GWRS
GROUNDWATER REPLENISHMENT SYSTEM

Orange County's Groundwater Replenishment System

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Outline

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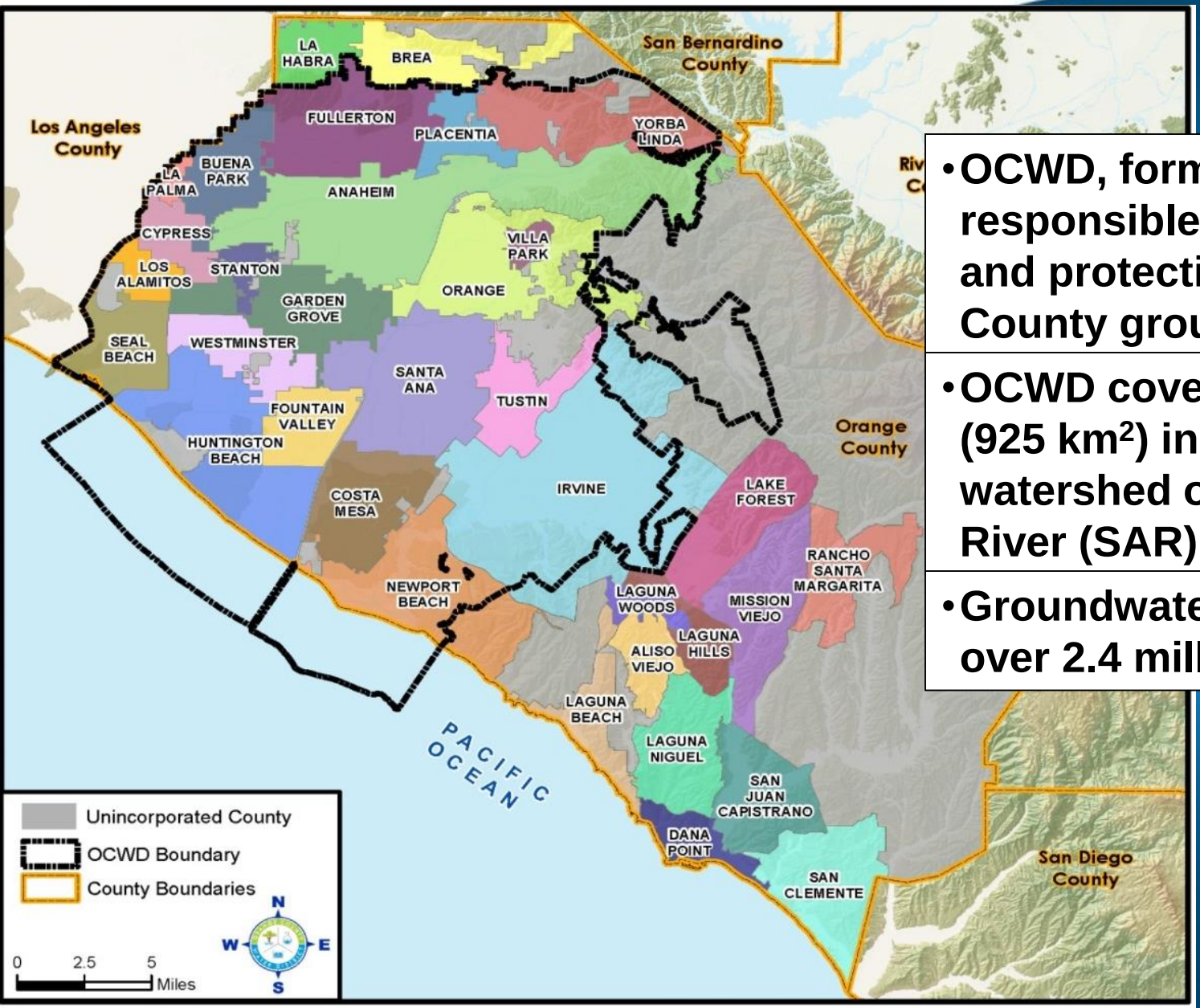
- Intro to OCWD & the Groundwater Replenishment System (GWRS)
- Source Control
- Monitoring & Water Quality
  - Pathogens
  - Chemicals
  - CECs
- Operations & Use of Critical Control Points (CCPs)
- Public Outreach
- Conclusions

Orange County Water District (OCWD)



- OCWD, formed in 1933, is responsible for managing and protecting the Orange County groundwater basin
- OCWD covers ~350 mi^2 (925 km^2) in the lower watershed of the Santa Ana River (SAR)
- Groundwater supply for over 2.4 million people

The Groundwater Replenishment System (GWRS)

GWRS
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- 100 million gallons per day (MGD) advanced water purification facility
- Influent is secondary-treated wastewater that would otherwise be discharged to the Pacific Ocean
- Provides a new 103,000 acre-feet per year source of water, which is enough water for nearly 850,000 people
- Operational since January 2008 (70 MGD)
- Initial Expansion on line in June 2015

GWRS Partnership

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OCSD

OCWD

Source Control

Primary Treatment

Secondary Treatment

Advanced Water Purification

Sewage

Reuse

Source Control

- Narrative requirement in GWRS Permit & DDW GRRP Regulations
- Commitment included in OCWD-OCSD GWRS Agreement
- Testing for DDW/SWRCB-specified wastewater contaminants
  - OCSD Lab – Raw Wastewater -> Secondary Effluent (WW Methods)
  - OCWD Lab – Secondary Effluent -> GWRS Final Product (DW Methods)
- Industrial discharge permitting recognizes potable reuse
- Chemical inventory of permitted industrial dischargers
- GIS/Database of “sewershed”
- Contaminant Source Investigations
- Outreach programs to public and industry

GWRS Advanced Water Purification Process

OCSD Secondary Effluent

Normally Goes to Ocean

Microfiltration (MF)

Backwash Sent to OCSD

Reverse Osmosis (RO)

Concentrate Disposal via OCSD Ocean Outfall

Ultraviolet Light (UV) with Hydrogen Peroxide

Seawater Barrier (36 injection well sites)

Recharge Basins in Anaheim

Rationale for Treatment Process Selection

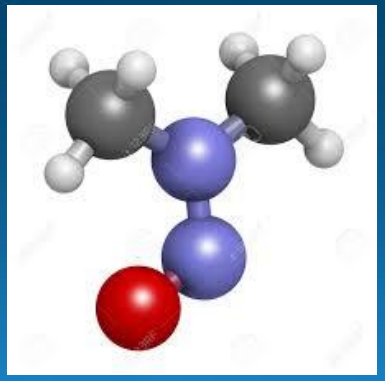
- 100% RO+AOP required for direct aquifer injection component
- Surface recharge component required >50% RO for RWQCB Basin Plan for salt & nutrient limits
- 100% RO+UV/AOP selected for multiple benefits
  - UV required for disinfection + NDMA
  - One unified treatment process for all flows
  - One common water quality for all recharge + injection
  - Greater overall salt reduction
  - Best available treatment for potable reuse

Control of Pathogenic Microorganisms

Pathogen	Minimum Log Reduction Requirements[1]	Pathogen Log Reduction Credits for GWRS					
		OCSD Plant 1	MF and Cl_2	RO	UV/AOP	Underground Retention Time	Total
Giardia cysts	10	0	4	2	6	0	12
Cryptosporidium oocysts	10	0	4	2	6	0	12
Viruses	12	0	1	2	6	3	12

- GWRS meets or exceeds the CA DDW 12/10/10 requirements for pathogen log removals (LRVs)
- LRVs established through demonstration testing, full-scale performance documentation, and allowances in specific regulations (e.g., retention time)
- LRVs tied to operating requirements/conditions documented in required Operation Optimization Plan (OOP)

Control of Chemical Risk



www.123rf.com/photo_25287747_n-nitrosodimethylamine-dimethylnitrosamine-ndma-dmn-pollutant-molecule-highly-toxic-especially-to-th.html

- Source control
- RO + UV/AOP removes/treats a wide range of chemicals
- Continuous online monitoring to verify performance
  - OOP document includes response plans for excursions
  - Use historical operations as baseline
- Regular laboratory testing for a wide range of chemicals
  - Comprehensive organic & inorganic testing <u>required quarterly</u>
  - More frequent individual unit process monitoring

GWRS Monitoring & Water Quality

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- DDW helped develop Regional Board permit requirements
- Test Final Product Water (FPW) quarterly for 400+ targets
  - Volatile Organic Compounds (e.g., industrial solvents)
  - Non-Volatile Synthetic Organic Compounds (e.g., pesticides)
  - Inorganics and metals (e.g., arsenic, lead, copper, nitrate)
  - Disinfection By-Products (e.g, TTHMs, HAAs, NDMA)
  - EPA Priority Pollutants
  - Pharmaceuticals and personal care products (PPCPs)
  - Endocrine Disrupting Compounds (EDCs)
- All results below permit limits or non-detect (ND)

Current OCWD CEC Monitoring Targets

Hormones	
Compound	**Type/Use**
17a-Estradiol	hair loss & hormone therapy
17a-ethynylestradiol	estrogen, contraceptive
17b-Estradiol	human sex hormone & steroid
4-androstene-3,17-dione	steroid hormone
Diethylstilbestrol	sythetic estrogen
Epitestosterone (cis-testosterone)	natural steroid
Equilin	horse estrogen, Premarin
Estriol	estrogen
Estrone	estrogen
Progesterone	steroid hormone

Personal Care Products & Other	
Compound	**Type/Use**
Aspartame	artificial sweetener
Bisphenol A	plasticizer
Caffeine	stimulant, food additive
N,N-diethyl-m-toluamide (DEET)	insect repellant
Neotame	artificial sweetener
Sucralose	artificial sweetener
Triclosan	antibacterial, antifungal
Tris-2-chloroethyl phosphate	flame retardant
NDMA	disinfection by-product

Pharmaceuticals	
Compound	**Type/Use**
Acetaminophen	analgesic medicine
Atenolol	beta blocker
Azithromycin	antibioitic
Carbamazepine	anticonvulsant
Diclofenac	anti-inflammatory (Volataren)
Dilantin	anti-convulsant
Erthromycin	antibioitic
Fluoxetine	anti-depression (Prozac)
Gemfibrozil	anti-cholesterol (Lopid)
Ibuprofen	anti-inflammatory (Advil, Motrin)
Iohexol	phase contrast media
Iopromide	phase contrast media
Meprobamate	anti-anxiety
Naproxen	anti-inflammatory (Aleve)
Primidone	anti-convulsant (Mysoline)
Sulfamethoxazole	antibioitic
Trimethoprim	bacteriostatic antibiotic

Covers original CDPH/DDW requirements + newer SWRCB CEC monitoring requirements

GWRS CEC Monitoring Results

- Quarterly Final Product Water (FPW) testing since 2008
  - Hormones & other EDCs never detected (RDLs = 1-2 ng/L)
  - Quantifiable detections of PPCPs are rare
  - NDMA: a bit more frequently detected, but consistently < 10 ng/L DDW NL
- Periodic assessments CEC removal by RO + AOP systems
  - CEC detections rare in RO permeate, similar to FPW
  - Paired AOP testing consistently ND
  - Loss of RO salt rejection w/ membrane age appears to generally precede loss of CEC rejection

Use of Critical Control Points (CCPs)

- Hazard Analysis and Critical Control Points (HACCP) concept
  - Designed to manage process risks vs. end of product/pipe testing
  - Widely applied to food & beverage industry
  - Water supply safety management by New Zealand, Australia, and WHO
- CCPs → steps/points where controls can be applied and measured
  - Have critical operating limits (ranges)
  - Response action(s) when process outside limits
- CCPs monitored w/ (semi)continuous online analyzers
  - Provide real-time feedback to operators
  - Generate large historical datasets on process performance
- CCPs included as voluntarily element in GWRS permit-required OOP via NWRI Independent Advisory Panel recommendation
- Compliments daily/weekly lab-analyzed process control monitoring

GWRS CCPs

- MF: Cl_2, turbidity, integrity (PDT), Δpressure (TMP)
- RO: Cl_2, Turbidity, EC, TOC
- UV/AOP: UV dose, power, transmittance
- Established response to deviations via OOP

Clear CCP Response Procedures

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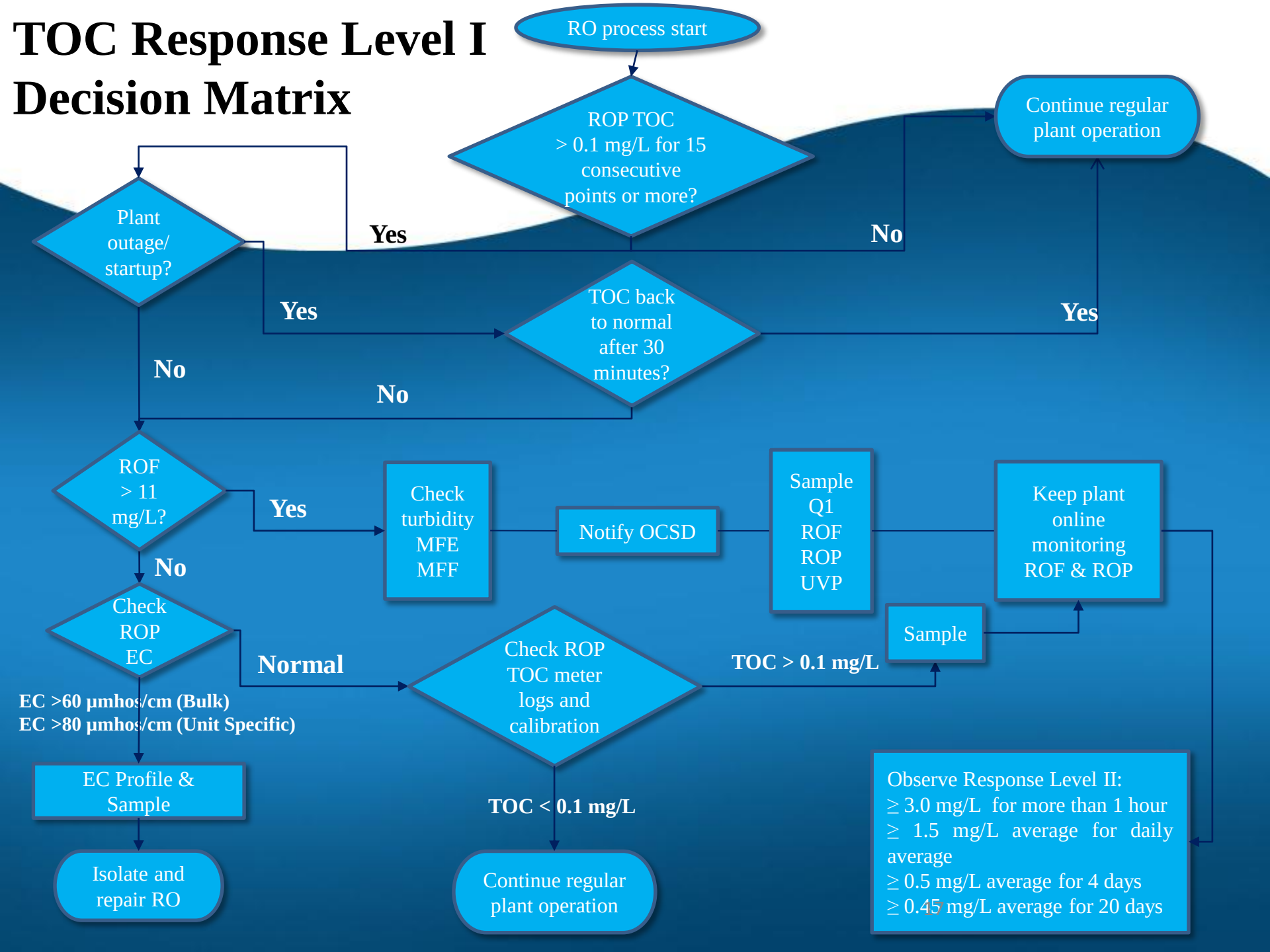
- Bulk RO Feed & Permeate analyzed for TOC every four minutes
- Make sure operators have clear response procedures to excursions

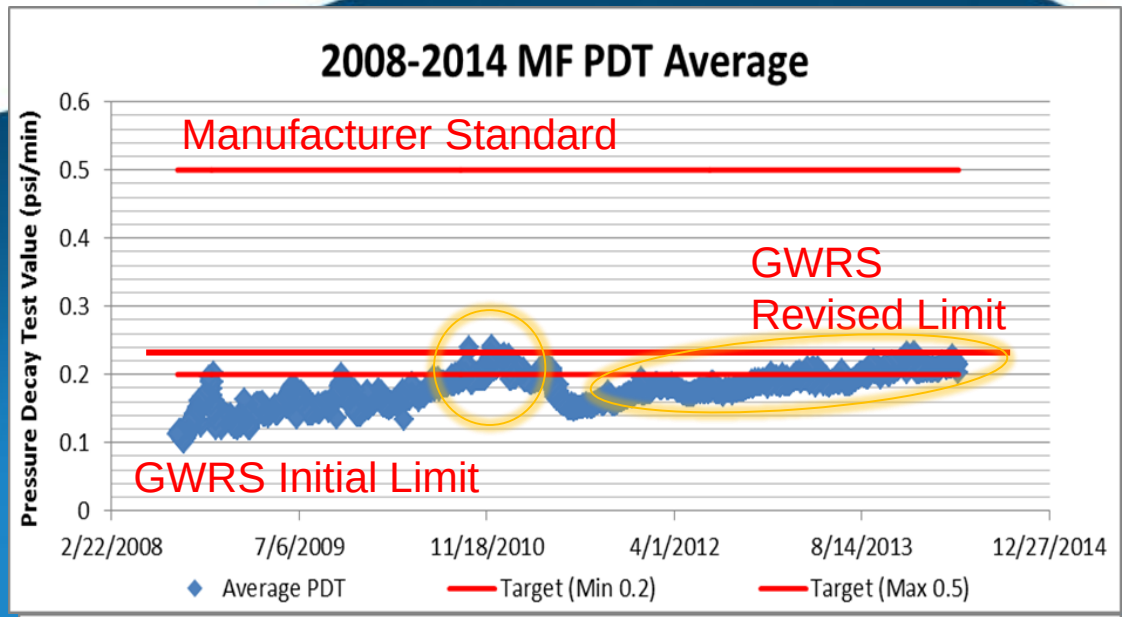
Response Level	ROP TOC (mg/L)	Duration	Response Type
I	0.10	1 hour	Investigate
II	3.00	1 hour	Shutdown
II	1.50	1 day	Shutdown
II	0.50	4 days	Shutdown
II	0.45	20 days	Shutdown

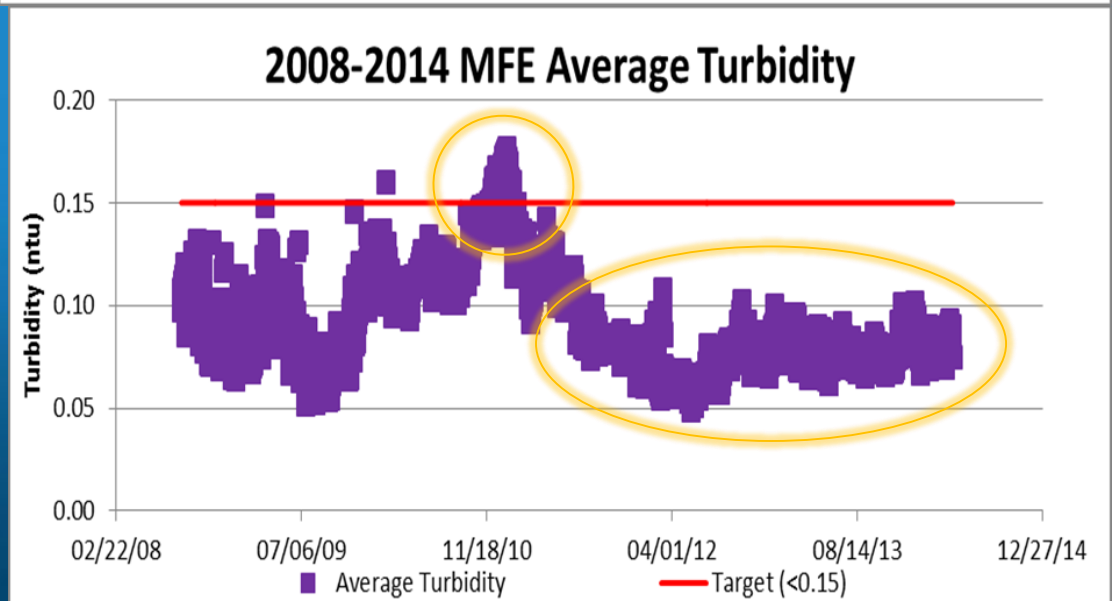
TOC Response Level I Decision Matrix



CCP Critical Limits

- CCP limits ≠ permit limits
- Make CCP limits (or equivalent) relevant and meaningful
- Continuous online data archive allows for powerful statistical analysis
- Periodic updates to limits important as facility ages





Public Outreach Key to GWRS Implementation

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

- No active opposition and support from:
  - 100% support from cities in OCWD service area
  - 100% support from OC state and federal elected officials
  - 100% support from Chambers of Commerce & OCBC
  - Many businesses including Edison and Sempra Energy
  - All major environmental groups
  - Several health experts, medical doctors, hospitals, pharmacists and scientists
  - Several key minority leaders
  - Educational, religious, police and fire leaders
  - More than 200 community groups like Kiwanis, Rotary, etc.
  - OC Tax, AARP, OC Farm Bureau and others

Conclusions

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- RO+AOP treatment is generally robust and reliable
- Commitment to source control is important
- Monitoring demonstrates & verifies performance
- CCPs can aid in reliable operations when coupled with clear response actions
- CCP limits can be updated periodically to remain relevant and take advantage of historical performance database
- Public outreach key to implementation & ongoing support

Thank you!

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A joint effort of the

Orange County Water District and Orange County Sanitation District