

# Efficacy of Membrane Technologies to Address Emerging Contaminants in Advanced Water Treatment and Water Reuse Applications

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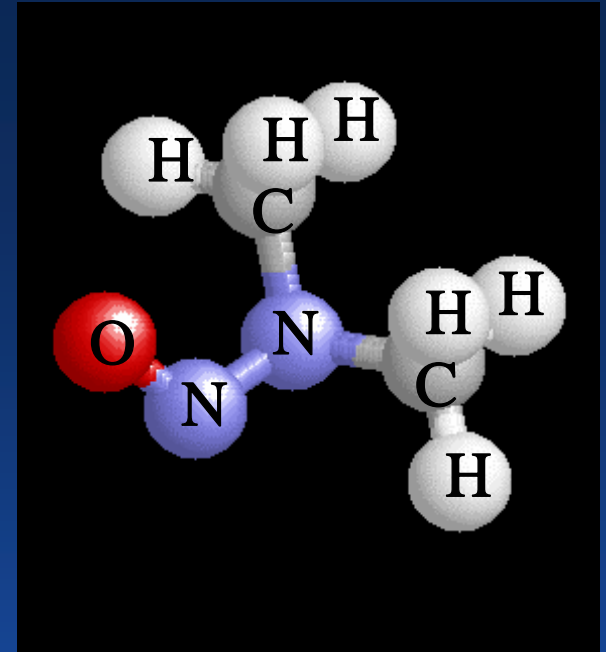
**April 3, 2007**

# Outline

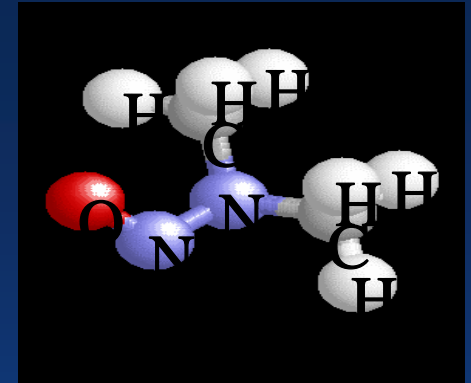
- Introduction to N-Nitrosodimethylamine (NDMA)
- NDMA Formation and Removal in Recycled Water
- Introduction to 1,2,3 – Trichloropropane (TCP)
- TCP Bench and Pilot Studies – Brackish Groundwater
- Summary

# NDMA

- Potent carcinogen
  - CA notification level 10 ng/L
  - OEHHA draft PHG 3 ng/L
- Very soluble in water (100 g/L)
- Persistent in groundwater aquifers
- Chloramine and polymer disinfection byproduct
- Potential problem for wastewater recycling projects



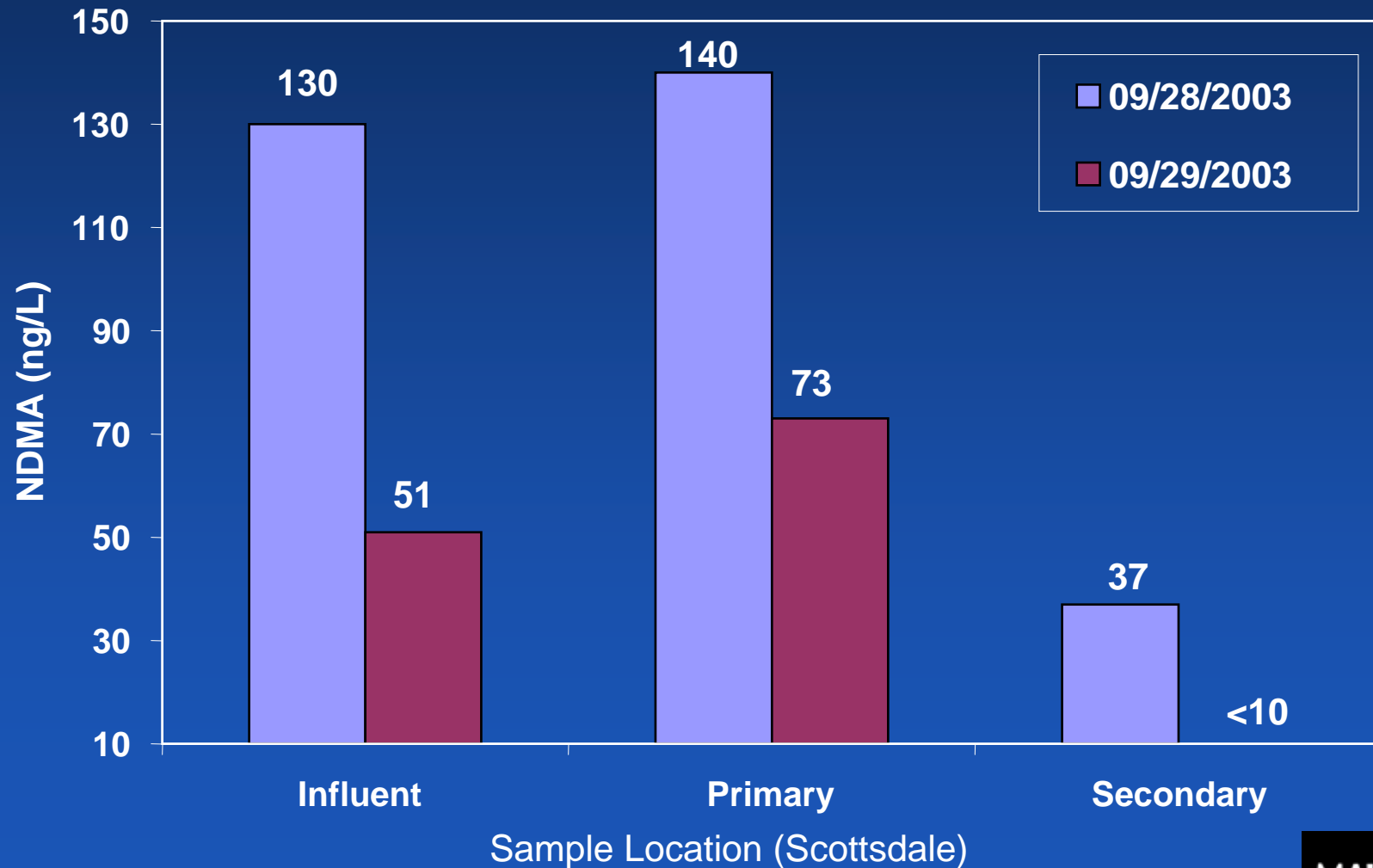
# NDMA (con't)



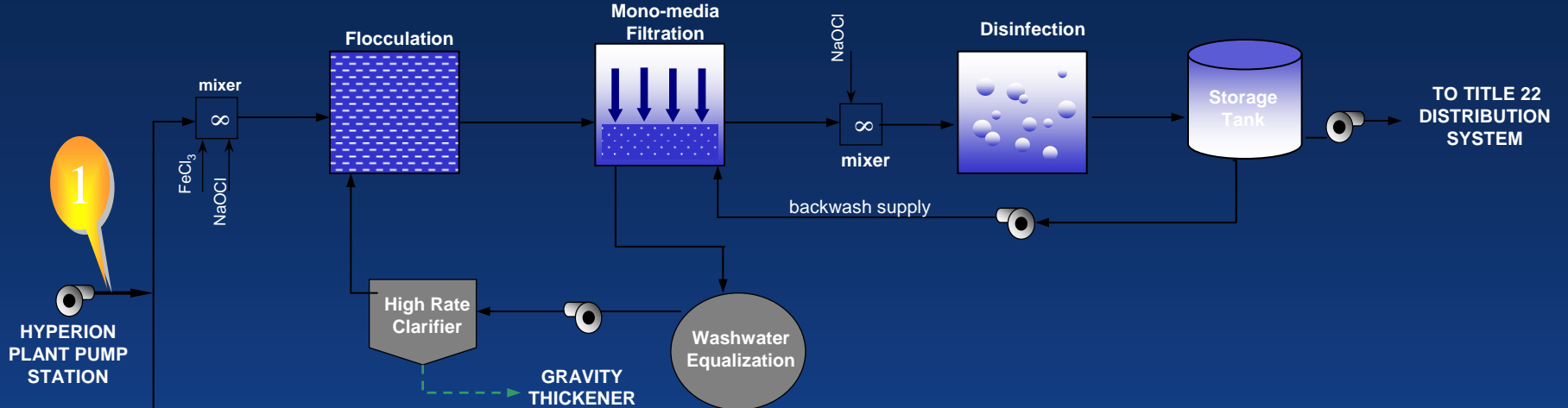
- In wastewater and recycled water:
  - Formed during chlorination
  - NDMA and NDMA precursors partially removed by secondary treatment
  - Re-forms if chlorinating (e.g., prior to MF)
  - NDMA not well removed by RO, but precursors are
  - UV is required for removal and is very effective

# Secondary Treatment

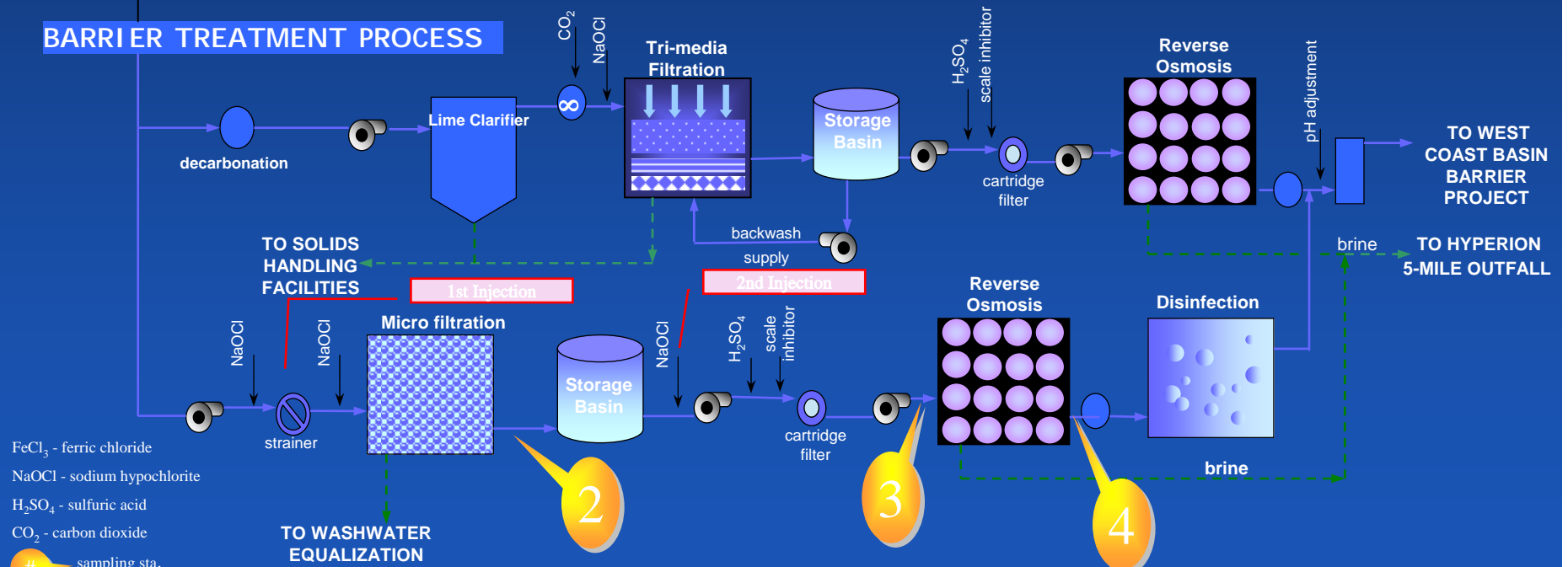
## Variable Removal of NDMA



# TITLE 22 TREATMENT PROCESS



# BARRIER TREATMENT PROCESS



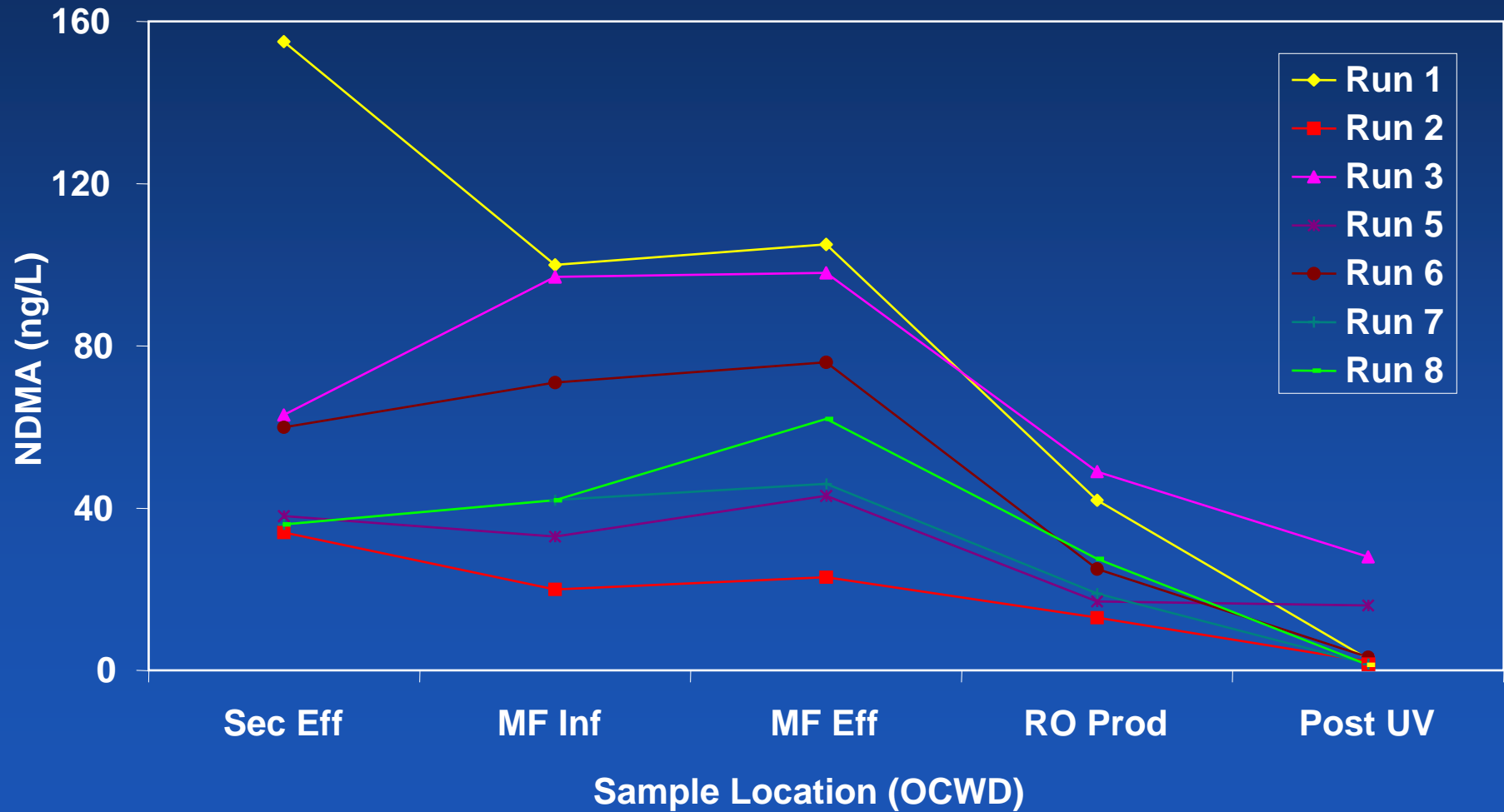
- FeCl<sub>3</sub> - ferric chloride
- NaOCl - sodium hypochlorite
- H<sub>2</sub>SO<sub>4</sub> - sulfuric acid
- CO<sub>2</sub> - carbon dioxide
- # - sampling sta.

# West Basin Water Recycling Plant

INDEPENDENT ENVIRONMENTAL ENGINEERS, SCIENTISTS AND CONSULTANTS

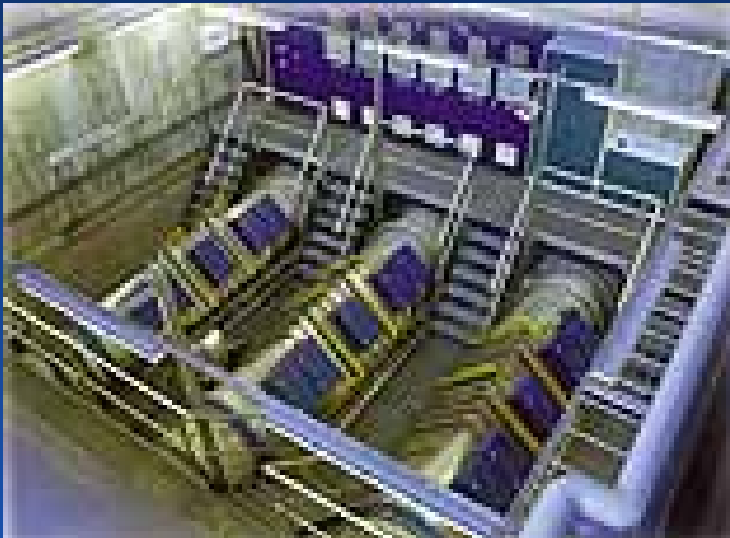


# Advanced Treatment



# Destruction using Advanced Treatment (UV Oxidation)

- Accepted by CalDHS (January 2001)



Wedeco K-Series



Calgon Rayox

Trojan  
UV8000



UV 3000

# UV-Photolysis and UV-Oxidation Kinetics

$$\frac{-d[C]}{dt} = \underbrace{\sum_{\lambda=200}^{300} \frac{\phi_c N_{0\lambda} F_{s\lambda} F_{c\lambda}}{V}}_{\text{UV-Photolysis}} + \underbrace{kc[C][\bullet OH]}_{\text{UV-Oxidation}}$$

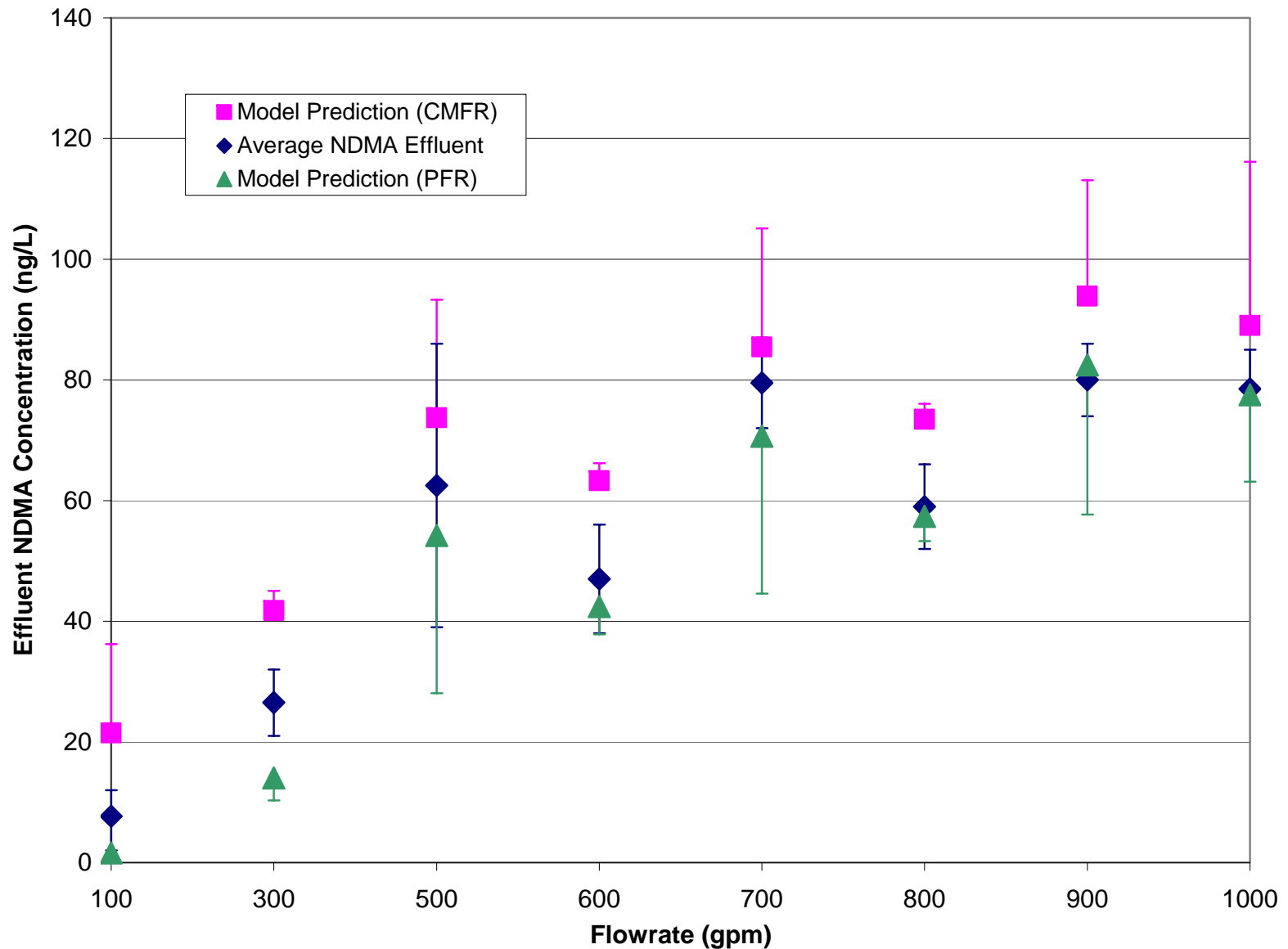
[C] is the concentration of micropollutant C

$\phi_c$  is the quantum yield for compound C

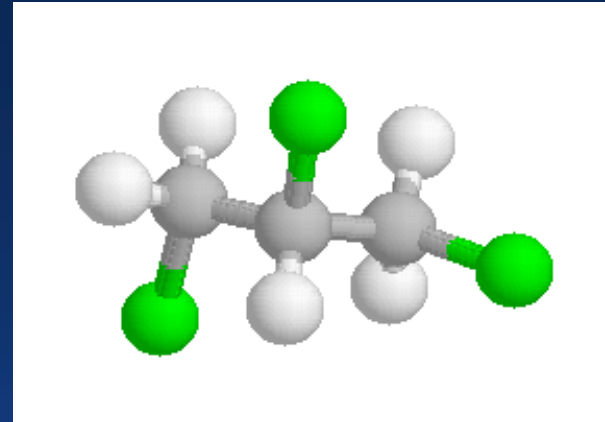
$N_{0\lambda}$  is the incident photon flux at wavelength  $\lambda$  nm

V is the reactor volume

# Actual vs. Model-Predicted Effluent NDMA Concentration



# 1,2,3 - TCP



- Causes cancer in laboratory animals
- Reasonably considered to be a human carcinogen
- Added to CA Title 22 list of chemicals known to the state to cause cancer
- California Notification Level – 5 ng/L

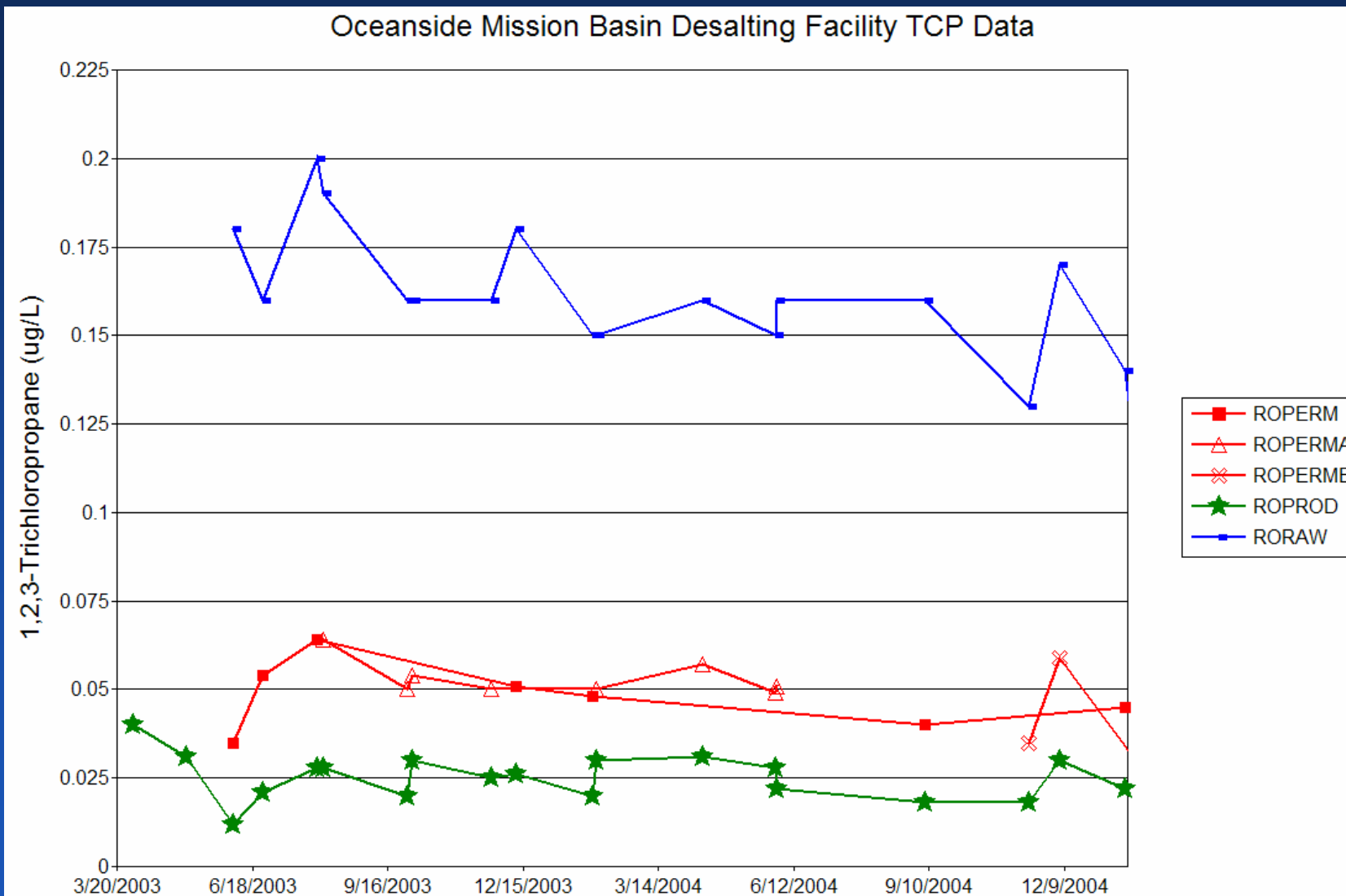
# Evolution of TCP

Year	Event	Regulatory Level (µg/L)	Detection Limit (µg/L)
1987	D-D Nematocide banned in U.S.		
1992	CA Prop 65/DHS Action Level	0.05	0.5
1996	Burbank OU Detections: 2-5 µg/L		0.1
1999	Burbank OU Detections: 50-70 µg/L		0.05
1999	DHS Action Level	0.005	
2001	California UCMR Monitoring		0.005

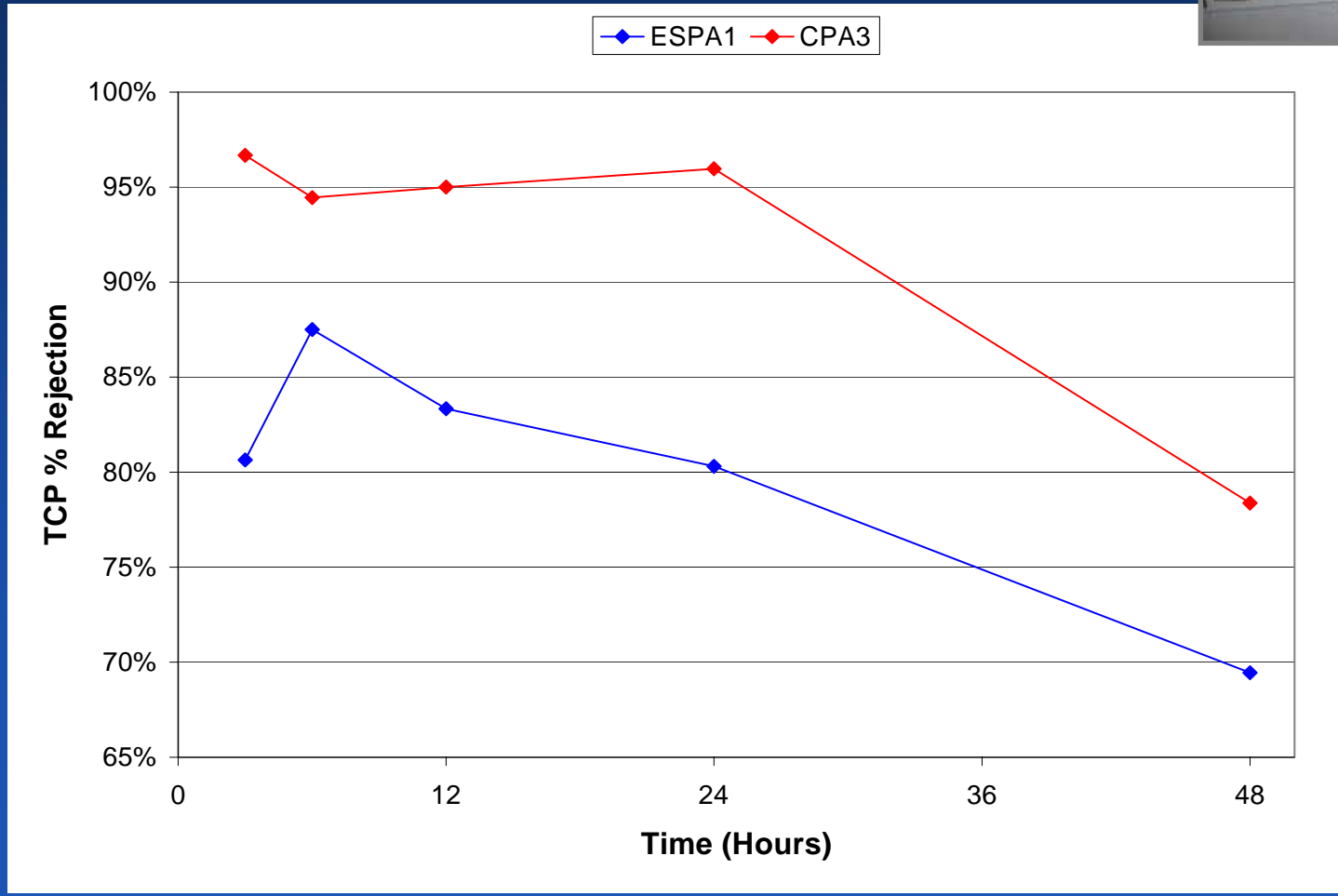
# Where does it occur in CA?

County	Total Sources	Sampling Results (ug/L)						Total Systems
		<0.0051	0.0051 - 0.05	0.051 - 0.5	0.51 - 5.0	5.1 - 50	>50	
Kern	93	1	39	49	4			18
Fresno	41		29	10	2			8
Los Angeles	36		22	8	3	2	1	14
Tulare	26		19	5	1	1		5
Merced	23		8	10	5			10
San Bernardino	21		18	2	1			6
Riverside	16	1	13	2				6
San Joaquin	8		5	3				2
San Mateo	7		3	3	1			2
Stanislaus	7		4	3				5
San Diego	6		3	1	2			2
Monterey	1			1				2
Solano	1					1		1
Sacramento	1			1				1
Kings	1		1					1
Madera	1		1					1
<b>TOTAL</b>	<b>289</b>	<b>2</b>	<b>165</b>	<b>98</b>	<b>19</b>	<b>4</b>	<b>1</b>	<b>84</b>

# Oceanside: RO does not remove TCP



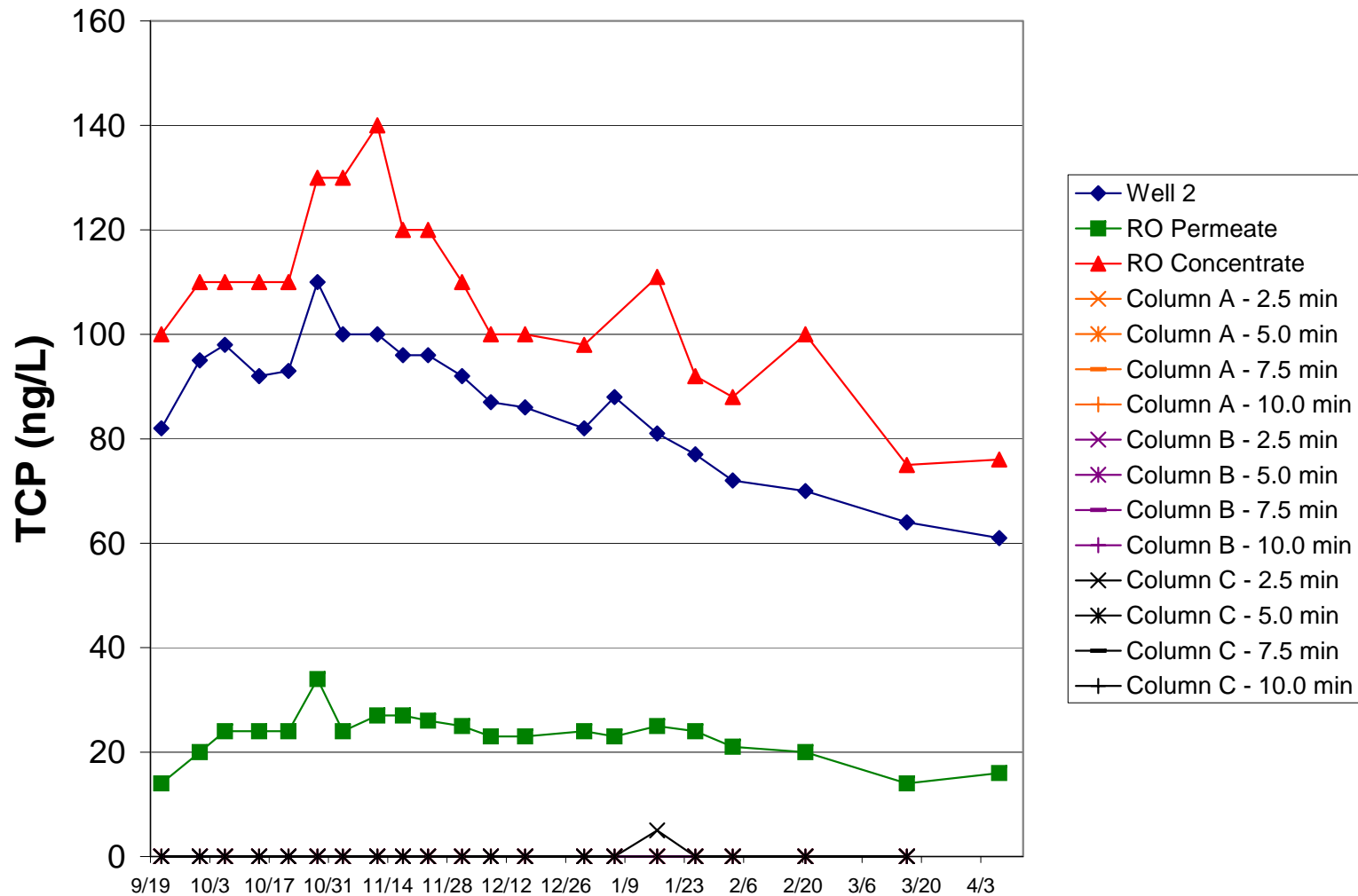
# Bench RO Experiments



# RO + GAC Pilot Testing



# Pilot Results



# Summary

- RO membrane technology does not adequately remove NDMA or TCP
- Use advanced treatment (GAC/UV)
  - Complete removal of NDMA precursors using RO
  - Good removal of NDMA using UV
  - Complete removal of TCP by GAC
  - Needed at most utilities to meet California notification levels

# Questions?

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***THANK YOU!***