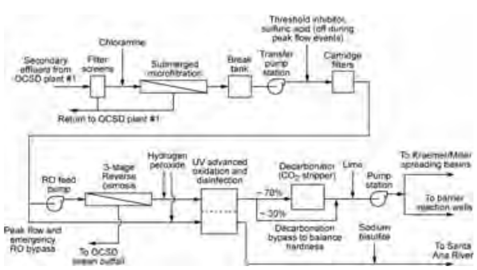
Stainless Steel Cloth Filter for Filtration of Secondary Effluent



Virginia Pipeline Project, Adelaide, Australia



Technologies for the Removal of TDS, Trace Constituents, and Unknowns



Adapted from OCWD

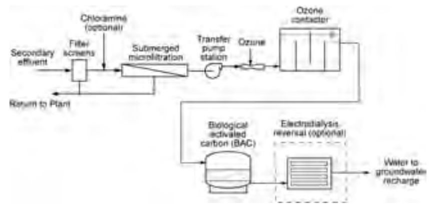
Microfiltration, Cartridge Filters, Reverse Osmosis, and Advanced Treatment (UV), OCWD

Orange County Water District, OCWD

Decarbonator (CO_2 Stripping)

Lime Saturator (pH adjustment)

Technologies for the Removal of Trace Constituents and Unknowns



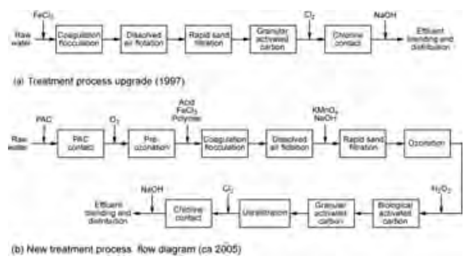
Adapted from Sundaram et al., 2009

Comparison of Technologies for the Removal of Trace Constituents & Unknowns

Item	MF-Ozone-BAC	MF-RO-UV/Peroxide
Fate of trace organics	Degraded	Removed and degraded
Reject/side streams	Minor (periodic backwash water)	Major (up to 20%)
Salinity	Unchanged	Decreased significantly
Corrosivity	Unchanged	Increased (requires buffering)
Energy consumption without MF	0.03 - 1.0 kWh/m³	8 - 10 kWh/m³

Adapted from Sundaram et al., 2009

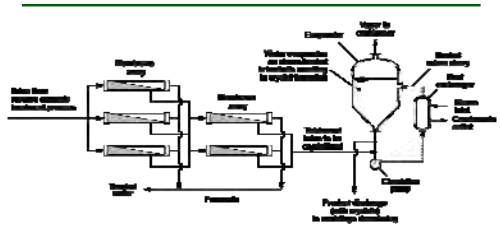
Goreangab Water Reclamation Plant Windhoek, Namibia



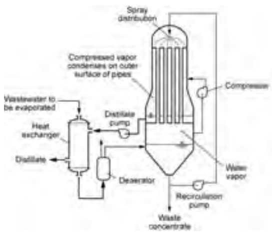
Brine Management: Environmental Challenges and Concerns

- Removal of brine is needed to limit the accumulation of salts for the long-term sustainability of agricultural production
- Discharge of brine to the ocean is unsustainable and may be environmentally unfriendly
- New technologies are being developed for brine management
- Brine management is energy intensive

Brine Management with Reverse Osmosis and Crystallization



Brine Management: Concentration with Falling-Film Evaporator



REGULATORY REQUIREMENTS

Science Versus Regulations

Pre 1880s

Physical observations - No Science - Common sense practices (regulations)

Enlightenment 1880-1980s

Science develops - Semi-scientific, observational, and empirical regulations follow

Post 1980s

Science leaps ahead - Science based regulations have evolved, but have have not kept pace - Semi-empirical and empirical LEGACY regulations persist.

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Kraemer/Miller Spreading Basins, OCWD

Indirect Potable Reuse - Major Concerns

- Water quality
- Treatment reliability
- Trace organics
- Unknowns unknowns
- Limited health effects data
- Public acceptance

Adapted from Dr. J. Crook

Florida Regulations for Injection of Reclaimed Water into Potable Aquifers

Quality limits	Treatment required	Other requirements
• No detectable total coli/100 mL • ≤ 5 mg/L TSS • ≤ 10 mg/L total N • ≤ 20 mg/L BOD • ≤ 3 mg/L TOC • ≤ 0.2 mg/L TOX • Drinking water MCLs	• Secondary • Filtration • Organics removal process • Disinfection	• Multiple barriers for control of pathogens and chemicals • Monitor reclaimed water for unregulated organics • Pilot testing required

Courtesy Dr. J. Crook

Draft California Regulations for Groundwater Recharge into Potable Aquifers

Quality limits	Treatment required	Other requirements
• ≤ 5 mg/L total N • ≥ 5 log virus inactivation • ≤ 2.2 total coli/100 mL • ≤ 2 NTU • ≤ 0.5 mg/L TOC of wastewater origin • Drinking water MCLs	Spreading • Secondary • Filtration • Disinfection • SAT Injection • Secondary • Filtration • Reverse osmosis • AOP* (H_2O_2 + UV)	• ≥ 80% dilution for spreading (to start) • ≥ 50% dilution for injection • 6-month retention time underground • Monitor reclaimed water and monitoring wells for unregulated constituents specified by CDPH

*AOP must reduce NDMA and 1,4-dioxane by at least 1.2 logs and 0.5 logs, respectively.

Courtesy Dr. J. Crook

Retention Time Constraint

Premises

- An environmental barrier was needed due to limited process control and monitoring
- A 6 month residence time was thought to provide sufficient opportunity for mixing, dilution, and assimilation.

Realities

- The quality of the advanced treated water is now superior to most environmental water supply sources.
- Effective process control and monitoring, now standard, essentially eliminates risk
- A 6 month time constraint is a legacy regulation

PUBLIC EDUCATION/ ACCEPTANCE

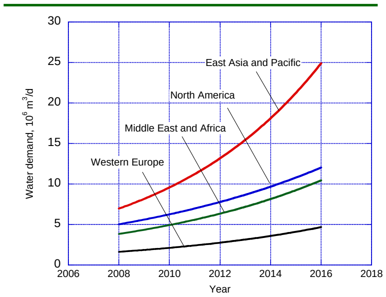
Public Involvement Techniques Employed in San Diego

- Public Surveys
- Citizens Advisory Committee
- Public Information
- Media Coverage
- Speaking Engagements
- Tours of Pilot Plant including taste tests

Public Acceptance

- Stakeholder and public acceptance is essential
- Must demonstrate reclaimed waste is safe with respect to chemical and biological quality
- Diligent outreach programs critical to gain public support for any reuse plan
- Outreach programs must deal with a standardized (understandable) vocabulary
- In dealing with the public, success of any reuse plan will be based on TRANSPARENCY, regardless of outcome

Reuse: Projected Worldwide Growth



Source: GWI Global Water Market 2008

Closing Thoughts

- Technology is now available to produce water for any use including direct potable pipe to pipe reuse
- Must resolve disconnect between existing standards and regulations and scientific findings
- In promoting water reuse, the profession must speak with a unified vocabulary
- Water reclamation and reuse will be a critical element in the development of sustainable strategies for water resources management

THANK YOU FOR LISTENING