

The Application of Pathogen Control Requirements at

Orange County Water District's

Groundwater Replenishment System



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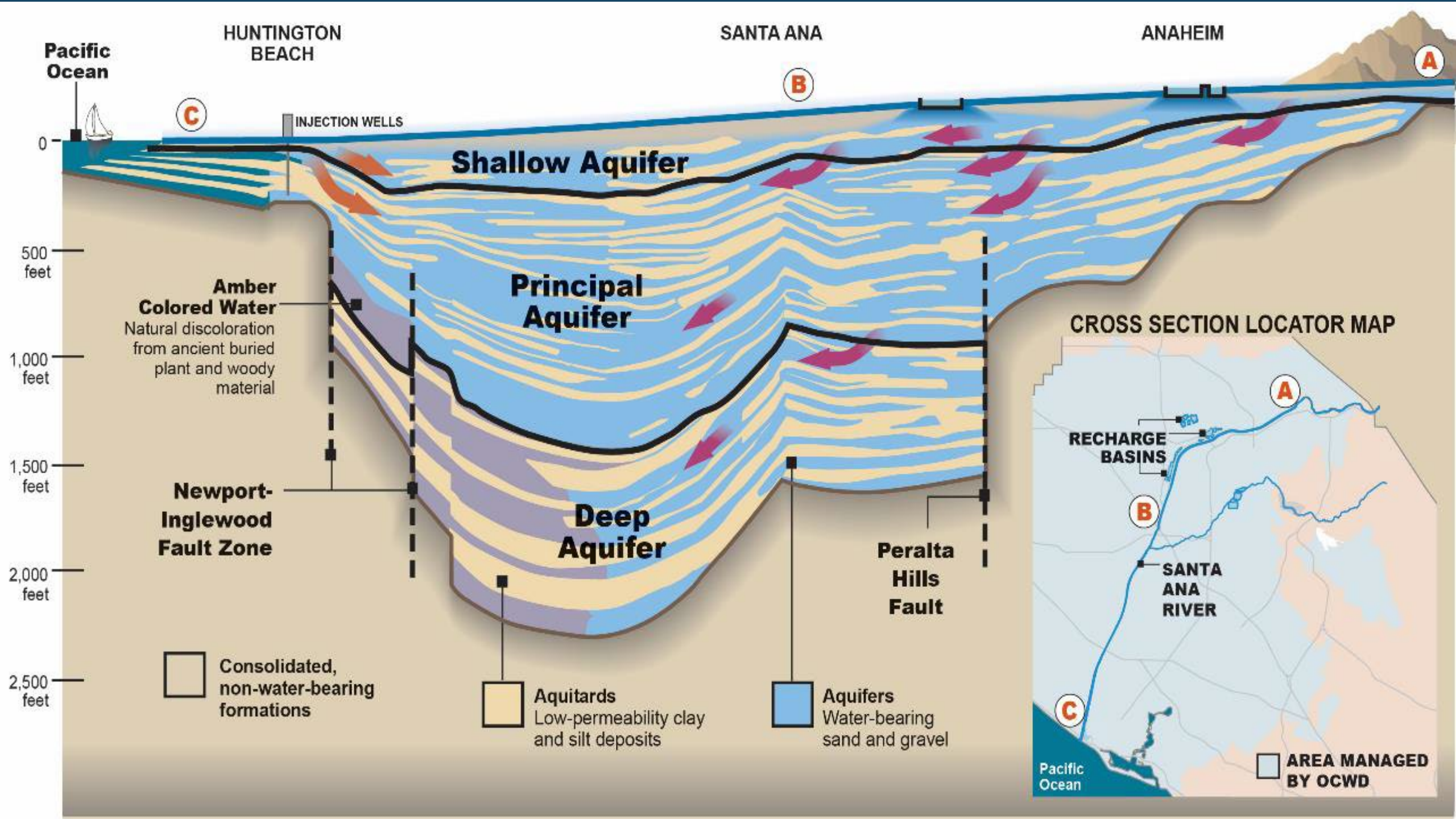
Orange County Water District (OCWD)

- Formed in 1933 by State of California
- Manage ~900 km² groundwater basin
- Groundwater = 85% of water supply
- Annual basin extractions = ~370,000 ML
- 2.5 million residents

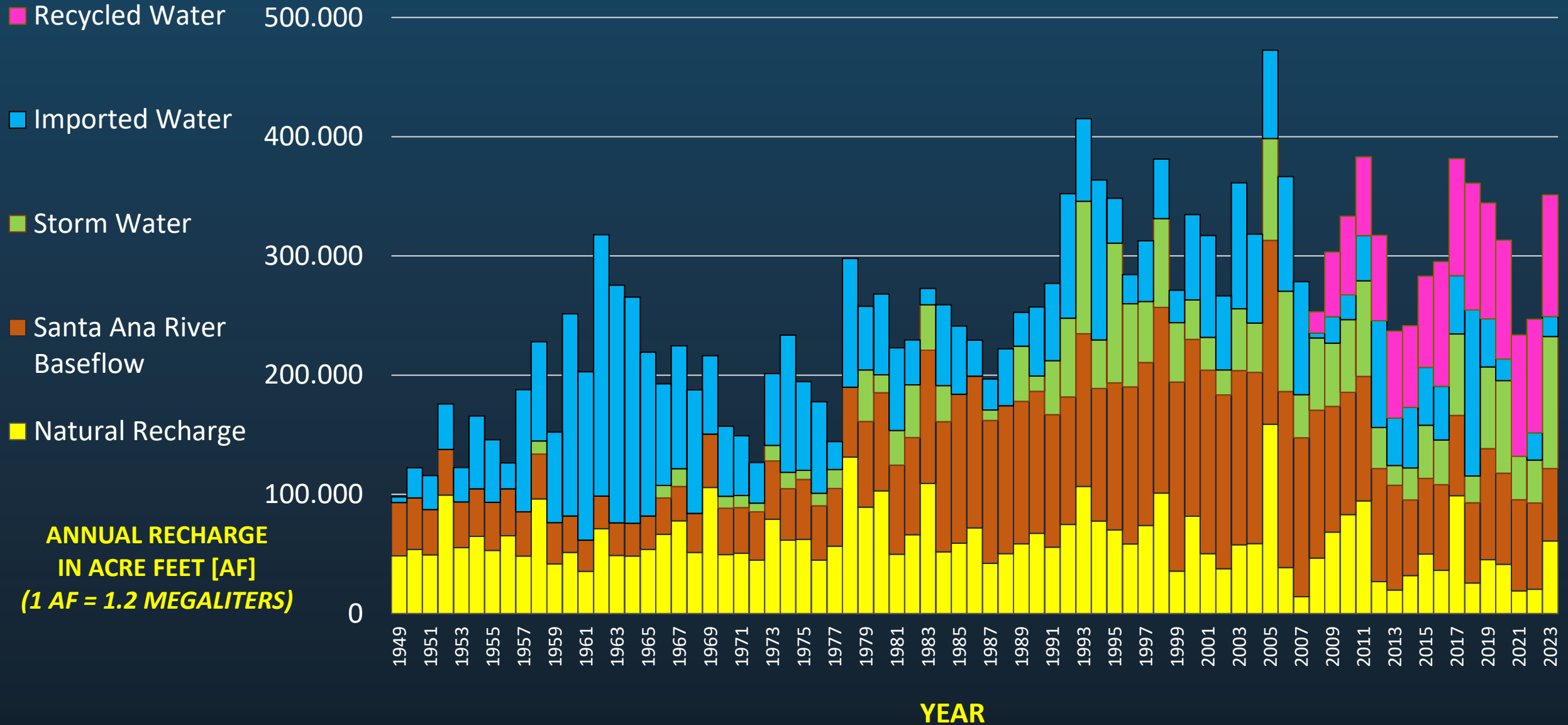


Much of Southern California is Dependent on Imported Surface Water

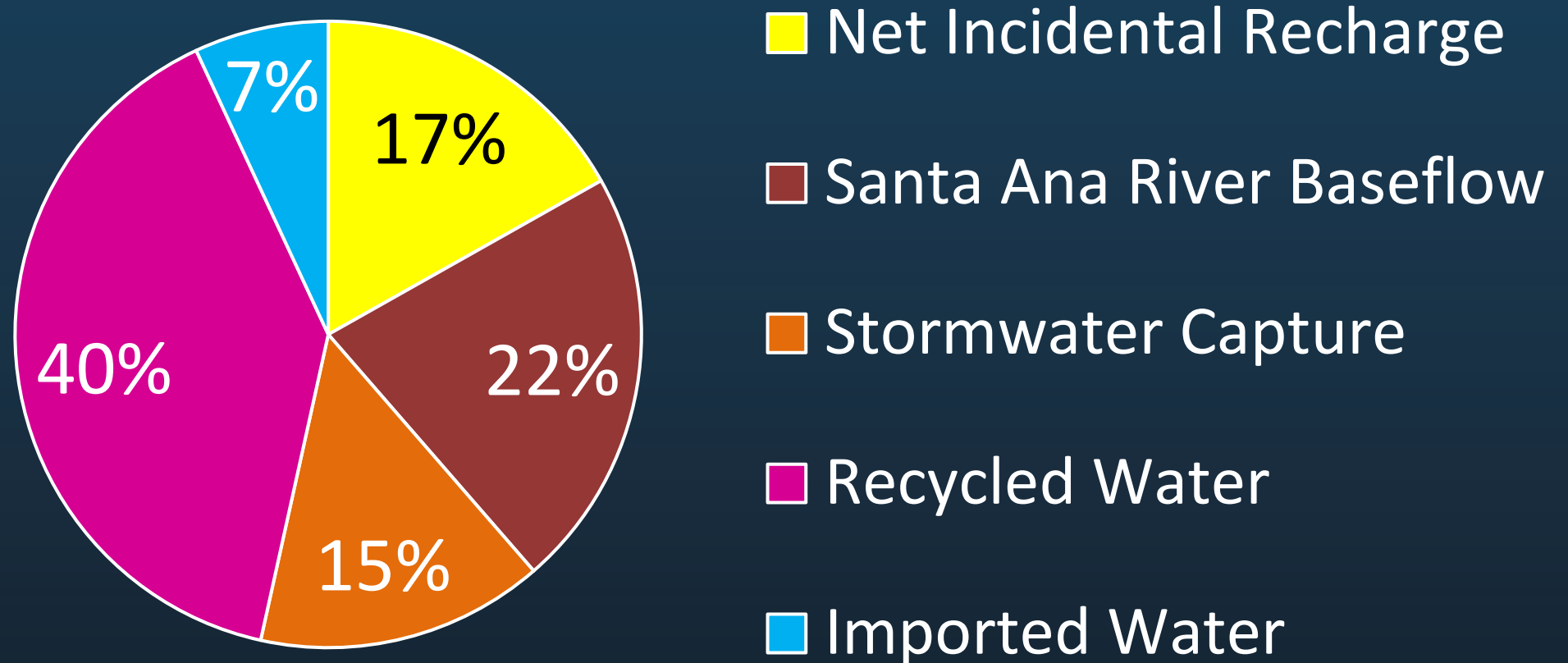




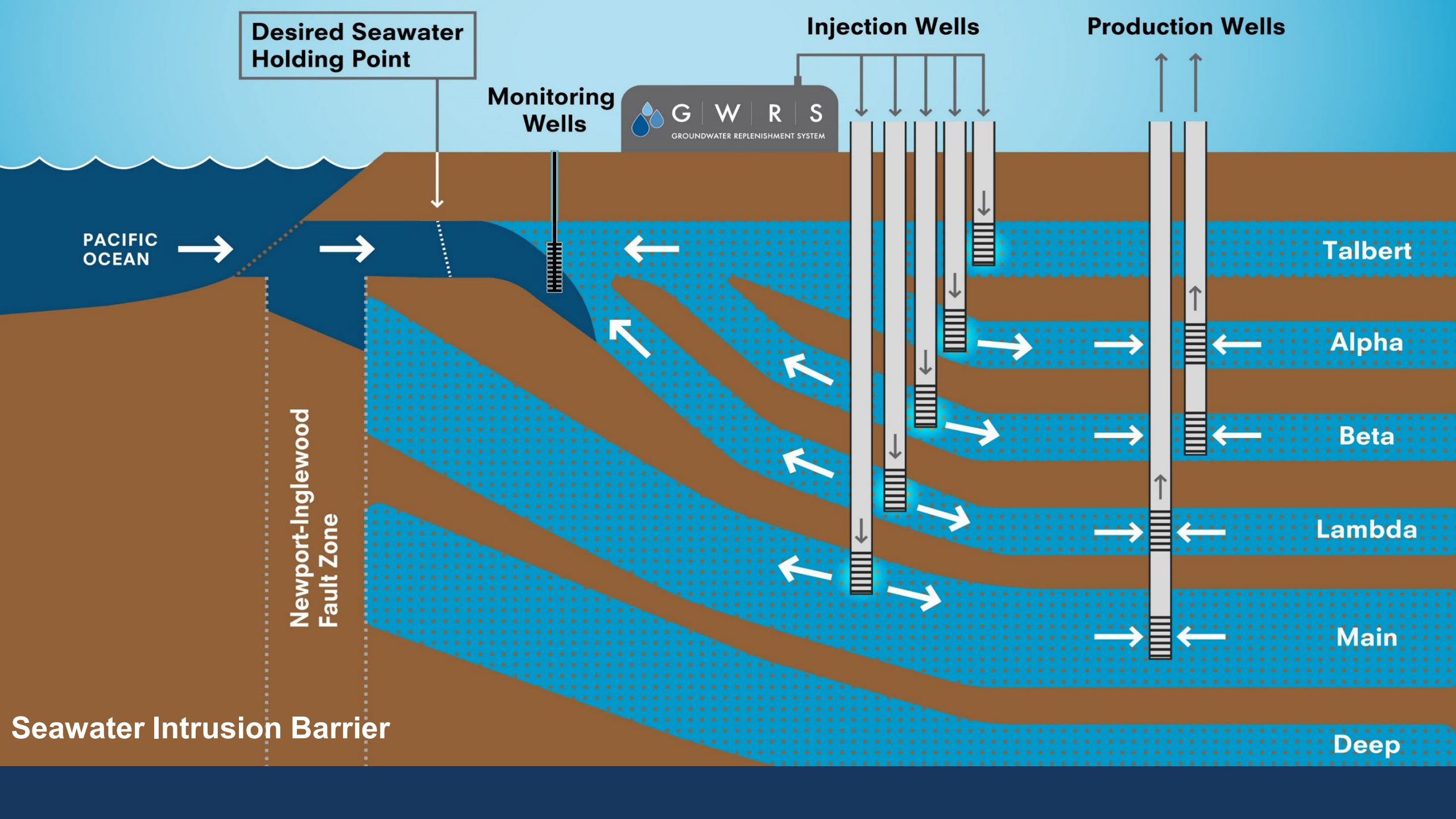
Sources of Groundwater Recharge



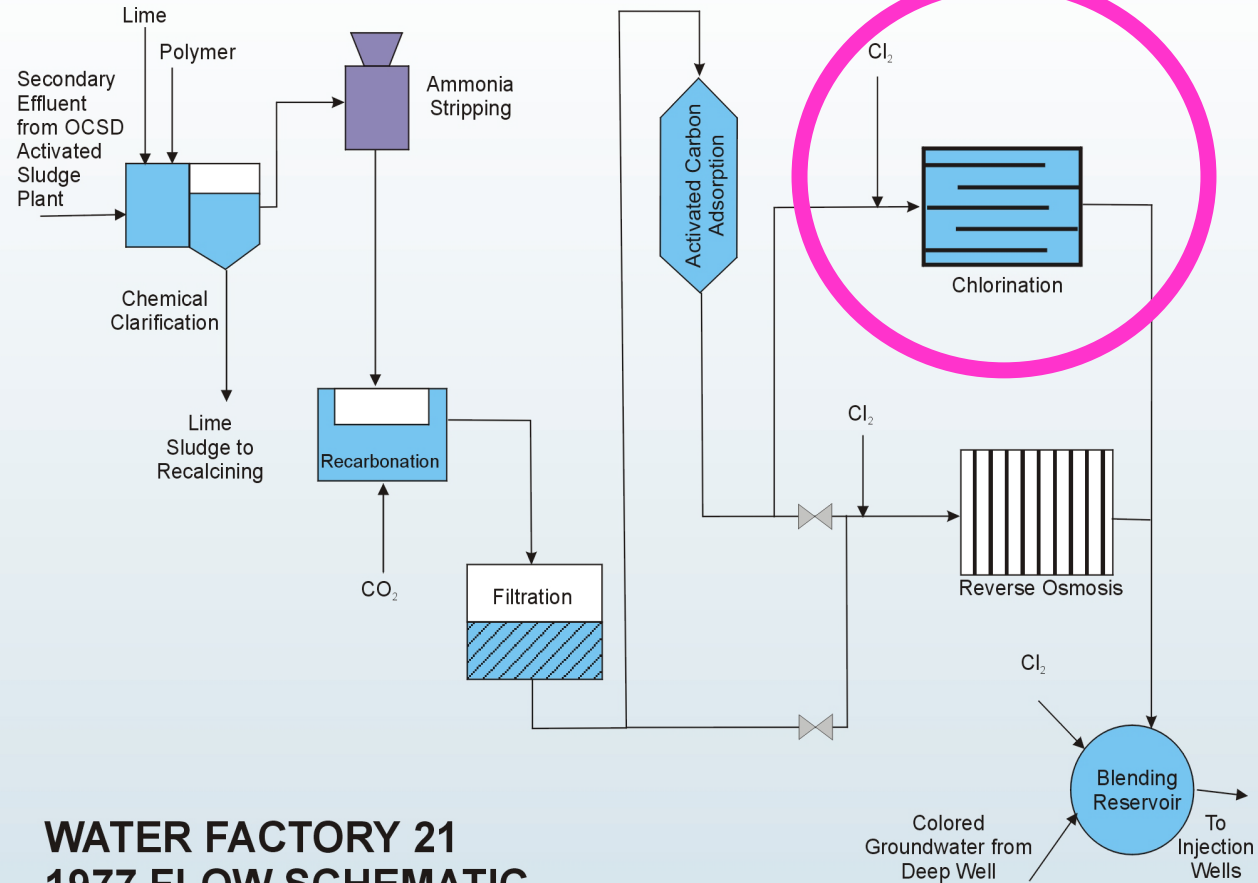
Anticipated Annual Average Total Replenishment after Recycled Water Expansion



Projected Annual Average Recharge:
300,000 AFY (370,000 ML)



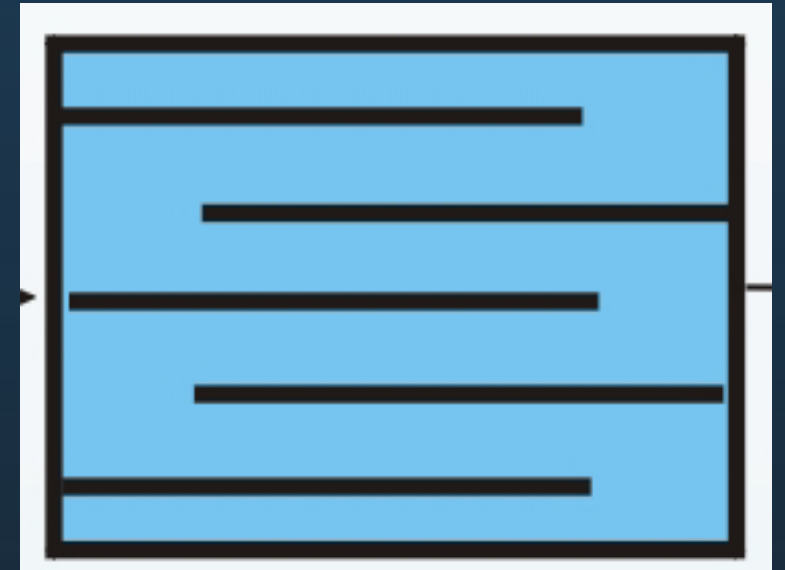
Water Factory 21 – First of Its Kind



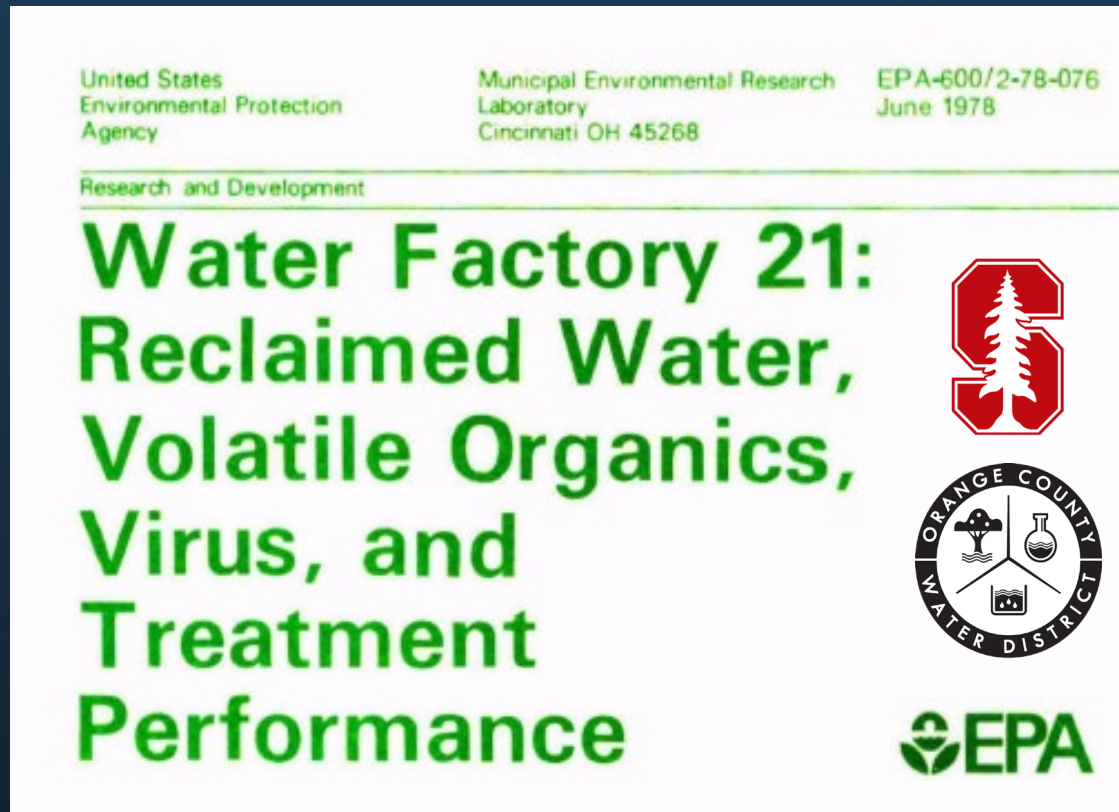
Operated from 1976 - 2003

Water Factory 21 (WF-21) used chlorine for primary disinfection

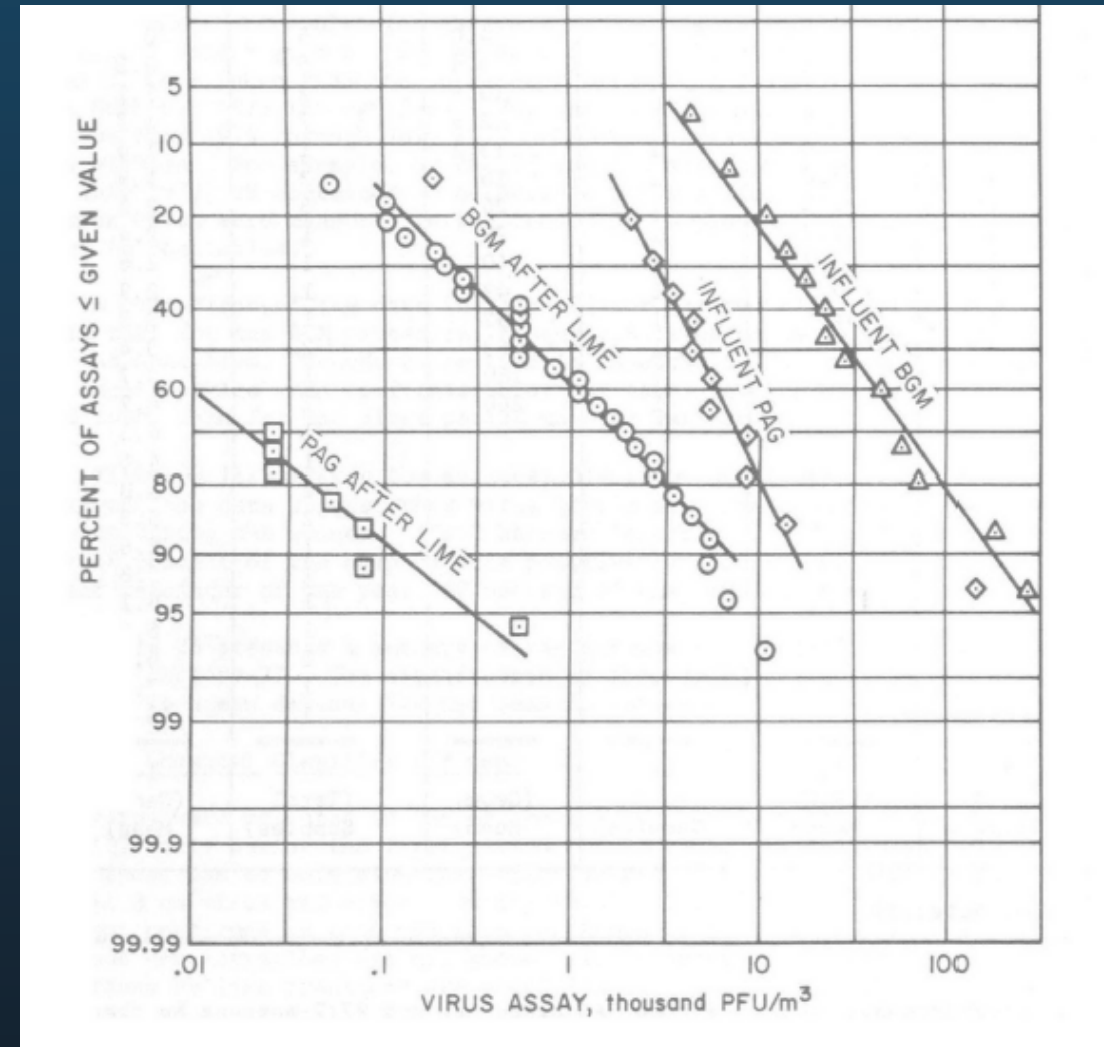
- One contact basin (27m X 16 m)
- 30-minute contact time
- 3 inline chlorine feeders (2000 lbs/day each)
- Permit limit for *E.coli* < 2.0 MPN/100 ml



Early WF-21 studies showed effective removal of viruses via other processes



- Lime clarification (pH > 11.3)
97.7 - 99.88% virus removal



- RO and final effluent consistently “non-detect” for culturable virus

What is the Groundwater Replenishment System (GWRS)?



- Successor to Water Factory 21
- Product water used for
 - Enlarged seawater barrier injection
 - **Direct replenishment injection**
 - **Surface recharge of groundwater**
- World's largest potable reuse project
 - Phase I Facility 2008 (265,000 m³/day)
 - Initial Expansion 2015 (378,000 m³/day)
 - Final Expansion 2023 (492,000 m³/day)





G | W | R | S



GROUNDWATER REPLENISHMENT SYSTEM

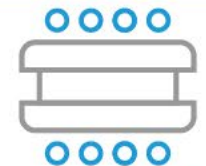
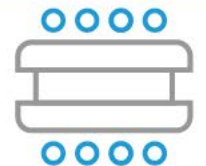
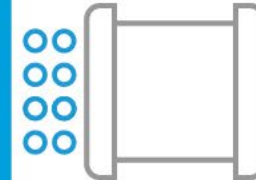
Low Pressure
Membrane Filtration

Reverse Osmosis

Ultraviolet Light + H₂O₂

Recharge
Basins
○○○○

OC San
Secondary
Effluent

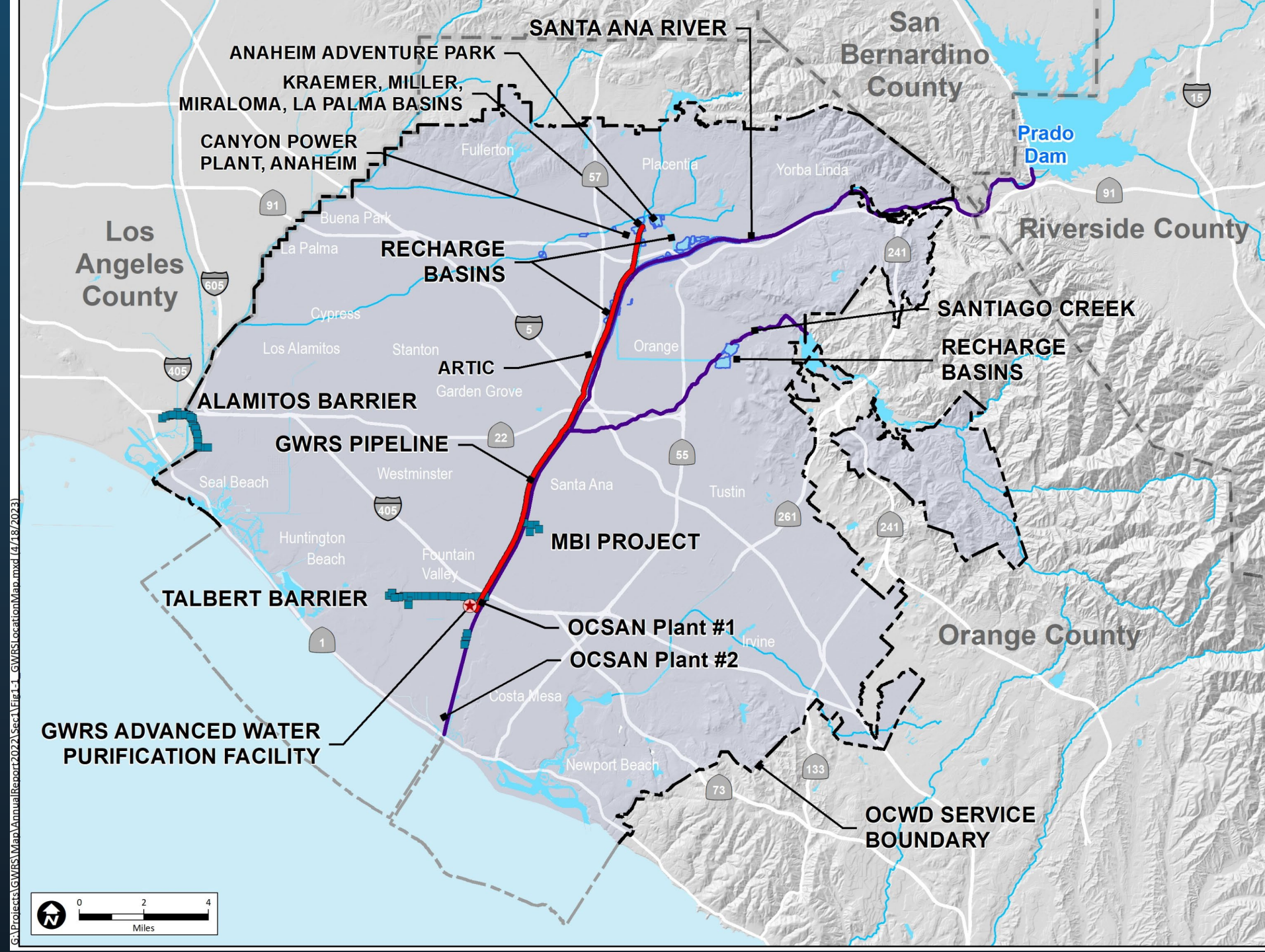


Backwash
Sent to OC San

Concentrate Discharged
to OC San Outfall

○○○○
Seawater
Barrier &
Mid-Basin
Injection
Wells

GWRS Injection and Recharge Locations



**Basins
Dedicated to
GWRS
Recharge
Minimize
Clogging and
Maximizes
Recharge
Rates
(3-5 m/day)**



La Palma Basin, April 2017

Initial GWRS Phase I AWT designed to meet California 1997 Draft Wastewater Reclamation Criteria for Groundwater Recharge via Direct Injection

Applicable Regulatory Requirement	1997 Reference*	Method of Compliance
Recycled water filtration to achieve turbidity ≤ 2 NTU average and ≤ 5 NTU for 95% of the time	Section 60320.03 (b)	Filtration provided by MF
Recycled water median number of total coliforms $\leq 2.2/100$ mL and $\leq 23/100$ mL in more than one sample per 30-day period	Section 60320.03 (c)	Disinfection using UV

- **Virus Log Removal/Inactivation design criteria by AWT Plant**
 - Reverse Osmosis (RO) = 2-log
 - Ultraviolet (UV) light = 4-log

2004 State of California Permit for GWRS: Pathogen Removal Requirements

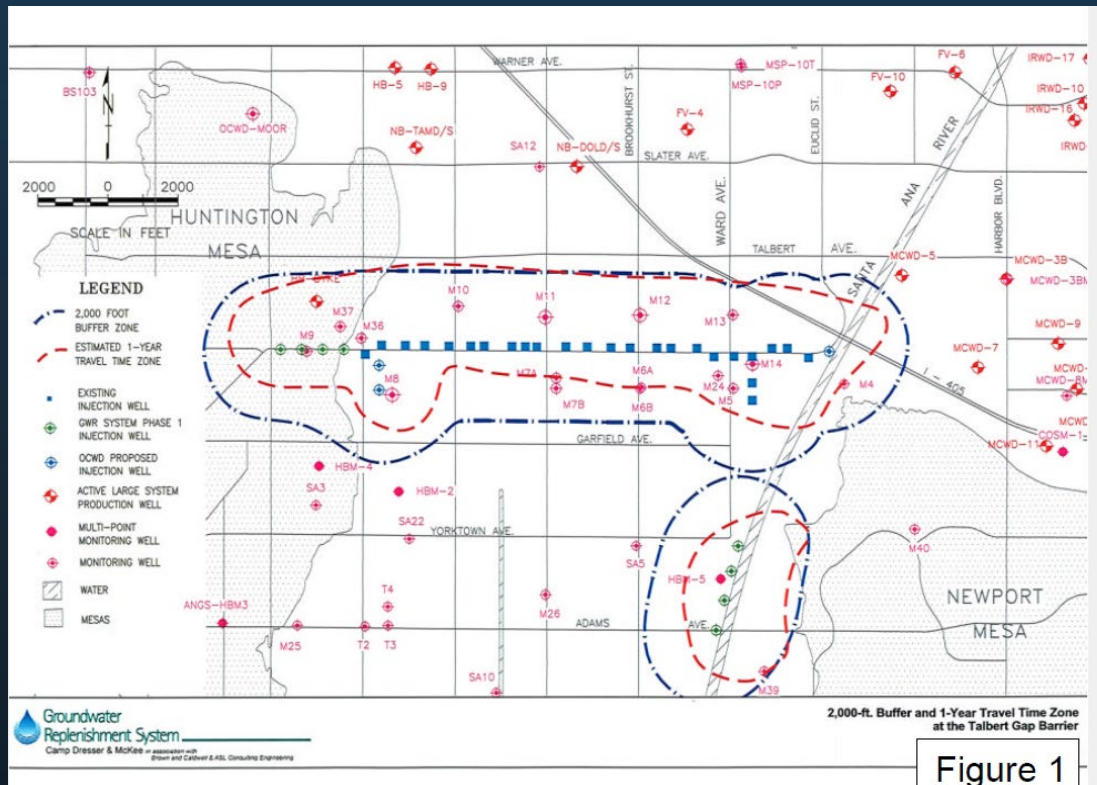
- Membrane filtration + UV to achieve at least 5-log inactivation
- UV disinfection to comply with 2003 NWRI UV Guidelines
 - Design UV dose $> 50 \text{ mJ/cm}^2$
 - Effluent turbidity always $< 0.5 \text{ N}$ & $< 0.2 \text{ NTU}$ 95% of the time
 - RO permeate UV transmittance $> 90\%$ at 254nm
- UV eventually operated at $> 111 \text{ mJ/cm}^2$ based on MS-2 validation challenge
- Finished water total coliform monitoring limits (daily monitoring required)
 - 7-day median $< 2.2 \text{ MPN/100 ml}$
 - $< 23 \text{ MPN/100 ml}$ in any one sample in any 30-day period
 - $< 240 \text{ MPN/100 ml}$ in all samples



2004 Permit: Subsurface Retention Time Requirements for Pathogen Control

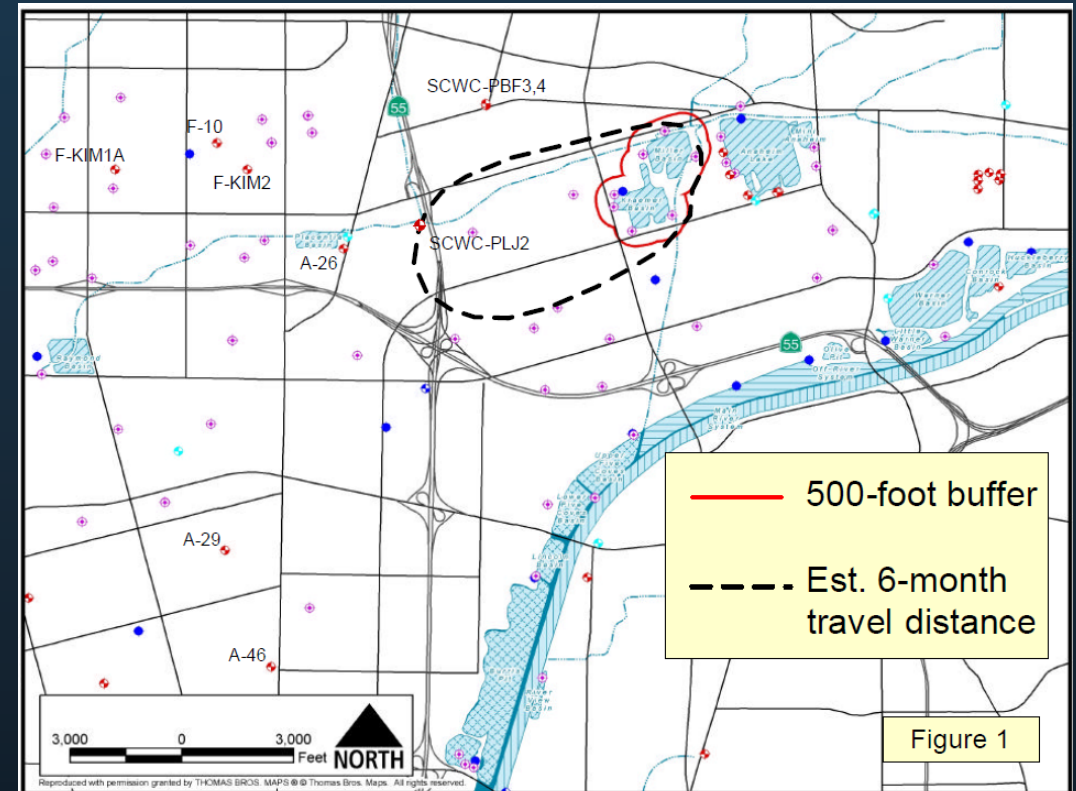
Direct Injection at Seawater Barrier

- > 12 months travel time
- >600m travel distance

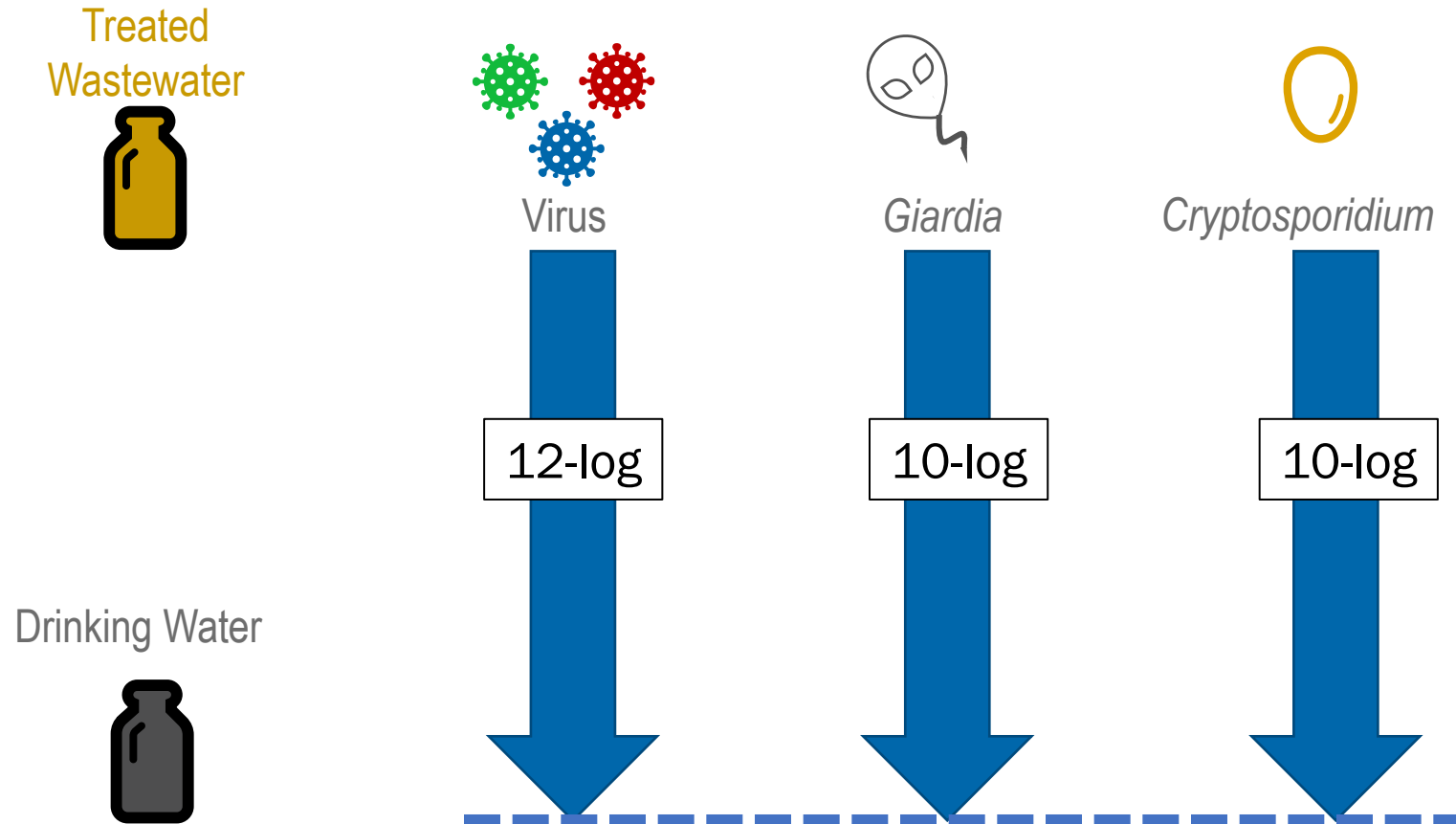


Surface Spreading

- >6 months travel time
- >150m travel distance



California 2014 Final Groundwater Recharge Reuse Project (GRRP) Requirements for Pathogen Reduction

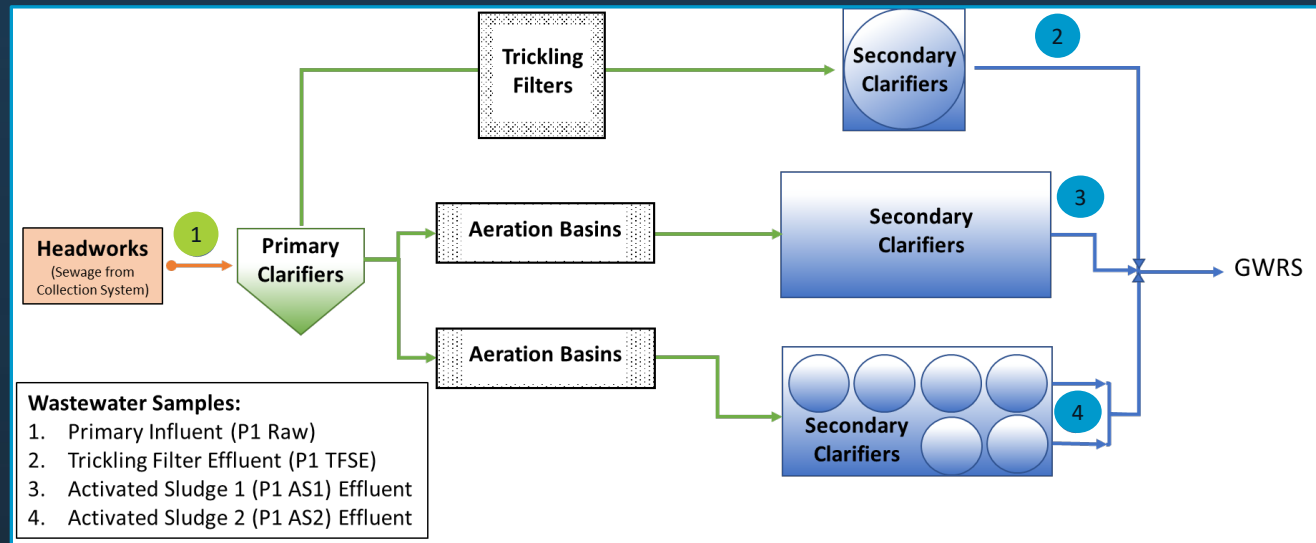


- 3 treatment barriers with at least 1-log for each pathogen
- No single barrier can receive more than 6-log
- Subsurface retention time can serve as one of these treatment barriers

2023 Summary of GWRS Pathogen Removal

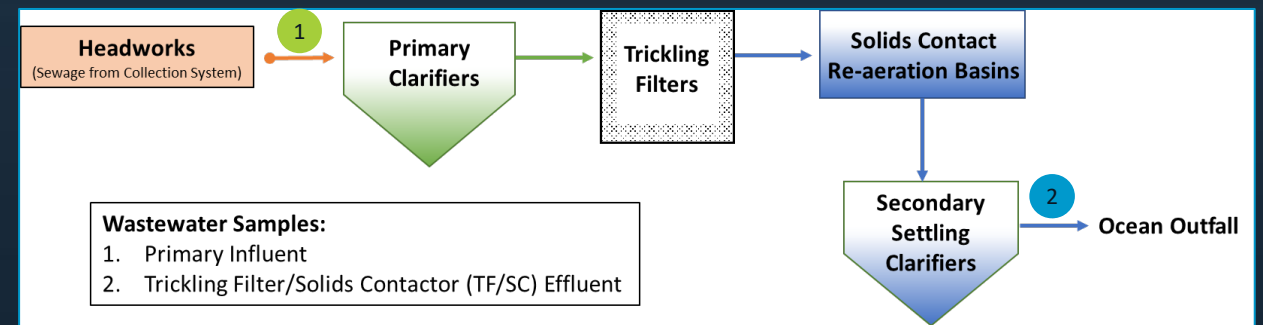
Pathogen	Minimum Log Reduction Requirements	GWRS Pathogen Log Reduction Credits					
		OC San Plants 1 & 2	MF/UF & Cl ₂	RO	UV/AOP	Underground Retention Time	Total
Viruses	12	0.7	0	2.0-3.4	6.0	4.0	12.7-14.1
<i>Giardia</i> cysts	10	0	4.0	2.0-3.4	6.0	0	12.0-13.4
<i>Cryptosporidium</i> oocysts	10	0	4.0	2.0-3.4	6.0	0	12.0-13.4

OC San Virus LRV Study Wastewater **Influent** and **Effluent** Monitoring Locations

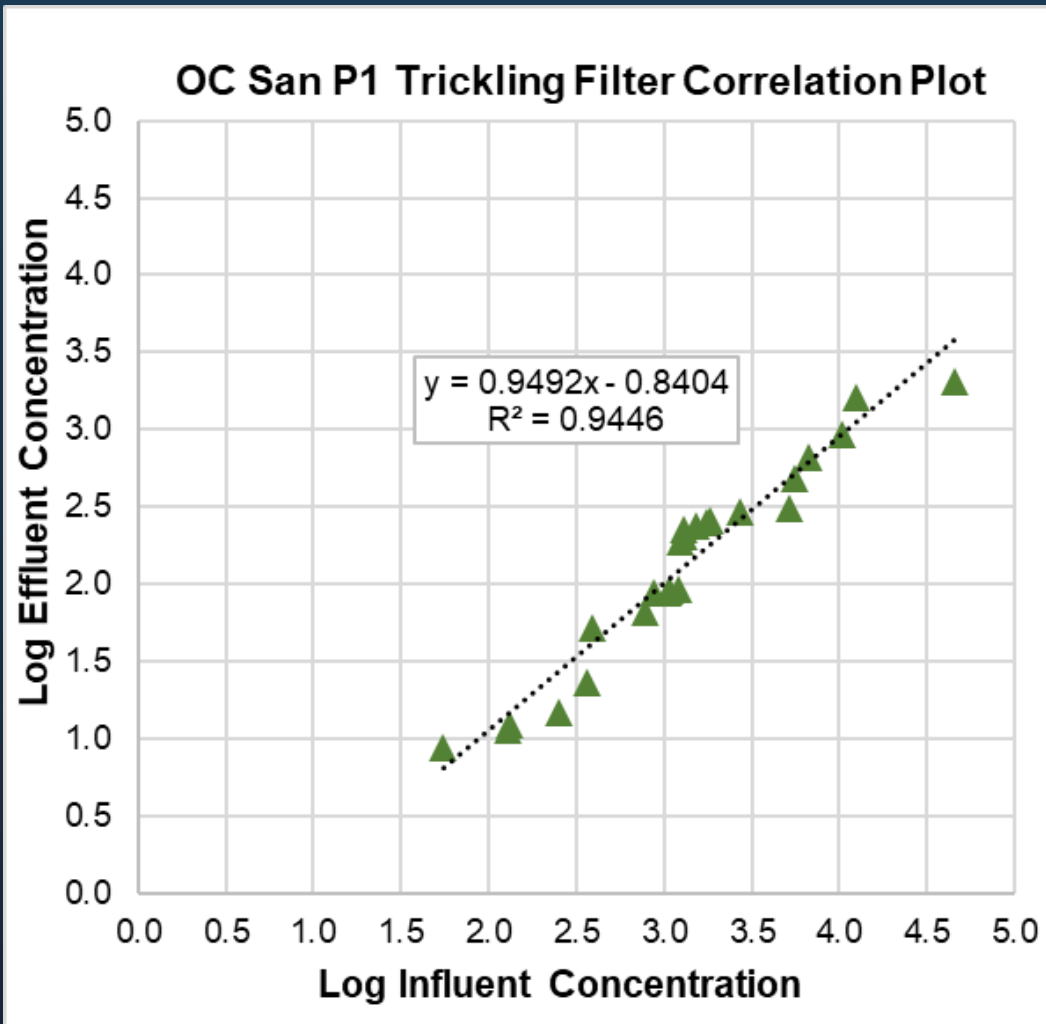


- OC San Reclamation Plant 1
 - P1 Influent (1)
 - P1 TF Effluent (2)
 - P1 AS1 Effluent (3)
 - P1 AS2 Effluent (4)

- OC San Treatment Plant 2
 - P2 Influent (1)
 - P2 TF/SC Effluent (2)



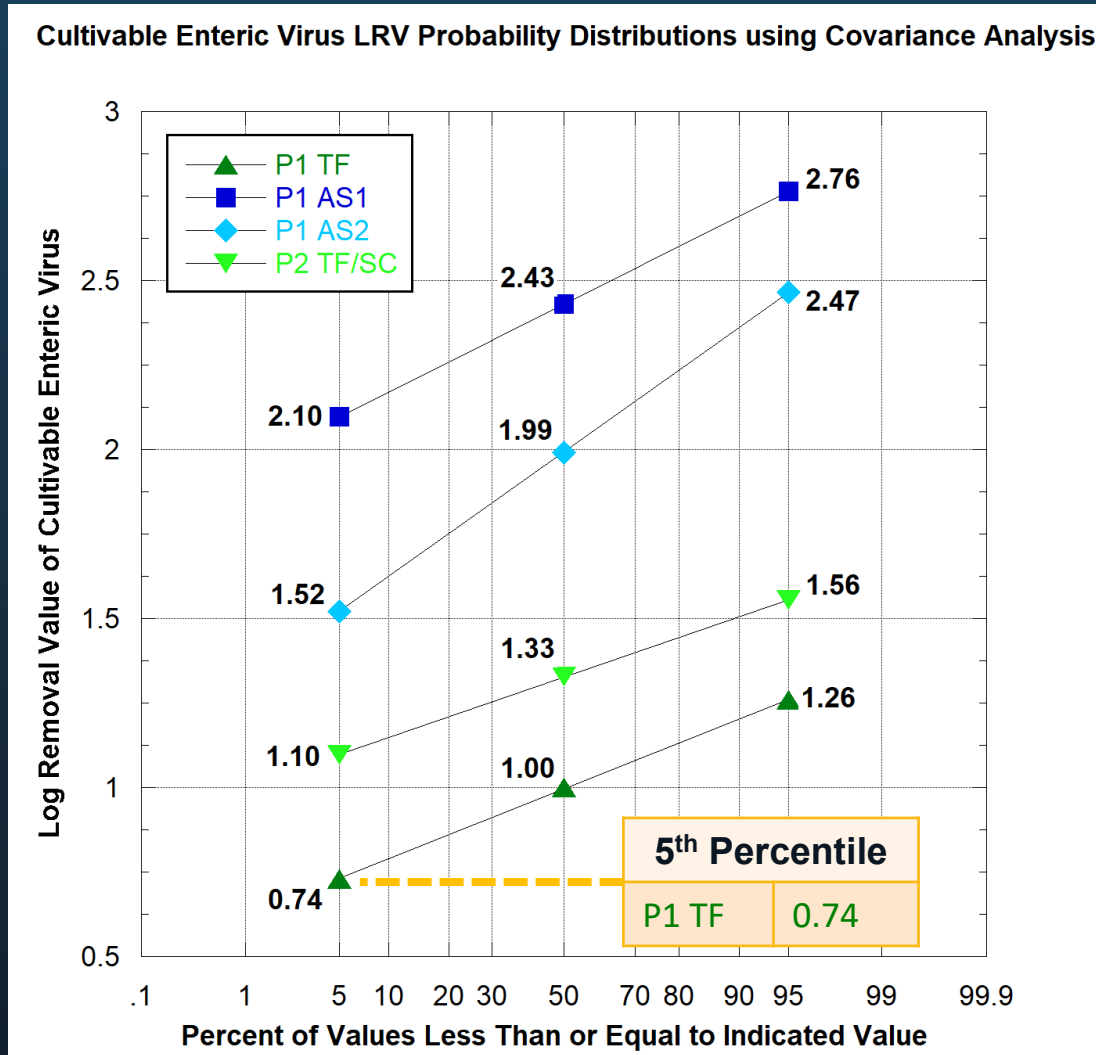
Covariance Method for LRV Calculation



- Covariance is an accepted method to calculate the difference between two dependent (correlated) distributions
- OC San influent-effluent data highly correlated



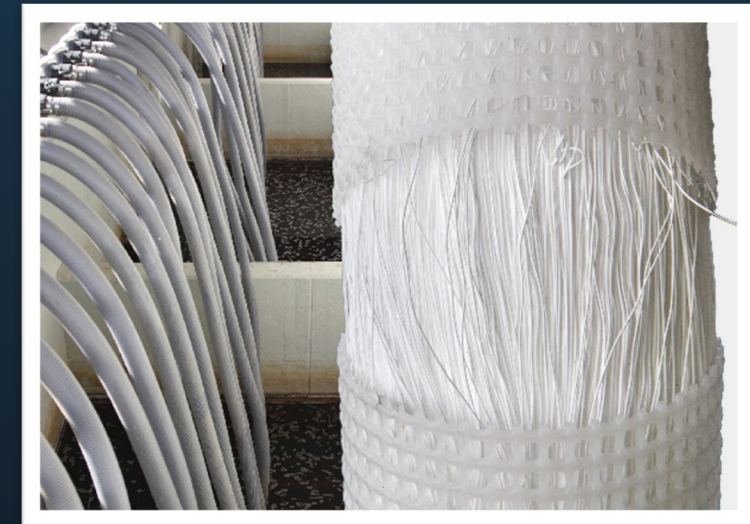
Covariance Method Results for OC San Virus LRV



- 5th percentile cultivable virus removal at Plant 1 TF = 0.74 log (*worst performing process*)
- Proposed virus LRV = 0.7 log
- Still awaiting state review & approval

MF/UF + Chlorine LRVs for *Crypto* & *Giardia*

- Two submerged Memcor/DuPont membrane types
 - Polypropylene microfiltration (0.2 micron pore size)
 - PVDF ultrafiltration (0.04 micron pore size)
- Daily pressure decay tests (PDTs) in all 48 MF/UF cells
 - Use 2005 USEPA Membrane Filtration Guidance Manual
 - Translates PDT into protozoa LRV; **does not support virus credit**
 - Any cell confirmed <4.00 log is taken offline for inspection & repair
- Turbidity compliance
 - <0.5 NTU turbidity always
 - <0.2 NTU 95% of time



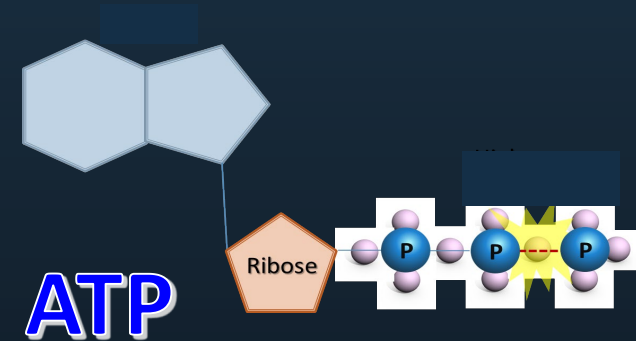
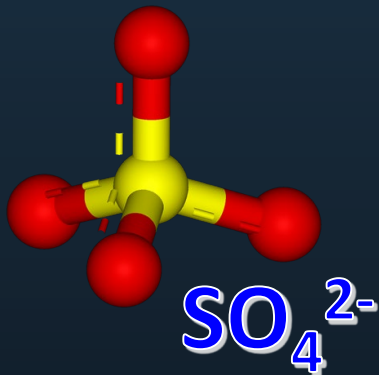
Example Monthly MF/UF Daily PDT Report

Date	MicroFiltration Process online monitoring results															
	Log Removal Value															
	A01	A02	A03	A04	A05	A06	A07	A08	B01	B02	B03	B04	B05	B06	B07	B08
LRV	LRV	LRV	LRV	LRV	LRV	LRV	LRV	LRV	LRV	LRV	LRV	LRV	LRV	LRV	LRV	LRV
10/01/23	5.00	N/A**	5.28	5.07	5.13	5.16	5.11	5.06	5.24	5.41	4.93	4.89	5.17	4.98	5.11	5.09
10/02/23	5.00	5.23	5.21	5.09	5.16	5.14	5.12	5.13	5.25	5.40	4.89	4.90	5.31	4.94	5.08	5.07
10/03/23	4.97	5.19	5.21	5.07	5.09	5.46	5.13	5.07	5.18	5.37	4.90	4.90	5.26	4.95	5.09	5.07
10/04/23	5.04	5.16	5.35	5.11	5.07	5.31	5.12	5.09	5.23	5.45	4.90	4.88	5.25	4.96	5.11	5.07
10/05/23	5.06	5.16	5.33	5.04	5.04	5.23	5.13	5.07	5.16	5.38	4.91	4.85	4.95	4.90	5.05	5.02
10/06/23	5.10	5.13	5.24	4.99	5.03	5.22	5.07	5.07	5.16	5.33	4.92	4.82	5.09	4.87	5.02	4.98
10/07/23	5.04	5.13	5.25	4.97	5.00	5.15	5.08	5.10	5.17	5.26	4.89	4.83	5.16	4.83	5.02	4.94
10/08/23	5.04	N/A**	5.19	5.01	5.02	5.16	5.07	5.08	5.16	5.29	4.87	4.85	5.18	4.85	5.00	4.94
10/09/23	5.02	5.20	5.16	4.97	5.03	5.14	5.07	5.09	5.09	5.28	5.03	4.81	5.16	4.86	5.02	4.93
10/10/23	5.01	5.06	5.23	5.03	4.98	5.16	5.03	5.08	5.11	5.32	4.95	4.79	5.13	4.91	5.00	4.90
10/11/23	4.99	5.04	5.18	5.03	4.99	5.12	5.01	5.03	5.26	5.29	4.93	4.77	5.10	4.94	5.05	4.91
10/12/23	4.96	5.09	5.09	4.98	4.94	5.12	5.14	5.04	5.28	5.24	4.91	4.76	5.07	4.93	5.02	5.03
10/13/23	4.95	5.07	5.16	5.03	4.92	5.17	5.10	5.05	5.24	5.28	4.93	4.78	5.10	4.92	5.01	5.05
10/14/23	4.97	5.04	5.14	5.02	4.89	5.05	5.09	5.07	5.21	5.25	4.91	4.77	5.14	4.89	4.99	5.00
10/15/23	4.95	5.08	5.15	5.05	4.96	5.11	5.06	5.06	5.20	5.19	4.92	4.77	5.14	4.87	4.96	4.99
10/16/23	4.97	5.04	5.22	5.03	5.06	5.08	5.11	5.03	5.24	5.33	4.93	4.77	5.12	4.87	4.93	4.99
10/17/23	4.92	5.04	5.11	5.00	5.02	5.02	5.10	5.04	5.20	5.22	4.94	4.75	4.53	4.88	4.96	4.95
10/18/23	4.93	5.02	5.15	4.96	5.03	5.03	5.04	5.07	5.13	5.22	4.89	4.73	4.61	4.87	4.97	4.94
10/19/23	4.89	4.99	5.12	4.87	5.00	4.96	5.02	4.96	5.12	N/A**	4.87	4.71	4.92	4.86	4.96	4.92
10/20/23	4.90	4.99	5.11	4.96	4.98	4.94	5.06	4.98	5.09	N/A**	4.86	4.84	N/A**	N/A**	4.94	4.88
10/21/23	4.94	5.04	5.11	4.95	4.97	4.99	5.02	5.04	5.09	5.35	4.87	4.85	N/A**	4.91	4.93	4.84
10/22/23	4.89	4.95	5.07	4.95	4.99	5.00	5.04	5.02	5.10	5.26	4.86	N/A**	N/A**	4.86	4.93	4.85
10/23/23	4.95	5.06	5.10	4.96	4.98	5.03	5.07	4.97	5.12	5.19	4.87	N/A**	N/A**	4.85	4.93	4.85
10/24/23	4.87	5.01	5.08	4.91	4.97	4.91	5.04	4.96	5.09	5.21	4.85	4.90	5.32	4.82	4.91	4.83
10/25/23	4.85	4.96	5.08	4.96	4.98	4.91	4.99	4.95	5.08	5.31	4.80	4.86	5.24	4.83	4.91	4.83
10/26/23	4.91	5.00	5.07	4.94	4.96	4.91	5.00	4.95	5.11	5.33	4.79	4.85	5.28	4.83	4.91	4.85
10/27/23	4.95	4.99	5.07	4.90	4.99	4.91	5.00	4.98	5.07	5.33	4.83	4.84	5.31	4.80	4.92	4.82
10/28/23	4.91	4.90	5.05	4.88	4.97	4.87	5.02	4.97	5.04	5.28	4.79	4.82	4.61	4.77	4.98	4.76
10/29/23	4.96	4.93	5.02	4.86	4.95	4.85	5.01	4.90	5.04	5.30	4.77	4.81	4.29	4.77	5.01	4.77
10/30/23	4.96	5.00	5.03	4.86	4.93	N/A**	4.97	4.89	5.02	5.34	4.76	4.78	4.77	4.73	4.99	4.73
10/31/23	4.87	4.95	5.01	4.80	4.90	N/A**	4.99	4.91	5.02	5.36	4.73	4.80	4.37	4.73	4.97	4.72

Notes:
 Giardia and Crypto LRV based on USEPA Membrane Filtration Guidance Manual and sensitive at less than 3 micron.
 ** Cell offline for maintenance.

GWRS RO Pathogen Log Reduction

- GWRS LRV credit currently granted via TOC (~2 log) and EC (~1.5 log) surrogate monitoring
- Ongoing multi-year OCWD study to identify easily monitored alternative surrogates giving more credit
 - Sulfate, strontium, free ATP all promising options
 - OCWD currently piloting online instrumentation
 - Use of strontium instrument is pending DDW review



Summary of OCWD RO LRV Study Results

Surrogate	Study Average LRV	Min LRV	Max LRV
Strontium¹	3.28	3.01	3.38
Sulfate ¹	2.90	2.79	3.00
Free ATP ²	3.03	2.60	3.30
Fluorescence Peak C ²	2.70	2.27	3.00
TOC ²	2.01	1.77	2.36
EC ²	1.50	0.72	1.54

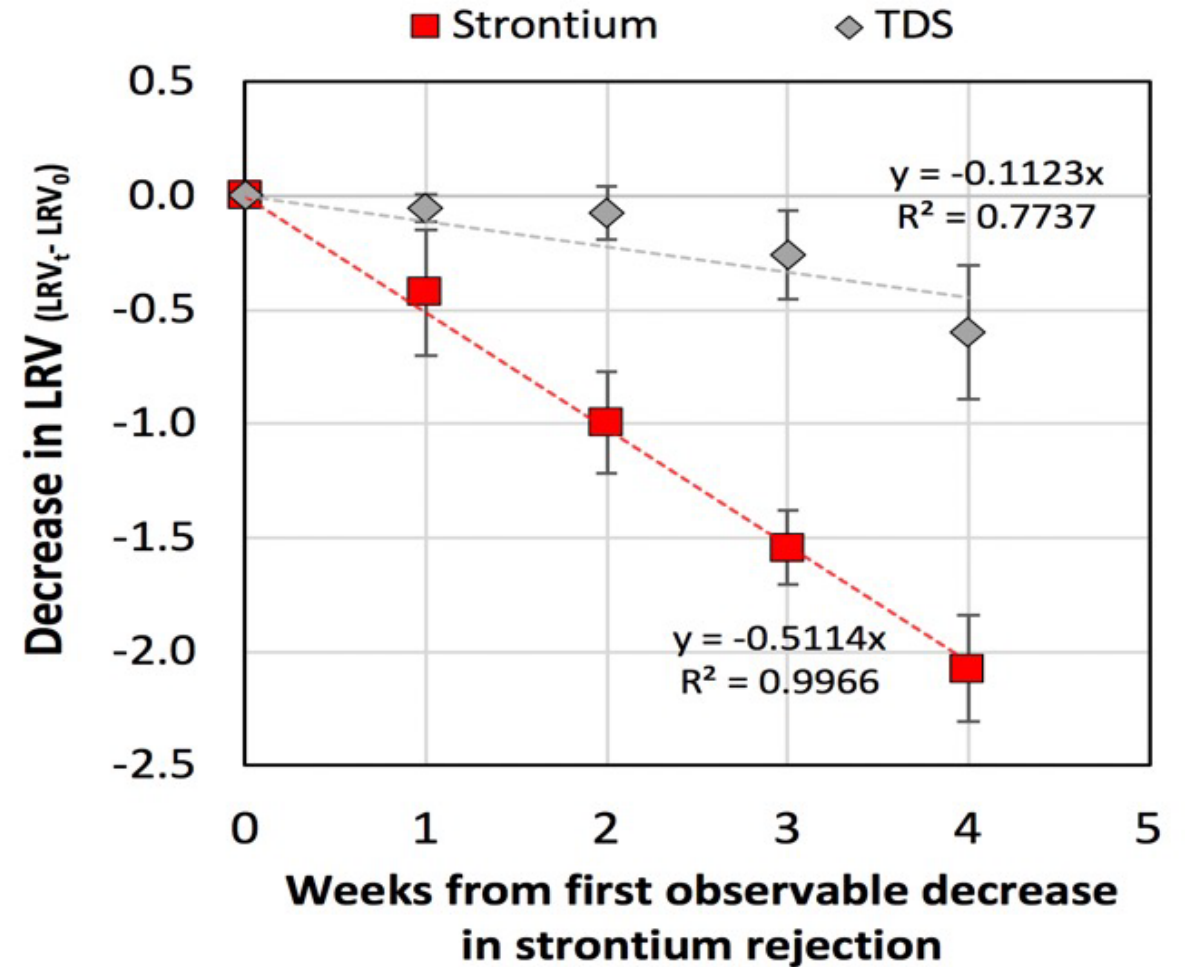
Unit B01 (Membranes: Hydranautics ESPA2-LD)

¹Grab Samples

²Continuous (online)

Strontium Log Reduction Value

- Strontium can detect RO integrity issues sooner than TDS



Sen, S. et al., *WaterReuse CA Annual Conference 2021*.

Tiered LRV Approach Approved for RO

	<i>future</i>	<i>current</i>		<i>future</i>
RO System Monitoring	Tier 1	Tier 2	Tier 3	Tier 4
Surrogate	Strontium, ATP, or Sulfate	TOC	EC	Strontium or Sulfate
Frequency	Continuous online (Each monitoring location at least once daily)	Continuous online (15-min data)	Continuous online (15-min data)	Grab (Daily samples)
Monitoring locations	Combined (bulk) ROF & per-train ROP	Combined (bulk) ROF & ROP	Combined (bulk) ROF & ROP	Combined (bulk) ROF & per-train ROP
Expected LRV for VIG/C	2.6 – 3.4	2.0 – 2.3	1.6 – 1.8	2.8 – 3.4
Proposed Awarded LRV	Based on actual removal determined by tiered methodology (must meet 1.0 minimum)			

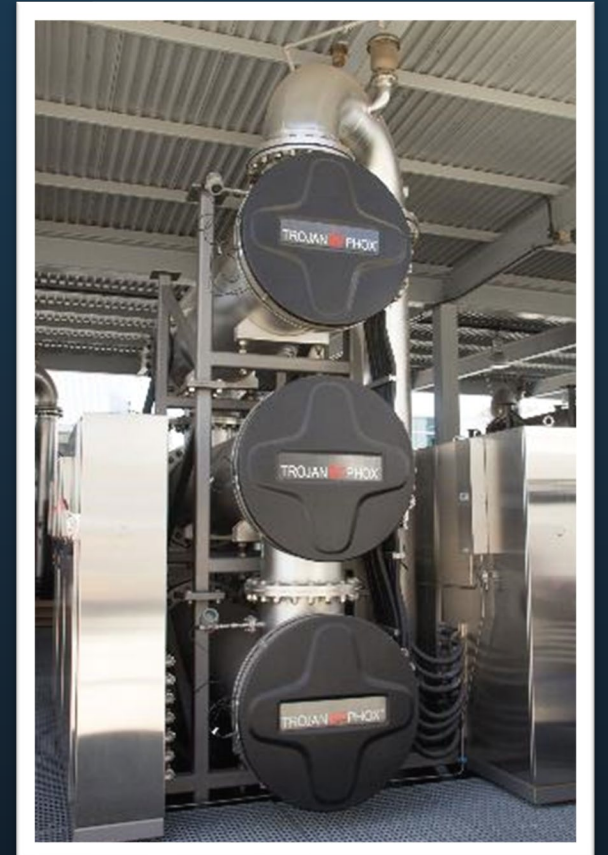
- Credit for Tiers 1-3 applied in preferential order, if instrumentation online
 - Anticipate maintaining current TOC and EC monitoring as backup to online strontium/sulfate
- Tier 4 only likely to be implemented if Tier 1 implemented but offline

Example Monthly RO Daily LRV Report

Date	Reverse Osmosis Process online monitoring results														Calculated TOC removal based on Daily Avg		Calculated EC removal based on Daily Avg	
	Turbidity (ntu)		Total Organic Carbon (TOC - ppm)						Electro Conductivity (EC)						%	Log	%	Log
	ROP		ROF			ROP			ROF			ROP						
avg	max	avg	min	max	avg	min	max	avg	min	max	avg	min	max					
10/01/23	0.015	0.015	6.971	6.526	7.513	0.048	0.045	0.057	1,574	1,539	1,614	38	33	44	99.30	2.16	97.58	1.62
10/02/23	0.015	0.015	7.169	6.651	7.667	0.050	0.044	0.056	1,566	1,498	1,662	39	34	44	99.31	2.16	97.53	1.61
10/03/23	0.015	0.015	7.188	6.659	7.747	0.052	0.047	0.058	1,614	1,550	1,797	40	36	44	99.27	2.14	97.55	1.61
10/04/23	0.015	0.015	6.979	6.574	7.598	0.053	0.047	0.063	1,965	1,582	2,422	54	35	74	99.24	2.12	97.25	1.56
10/05/23	0.015	0.015	6.710	6.474	7.136	0.052	0.047	0.064	2,320	2,145	2,558	65	55	76	99.22	2.11	97.19	1.55
10/06/23	0.015	0.015	6.516	6.337	6.821	0.052	0.046	0.060	2,404	2,219	2,603	67	59	77	99.20	2.10	97.20	1.55
10/07/23	0.015	0.015	6.676	6.463	7.146	0.049	0.044	0.057	2,360	2,215	2,525	61	54	71	99.28	2.14	97.42	1.59
10/08/23	0.015	0.015	6.804	6.452	7.267	0.045	0.041	0.054	2,217	2,034	2,476	56	50	66	99.34	2.18	97.47	1.60
10/09/23	0.015	0.015	6.749	6.415	7.276	0.043	0.038	0.051	2,277	2,108	2,537	57	50	67	99.36	2.19	97.52	1.60
10/10/23	0.015	0.015	6.725	6.347	7.126	0.048	0.042	0.054	2,303	2,115	2,518	58	50	67	99.29	2.15	97.49	1.60
10/11/23	0.015	0.015	6.676	6.398	7.090	0.049	0.036	0.059	2,395	2,217	2,644	63	57	74	99.27	2.14	97.36	1.58
10/12/23	0.015	0.015	6.698	6.467	7.005	0.049	0.044	0.061	2,435	2,213	2,648	63	54	73	99.27	2.13	97.40	1.59
10/13/23	0.014	0.015	6.675	6.511	6.864	0.047	0.041	0.056	2,366	2,163	2,628	58	48	68	99.29	2.15	97.59	1.62
10/14/23	0.015	0.015	6.692	6.428	7.075	0.049	0.043	0.098	2,391	2,193	2,645	58	49	76	99.27	2.14	97.55	1.61
10/15/23	0.015	0.015	6.771	6.363	7.346	0.046	0.038	0.054	2,310	2,083	2,605	61	52	77	99.32	2.17	97.37	1.58
10/16/23	0.015	0.015	7.001	6.732	7.536	0.048	0.038	0.057	2,258	2,014	2,616	63	50	82	99.32	2.17	97.21	1.55
10/17/23	0.015	0.015	7.106	6.602	8.390	0.064	0.044	0.160	2,432	2,247	2,642	69	61	78	99.11	2.05	97.15	1.55
10/18/23	0.015	0.015	6.664	6.579	7.436	0.052	0.045	0.061	2,447	2,249	2,694	68	60	78	99.24	2.12	97.21	1.55
10/19/23	0.014	0.015	6.980	6.708	7.450	0.055	0.046	0.067	2,382	2,236	2,667	67	58	79	99.21	2.10	97.18	1.55
10/20/23	0.015	0.015	6.743	6.461	7.105	0.051	0.044	0.057	2,337	2,197	2,460	65	58	72	99.24	2.12	97.22	1.56
10/21/23	0.015	0.015	6.640	6.263	7.053	0.049	0.042	0.057	2,376	2,231	2,538	64	58	71	99.26	2.13	97.31	1.57
10/22/23	0.015	0.015	6.672	6.331	7.323	0.045	0.041	0.055	2,276	2,133	2,557	59	53	69	99.33	2.18	97.40	1.59
10/23/23	0.015	0.015	6.605	6.280	7.094	0.044	0.038	0.054	2,318	2,091	2,561	61	51	75	99.33	2.17	97.36	1.58
10/24/23	0.015	0.015	6.557	6.306	6.962	0.043	0.000	0.057	2,350	2,145	2,602	62	53	70	99.34	2.18	97.35	1.58
10/25/23	0.015	0.015	6.364	6.098	6.796	0.048	0.043	0.061	2,388	2,220	2,625	63	55	75	99.24	2.12	97.35	1.58
10/26/23	0.015	0.015	7.017	6.587	7.814	0.065	0.047	0.103	2,293	2,061	2,536	60	43	81	99.07	2.03	97.39	1.58
10/27/23	0.014	0.015	6.953	6.503	7.908	0.071	0.061	0.091	2,352	2,187	2,597	63	52	73	98.98	1.99	97.32	1.57
10/28/23	0.015	0.015	6.435	6.049	7.214	0.062	0.056	0.069	2,481	2,360	2,697	66	60	76	99.04	2.02	97.33	1.57
10/29/23	0.015	0.015	6.559	5.956	7.341	0.055	0.052	0.063	2,320	2,154	2,643	60	53	73	99.15	2.07	97.40	1.58
10/30/23	0.015	0.015	6.492	6.296	6.867	0.055	0.049	0.067	2,455	2,239	2,735	63	52	76	99.15	2.07	97.43	1.59
10/31/23	0.015	0.015	6.503	6.168	6.905	0.067	0.062	0.072	2,490	2,279	2,692	66	59	75	98.97	1.99	97.33	1.57

UV-AOP Pathogen Log Credit

- UV-AOP dose/energy driven by 0.5-log 1,4-dioxane removal requirement
- 300 mJ/cm² adenovirus reduction equivalent dose (RED) required to receive maximum 6-log credit
- Adenovirus RED → NDMA RED via Trojan model
- 0.51-log removal NDMA → 6-log adenovirus removal
- Based on validation testing, >1.2 log NDMA removal occurs when 0.5 log 1,4-dioxane removal achieved



Underground Retention Time Pathogen Credit

APPLIED AND ENVIRONMENTAL MICROBIOLOGY, Apr. 1985, p. 778-781
0099-2240/85/040778-04\$02.00/0
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Vol. 49, No. 4

Virus Persistence in Groundwater

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Received 27 September 1984/Accepted 31 December 1984

More than 50% of the outbreaks of waterborne disease in the United States are due to the consumption of contaminated groundwater. An estimated 65% of the cases in these outbreaks are caused by enteric viruses. Little, however, is known about the persistence of viruses in groundwater. The purpose of this study was to determine whether measurable chemical and physical factors correlate with virus survival in groundwater. Groundwater samples were obtained from 11 sites throughout the United States. Water temperature was measured at the time of collection. Several physical and chemical characteristics, including pH, nitrates, turbidity, and hardness, were determined for each sample. Separate water samples were inoculated with each of three viruses (poliovirus 1, echovirus 1, and MS-2 coliphage) and incubated at the in situ groundwater temperature; selected samples were also incubated at other temperatures. Assays were performed at predetermined intervals over a 30-day period to determine the number of infective viruses remaining. Multiple regression analysis revealed that temperature was the only variable significantly correlated with the decay rates of all three viruses. No significant differences were found among the decay rates of the three viruses, an indication that MS-2 coliphage might be used as a model of animal virus survival in groundwater.

- Default 1-log/month virus credit based on Yates 1985 study
- Must verify retention via field tracer study
- State assumes temp of 12°C, but GWRS groundwater temps much higher
- Higher temps = more virus removal (confirmed via literature review)
- OCWD working on site-specific study to gain additional credit



Example Monthly LRV Summary Report

System No. 5020001, Project No. 742

Date	Total Documented Pathogenic Microorganism Reduction Achieved			Minimum Required Log Reduction Achieved			Compliance % Exceedance Time				
	Giardia	Cryptosporidium	Virus	Giardia (10)	Cryptosporidium (10)	Virus (12)	MFE		ROP		TOC
	LRV	LRV	LRV	Y/N	Y/N	Y/N	>0.2	>0.5	>0.2	>0.5	>0.5
10/01/23	12	12	12	Y	Y	Y	0.0	0.0	0.0	0.0	0.0
10/02/23	12	12	12	Y	Y	Y	0.0	0.0	0.0	0.0	0.0
10/03/23	12	12	12	Y	Y	Y	0.0	0.0	0.0	0.0	0.0
10/04/23	12	12	12	Y	Y	Y	0.0	0.0	0.0	0.0	0.0
10/05/23	12	12	12	Y	Y	Y	0.0	0.0	0.0	0.0	0.0
10/06/23	12	12	12	Y	Y	Y	0.0	0.0	0.0	0.0	0.0
10/07/23	12	12	12	Y	Y	Y	0.0	0.0	0.0	0.0	0.0
10/08/23	12	12	12	Y	Y	Y	0.0	0.0	0.0	0.0	0.0
10/09/23	12	12	12	Y	Y	Y	0.0	0.0	0.0	0.0	0.0
10/10/23	12	12	12	Y	Y	Y	0.0	0.0	0.0	0.0	0.0
10/11/23	12	12	12	Y	Y	Y	0.0	0.0	0.0	0.0	0.0
10/12/23	12	12	12	Y	Y	Y	0.0	0.0	0.0	0.0	0.0
10/13/23	12	12	12	Y	Y	Y	0.0	0.0	0.0	0.0	0.0
10/14/23	12	12	12	Y	Y	Y	0.0	0.0	0.0	0.0	0.0
10/15/23	12	12	12	Y	Y	Y	0.0	0.0	0.0	0.0	0.0
10/16/23	12	12	12	Y	Y	Y	0.0	0.0	0.0	0.0	0.0
10/17/23	12	12	12	Y	Y	Y	0.0	0.0	0.0	0.0	0.0
10/18/23	12	12	12	Y	Y	Y	0.0	0.0	0.0	0.0	0.0
10/19/23	12	12	12	Y	Y	Y	0.0	0.0	0.0	0.0	0.0
10/20/23	12	12	12	Y	Y	Y	0.0	0.0	0.0	0.0	0.0
10/21/23	12	12	12	Y	Y	Y	0.0	0.0	0.0	0.0	0.0
10/22/23	12	12	12	Y	Y	Y	0.0	0.0	0.0	0.0	0.0
10/23/23	12	12	12	Y	Y	Y	0.0	0.0	0.0	0.0	0.0
10/24/23	12	12	12	Y	Y	Y	0.0	0.0	0.0	0.0	0.0
10/25/23	12	12	12	Y	Y	Y	0.0	0.0	0.0	0.0	0.0
10/26/23	12	12	12	Y	Y	Y	0.0	0.0	0.0	0.0	0.0
10/27/23	12	12	12	Y	Y	Y	0.0	0.0	0.0	0.0	0.0
10/28/23	12	12	12	Y	Y	Y	0.0	0.0	0.0	0.0	0.0
10/29/23	12	12	12	Y	Y	Y	0.0	0.0	0.0	0.0	0.0
10/30/23	13	13	12	Y	Y	Y	0.0	0.0	0.0	0.0	0.0
10/31/23	12	12	12	Y	Y	Y	0.0	0.0	0.0	0.0	0.0

Conclusions

- **California pathogen removal requirements have evolved over time**
 - **Draft regulations starting in 1978 for Water Factory 21 (one chlorine contact basin)**
 - **Updated draft regulations for GWRS Phase 1 (e.g., 50-100 mJ/cm² UV dose)**
 - **Final 2014 regulations for GWRS Final Expansion (e.g., 300 mJ/cm² UV dose)**
 - **2023 DPR regulations**
- **Requirement for daily integrity test makes MF/UF virus credit challenging**
- **New & more sensitive monitoring approaches can increase RO credit**
- **UV credit is very important, can't operate w/o it and remain in compliance**
- **No immediate plans for OCWD to pursue DPR ☺**



Gracias!



A joint effort of the
Orange County Water District and Orange County Sanitation District