The GWR System – Indirect Potable Reuse as a New Water Source

Mehul Patel, P.E.
GWRS Process Manager
Orange County Water District

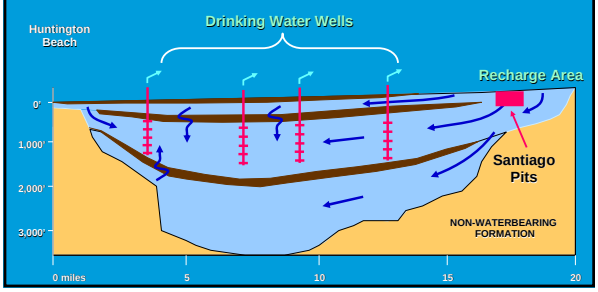
Presented To
University of South Florida
February 15, 2010

Orange County

- One hour south of Los Angeles
- Coastal community
- Dry, arid climate with little rain
- Sources of water include groundwater and imported water

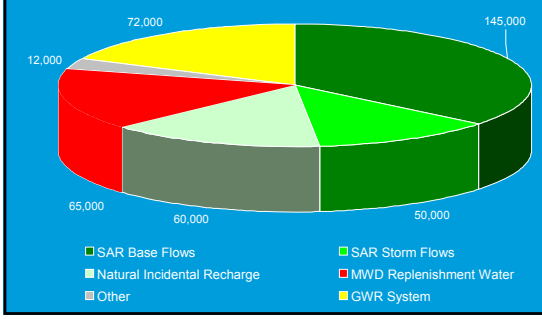
Orange County Water District

***Protect Water Quality *Manage Pumping *Replenish Basin**



OCWD Sources of Groundwater Recharge

Annual Total 339,000 to 404,000 afy

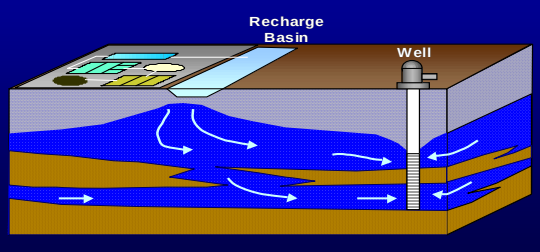


History of Potable Reuse at OCWD

- Partnership with OCSD since 1971
- Water Factory 21 for seawater barrier since 1976
  - Lime clarification, sand filtration, GAC (BAC), Chlorine disinfection
  - First RO treatment of recycled water in 1977
  - Blend of RO/GAC/Deep well water 15 MGD 1980-2000
  - UV added for NDMA destruction in 2001
- Research into RO and pretreatment 1977-2000
- Planning for Groundwater Replenishment (GWR System) 1995-2002
- Interim Water Factory 5 MGD (6.9 million m^3/yr) MF/RO/UV 2004-2006

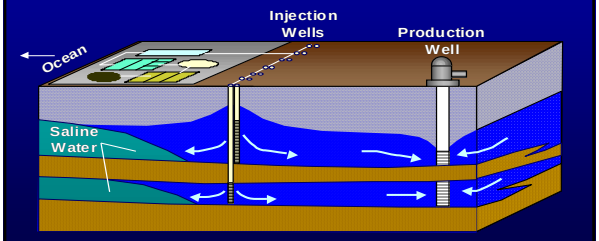
Indirect Potable Reuse Practiced by OCWD

Groundwater recharge by surface spreading



Indirect Potable Reuse Practice by OCWD

Groundwater recharge by direct injection for a salt water intrusion barrier



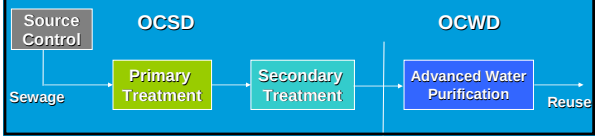
GWR System Components

Joint Partnership

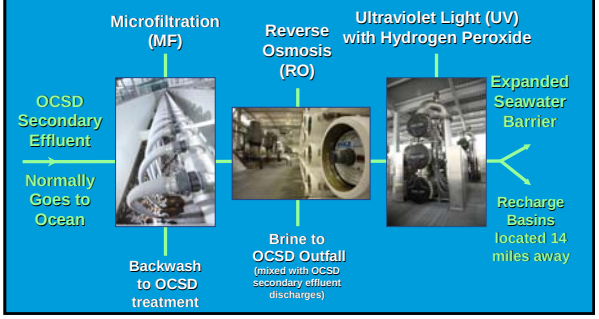
OCSD: Wastewater Collection, Source Control, Treatment and Disposal

OCWD: Manages and protects the Orange County Groundwater Basin

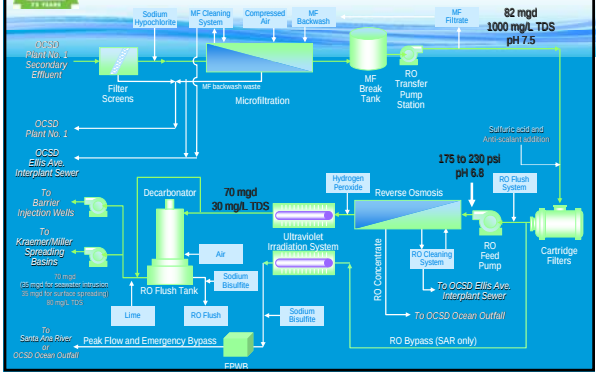
Partnership since 1972 for Wastewater Reclamation



GWR System Advanced Water Purification Process



AWPF Process Schematic



Microfiltration System

- 86 MGD Siemens CMF-S Microfiltration System
- Hollow fiber polypropylene membranes
- Removes bacteria, protozoa, and suspended solids
- 0.2 micron pore size
- In basin submersible system
- 15,808 membrane modules
- Two CIP systems

Reverse Osmosis System

- 70 MGD Reverse Osmosis System
- Hydranautics ESPA-2 Membranes
- Fifteen 3-stage array units (78:48:24) each sized at 5 mgd
- Recovery Rate: 85%
- Flux of 12 gfd
- Removes dissolved minerals, viruses, and organic compounds (incl. pharmaceuticals)
- Pressure range: 180 – 230 psi
- 15,750 membrane elements
- Two CIP systems

Ultraviolet/Advanced Oxidation System

- 70 MGD Trojan UVPhox System
- Low Pressure – High Output lamp system
- Destroys trace organics
- Uses Hydrogen Peroxide to form an Advanced Oxidation Process
- UV system given a 4-log virus removal credit to meet CA DPH Title 22 criteria for recycled water

Where Does GWR System Water Go?

- Water is returned to groundwater basin
  - Half (35 MGD) is sent to seawater intrusion barrier
  - Half (35 MGD) is sent to recharge basins in Anaheim

Regulatory Oversight

- California Dept. of Public Health (CDPH) establishes recycling criteria
  - Treatment and quality
  - TOC limit
  - Travel time
  - Blending
- Regional Water Quality Control Board issues reclamation permit
- Regional Board incorporates CDPH recommendations into permit
- CDPH public hearing - Feb 2003
- Regional Board permit - Feb 2004
  - Incorporate CDPH recommendations
  - 100% RO, AOP
  - Meet drinking water standards
  - Monitor for unregulated contaminants
  - Blend with storm water and imported water
  - 75% recycled water blend for injected water can increase to 100% once demonstrate receiving aquifer water quality for 1 yr (approval for 100% granted Nov. 2009 by CA DPH)
  - 6 months retention for spread water
  - 6 months retention for injected water

Multiple Barriers Protect Public Health

- Microbial contaminants –
  - MF removes bacteria and protozoa
  - RO removes viruses, bacteria
  - UV inactivates microbes, prevents replication
  - Retention time in groundwater
- Chemical contaminants –
  - Source control prevents introduction of contaminants
  - MF removes particles, suspended solids
  - RO removes dissolved salts, metals, organics, including pharmaceuticals, endocrine disruptors
  - UV with hydrogen peroxide destroys small organics
  - Groundwater provides buffering, biodegradation, ion exchange

Process Control Points

- Key points in treatment process monitored for failure by on line instrumentation
- Online sensors can detect treatment lapses Examples include:
  - Turbidity through MF
  - Pressure decay test with MF
  - Conductivity through RO
  - TOC through RO
  - UVT into UV AOP
  - UV power delivered
  - pH through decarbonation
  - pH through lime addition

Source Control

- Orange County Sanitation District "enhanced source control"
- Regulate discharges into sewer to prevent contamination
- First step in producing drinking water, first barrier
- OCWD helps identify compounds of concern and efficacy of advanced treatment
- Divert non-reclaimable wastes to different plant

INDEPENDENT ADVISORY PANEL

- Appointed By National Water Research Institute in 2004 as a requirement of the GWRS plant operating permit
- Leading Experts in Hydrogeology, Chemistry, Toxicology, Microbiology, Engineering, Public Health, Public Communications and Environmental Protection
- Review Operations, Monitoring and Water Quality
- Panel Makes Recommendations to OCWD and Regulatory Agencies to Assure Quality and Reliability

Water Quality Produced by GWRS

- Meets all drinking water standards
- Influent TDS 1000 mg/L, RO product <30 mg/L
- Influent TOC 11-12 mg/L, product water <0.15 mg/L
- Pharmaceuticals removed to non detect (ng/L RDLs)
- Other CECs also effectively removed by RO
- NDMA destroyed by UV
- 1,4-dioxane source control and removed by RO, AOP
- ND to trace THMs
- Best water available for aquifer replenishment

GWRS Water Quality

Parameter	Sample Location	Method	Permit Requirement	Reportable Detection	Actual Values
UV%T-254	RO Permeate	5910B	>90%	0.1%	98.80%
Turbidity	RO Permeate	Automated Plant Monitoring	<0.2 / 0.5 NTU	N/A	0.18 NTU
Total Recycled Water Flow	Final Product	Plant Monitoring	<70 mgd	N/A	N/A
Total Nitrogen	Final Product	4500NO3F	5 mg/L	0.4 mg/L	1.7 mg/L
Total Organic Carbon	Final Product	5310C	0.5 mg/L	0.01 mg/L	0.19 mg/L
Total Coliform	Final Product	9221B	2.2 MPN /100 ml	2 MPN /100 ml	ND
pH	Final Product	Automated Plant Monitoring	6 - 9	1 pH unit	8.22
Electrical Conductivity	Final Product	2510B	N/A	1 um/cm	80.96 um/cm

Feed Water To GWRS

Hormones	Result (ng/L)	Detection Limit (ng/L)
Diethylstilbestrol	ND	10
Progesterone	ND	10
17a-Ethynylestradiol	ND	10
17b-Estradiol	ND	10
17a-Estradiol	ND	10
Estriol	ND	10
Testosterone	ND	10
Epitestosterone	ND	10
Estrone	ND	10

Feed Water to GWRS

Pharmaceuticals	Result (ng/L)	Detection Limit (ng/L)
Triclosan	510	1
Ibuprofen	1000	5
Gemfibrizol	4300	1
Sulfamexthoxazole	2100	1
Primidone	140	1
DEET	77.7	1
Ciprofloxacin	820	100
Carbamazepine	260	1
Azithromycin	1200	5
Acetominophen	35.9	10
Caffeine	460	3

Pharmaceutical Results for Final Product Water

Parameter	Sample Location	Method	Permit Requirement	Reportable Detection	Actual Values
Pharmaceuticals and Other Substances					
Acetaminopen	Final Product	Pharma	N/A	10-20 ng/L	ND
Azithromycin	Final Product	Pharma	N/A	1 ng/L	ND
Caffeine	Final Product	Pharma	N/A	3 ug/L	ND
Carbamazepine	Final Product	Pharma	N/A	1 ng/L	ND
Ciprofloxacin	Final Product	Pharma	N/A	10-150 ng/L	ND
Ethylenediamine Tetra-Acetic Acid (EDTA)	Final Product	No developed Method	N/A	N/A	N/A
Gemfibrozil	Final Product	Pharma	N/A	1 ng/L	ND
Ibuprofen	Final Product	Pharma	N/A	1 ng/L	ND
Iodinated Contrast Media	Final Product	No developed Method	N/A	N/A	N/A
Lipitor	Final Product	No developed Method	N/A	N/A	N/A
Methadone	Final Product	No developed Method	N/A	N/A	N/A
Morphine	Final Product	No developed Method	N/A	N/A	N/A
Salicylic Acid	Final Product	No developed Method	N/A	N/A	N/A
Triclosan	Final Product	Pharma	N/A	1-5 ng/L	ND

EDC Results in Final Product Water

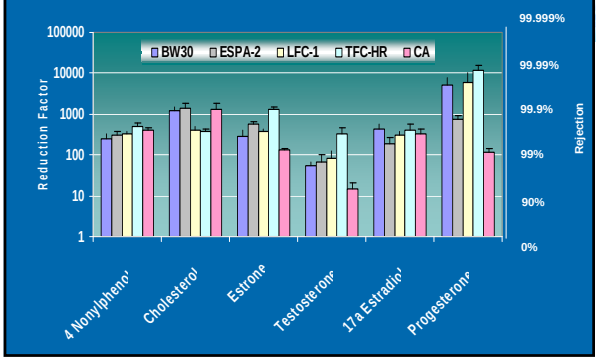
Parameter	Sample Location	Method	Permit Requirement	Reportable Detection	Actual Values
Endorcrine Disrupting Chemicals and Pharmaceuticals					
Hormones					
17a-Ethynyl Estradiol[27]	Final Product	Hormones	N/A	10 ng/L	ND
17-b Estradiol	Final Product	Hormones	N/A	10 ng/L	ND
Estrone	Final Product	Hormones	N/A	10 ng/L	ND
"Industrial" Endocrine Disruptors					
Bisphenol A	Final Product	Phenols	N/A	1 ug/L	ND
Nonylphenol	Final Product	Phenols	N/A	1 ug/L	ND
Nonylphenol Polyethoxylate[28]	Final Product	Phenols	N/A	10-30 ug/L	ND
Octylphenol[23]	Final Product	Phenols	N/A	2 ug/L	ND
Octylphenol Polyethoxylate	Final Product	No developed method	N/A	N/A	N/A
Polybrominated Diphenyl Ethers	Final Product	525	N/A	0.1 ug/L	ND

Unregulated Chemical Results in Final Product Water

Parameter	Sample Location	Method	Permit Requirement	Reportable Detection	Actual Values
UNREGULATED CHEMICALS					
Boron	Final Product	200.7	1 mg/L*	0.1 mg/L	0.25 mg/L
Hexavalent Chromium (dissolved)	Final Product	218.6	N/A	0.2-1 ug/L	ND
Vanadium	Final Product	200.7	50 ug/L*	0.5 ug/L	ND
Dichlorodifluoromethane	Final Product	524.2	1 mg/L*	0.5 ug/L	ND
Ethyl tert-butyl ether	Final Product	524.2	N/A	1 ug/L	ND
Tertiary-amyl methyl ether	Final Product	524.2	N/A	1 ug/L	ND
Tert-butyl alcohol	Final Product	524.2	12 ug/L*	2 ug/L	ND
1,2,3-Trichloropropane	Final Product	TCP-LOW	0.005 ug/L*	0.005 ug/L	ND
n-Nitrosodimethylamine (NDMA)	Final Product	Isotopic Dilution – GC/MS/MS-CI	10 ng/L*	2 ng/L	ND
1,4-Dioxane	Final Product	Purge andTrap GC/MS	3 ug/L*	1 ug/L	ND

* CDPH Drinking Water Notification Level

Various RO Rejection Efficiencies at OCWD



Project Funding and Timing

- Cost: approximately $481 million
  - Split equally between OCWD and OCSD
- Produces 72,000 Acre-Feet of water (enough for 500,000 people each year)
  - Built to double supply if demand increases in future
- Costs comparable to imported water
  - $92 million in state and federal grants and an $86 million subsidy for operation and maintenance from Metropolitan Water District
  - Current Unit Cost of Water is $500 per acre foot ($1.53/1000 gal)
  - Without outside funding cost of water would be approximately $800 per acre foot ($2.45/1000 gal)
- Operational since January 2008

GWR System Actual Unit Water Costs (2009)

	July	August	September	October	November	December
Electricity	$146	$127	$131	$99	$118	$106
Chemicals	$62	$74	$64	$68	$63	$69
Labor	$115	$107	$112	$107	$156	$125
Plant Maintenance	$52	$39	$71	$58	$72	$72
R&R Fund Contribution ($4.5 Million Annually)	$67	$63	$65	$64	$95	$70
Debt Service ($11.5 Million Annually)	$170	$162	$611	$165	$242	$180
Subtotal	$612	$573	$656	$562	$746	$622
MWD LRP Subsidy (1)	-$14	-$121	-$121	-$121	-$121	-$121
OCSD contribution to maintenance cost (2)	-$7	-$7	-$7	-$7	-$11	-$8
Total ($/AF)	$591	$445	$483	$434	$614	$493
Production (AF)	5633	5910	5751	5820	3963	5334

(1) MWD LRP Subsidy of $121/af begins after first 5,000 af of water produced.
(2) Currently estimated at $500,000 annually.

How Does the Water Cost Compare?

- Comparable to alternative sources
- One Acre Foot (AF) = water for two families/yr
- Typical OC retail water rate >$900/AF in 2009
- GWR $560/AF ($1.72/1000 gal) with grants and subsidies
  - $121/AF operating subsidy from MWD (regional water importer)
- GWR $850/AF ($2.60/1000 gal) without grants/subsidies
- Raw MWD water for recharge: $536/AF increasing to $637 ($1.95/1000 gal) by Jan 2011
- Treated MWD water for direct use: $753/AF increasing to $899 ($2.75/1000 gal) by Jan 2011

Benefits of GWR System

- Protects from seawater intrusion
- Provides water to refill basin in times of drought and population growth
- Eliminates need for a new ocean outfall
- Uses about half the energy needed to import water from Northern California
- Improves water quality
- Model for IPR schemes in other parts of the world
  - Australia, Singapore, etc.

Even Indirect Projects Have Failed to Gain Public Support

- San Diego – “toilet to tap” rejected twice
- Los Angeles – DWP East Valley project
- Upper San Gabriel
- Dublin/San Ramon
- Queensland, Australia

What Have We Learned from Potable Reuse in OC?

Public can accept potable reuse if:

- Need is clear
- Safety is assured - multiple barriers
- Quality is better than alternatives
- Public health agencies have continuing oversight
- Independent scientific review
- Outreach is effective and ongoing
- Politicians and community leaders make commitment
- The more people understand the more they accept the idea

Strong Community Support

Proactive face-to-face outreach with more than 1,200 presentations, 700 tours and many news stories that resulted in:

- No active opposition
- 100% support from local, state and federal elected officials
- 100% support from businesses and major environmental groups
- Support from several health experts, medical doctors, hospitals, pharmacists and scientists
- Educational, religious, police, fire leaders, minority leaders and more than 200 community organizations

PUBLIC OUTREACH PROCESS FOR GWRS

Members of Parliament, Victoria, AUS

- Meetings with All Elected Officials… Local, State and National
- Presentations to Community Groups, Organizations, Clubs, etc… Over 1,500 to Date
- Tours of the Advanced Water Purification Plant
- Tours of the Recharge Facilities
- Press Releases, Editorial Board Briefings, Briefings for Each New Reporter
- Cable/Local TV Appearances

Widespread Unplanned Potable Reuse

- Most major water supplies have wastewater component
- OC depends on Colorado River, State Water Project, Santa Ana River (wastewater dominated)
- Philadelphia - Schuylkill River
- Cincinnati – Ohio River
- Washington D.C. – Occoquan River
- Worldwide - rivers receive wastewater and provide drinking water

EARLY INDIRECT POTABLE REUSE PROJECTS

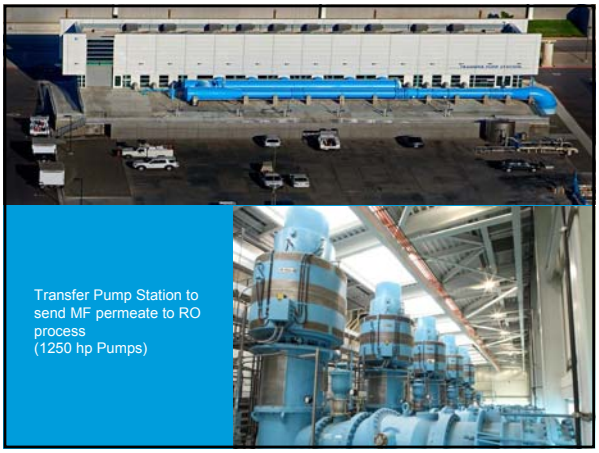
Project	Start	Size (MGD)	Treatment	Use
Whittier Narrows, CA	1963	40	Tertiary	Percolation
South Lake Tahoe, CA	1966	6.5	Tertiary, GAC	Injection
Windhoek, Africa	1969	4.5	Advanced without membranes	DPR
Water Factory 21, OCWD	1976	5	RO,UV	Injection
Upper Occoquan, VA	1981	24	Tertiary, GAC	Reservoir
El Paso, TX	1986	6.5	Tertiary, GAC	Injection
West Basin, LA	1996	5	MF, RO	Injection
Scottsdale, AZ	2002	9	MF, RO	Injection

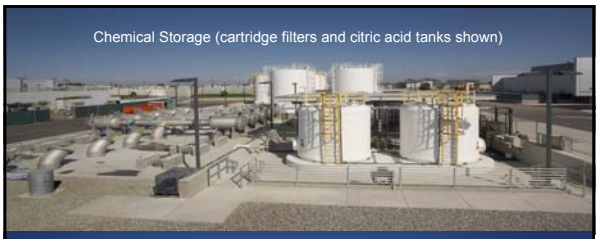
RECENT ADVANCED WATER PURIFICATION PROJECTS

Project	Start	Size (MLD)	Treatment	Use
GWR System, OCWD	2008	70	MF, RO, UV	Percolation/ Injection
Singapore NEWater	2003	9	MF, RO, UV	Reservoir
West Basin Expansion, LA	2006	6.5	MF, RO, UV	Injection
LA Harbor Project	2006	6.5	MF, RO	Injection
Alamitos Gap, LA	2005	3	MF, RO, UV	Injection
Western Corridor Recycled Water Project (Bundamba, Luggage Point, Gibson Island, Queensland)	2007	Up to 60	MF, RO, UV	Reservoir

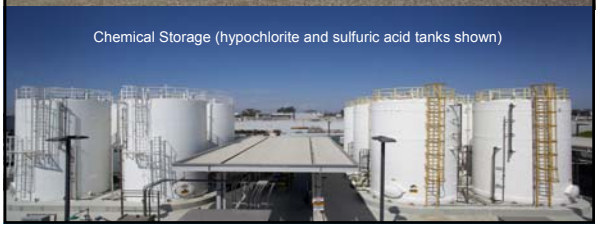

Aerial view of GWRS facility and adjacent OCSD Plant 1


Microfiltration
(Basins and module cut away)
Microfiltration
(Top of basins at ground level)
MICROFILTRATION
Microfiltration
(Aerial view)


Transfer Pump Station to send MF permeate to RO process
(1250 hp Pumps)



Chemical Storage (cartridge filters and citric acid tanks shown)



Chemical Storage (hypochlorite and sulfuric acid tanks shown)

Reverse Osmosis
(Exterior of building)

Reverse Osmosis
(View of one 5 mgd unit)

UV/AOP System

Kramer Basin percolation pond filled with GWRS water

Lime Saturator

Santa Ana River Recharge

- Santa Ana River baseflow 150,000 acre feet per year (AFY)
- Stormflow avg 50,000 AFY
- Baseflow dominated by tertiary effluent discharges > 150 MGD
  Santa Ana River Water Quality and Health (SARWQH) Study 1994-2004

Imported Water Recharge

- Colorado River water and State Water Project water (from Sacramento/San Joaquin Delta)
- OCWD average 65,000 AFY (80 million m^3/yr) imported water recharge mostly Colorado River water
- Imported water sources all receive effluent discharges from upstream cities
- Replenishment water less available than past