Potable Reuse for Inland Locations: Pilot Testing Results from Tucson for a New Potable Reuse Treatment Scheme

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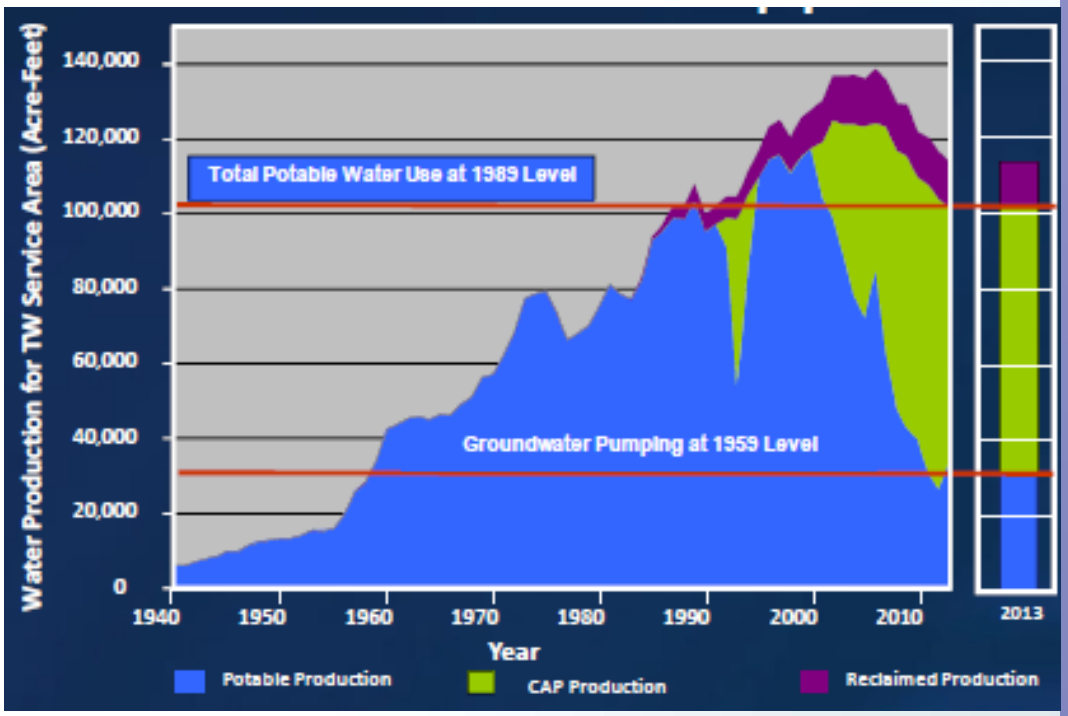
Tucson's Potable Reuse Project

What are Tucson's drivers for reuse?

- Tucson is exploring potable reuse to diversify their water supply portfolio
- Tucson is transitioning to more renewable water supplies



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
  - Mitigating concentrate disposal

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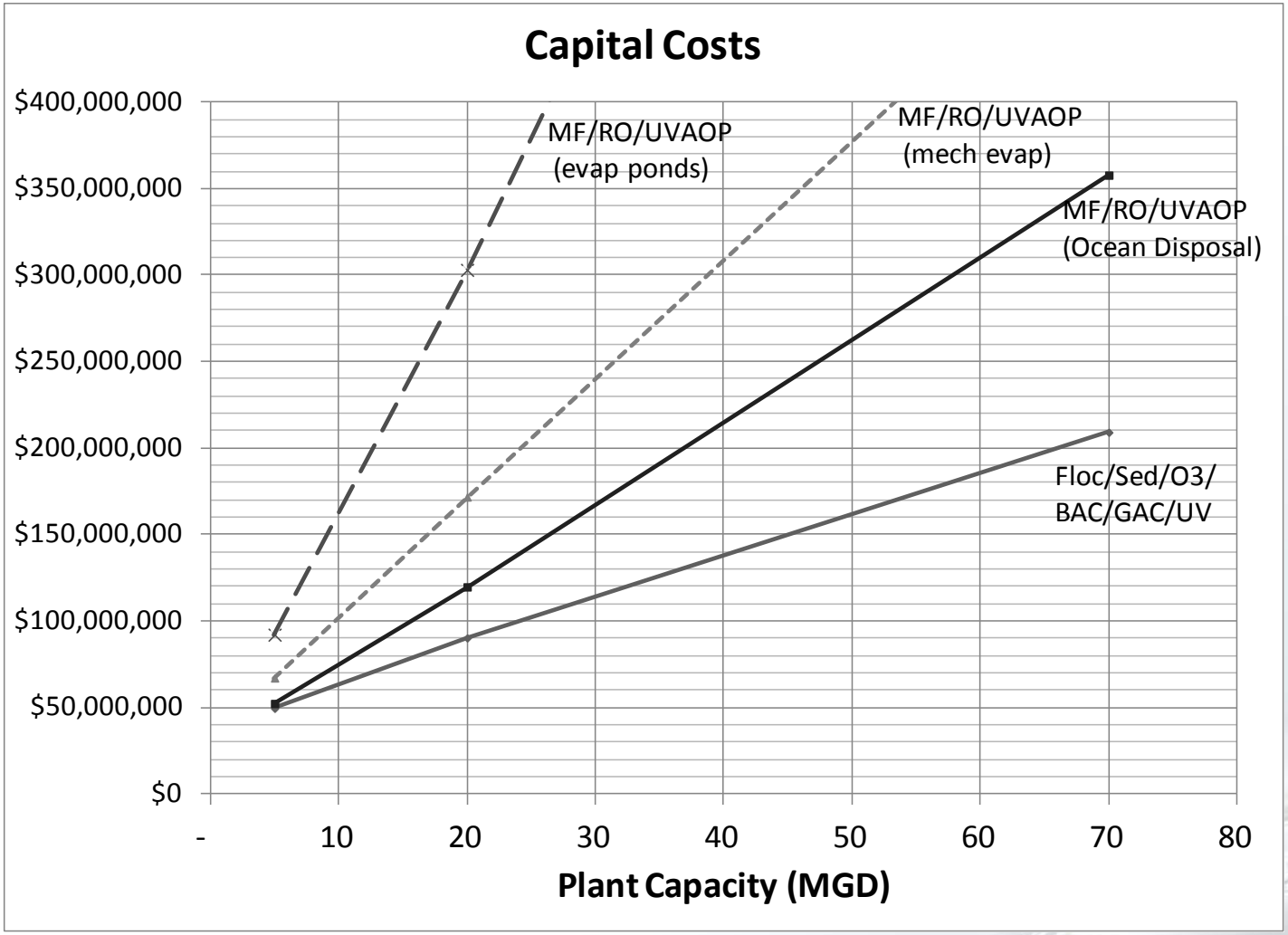
RO-Based treatment can be expensive, especially at inland locations



Figures taken from WRRF-10-01. Figures are WateReuse Research Foundation's Intellectual Property

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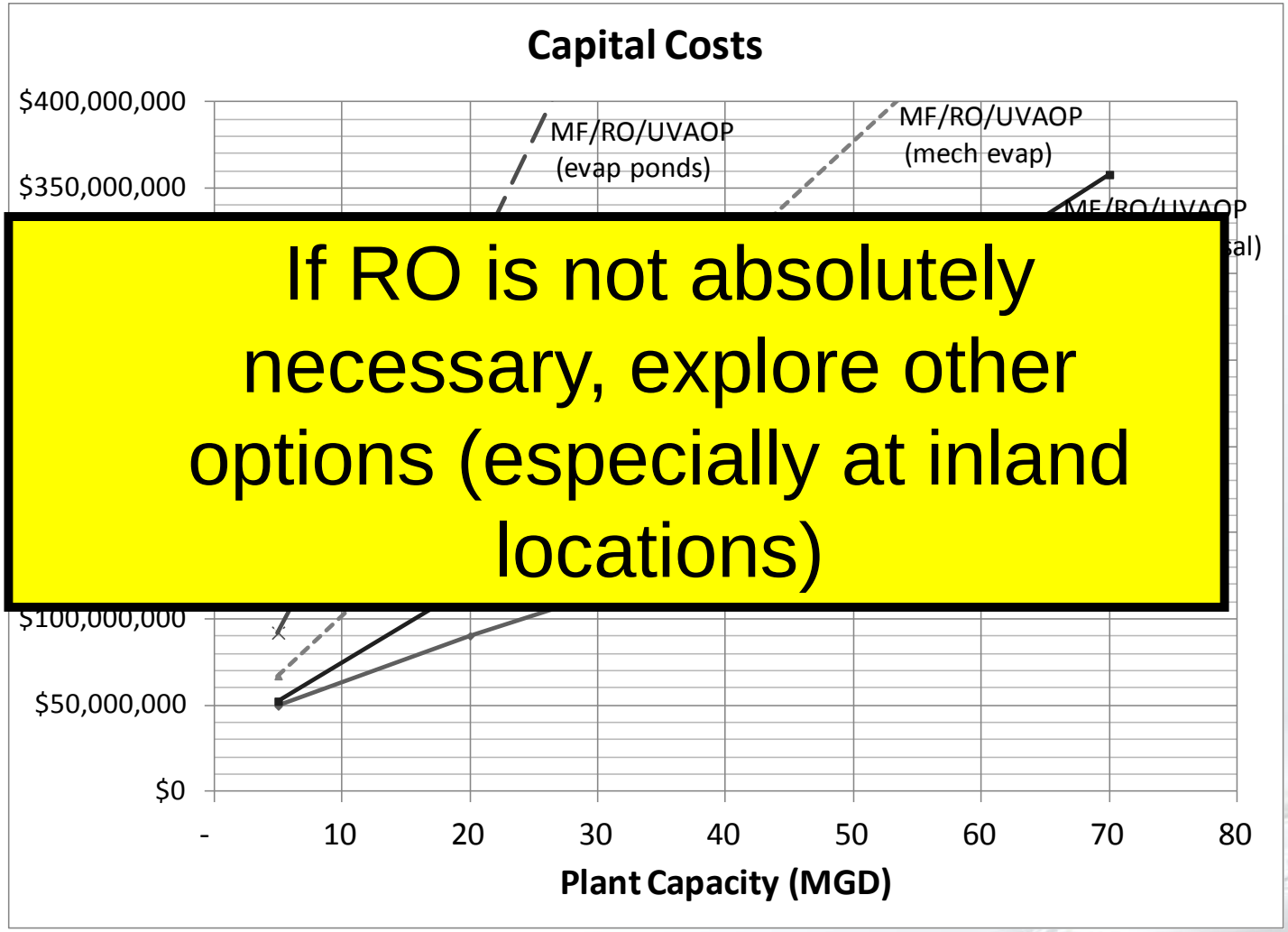

If RO is not absolutely necessary, explore other options (especially at inland locations)

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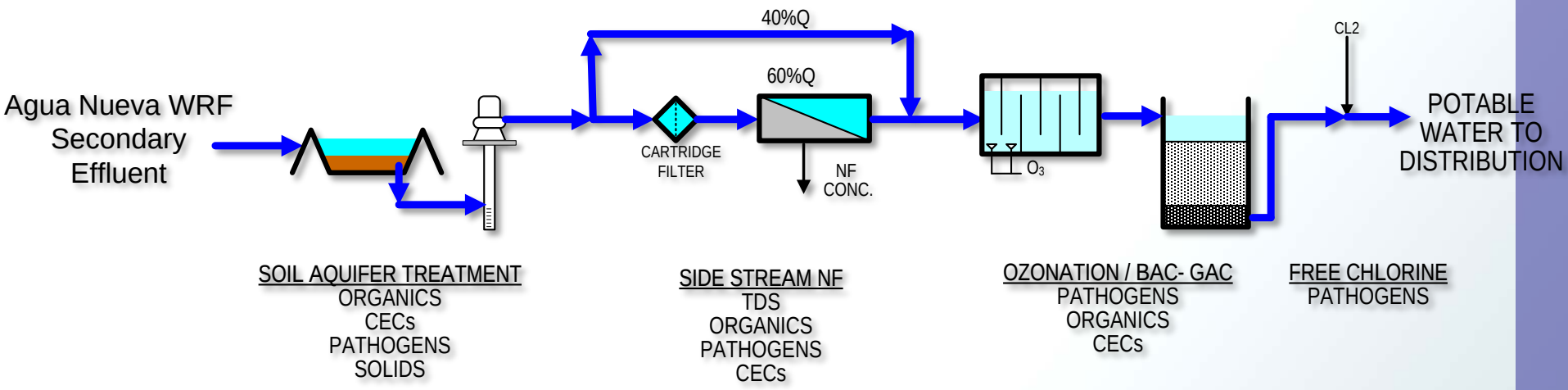
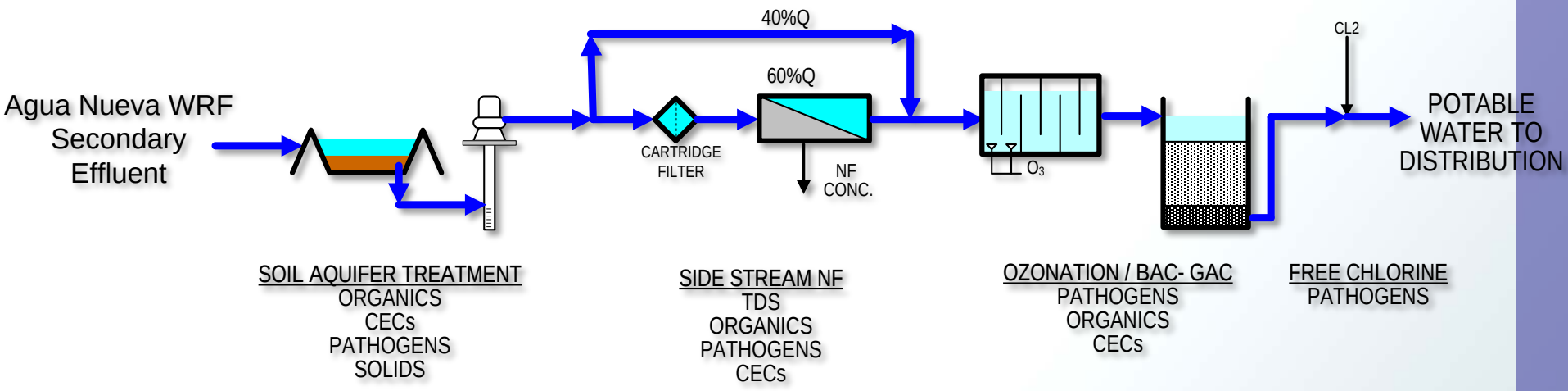
Proposed Treatment Scheme



Proposed Treatment Scheme



- ✓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 – 800 mg/L
  - Goal is < 500 mg/L; side-stream NF treatment

Pilot Testing Project Goals & Phasing

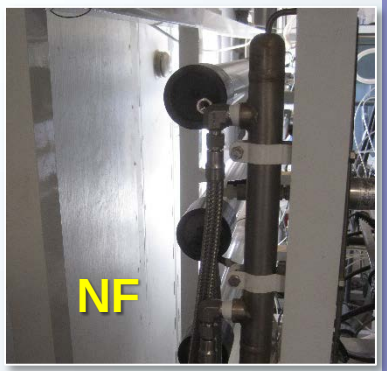
- **Primary Goal:**
  Test the viability of the proposed treatment scheme for Tucson Water's future Potable Reuse Project through water quality testing and treatment process performance monitoring
- **Secondary Goals:**
  1. Test the viability of short-term SAT as a pretreatment approach to NF
  2. Test ozone for oxidation of CECs
  3. Determine GAC regeneration requirements
  4. Test the viability of using NF concentrate for crop irrigation
- **Operation**
  6-months total; two three month phases

Pilot Facilities

Location: Tucson's Sweetwater Recharge Basins

Source: Monitoring Well 069B (~10 gpm)

Duration: Oct 2014 – April 2015

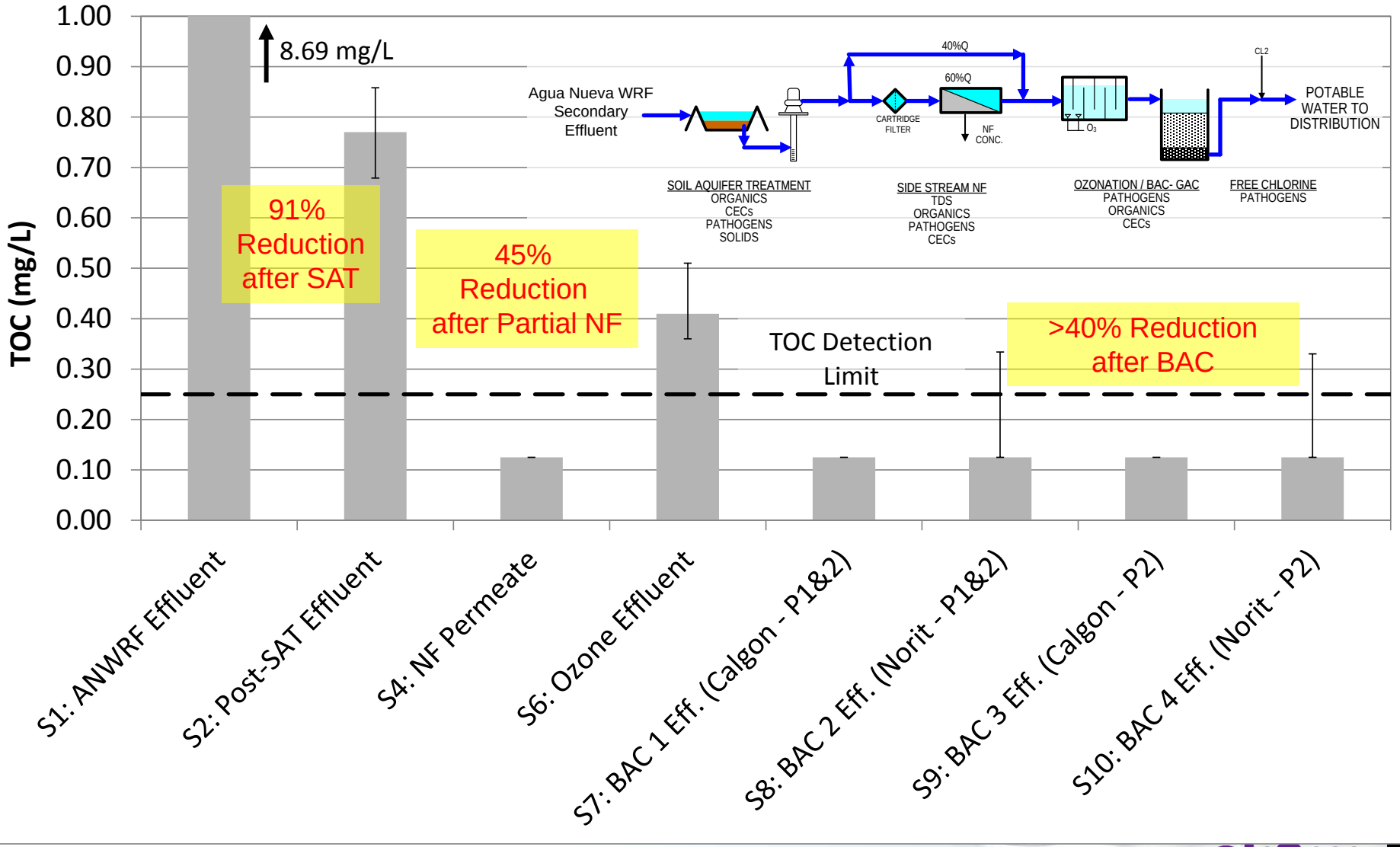


Water Quality Testing

Parameter	Lab	Sample Location and Frequency									
		Agua Nueva Effluent (Sweetwater Recharge Basin Feed)	Post-SAT Effluent (Shallow Monitoring Well)	NF Feed (after Cartridge Filtration)	NF Permeate	NF Concentrate	Ozone Effluent	BAC1 Calgon Effluent (Phase I and II)	BAC2 Norit Effluent (Phase I and II)	BAC3 Calgon Effluent (Phase II only)	BAC4 Norit Effluent (Phase II only)
Sample Designation		**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
Tucson Water Designation		**510**	**Well WR-069B**	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
pH	Field			Daily		Daily					
Temperature	Field			Daily							
Conductivity	Field			Daily	Daily	Daily					
SDI	Field		3x/week	3x/week							
Ozone Residual	Field						Weekly				
Turbidity	Field		Weekly								
TSS	TW		Weekly			Biweekly					
Alkalinity	TW	Monthly**	Weekly		Weekly	Biweekly					
TDS	TW	Monthly**	Weekly		Weekly	Biweekly					
TOC	TW	Biweekly**	Weekly		Weekly		Weekly	Weekly	Weekly	Weekly	Weekly
Total Nitrogen	TW	Monthly**	Biweekly		Biweekly	Biweekly					
Total Phosphorus	TW	Monthly**	Biweekly		Biweekly	Biweekly					
Bromide	TW		Biweekly		Biweekly	Biweekly					
Calcium	TW		Biweekly		Biweekly	Biweekly					
Magnesium	TW		Biweekly		Biweekly	Biweekly					
Sodium	TW		Biweekly		Biweekly	Biweekly					
Sulfate	TW		Biweekly		Biweekly	Biweekly					
Chloride	TW		Biweekly		Biweekly	Biweekly					
Boron	TW		Biweekly		Biweekly	Biweekly					
Silica	TW		Biweekly		Biweekly	Biweekly					
Barium	TW		Biweekly								
Strontium	TW		Biweekly								
UVT-254	UA		Weekly		Weekly		Weekly	Weekly	Weekly	Weekly	Weekly
Bromate	UA		Monthly		Monthly		Biweekly	Biweekly	Biweekly	Biweekly	Biweekly
CECs	UA	Monthly	Biweekly		Biweekly		Biweekly	Biweekly	Biweekly	Biweekly	Biweekly
EEM	UA	Monthly	Biweekly		Biweekly		Biweekly	Biweekly	Biweekly	Biweekly	Biweekly
NDMA	UA	Monthly	Biweekly					Biweekly	Biweekly	Biweekly	Biweekly
Heterotrophic Plate Counts (5-day)	TW		Biweekly			Biweekly		Biweekly	Biweekly	Biweekly	Biweekly
Total Coliform	TW		Monthly		Monthly			Monthly	Monthly		
E. Coli	TW		Monthly		Monthly			Monthly	Monthly		
Enteric Virus	UA	Monthly***	Monthly***				Monthly***				
Crypto / Giardia	UA	Monthly***	Monthly***				Monthly***				

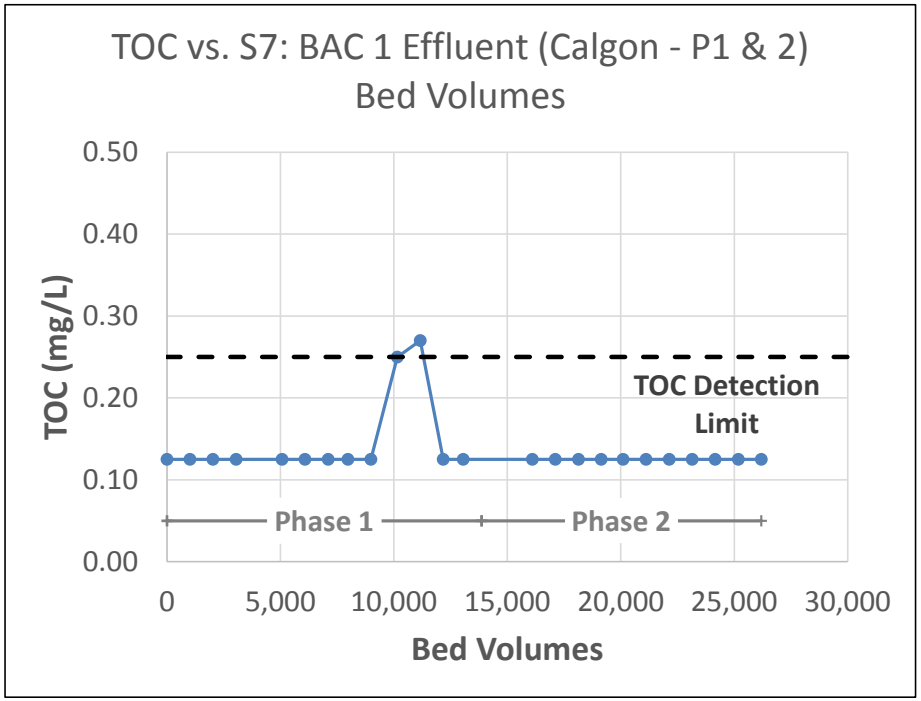
- Field Parameters
- Metals, Salts, Nutrients
- Trace Organics (CECs)
- Nitrosamines & Bromate
- Pathogens/Microorganisms

Total Organic Carbon (50th percentile)

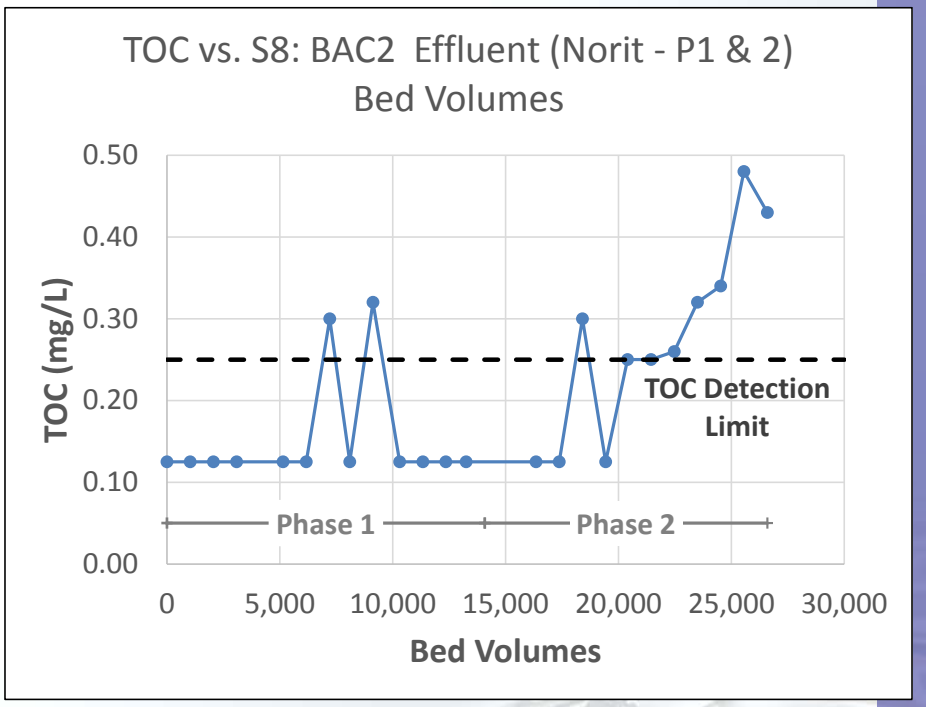


Total Organic Carbon versus Filtration Bed Volumes

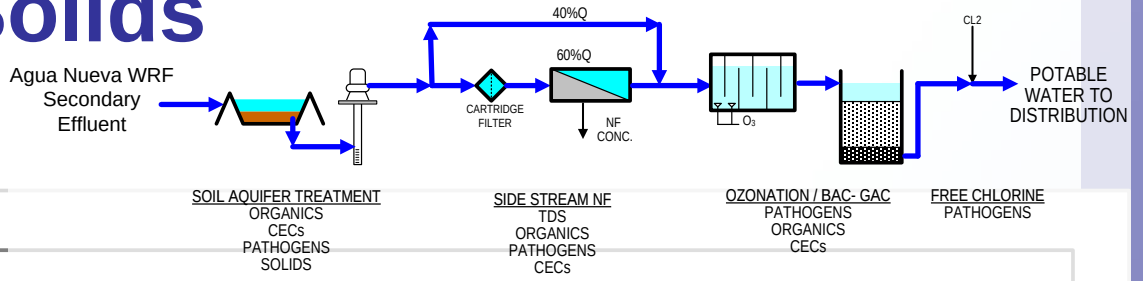
No breakthrough for Calgon BAC after 6 months

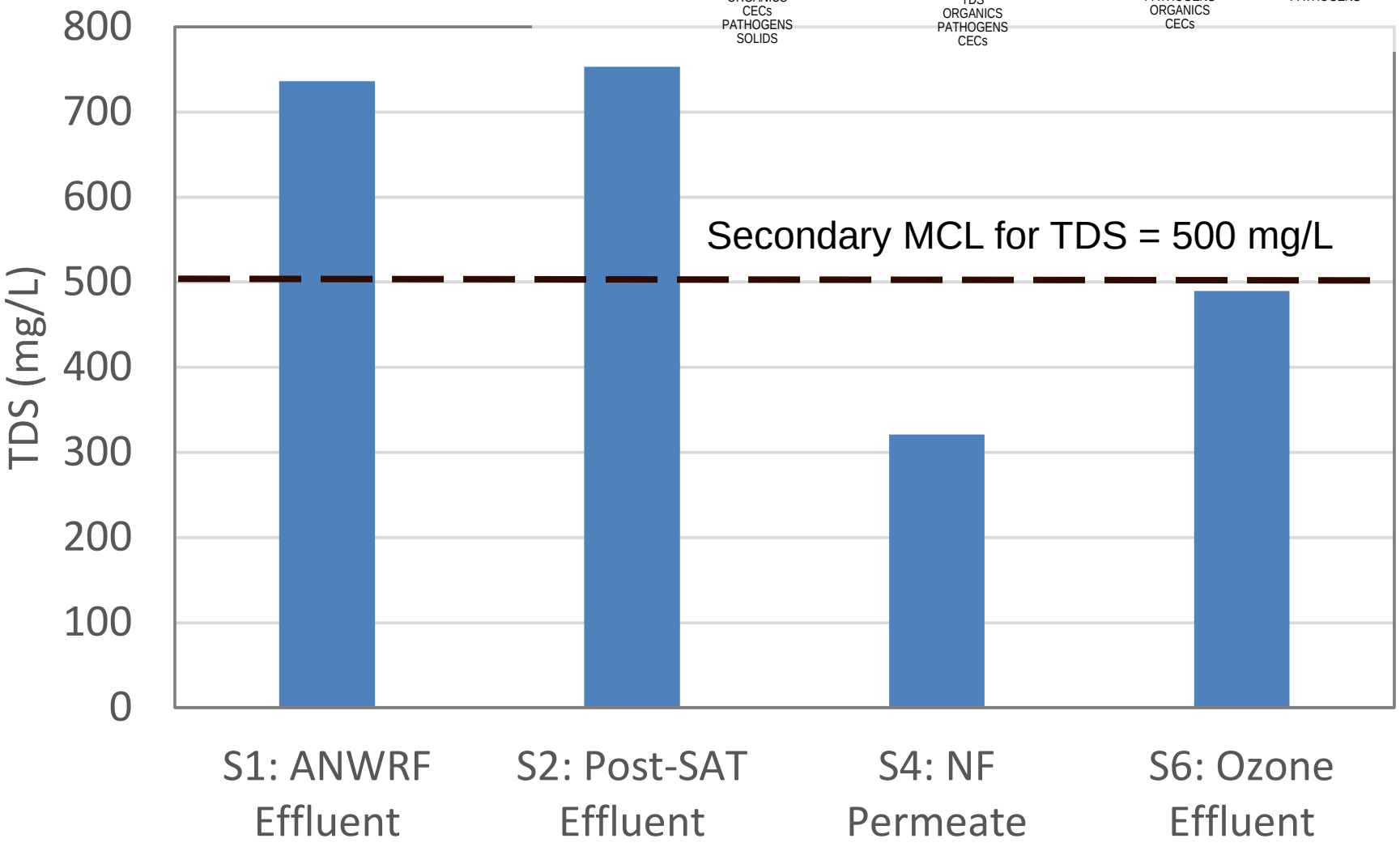


Breakthrough observed for Norit BAC



Total Dissolved Solids (50th percentile)



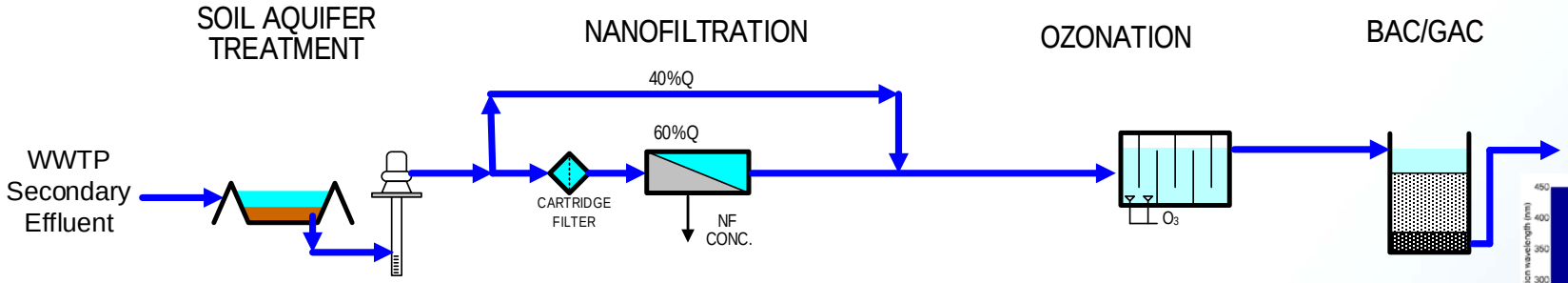


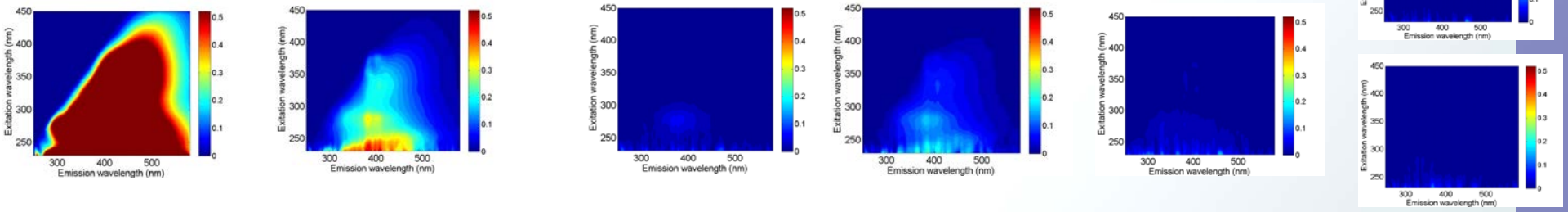
Chemicals of Emerging Concern

- 44 CECs monitored – **All below the detection limit in finished water**
- Some CECs are recalcitrant to certain treatment, so multiple barriers is important

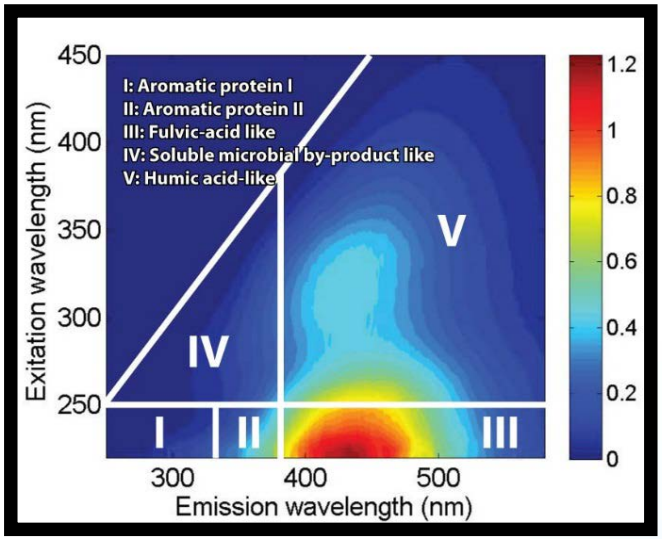
2015/04/30	Concentration of Trace Organics in ng/L								
Compounds	Category	Agua Nueva Effluent	Well 69B	Ozone Influent	Ozone Effluent	BAC C1 (Calgon) Effluent	BAC C2 (Calgon) Effluent	BAC C3 (Norit) Effluent	BAC C4 (Norit) Effluent
Benzophenone	Industry (paint,	129	< 30	< 16	< 30	< 28	< 29	< 30	< 29
Benzotriazole	De-icing, inhibitor,	4236	4755	4051	2416	< 480	< 480	< 470	< 500
Caffeine	stimulant	< 4.0	< 5.2	< 4.4	< 5.6	< 3.9	< 4.1	< 3.7	< 3.8
Carbamezapine	Anit-epileptic	363	487	126	< 1.6	< 1.6	< 1.5	< 1.5	< 1.5
DEET	Insect repellant	172	7.0	14	< 6.0	< 4.1	< 4.0	< 3.8	< 3.6
Gemfibrozil	cholesterol drug	5.4	< 1.0	< 1.0	< 1.1	< 0.9	< 0.9	< 0.9	< 0.9
Ibuprofen	anti-inflamatory,	< 2.8	< 3.7	< 3.5	< 4.9	< 3.6	< 3.5	< 3.0	< 3.5
Iopamidol	Angiography	29677	3188	913	1395	< 27	< 28	< 26	< 31
Iopromide	x-ray contrast	5465	< 24	< 34	< 24	< 27	< 28	< 26	< 31
Meprobamate	tranquilizer	455	58	28	29	< 10	< 10	< 10	< 10
PFOA	cookware, textiles, clothing,	2.2	32.3	16.3	15.8	< 0.8	< 0.8	< 0.7	< 0.7
PFOS	Stain repellant	< 6.3	256	124	123	< 3.5	< 3.5	< 3.8	< 3.9
Primidone	Anit-epileptic	14	165	90	87	< 4.3	< 5.7	< 4.8	< 4.8
Sucralose	Artifical sweetner	51567	26702	7595	13459	< 220	< 240	< 240	< 250
Sulfamethoxazole	antibiotic	1903	36	15	< 8.0	< 5.0	< 4.9	< 4.5	< 4.9
TCEP	Flame retardant	128	181	31	125	< 22	< 22	< 23	< 23
TCPP	Flame retardant	715	< 24	129	83	< 22	< 22	< 23	< 23
Triclosan	soap	44	< 12	< 9	< 13	< 13	< 14	< 13	< 14

Trace Organics Removal
Excitation Emission Matrix Results

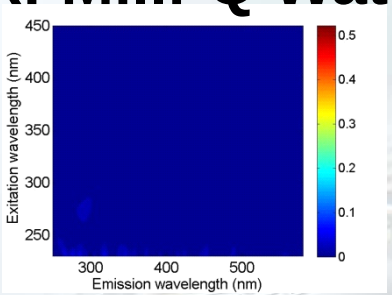




Legend

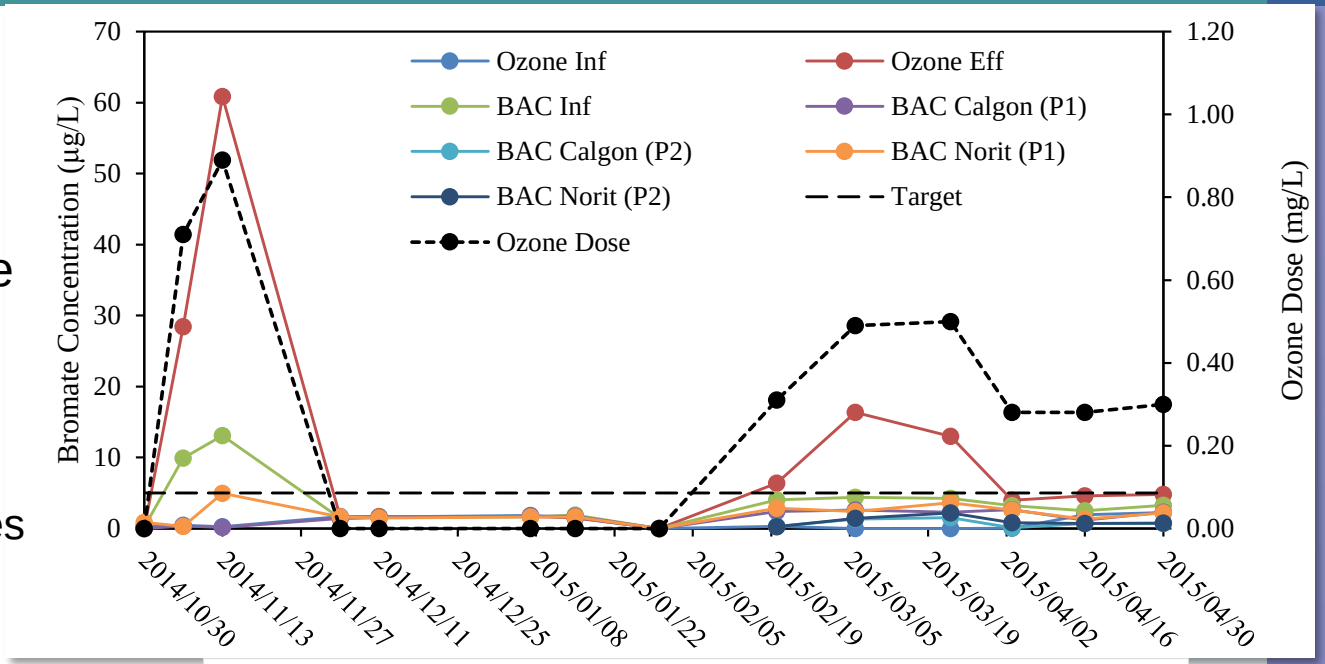


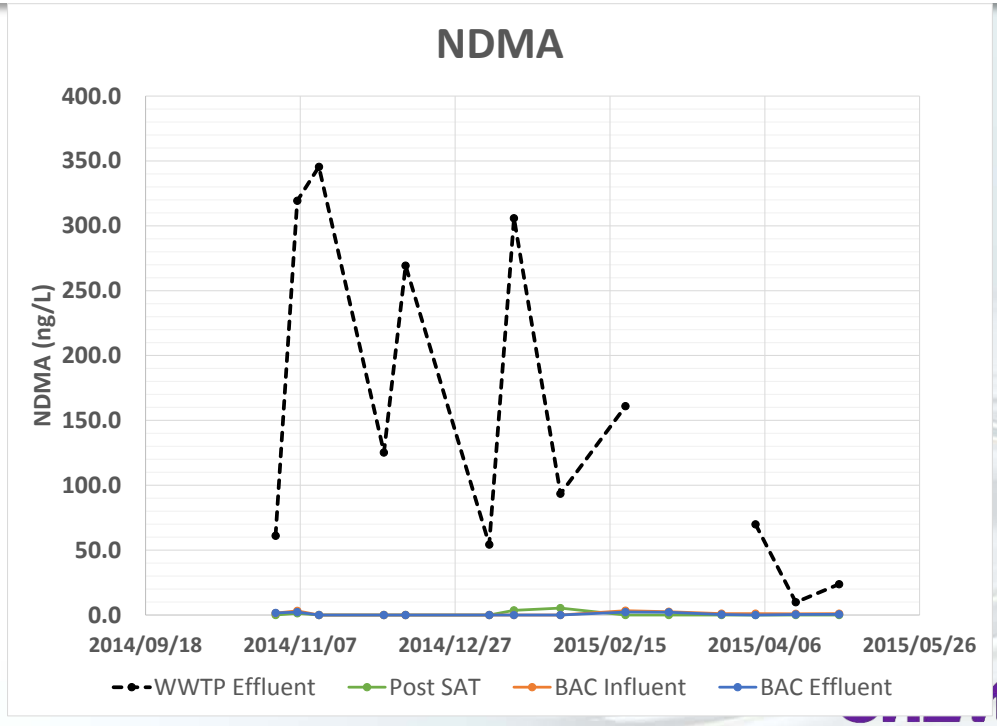
Blank: Milli-Q Water



Bromate & NDMA

- Bromate and NDMA are disinfection byproducts from ozone addition
- Bromate formation:
  - Significant at O3 doses > 0.5 mg/L (O3:TOC ratio > 1.0)
  - Low at O3 doses < 0.5 mg/L (O3:TOC <1.0)
- NDMA Formation:
  - Very high in the WWTP secondary effluent
  - Excellent removal by SAT (< 10 ng/L)
  - Small production by ozone, but subsequent removal by BAC





Bromate & NDMA

- B
  - C
  - f
- B
- N
  - SAT (< 10 ng/L)
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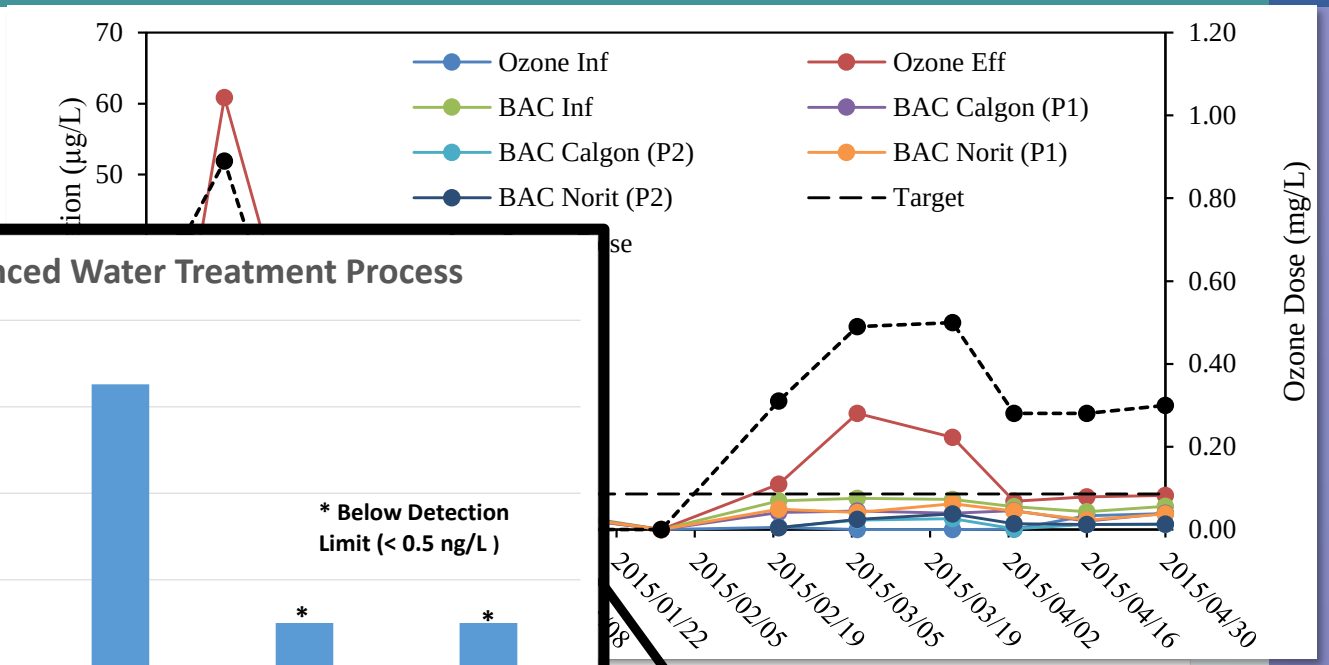
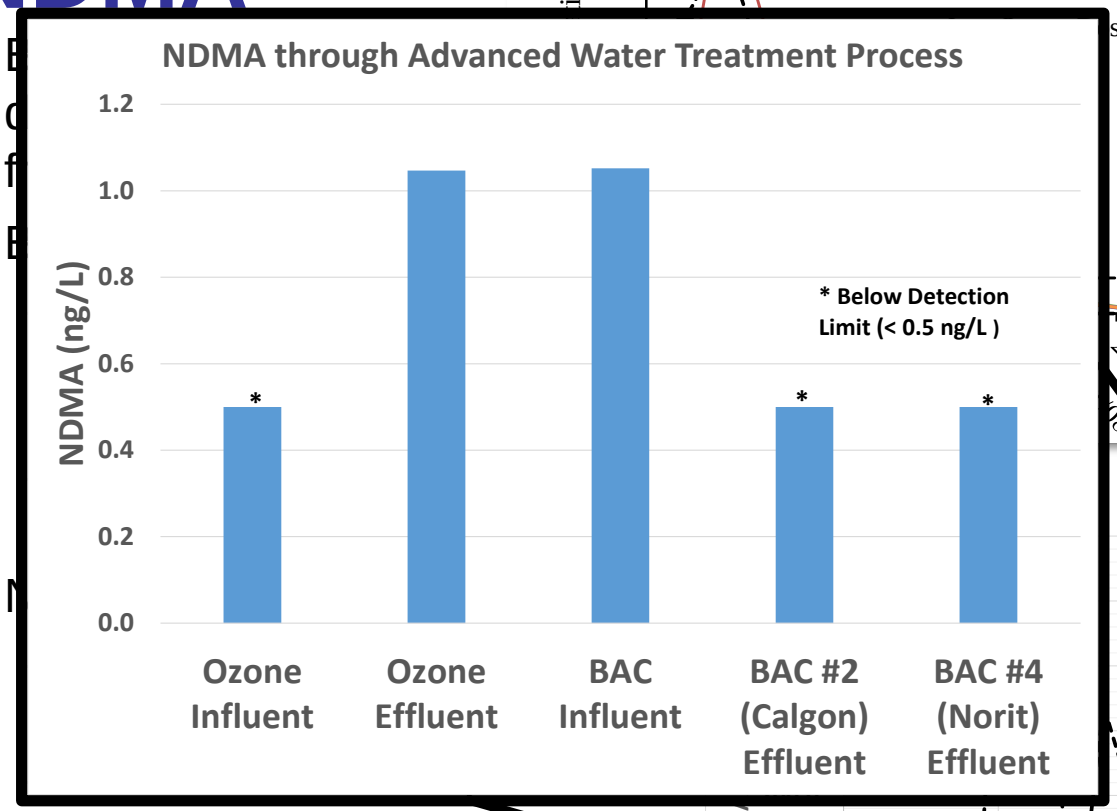
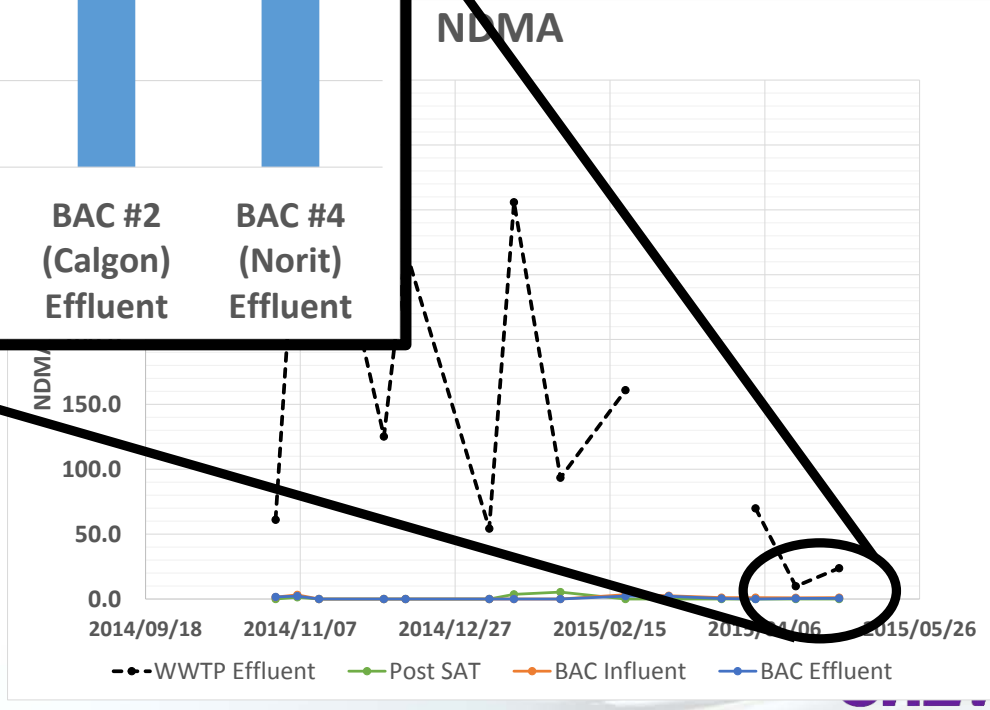
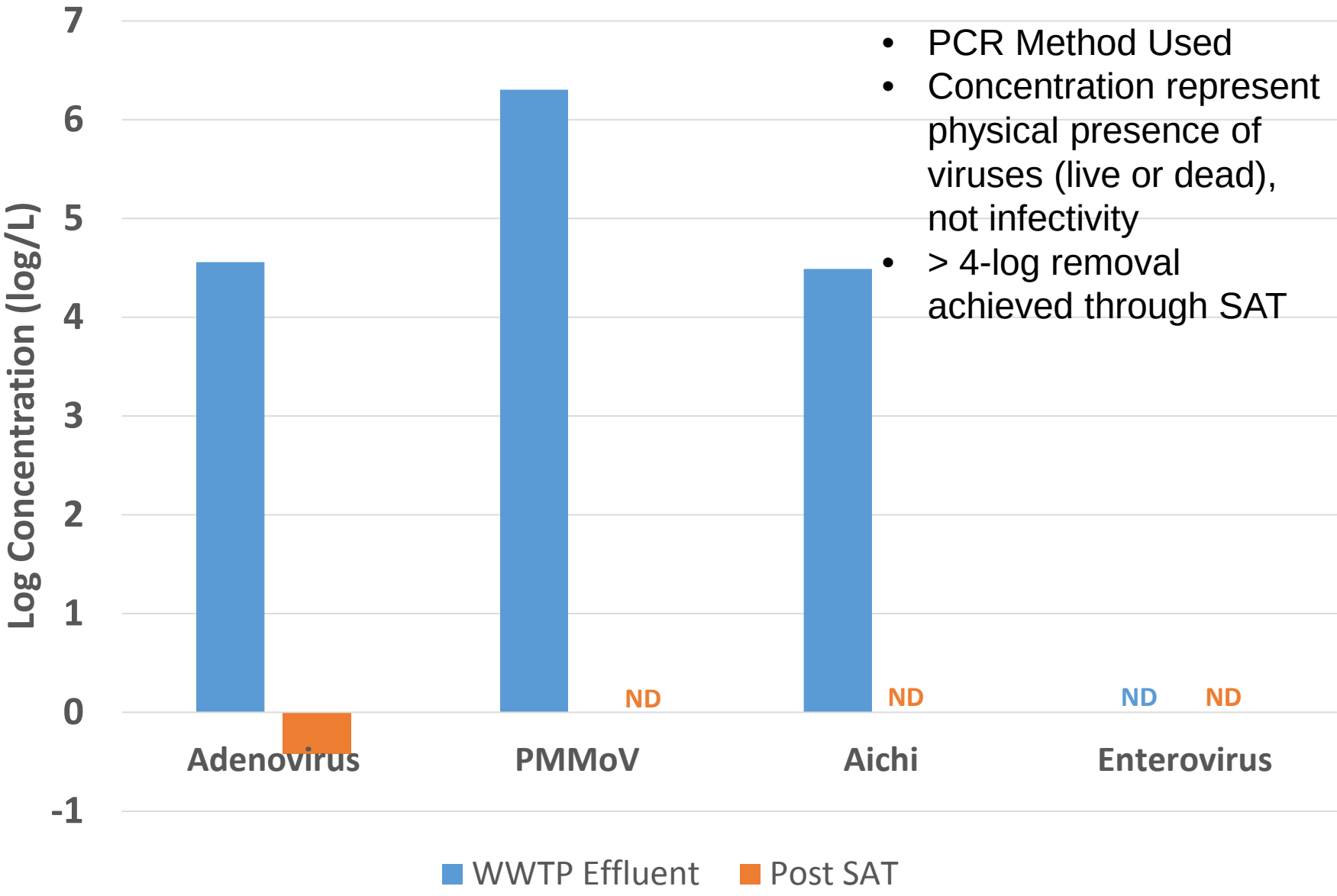






Virus Removal by Soil Aquifer Treatment



- PCR Method Used
- Concentration represent physical presence of viruses (live or dead), not infectivity
- > 4-log removal achieved through SAT

Conclusions

Issue	Answer
Do multiple organics barriers provide suitable water quality?	Yes; finished water quality: 1) **TOC< 0.25 mg/L** 2) **All 44 CECs non-detect**
Can TDS goal be met with sidestream NF treatment?	Yes, TDS < 500 mg/L consistently met
Can bromate and NMDA formation be controlled?	Yes, both were well below regulated limits: Bromate < 3 µg/L (MCL = 10 µg/L) NDMA < 0.5 ng/L (CA limit 10 ng/L)
Are pathogens adequately removed?	Yes, post-SAT water was non-detect for viruses and protozoa; >4-log removal of viruses by just SAT
Is GAC-based train suitable for potable reuse at Tucson?	Yes and costs are much lower than RO-based train

- Final Report for WRRF13-09 will be published in 2015 / 2016

Acknowledgements

Team Member	Role
Justin Mattingly, WRRF	*WRRF Project Manager*
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Dr. Wendell Ela, UA	*Co-PI; NF Pilot Operations, Membrane Autopsy*
Dr. Bob Arnold, UA	*Proxy for Wendell Ela*
Michael Hwang, CH2M HILL	*Project Engineer*
Jim Lozier, CH2M HILL	*Membrane Expert*
Jeff Biggs, TW	*Tucson Water Project Manager*
Bruce Prior, TW	*Hydrogeologist*
Terry Miley, TW	*Hydrogeologist*
Tucson Water Quality Laboratory	*Water Quality Analysis*
Dan Candelaria, CH2M HILL	*Pilot Construction and Operation Support*
Tarun Anumol, UA	*Lead Ozone and BAC/GAC Operations; WQ Testing*
Josh Campbell, UA	*NF Pilot Operations, Membrane Autopsy*

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Questions?