CALIFORNIA'S DRAFT CRITERIA FOR GROUNDWATER RECHARGE WITH RECYCLED WATER

Stakeholder Meetings
December 2011

Drinking Water Program
California Dept. of Public Health

Approach - General

- Present the overarching goals and principles behind the draft regulation
- Present the intent, approach, and supporting science for the individual sections
- Answer questions about intent and general approach

Presentation Outline

- Overview of Principals - Bob Hultquist
- General Requirements - Bob Hultquist
- Public Hearing, Lab Analysis & Source Control - Brian Bernados
- Pathogen Microorganisms - Bob Hultquist
- Nitrogen and Regulated - Brian Bernados
- Unregulated Chemical Control Overview, TOC, RWC & Diluent Water - Bob Hultquist

Short Break

Presentation Outline, cont.

- Unregulated Chemical Control Indicators, Surrogates and FAT - Brian Bernados
- Additional Constituents, Optimization and Operations Plan - Brian Bernados
- Response Time - Bob Hultquist
- Monitoring Well, Reporting - Bob Hultquist
- Alternatives, Engineering Report and Summary - Bob Hultquist

Principles

- Replenish groundwater (GW) basins used as drinking water sources
- Low tolerable risk
  - One in 10,000 (10^{-4}) annual risk of infection from Pathogenic Microorganisms
  - Drinking water standards
  - Unregulated chemical control
- No degradation of an existing water source
- Multiple barriers

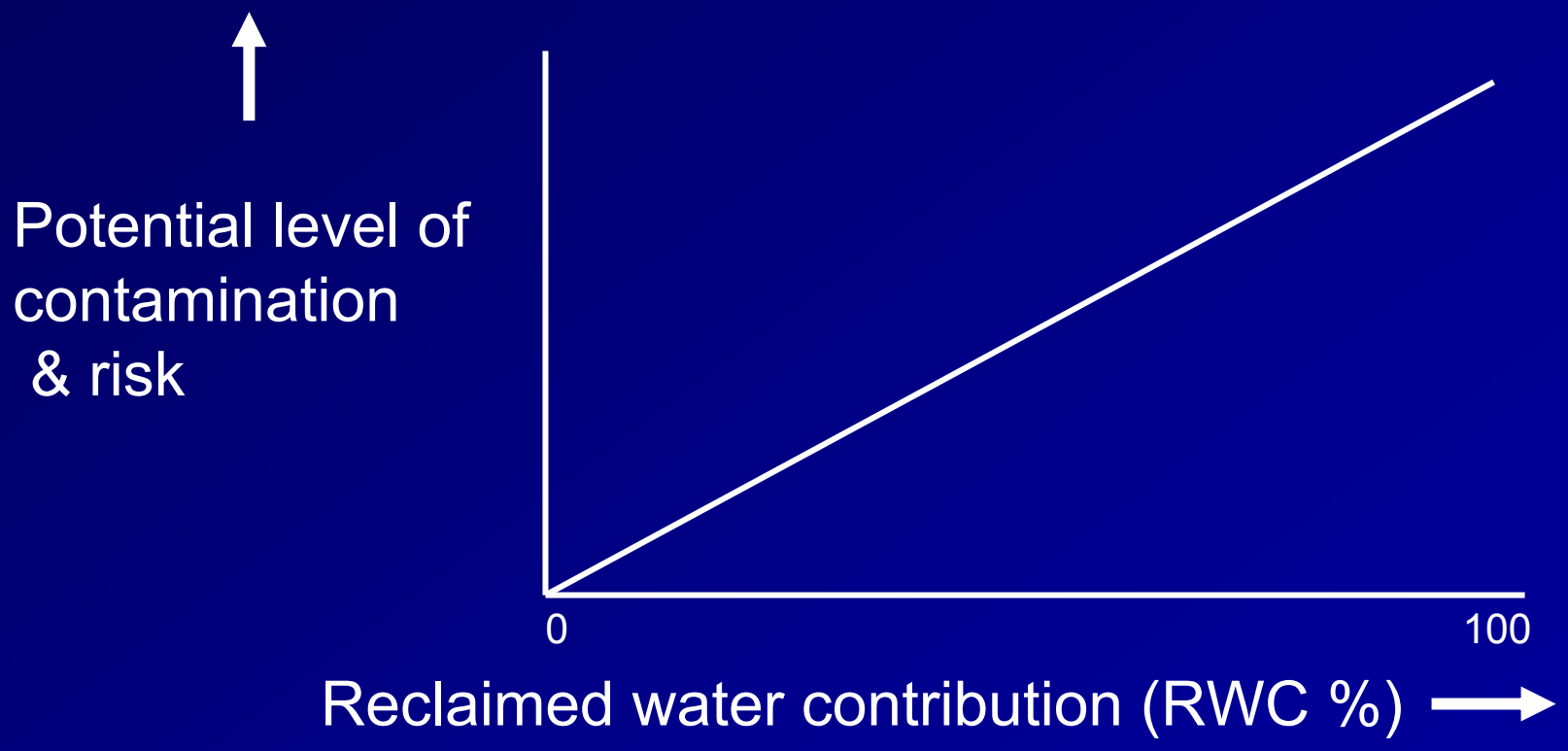
Groundwater Protection Challenges

- If there is contamination, it could persist
- Plumes may be difficult to track
- In a large aquifer, there may be numerous dispersed wells and it may not be feasible to provide treatment to each
- There may be individual residence wells or business wells

Indirect Potable Reuse

- Make a source of drinking water
  - not drinking water
  - not direct potable reuse
- Storage in an aquifer
- Some natural treatment
- Time to identify and respond to a treatment failure

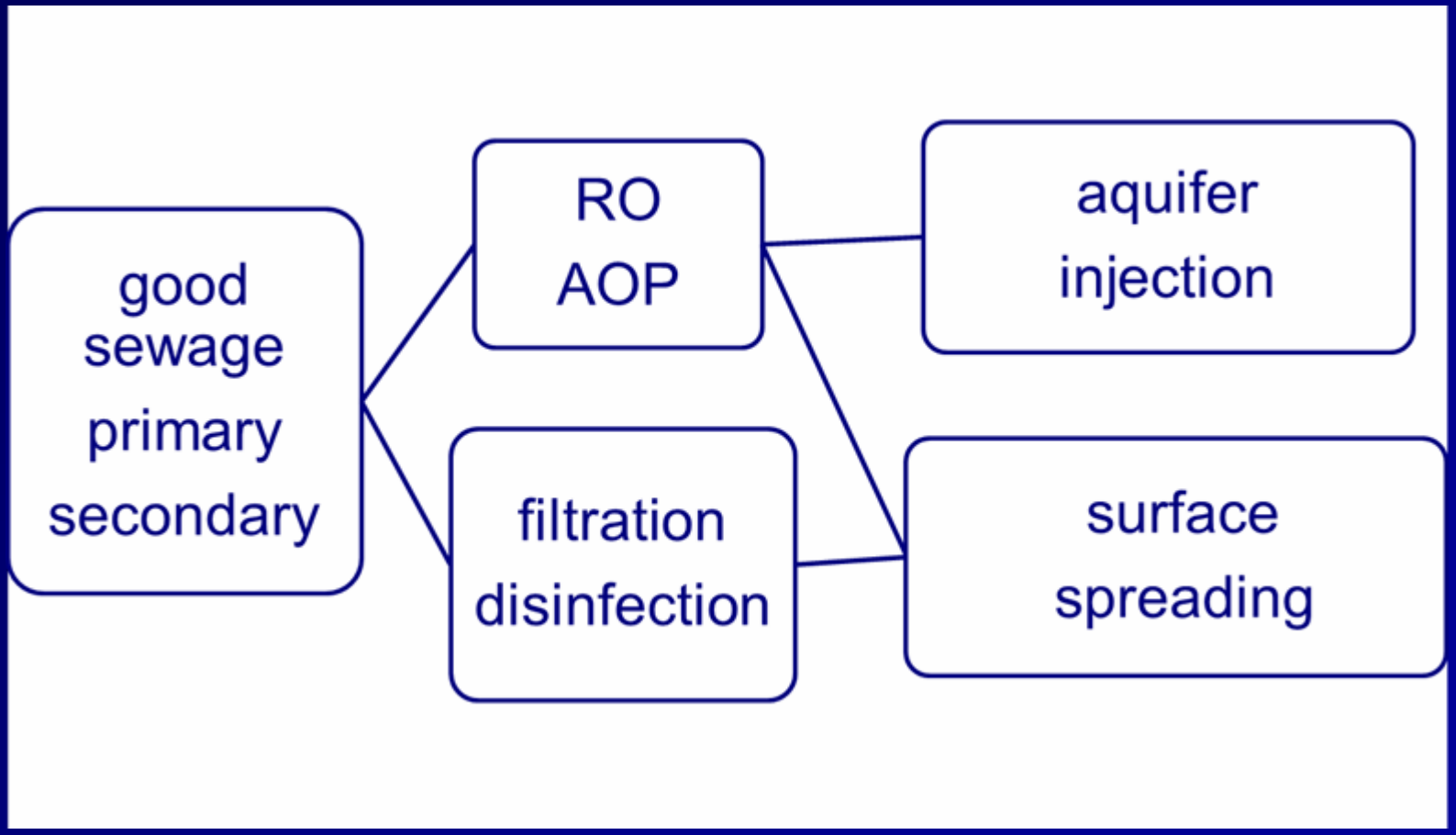
Degrees of Indirect Potable Reuse



Project Types

- Organize criteria by method of recharge to simplify identifying relevant requirements
- Surface spreading w/o full advanced treatment (FAT) – Article 5.1
  - Scheme relies on soil aquifer treatment (SAT)
- Subsurface application – Article 5.2 (FAT required)
  - FAT is continuous advanced treatment of the entire flow
- Surface spreading with FAT – Article 5.3

Schemes


good
sewage
primary
secondary
RO
AOP
filtration
disinfection
aquifer
injection
surface
spreading

Groundwater Replenishment Reuse Project (GRRP) 60301.390

- A GRRP is a project using recycled municipal wastewater
  - for the purpose of replenishment of groundwater that is designated a source of water supply in a Water Quality Control Plan, or
  - which has been identified as a GRRP by the RWQCB

General Requirements 60320.100 & 200

a. The type of project that must comply with the Article
b. Plan for alternative source of potable water or remedial treatment in case GRRP causes an unsafe source
c. Benchmark sampling
d. Hold recycled water underground long enough to meet requirements of pathogen barrier (if needed) and response time requirements

General Requirements - 2

e. Map showing
   - The GRRP facilities
   - Monitoring and drinking water wells
   - The boundary within which certain requirements are not met (more later)

f. New GRRPs demonstrate managerial and technical capacity to meet requirements

g. Commissioning tests

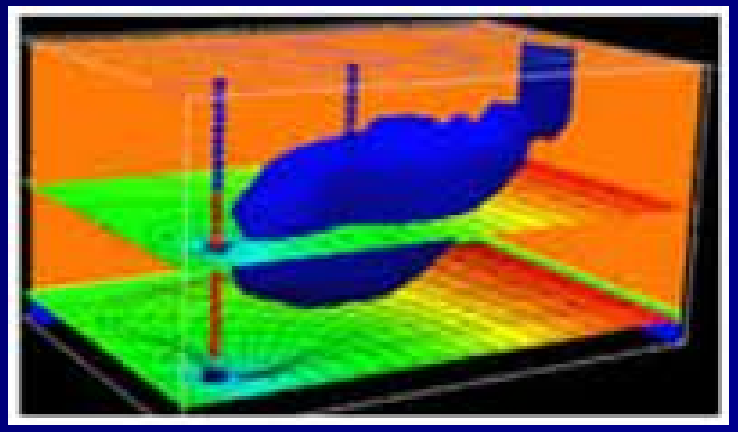
h. Hydrogeological assessment

Boundary for Groundwater recharge

- The boundary is the downgradient limit of the zone around the recharge site necessary to meet all requirements
  - The time required to provide the pathogen barrier (if needed)
  - The time to react to a treatment failure
  - The time to achieve effective soil-aquifer treatment
  - RWC compliance, if necessary

Boundary - 2

- The boundary may be complex in three-dimensions due to different water velocities in different aquifers



- Within the boundary, water may not be withdrawn as an unimpaired drinking water source

Public Hearing 60320.102 & 202

- Intent - to foster informed comment by the public
- Hearing held by the project sponsor prior to:
  - New project
  - A higher recycled water contribution
- Present information on the project
  - Made public before hearing
  - Must be provided via the Internet
  - Approved by the Department
- At least 30 days prior to the hearing, Post on the Internet and Notify public & down-gradient well-owners of the hearing

Lab Analyses 60320.104 & 204

- Department approved labs for constituents that have maximum contaminant levels (MCLs)
- That means labs accredited by the CDPH Environmental Lab Accreditation Program (ELAP)
- CDPH approved drinking water methods for MCLs assure low detection levels
- Analyses for chemicals without MCLs shall be described in the Operations Plan

Source water control 60320.106 & 206

- A pollutant source control program beyond typical industrial pretreatment that includes
  - an assessment of the fate of Department-specified contaminants,
  - contaminant source investigations and contaminant monitoring
  - an outreach program to industrial, commercial, and residential for the purpose of managing and minimizing the discharge of contaminants

    nodrugsdownthedrain.org
  - an up-to-date inventory of contaminants discharged into the wastewater collection system so that new contaminants of concern can be readily evaluated

Pathogenic Microorganism Control 60320.108 & 208

- Intent – ensure that pathogens will not exceed the tolerable risk dose in drinking water

- Approach - set a log reduction requirement from raw sewage to useable groundwater
  - –12-log Virus
  - –10-log *Giardia* cysts
  - –10-log *Cryptosporidium* oocysts

Pathogenic Microorganisms - 2

- Start from:
  - For virus and *Giardia* - Water Reuse (Asano et al, 2007) Table 3-9, high end of range
  - For *Cryptosporidium* use high (and rounded up) levels from studies in Melbourne and Norway
- End point is USEPA allowable drinking water density (modified for Cryptosporidium infectious dose and exposure)
  - One in 10,000 (10^{-4}) annual risk of infection goal

Multi-barrier Pathogen Control

- 3 separate barriers for reliability
- A project may select a set of treatment and retention time barriers to meet the log reduction value (LRV) required
- Title-22 Filtration/disinfection required only for surface spreading projects w/o FAT
- 1-log ≤ individual barrier LRV ≤ 6-log
  - Significant barriers
  - Barriers that can be validated

Barrier Validation

- Must validate each of the treatment processes used to meet log reduction, except for retention time underground
  - Demonstration report,
  - Or a challenge test
  - Either must provide evidence of the treatment process's log reduction.
- Operations Plan must specify on-going monitoring to verify performance of each treatment process's ability to achieve its credited log reduction

Barriers - 2

- Retention time barrier
  - 1-log virus reduction for each month of subsurface retention
    - Yates et al 1985
  - Verify with added or approved intrinsic tracer study
    - retention time is the time for first two percent (2%) to arrive
  - Limit on credit prior to added tracer study (see table)
  - For spreading projects,
    - full Log reduction requirement for *Cryptosporidium* and *Giardia* is met when 6-month retention it met

Methods to Determine LRV

Planning and Engineering Report Effort vs. LRV			
Method	General Accuracy	General Level of Effort	Log Virus per month
Formula (Darcy's)	Poor	limited info on aquifer	0.25
3-D model	Fair	A lot of info on aquifer	0.50
Intrinsic Tracer	Better	quantify existing indicators	0.67
Added Tracer	Best Available	track added Tracer (T_2)	1.0

Pathogenic Microorganisms - 3

- Failure to meet an LRV - consequences
  - Investigate, correct problem, and notify for a failure to meet the total log reduction
  - Shut down if the virus LRV is less than 9-log or the Giardia or Cryptosporidium LRVs are less than 8-log

Nitrogen Compound Control 60320.110 & 210

- Goal is to preclude exceeding the nitrite or nitrate MCL
- Collect 2 samples each week, at least 3 days apart
- Comply in effluent or in recharge water
- Limit =10 mg/L as N - average of 2 consecutive samples
  - If > 10 mg/L total N, consequences include:
    - Notify CDPH & RWQCB
    - Monitor, investigate and take actions
- If average of 4 consecutive samples >10 mg/L total N, suspend application
- Provisions allow for reduced monitoring in future

Regulated Chemicals 60320.112 & 212

- A chemical or physical drinking water standard must be met:
  - In the plant effluent
  - Or recharge water (accounting for dilution)
- Quarterly testing for chemicals with primary MCL
- Annual testing for chemicals with secondary MCL
- Consequences for exceeding standard:
  - 4 conditions specified
  - Including resampling to confirm
  - Responses to exceedance

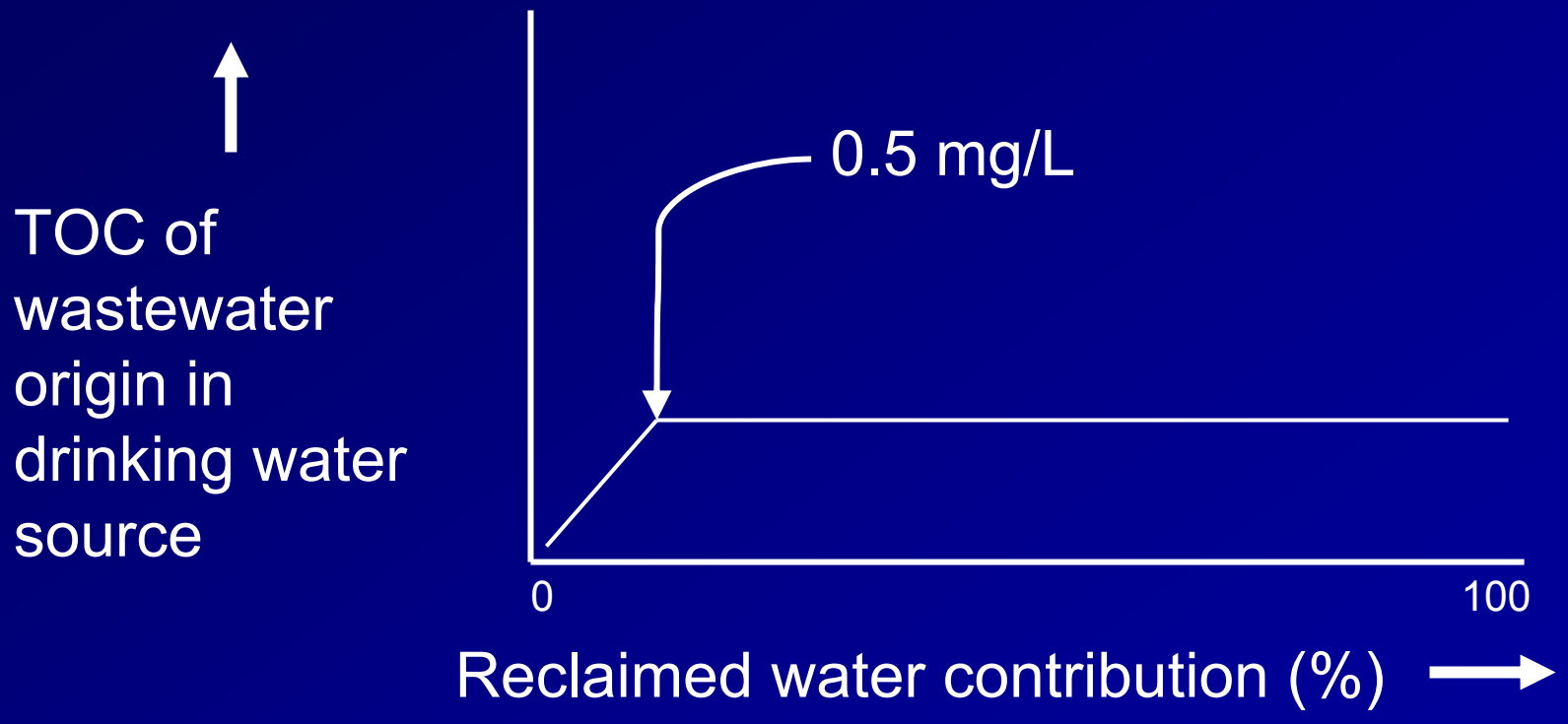
Unregulated Chemical Control Overview

- 60320.114 , 116, 118 and 201, 214, 216 & 218
- The Diluent Water, Recycled Water Contribution (RWC), Total Organic Carbon (TOC) and Soil Treatment Process (SAT) Requirements, and Advanced Treatment Criteria sections work in concert to limit the concentration of any potentially harmful unregulated or unknown chemical.
- TOC used as a surrogate for the unknown organic chemicals

Unregulated Chemical Control - 2

- A limit of 0.5 mg/L for TOC from recycled water in the groundwater ensures effective treatment and/or dilution is used
  - Ensure use of best RO membranes with excellent organic chemical removal
  - Gets soil treatment projects to a recycled water TOC comparable to projects found to be safe

TOC equation intent



Unregulated Chemical Control - 3

For spreading projects,

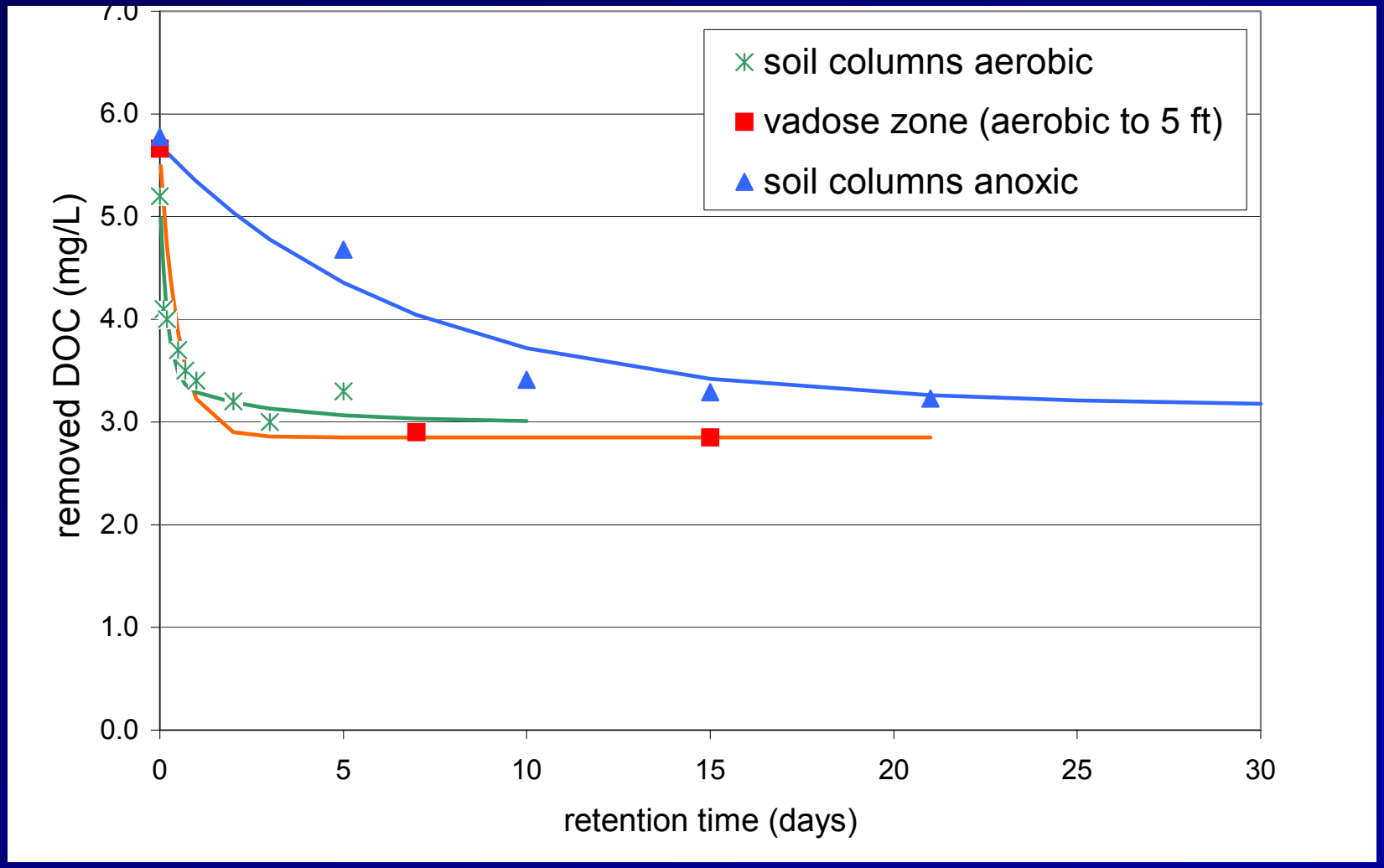
- Reclaimed water compliance calculation:

  $$TOC \leq (0.5\ mg/L) / (RWC)$$

  allows a GRRP to balance treatment and dilution as needed to comply
- SAT alone cannot meet the 0.5 mg/L TOC level (due to the non-biodegradable TOC fraction) and must be supplemented with dilution
- Can treat a portion of the flow to reduce TOC and increase the RWC

FAT projects must meet 0.5 mg/L in the RW

Soil Treatment (Peter Fox)



Recycled Water Contribution 60320.116 and 216

$$\frac{\text{(reclaimed water flow)}}{\text{(reclaimed water + diluent water flow)}}$$

- RWC must be met each month using the previous 120 months of data
  - Chronic exposure threat
  - Extended drought
- RWC calculations begin after 30 months
- Meet RWC everywhere beyond the boundary

Recycled Water Contribution - 2

- The initial maximum RWC for a GRRP is set by CDPH based on information provided in the engineering report and as a result of the public hearing
- Initially, shall not exceed 0.20 for projects w/o FAT
- FAT project initial RWC as justified
- May increase the RWC above the initial value if:
  - Increase approved by CDPH and RWQCB
  - For previous 52 weeks, the 20-week running average TOC ≤ (0.5 mg/L)/(RWC proposed)
  - Receive permit from RWQCB

Recycled Water Contribution - 3

Spreading projects only

- Prior to operating a GRRP at an RWC greater than 0.50 or 0.75, project sponsor must:
  - Provide proposal to CDPH prepared & signed by PE with 3 years experience in RW & potable
  - For previous 52 weeks, the 20-week running average TOC ≤ (0.5 mg/L)/(RWC proposed)
  - Submit updated engineering report and Operations Plan
  - Show that monitoring wells are located properly and receiving recharge water

Diluent Water 60320.114 & 214

- Diluent water quality must meet primary MCLs and NLs
  - Use approved potable water source
  - Or GW or stormwater if a source water evaluation is done
- Quantity to be used in the RWC calculation must be identified such that:
  - The diluent and recycled water must be in the correct proportions (RWC) over the compliance averaging period

TOC and Soil Treatment 60320.118 & 218

- TOC ≤ (0.5 mg/l) / (RWC)
  - For spreading projects
    - In the recycled water, or
    - After soil treatment but not influenced by dilution (otherwise would benefit from dilution twice)
    - Mound or lysimeter
    - 3 options to avoid dilution confounding the result
  - In the recycled water for FAT projects
  - Not to exceed on 20 week running average or the average of the last 4 weekly TOC results

BREAK

Framework Using Indicators and Surrogates

- Goal is to develop a monitoring program of specific chemicals indicators and surrogates
- "Monitoring Strategies for CECs in Recycled Water Recommendations of a Science Advisory Panel Convened by the SWRCB"
- Work by Shane Snyder & Jorg Drewes
- WateReuse 03-014, Drewes, Sedlak, Snyder, Dickenson - "Development of Indicators and Surrogates for Chemical Contaminant Removal during Wastewater Treatment and Reclamation"
- Environmental Sci. Technol. 2009, 43, 6242–6247

Monitoring Strategies for CECs in Recycled Water Recommendations of a Science Advisory Panel Convened by the SWRCB

- “changes in bulk parameters do correlate with changes of indicator chemicals”
- “Thus, to ensure proper performance of unit operations regarding the removal of CECs, a combination of appropriate surrogate parameters and performance indicator CECs should be selected that are tailored to monitor the removal efficiency of individual unit processes”
- Defines surrogate/indicator framework

“The selection of a practical set of indicator compounds is driven by . . .

- “. . . treatment performance and less so by toxicological relevance.
- Thus, selecting multiple indicators representing a broad range of properties will allow accounting for compounds currently not identified (“unknowns”) and new compounds . . .
- The underlying concept is that absence or removal of an indicator compound during a treatment process would also ensure absence or removal of unidentified compounds with similar properties.”
- 2 phases: piloting/start-up and full-scale
- Suggests a 5-step process

Soil Treatment 60320.118 f

- Indicators of the effectiveness of SAT must be identified and measured
- Pick at least 3 relevant indicators based upon an occurrence study approved by CDPH
- Monitor quarterly
  - prior to SAT and
  - no more than 30 days downgradient
- If a 90% reduction (excluding the effect of dilution) is not demonstrated
  - investigate
  - and report

SAT - Indicator Compound Examples for Soil Treatment Process (from WRF 03-014)

SAT removes > 90% of these:

- Acetaminophen
- Atenolol
- Atorvastatin (Lipitor)
- Bisphenol A
- Caffeine
- DEET
- Diclofenac
- Erythromycin–H_2O
- 17β-Estradiol (E2)
- Estriol (E3)
- Estrone (E1)
- Fluoxetine (Prozac)
- Gemfibrozil
- Hydrocodone (Vicodin)
- Ibuprofen
- Iopromide
- Ketoprofen
- Metoprolol (Lopressor)
- Naproxen
- Nonylphenol
- Propranolol

Indicator Compounds For Verifying Location of Monitoring Wells

(from WRF 03-014)

SAT removes < 25% of these:

- Carbamazepine
- Dilantin
- Primidone
- TCEP
- TDCPP
- TCIPP

SAT removes more than 25% but < 50% of

- Chloroform

SAT removes more than 50% but < 90% of

- Meprobamate

Advanced Treatment Criteria

- Goal is to remove the organic chemicals that may pose a health threat
- Continuous treatment of the entire flow with Reverse Osmosis (RO) and Advanced Oxidation Process (AOP)
- RO permeate is free of almost all organics
- AOP used to degrade any that pass through RO (NDMA & 1,4-dioxane) including unknown chemicals and
- AOP provides multi barrier treatment
  - 1998 report by NRC - potable reuse should include multiple, independent barriers to organic chemical contaminants

Advanced Treatment 2008 vs. 2011

- 2008 advanced oxidation treatment to provide treatment equivalent to
  - a 1.2 log NDMA reduction and
  - a 0.5 log 1.4-dioxane reduction
  - Received comments regarding Ozone / H_2O_2
- 2011 advanced oxidation to provide
  - NDMA reduction to NL and
  - 1.4-dioxane reduction to NL
  - 2 options to design AOP
  - Ozone may be more attractive in some cases

Section 60320.201 a

- “A GRRP shall use a reverse osmosis membrane that:”
- (1) “utilizing ASTM method D4194-03 (2008), achieves an average rejection of NaCl > or = 99.5 % with a 15% recovery”
- “(2) through bench-scale testing conducted pursuant to section 60320.200(g), initially produces a permeate having TOC concentrations of 0.25 mg/L or less.”

Section 60320.201 b
Potential RO Surrogates

- "on-going performance monitoring (e.g. conductivity or TOC) that indicates when the integrity of the process has been compromised. "
- Online continuous
  - Conductivity
  - Low-level TOC
  - UV absorbance
  - Sulfate
  - Nitrate
  - Ammonia
  - Sucralose?

RO Effectiveness

- RO is effective at removing large and/or ionic compounds via:
  - Size exclusion
  - Electrostatic repulsion
  - Adsorption phenomena
- Most CECs are large organic molecules with a MW > 250 and are well removed; however,
- RO is less effective at removal of small non-ionic, neutral compounds
  - NDMA
  - chloroform
  - 1,4-dioxane

Indicators Detected After RO (a Few Times @ Very Low Levels:)

4-nonylphenol	Acetaminophen
Bisphenol-A	Caffeine
Carbamazepine	Clofibric acid
DEET	Diclofenac
Estradiol	Galaxolide
Gemfibrozil	Ibuprofen
Ketoprofen	Meprobamate
Musk ketone	Oxybenzone
Primidone	Sulfamethoxazole
Triclocarban	TCEP

other fire retardants TDCPP & TCIPP

Advanced Oxidation Process (AOP)

- AOP can reduce organics that pass RO
- Especially 2 contaminants with NLs
  - NDMA reduction
    - NDMA has a small MW of 74
    - Concentration varies, but always detected
    - Passes through RO and requires AOP
  - 1,4-dioxane reduction
    - 1,4-dioxane has MW of 88
    - Passes through RO and requires AOP

UV AOP & 1,4-dioxane

- While NDMA is generally photoliable, 1,4-dioxane is not, so UV can not photolyze 1,4-dioxane well
- The addition of H_2O_2, creates hydroxyl radicals to meet the 0.5-log reduction of 1,4 dioxane, which is photostable.
- BUT what is the optimum dose?
- It is currently difficult to quantify hydroxyl radicals, as they are very reactive and short-lived.
- Recent research has shown chloramine residual may be a surrogate

2 Options for AOP 60320.201 c & d

- Similar to the previous approach
  - Design using 0.5-log reduction of 1,4-dioxane to determine the equipment size and dose for AOP
- OR new approach based on SWRCB SAP
  - Utilize an oxidation process that achieves optimal removal of many indicator compounds.
  - Establish at least one surrogate or operational parameter that reflects the removal of at least five of the nine indicator compounds selected . . .
  - Uses chemical structures and functional groups of indicator compounds

First Option for AOP 60320.201 c

- Based upon latest research, such as
- Environ. Sci. Technol. 2009, 43, 6242–6247
- *Applying Surrogates and Indicators to Assess Removal Efficiency of Trace Organic Chemicals during Chemical Oxidation of Wastewaters*
- By Dickenson, Drewes, Sedlak, Wert & Snyder
- "Potential surrogate parameters and indicator compounds, identified by reviewing previous publications and classified by their structural properties, were tested in pilot- and full-scale treatment systems."

AOP Removal> 90% of Most Indicator Compounds Removal Categories / Structure

(A) Hydroxy Aromatic

Acetominophen, Bisphenol A, Estrone, Triclosan

(B) Amino/Acyl amino Aromatic

Atorvastatin, Sulfamethoxazole

(C) Nonaromatic C=C

Carbamazepine, Codeine, OTNE

(D) Deprotonated Amine

Atenolol, Caffeine, Diclofenac, Trimethoprim

(E) Alkoxy Polyaromatic – Naproxen, Propranolol

(F) Alkoxy Aromatic – Gemfibrozil, Hydrocodone

(G) Alkyl Aromatic

DEET, Dilantin, Ibuprofen, Primidone

AOP <90% Removal of Some Indicator Compounds Removal Categories / Structure

Typical Expected Intermediate Removal 50-90% using ozone

- (H) Saturated Aliphatic
  - Iopromide
  - Meprobamate
- (I) Nitro Aromatic
  - Musk ketone
  - Musk xylene

For UV / H_2O_2

- Removal of Meprobamate is 20-50%

AOP Optimal Removal

- 0.5-log (69%) for each indicator in the functional groups in (1)(A) through (1)(G) – [good removal], and
- 0.3-log (50%) for each indicator in the functional groups in (1)(H) and (1)(I) [intermediate removal].
- at least one surrogate or operational parameter that reflects the removal of 5 of 9 indicator groups
  - at least one of the five indicators represents at least one functional group in (1)(A) through (1)(G),
  - at least one of the five indicators represents at least one functional group in (1)(H) or (1)(I),
  - at least one surrogate or operational parameter is monitored continuously

Example Application of surrogate/indicator framework to an treatment processes

Step 1 - Conduct occurrence study of indicators in the feedwater; one for each of the 9 groups.

[e.g., Acetominophen, Atorvastatin, Carbamazepine, Caffeine, Naproxen, Gemfibrozil, DEET,

Meprobamate, Musk ketone]

Step 2 - Define conditions for proper operation

[size, dose, flow, etc.]

Step 3 - identify those surrogate or operational parameters with a measurable removal –

[e.g., UVA_{254}, fluorescence,

chloramine residual, or ozone residual]

Example Application of surrogate/indicator framework to an overall treatment train

Step 4 – Submit test protocol.

Conduct piloting by spiking or monitor for detectable indicators (5 of 9 groups) to determine the removal differentials under normal operating conditions.

[e.g., DEET, Meprobamate, Caffeine, Acetominophen, BPA]

Step 5 - Confirm operational conditions of full-scale, monitor surrogate / operational parameters; and monitor differential of selected indicator on a regular basis

[for good or intermediate removal depending on functional group]

2nd Option for AOP 60320.201 d

- Conduct pilot testing demonstrating that AOP will provide a 0.5-log (69%) reduction of 1,4-dioxane.
- Submit pilot testing protocol to CDPH for review. Pilot testing shall include challenge or spiking tests, using 1,4-dioxane, to demonstrate the 0.5-log reduction
- Establish surrogate and/or operational parameters that show the 0.5-log 1,4-dioxane design criteria is being met.
  - Dose
  - Chloramine residual
  - other
- At least one surrogate or operational parameter shall be capable of being monitored continuously

60320.201 e, f, and g

e) During the full-scale operation of the AOP, continuously monitor the surrogate and/or operational parameters established.

f) Within 60 days after completing 12-months of monitoring submit a report on AOP
   - Monitoring results
   - Removal differential of indicators
   - Efficacy of the surrogate and/or operational parameters to reflect the removal differential of the indicator compounds
   - actions taken, etc.

g) Similar type of report on RO performance

60320.201 h and i

h) Quarterly, tabulate the % that did not meet the surrogate and/or operational parameter limits that assure proper performance of RO and AOP. If > 10%, within 30 days after the end of the quarter:

1) submit a report describing the corrective actions planned or taken
2) consult with CDPH and, if required, comply with an alternative monitoring plan approved by CDPH

i) Monthly collect grab samples after RO/AOP and analyze for all MCLs & NLs. If no exceedances, may apply for less monitoring after 12 mo.

Additional Constituent Monitoring 60320.120 & 220

Recycled municipal wastewater & monitoring wells

- Quarterly for chemicals
  - Priority Toxic Pollutants,
  - Chemicals with notification levels,
  - Any specified by CDPH based on source control
  - May reduce to annual after review of 2 years data
- Annually for constituents indicating the presence of municipal wastewater as specified by the Department

Operation Optimization and Plan 60320.122 and 220

- Intent – to assure that the facilities are operated:
  - To achieve compliance with requirements
  - In a manner consistent with the project engineering report and findings of fact
  - To achieve optimal reduction of contaminants
  - Identify monitoring and analytical methods
- An operations plan must be up-to-date and receive approval

Response Retention Time 60320.124 & 224

- Intent – that inadequately treated recycled water not enter a potable water system in the event of a treatment failure
- Between the recharge and extraction of the water, sufficient time must elapse to allow for:
  - The identification of any treatment failure
  - A response that will protect the public from exposure to inadequately treated water
    - Provide alternative source of water
    - Remedial treatment at the wellhead

Response Time - 2

- The time is the aggregate of the period:
  - Between treatment verification samples or measurements
  - To make the measurement or analyze the sample
  - To evaluate the results
  - To make a decision
  - To activate the response
  - For the response work

Response Time - 3

- Retention time
  - Verify with added tracer study
  - Limit on credit prior to added tracer study
- Minimum 2 months
  - Less than 2 months is not credible given the uncertainty in the failure identification, SAT monitoring, response effectiveness, and institutional procedures
  - This is not direct potable reuse
  - Should not infer that 2 months will be readily approved

Methods to Determine Retention Time to drinking water wells

Planning and Engineering Report Effort vs. Time			
Method	General Accuracy	General Level of Effort	Time multiplier
Formula (Darcy's)	Poor	limited info on aquifer	0.25
3-D model	Fair	A lot of info on aquifer	0.50
Intrinsic Tracer	Better	quantify existing indicators	0.67
Added Tracer	Best Available	track added tracer	1.0

Monitoring Well 60320.126 & 226

- Location/construction
  - 2 weeks to 6 months travel time in the saturated zone downgradient to give chemical/physical processes a chance to work
  - 30 days upgradient of well to give some warning
  - Be able to sample each aquifer
  - Must be getting recycled water
- Monitoring
  - Benchmark and each quarter for listed chemicals plus others specified by CDPH

Reporting 60320.128 & 228

- Intent – to assure that the CDPH, Water Boards, and Public Water Systems with proximate wells are informed of the state of compliance with requirements
- Annual report on compliance and exceptions
- Updated Engineering Report every five years

Alternatives 60320.130 & 230

- Intent - to accommodate unforeseen or yet to be approved methods of meeting the intent of a requirement
- Demonstrate “at least the same level of protection to public health”
- May be proposed for ANY requirement
- Evaluation by an independent panel of experts probably required

Engineering Report
60323

- Intent – that the CDPH and Water Boards will have sufficient information to evaluate and permit the recharge project
- A report that:
  - Describes the project facilities and shows how each requirement will be met
  - Includes a contingency plan that assures that inadequately treated wastewater will not be delivered to the use area

Articles in Summary

- 5.1 Surface Spreading w/o FAT – SAT
  - RWC critical
- 5.2 Subsurface – FAT
  - 100% RWC possible
- 5.3 Surface with FAT
  - 100% RWC possible
  - Possible reduced monitoring
  - Other regulatory benefits?

ANCRONYMS

AOP	advanced oxidation process
CDPH	California Department of Public Health
CEC	compound of emerging concern
FAT	full advanced treatment
GRRP	Groundwater Replenishment Reuse Project
GW	groundwater
LRV	log reduction value
MCLs	maximum contaminant levels
MW	molecular weight
NL	notification level
NRC	National Research Council
RO	reverse osmosis
RWC	recycled water contribution
RWQCB	Regional Water Quality Control Board
SAT	soil aquifer treatment
T_2	The retention time when the first two percent (2%) of recharge water arrives at the downgradient endpoint.
TOC	total organic carbon
UV	ultra-violet