WATEREUSE CALIFORNIA

Orange County Chapter

Potable Reuse for Inland Applications: Pilot Testing Results from a New Potable Reuse Treatment Scheme (WRRF-13-09)

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December 18, 2014

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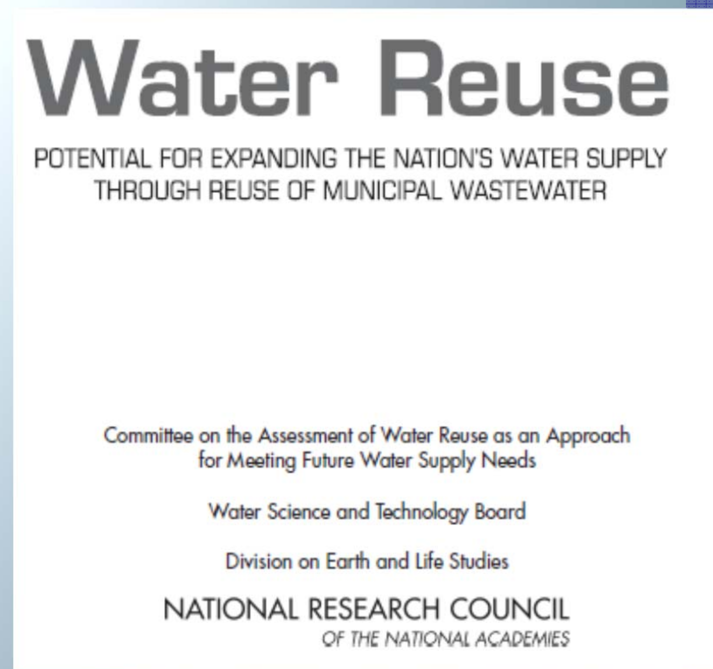
Outline

- Potable Reuse Background – Drivers and Applications
- Tucson's Water Supply and Potable Reuse Plans
- Pilot Facilities and Initial Results
- Conclusions

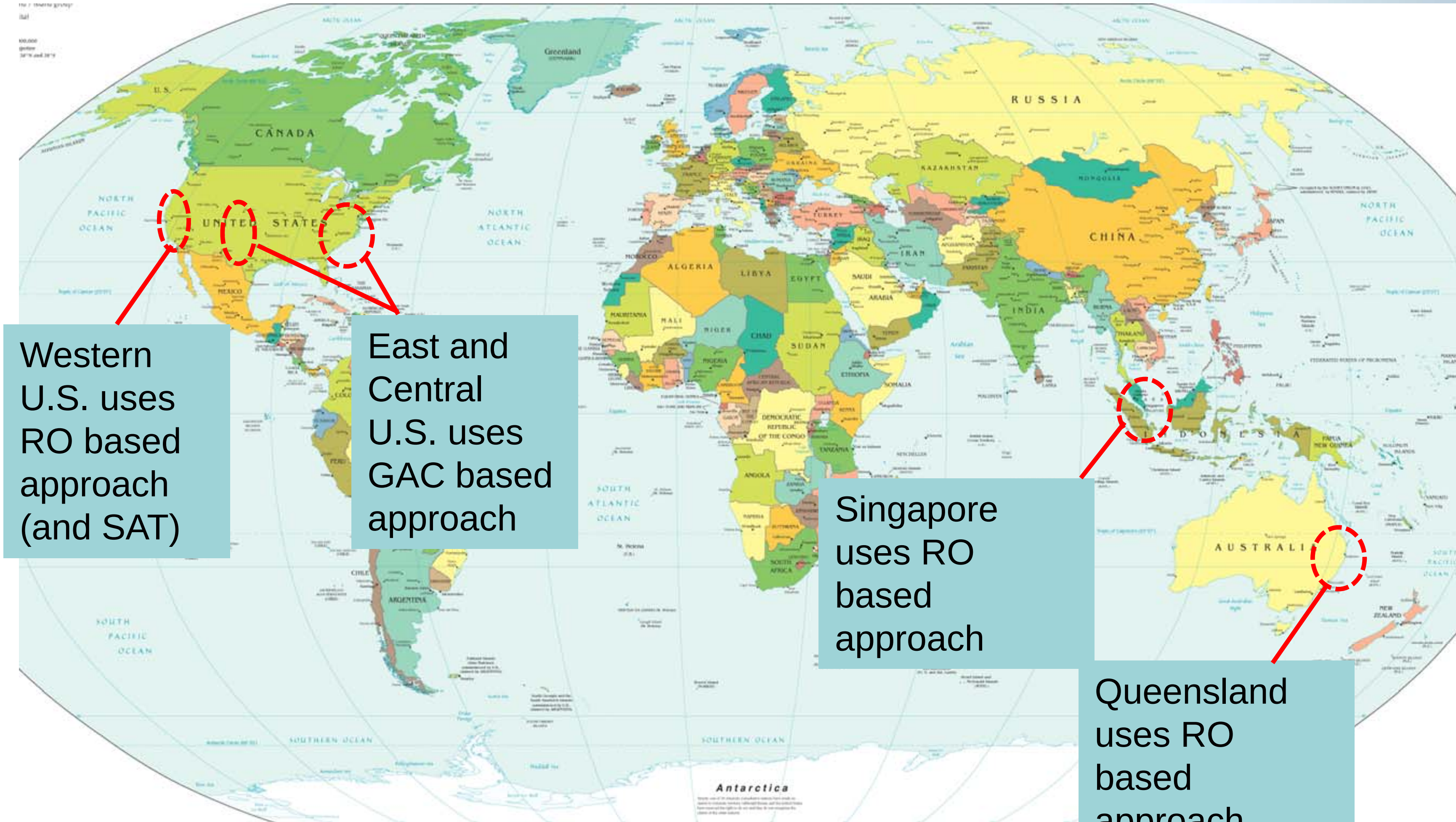
Current Drivers towards Potable Reuse

- Drivers for water reuse: population growth, climate change and drought, easy supplies have already been tapped
- Why is there a trend in some areas to move away from non-potable reuse and towards potable reuse?
  - low reuse non potable water demand during winter months
  - Non-potable demands often are geographically separated by large distances which results in very high pumping and piping costs
- Some locations are looking towards direct potable reuse
  - California discharges 3.5 MAF/year of treated wastewater to the ocean and DPR is likely the only option that will allow reuse



Potable Reuse Plants

RO-Based (West U.S. and International) vs. GAC-Based (East and Central U.S)



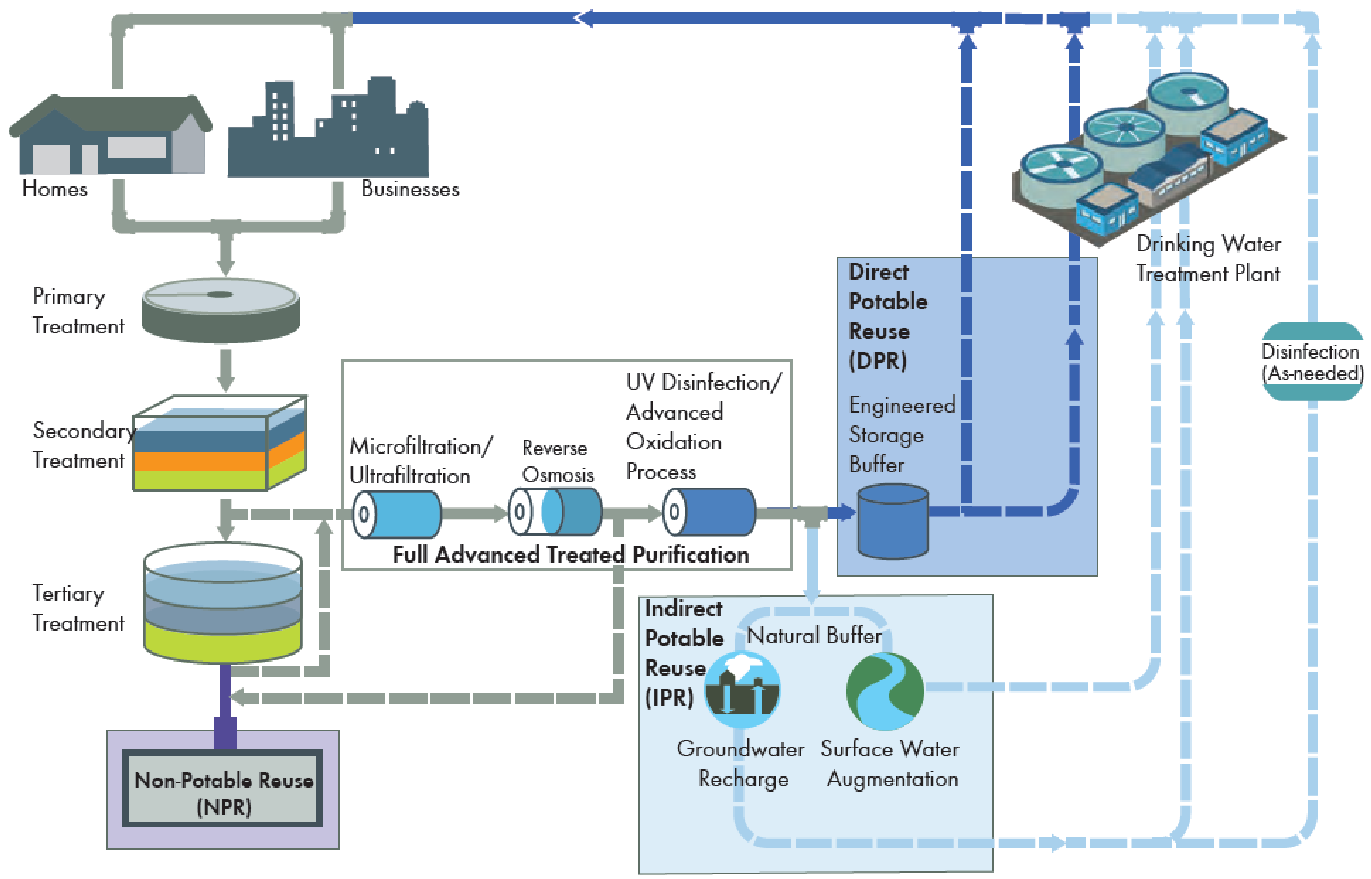
Western U.S. uses RO based approach (and SAT)

East and Central U.S. uses GAC based approach

Singapore uses RO based approach

Queensland uses RO based approach

Non Potable Reuse/IPR/DPR



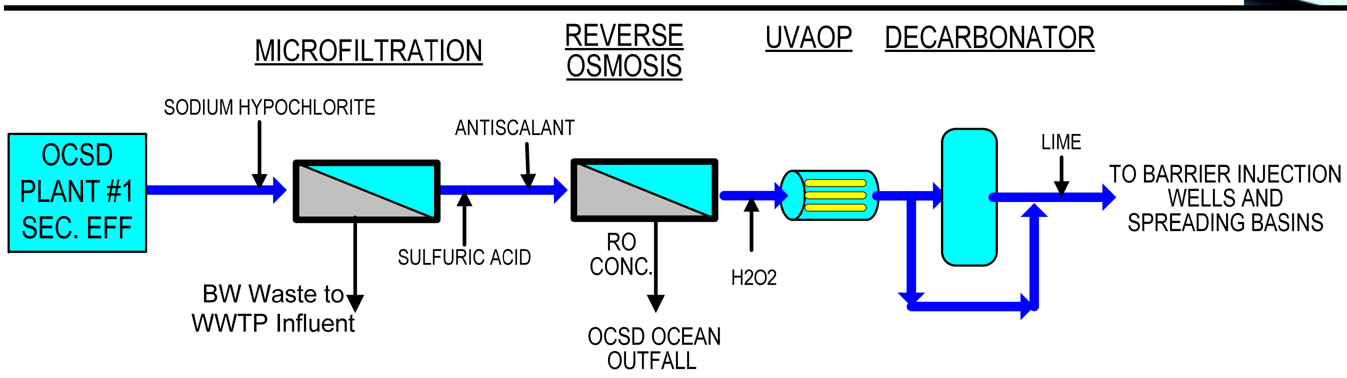
Non-potable reuse. NPR includes any application of recycled water not involving drinking water for human consumption. NPR water originates from homes and businesses as municipal wastewater and undergoes tertiary treatment at a reclamation facility to meet specific water quality standards (i.e., Title 22 of the California Code of Requirements).

Indirect potable reuse. IPR is the application of multiple levels of treatment to achieve full advanced treated purified water for groundwater recharge or surface water augmentation, upstream of a water treatment plant, using these natural buffers for treatment.

Direct potable reuse. DPR is the planned introduction of full advanced treated purified water directly into a public water system's treated or raw water supply using engineered storage buffers, generally tanks or other closely controlled storage.

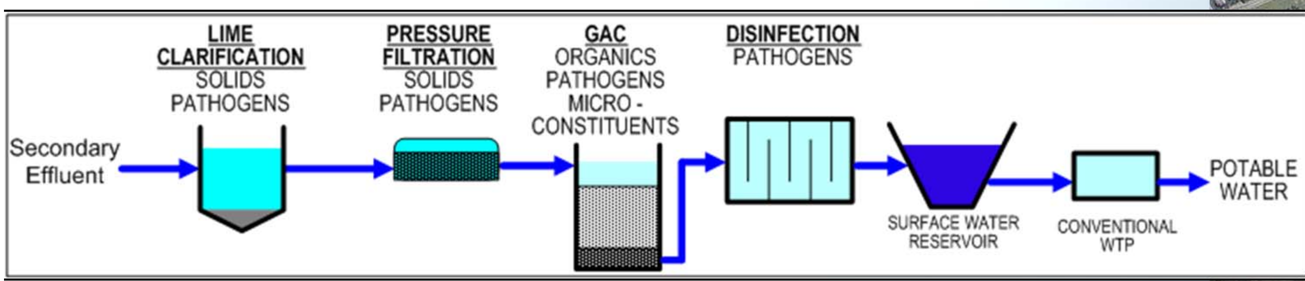
Potable Reuse: Full-Scale Examples

GWRS– RO Based Treatment (70/100 mgd)



Courtesy of Jim Kutzie, OCWD

UOSA (VA) – GAC Based Treatment (54 mgd)



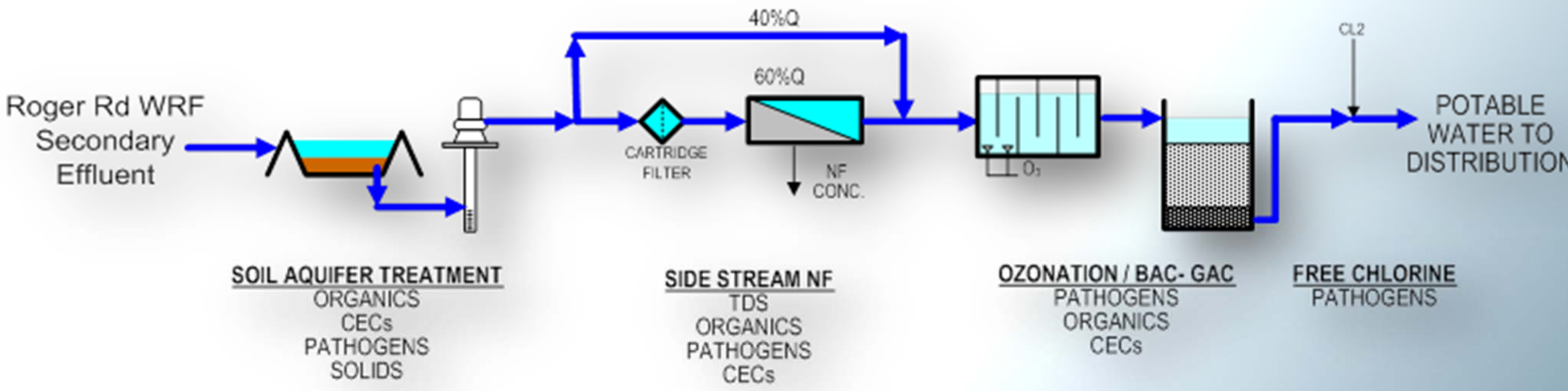
- Multiple barriers provided by each treatment train for removal of bulk organic matter, trace organics, and pathogens
- **Disposal of RO concentrate required for Train #1; very expensive for inland locations**

Tucson's Potable Reuse Project

- Independent Expert Advisory Panel recognizes the importance of a potable reuse project to the City of Tucson
- What treatment is needed? MF-RO-UVAOP has been shown to be effective, but Tucson Water wants to explore alternative treatment methods, while:
  - Providing multiple barriers for organics and pathogens
  - Removing salt
  - Reducing energy consumption
  - Reducing/eliminating concentrate streams

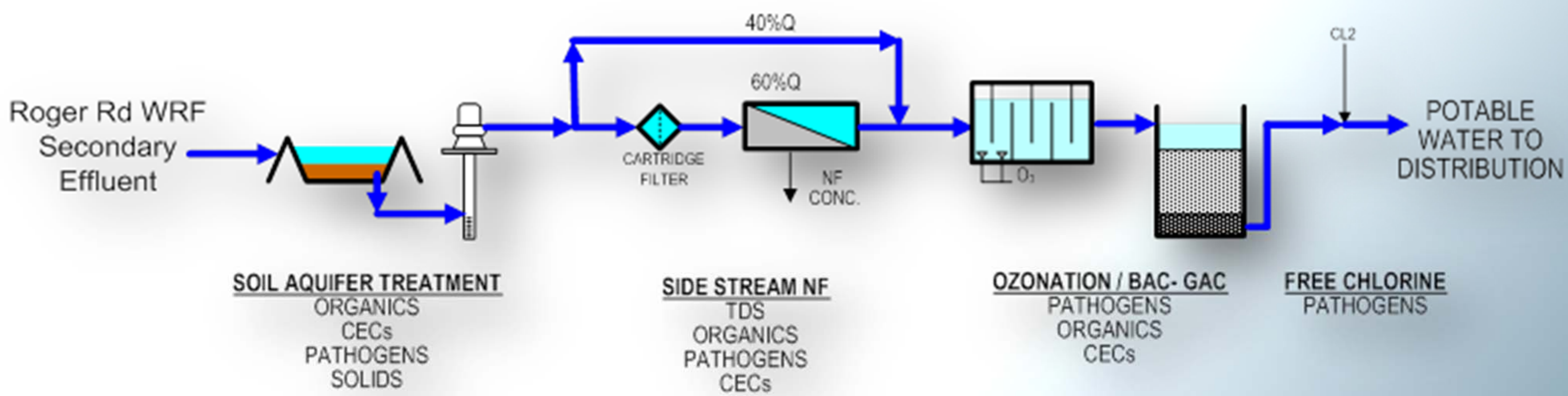
> "It is the unanimous conclusion of the Panel that the efforts described in the *Recycled Water Master Plan* will be a **landmark development** in the acceptance and implementation of IPR and will contribute to the **City of Tucson's renewable water resources portfolio.** The proposed new recycled water programs identified in the *Recycled Water Master Plan* will supplement existing sources and provide a greater degree of independence, thus improving the **reliability and sustainability** of existing water supplies."

Proposed Treatment Scheme



- **Soil Aquifer Treatment (SAT):**
  - Provides excellent removal of organics, pathogens, and nitrogen compounds
  - Use short-term SAT (2 weeks) to lower implementation costs and make application more universally applicable
- **Nanofiltration:**
  - Very good removal of pathogens, organics, and divalent ions (moderate removal of monovalent ions)
  - Operates at lower pressure than RO - meet specific TDS goals at lower power requirements
  - Concentrate handling is less expensive and may allow beneficial use
- **Ozone and BAC Filtration / GAC Adsorption:**
  - Excellent oxidation of trace organics and inactivation of pathogens
  - BAC filtration / GAC Adsorption will remove transformed organics by both biological and adsorptive mechanisms.

Proposed Alternative Treatment Scheme



- **Soil Aquifer Treatment (SAT)**
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- **Ozon**
  - Excellent oxidation of trace organics and inactivation of pathogens
  - BAC filtration / GAC Adsorption will remove transformed organics by both biological and adsorptive mechanisms.

✓Provides multiple barriers for organics and pathogens
✓Removes salt
✓Reduces energy consumption
✓Mitigates concentrate disposal

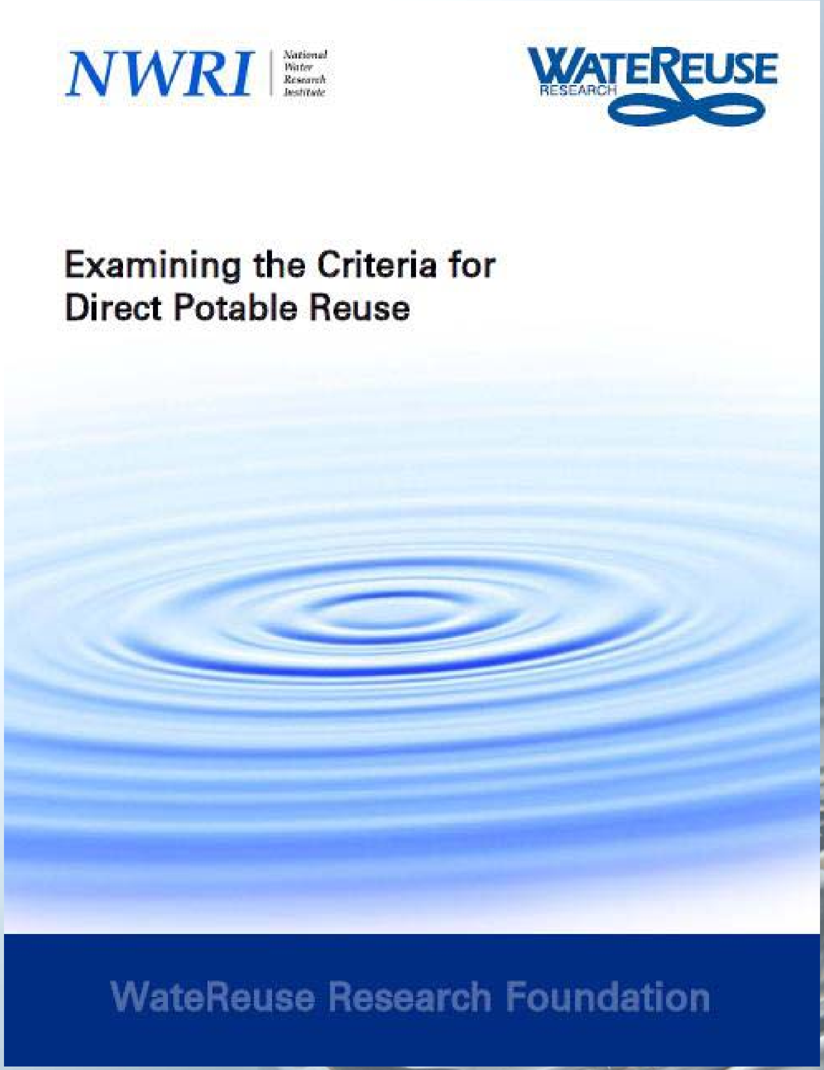
Other Water Quality Concerns

- NDMA
  - Significant formation can occur with ozone addition to secondary effluent
  - SAT and NF will remove precursors and BAC will remove NDMA formed
- Bromate
  - Bromide concentrations in secondary effluent are high (0.2 – 0.3 mg/L), could lead to elevated bromate with ozone addition
  - Add ozone at sub-residual doses if possible
- TDS
  - Secondary effluent 650 – 750 mg/L
  - Goal is < 500 mg/L; side-stream NF treatment

WRRF 11-02 Panel Report Specifies Treatment Goals

From Raw Wastewater to Potable Water:

- 12-log virus
- 10-log protozoa (*Cryptosporidium* and *Giardia)*
- 9-log bacteria ?


NWRI National Water Research Institute
WATEREUSE RESEARCH

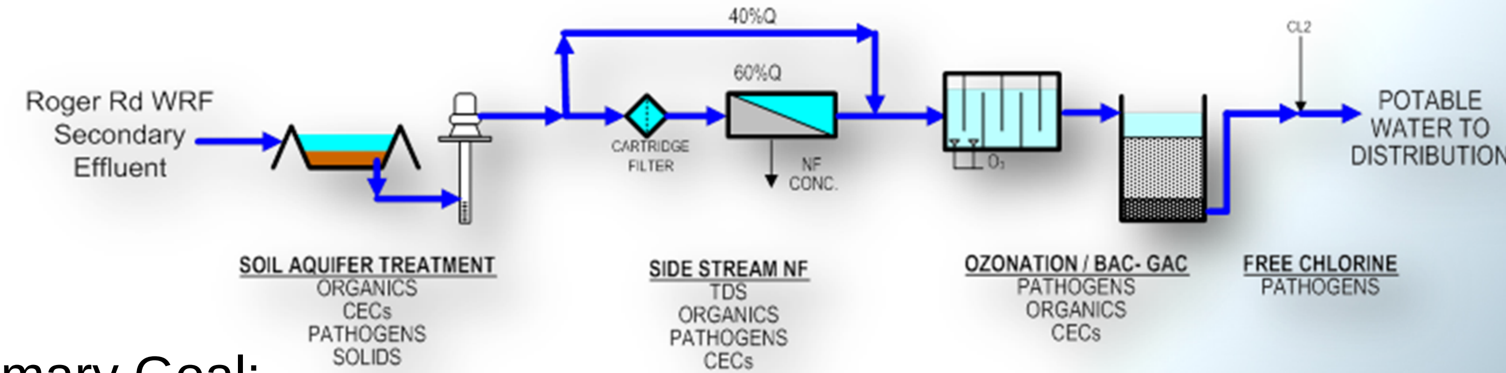
Examining the Criteria for Direct Potable Reuse

WateReuse Research Foundation

Water Quality Concerns (cont'd)

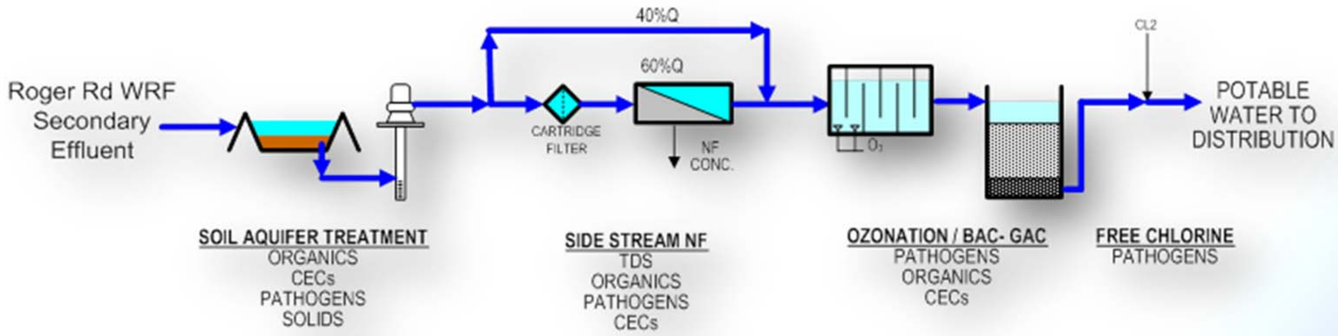
- Summary
  - Bulk organics, CECs: multiple barriers from SAT, NF, ozone, BAC/GAC filtration/adsorption
  - Pathogens: Multiple barriers from SAT, NF, ozone, BAC/GAC filtration, and chlorine disinfection (UV could be added if necessary)
  - TDS: partial NF treatment
  - Bromate: ammonia addition if needed
  - NDMA: Removal by BAC; lower O3 dose to sub-residual dose if necessary

Pilot Testing Project Goals



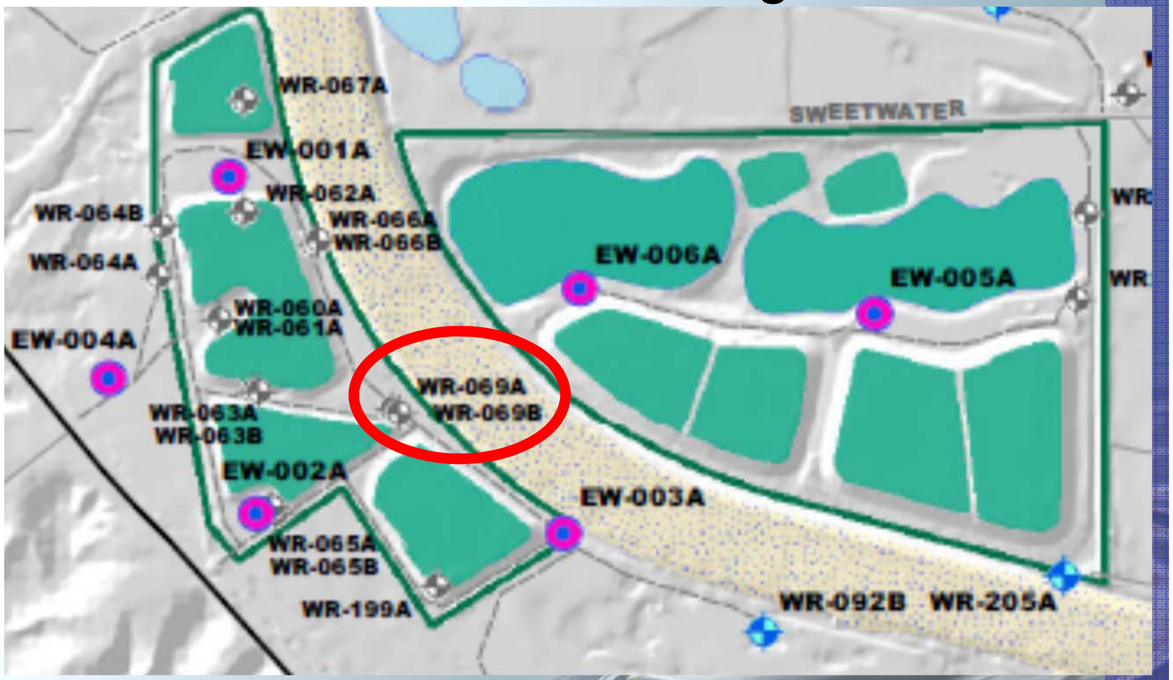
- Primary Goal:
  - Test the viability of the proposed treatment scheme for Tucson Water's future Potable Reuse Project through water quality testing and treatment process performance monitoring
- Secondary Goals:
  - Test the viability of short-term SAT as a pretreatment approach to NF, which would allow substitution of NF for RO at locations where possible.
  - Evaluate GAC regeneration requirements by comparison of 3-month old BAC to virgin GAC
  - Test ozone for oxidation of CECs
  - Test the viability of using NF concentrate for crop irrigation through characterization of concentrate stream for constituents critical to crop growth and health

Pilot Facilities

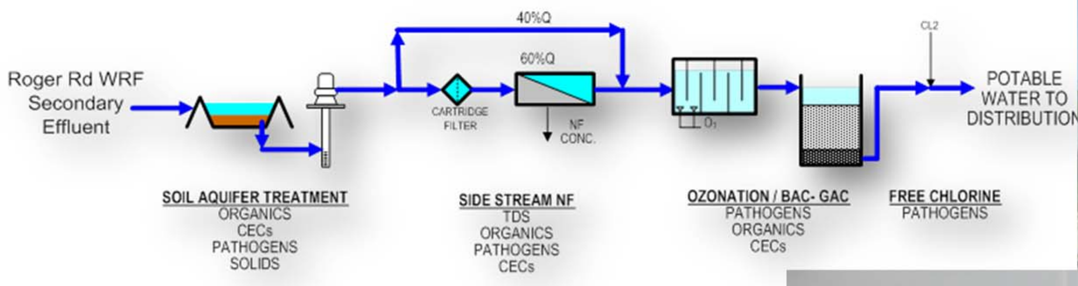


- Soil Aquifer Treatment (SAT)
  - Tucson Water operates 11 recharge basins
  - Monitoring Well 069B used in pilot because of short travel time (2 weeks) and close proximity to recharge basins

Tucson's Sweetwater Recharge Basins



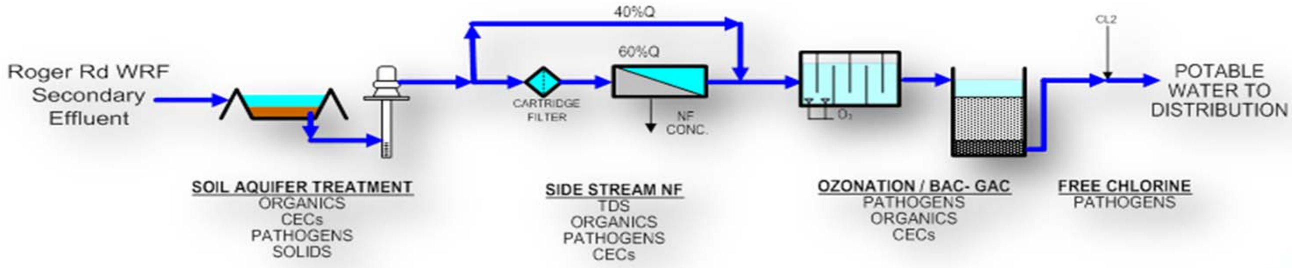
Pilot Facilities (cont'd)



- Phase I:
  - 3 months
  - Extensive water quality sampling

- Phase II – 3 months:
  - 3 months
  - Compare virgin GAC performance to 3-month old BAC/GAC

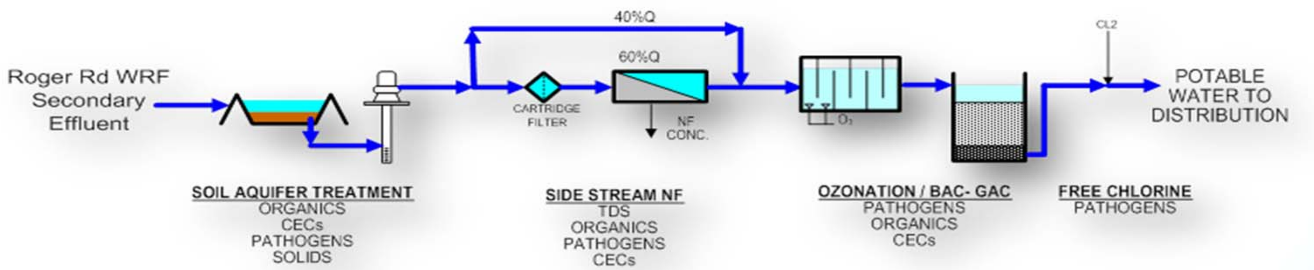
Initial Water Quality Results



- Soil Aquifer Treatment (SAT)
  - Travel time measured at approximately 2 weeks
  - Soil aquifer treatment lowered the TOC in the secondary effluent to less than 1 mg/L (>80% reduction)
  - Significant reduction in chemicals of emerging concern (CECs)

Compound	Post SAT (ng/L)
Caffeine	<6.8
Trimethoprim	<2
PFBA	<17
Primidone	13
Meprobamate	4.6
Sulfamethoxazole	4.1
Diphenhydramine	<1.6
Hydracortisone	<2.4
Ditiazem	<1.4
Simazine	<1.7
Dexamethasone	<6.6
Carbamezapine	51
PFHxA	<5.7
Fluoxetine	<1.5
TCEP	25
Atrazine	<1.7
DEET	<2.9
Propylparaben	<2.7
Bisphenol A	<14
Testosterone	<3.4
Clofibric Acid	<2.3
Naproxen	<2.3
Norgestrel	<2.4
PFOA	<1.5
Benzophenone	8.1
Ibuprofen	<20
Gemfibrozil	<2.1
Triclocarban	<1.7
Triclosan	<2
PFOS	24
Iopamidol	1470
Iohexol	< 57
Iopromide	< 22
Acesulfame	303
Sucralose	7670
Atenolol	14

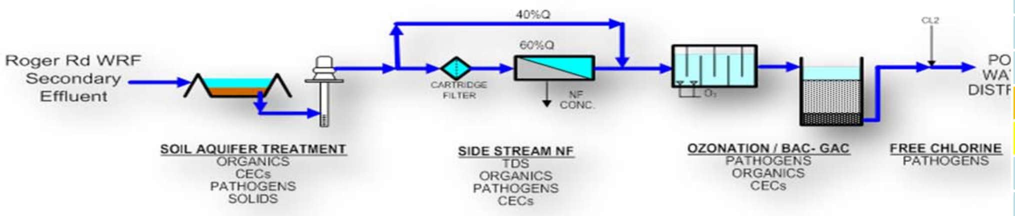
Initial Water Quality Results



- Ozone
  - Bromide concentration in secondary effluent is relatively high (0.1 – 0.35 mg/L)
  - Bromate formation low (<10 µg/L) at ozone doses less than 1:1 O3/DOC (sub-residual dose)
  - NDMA formation low (<10 ng/L) ; ammonia addition or pH reduction further reduced NDMA formation

Sample	Bromate (µg/L)	NDMA (ng/L)
Feed	<0.4	< 1.0
Ozone at 0.5 mg/L	2.0	2.1
Ozone at 0.75 mg/L	2.3	2.6
Ozone at 1.0 mg/L	6.4	2.4
Ozone 1.0 mg/L; pH=6.5	3.4	1.8
Ozone 1.0 mg/L, NH3=0.5 mg/L	2.5	< 1.0

Initial Water Quality Results



- Ozone (cont'd)
  - CECs: Good reduction in some compounds, but little reduction in recalcitrant compounds
  - BAC/GAC will provide additional removal of recalcitrant compounds

- More pilot data was collected in fall 2014

Compound	Post SAT (ng/L)	Post O3 at 1 mg/L (ng/L)
Caffeine	<6.8	<14
Trimethoprim	<2	<2.4
PFBA	<17	<21
Primidone	13	<20
Meprobamate	4.6	4.2
Sulfamethoxazole	4.1	<3.3
Diphenhydramine	<1.6	<1.9
Hydracortisone	<2.4	<2.6
Ditiazem	<1.4	<1.7
Simazine	<1.7	<1.6
Dexamethasone	<6.6	<5.1
Carbamezapine	51	<4.9
PFHxA	<5.7	<6.1
Fluoxetine	<1.5	<2
TCEP	25	34
Atrazine	<1.7	<1.6
DEET	<2.9	<3.4
Propylparaben	<2.7	<3.4
Bisphenol A	<14	<13
Testosterone	<3.4	<2.9
Clofibric Acid	<2.3	<2.6
Naproxen	<2.3	<2.6
Norgestrel	<2.4	<2.6
PFOA	<1.5	<1.7
Benzophenone	8.1	6.6
Ibuprofen	<20	<24
Gemfibrozil	<2.1	<2.4
Triclocarban	<1.7	<2.3
Triclosan	<2	<2.6
PFOS	24	26
Iopamidol	1470	1230
Iohexol	< 57	< 58
Iopromide	< 22	< 22
Acesulfame	303	102
Sucralose	7670	6890
Atenolol	14	14

Conclusions

- Full-scale potable reuse plants have historically used RO- and GAC-based treatment trains, although recent trend in the industry is leaning more towards RO.
- Alternative treatment for potable reuse should be considered for inland utilities due to difficulty and cost of RO concentrate disposal
- SAT-NF(side-stream)-Ozone-BAC/GAC being considered by Tucson for potable reuse
- Short term soil aquifer treatment provides excellent removal of bulk organics, including CECs
  - Excellent pathogen removal is also expected (data pending)
- Ozone added at sub-residual doses provides oxidation of organics without significant bromate and NDMA formation
- Additional data will be collected on NF and BAC/GAC performance over next 6 months

Questions

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