Overview: Assessing performance of treatment for CECs

R. Rhodes Trussell

Trussell Technologies, Inc.

CALIFORNIA Water Boards

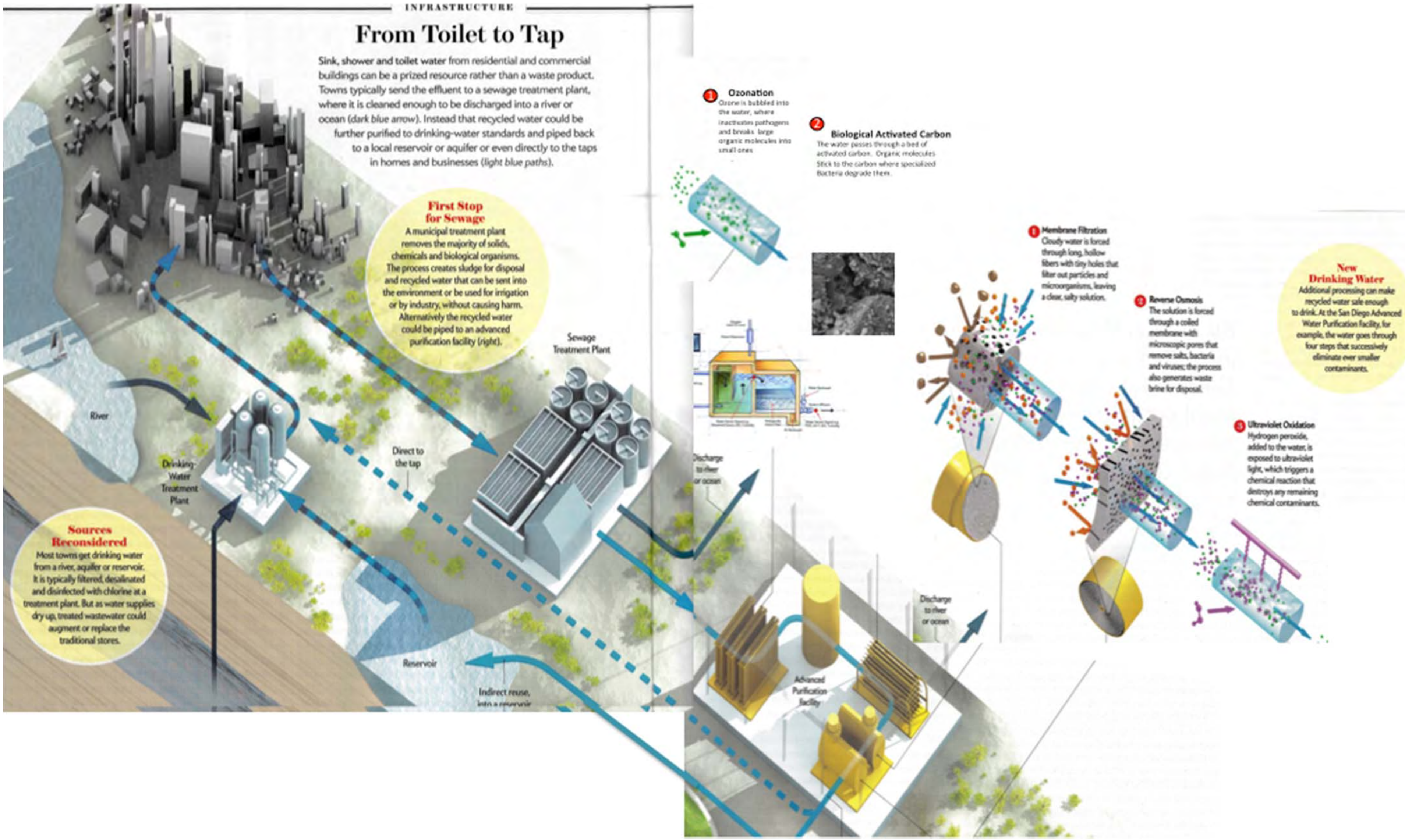
STATE WATER RESOURCES CONTROL BOARD

REGIONAL WATER QUALITY CONTROL BOARDS

SWRCB Recycled Water Research Workshop: Contaminants of Emerging Concern and Treatment Performance, Oct 27/28, 2015

SCCWRP HQ

Costa Mesa, CA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From Toilet to Tap
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Sewage Treatment Plant
River
Drinking-Water Treatment Plant
Direct to the tap
Sources Reconsidered
Most towns get drinking water from a river, aquifer or reservoir. It is typically filtered, desalinated and disinfected with chlorine at a treatment plant. But as water supplies dry up, treated wastewater could augment or replace the traditional stores.
Reservoir
Indirect reuse, into a reservoir
Discharge to river or ocean
Advanced Purification facility
Discharge to river or ocean
1 Ozonation
Ozone is bubbled into the water, where inactivates pathogens and breaks large organic molecules into small ones
2 Biological Activated Carbon
The water passes through a bed of activated carbon. Organic molecules Stick to the carbon where specialized Bacteria degrade them.
1 Membrane Filtration
Cloudy water is forced through long, hollow fibers with tiny holes that filter out particles and microorganisms, leaving a clear, salty solution.
2 Reverse Osmosis
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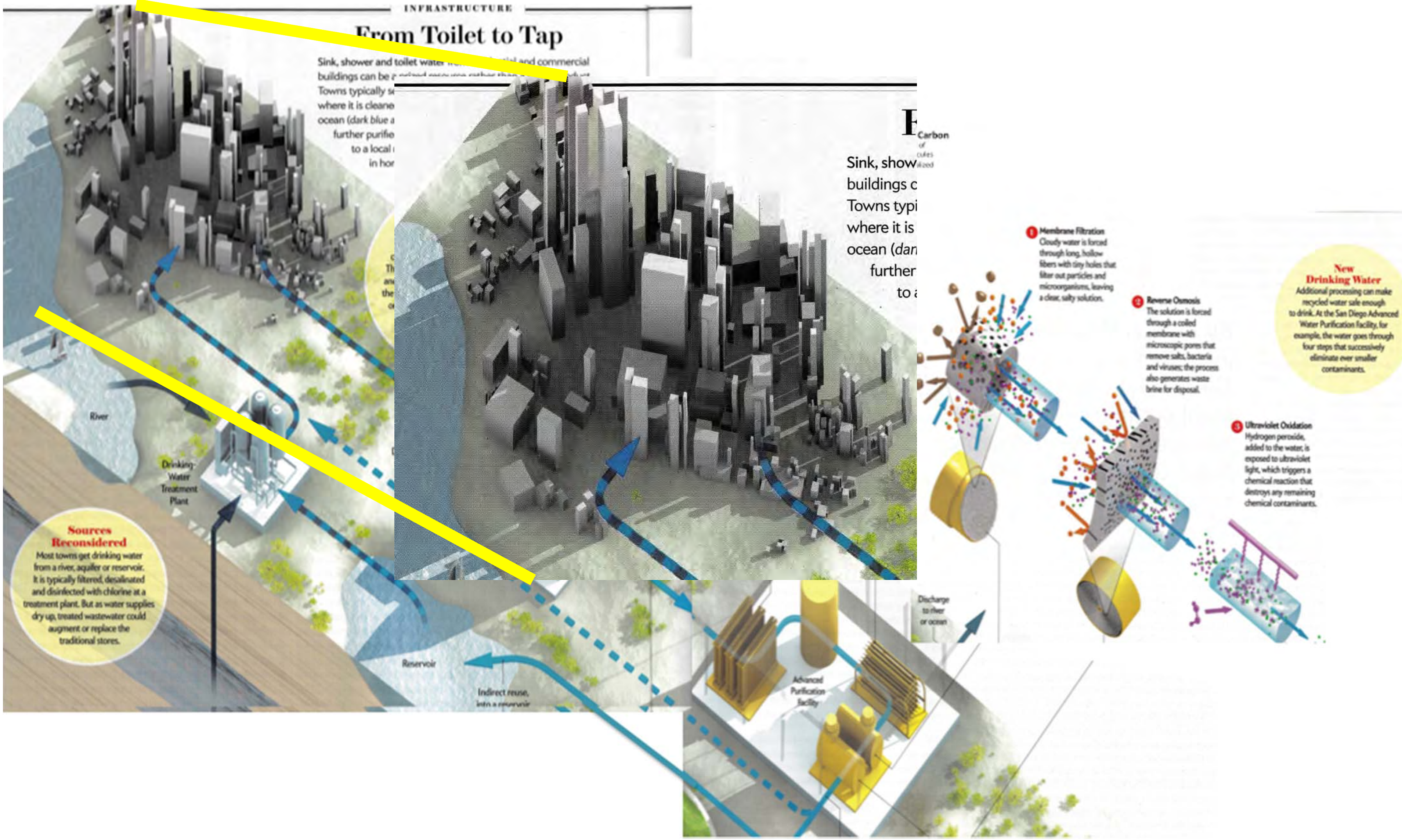
New Drinking Water
Additional processing can make recycled water safe enough to drink. At the San Diego Advanced Water Purification facility, for example, the water goes through four steps that successively eliminate ever smaller contaminants.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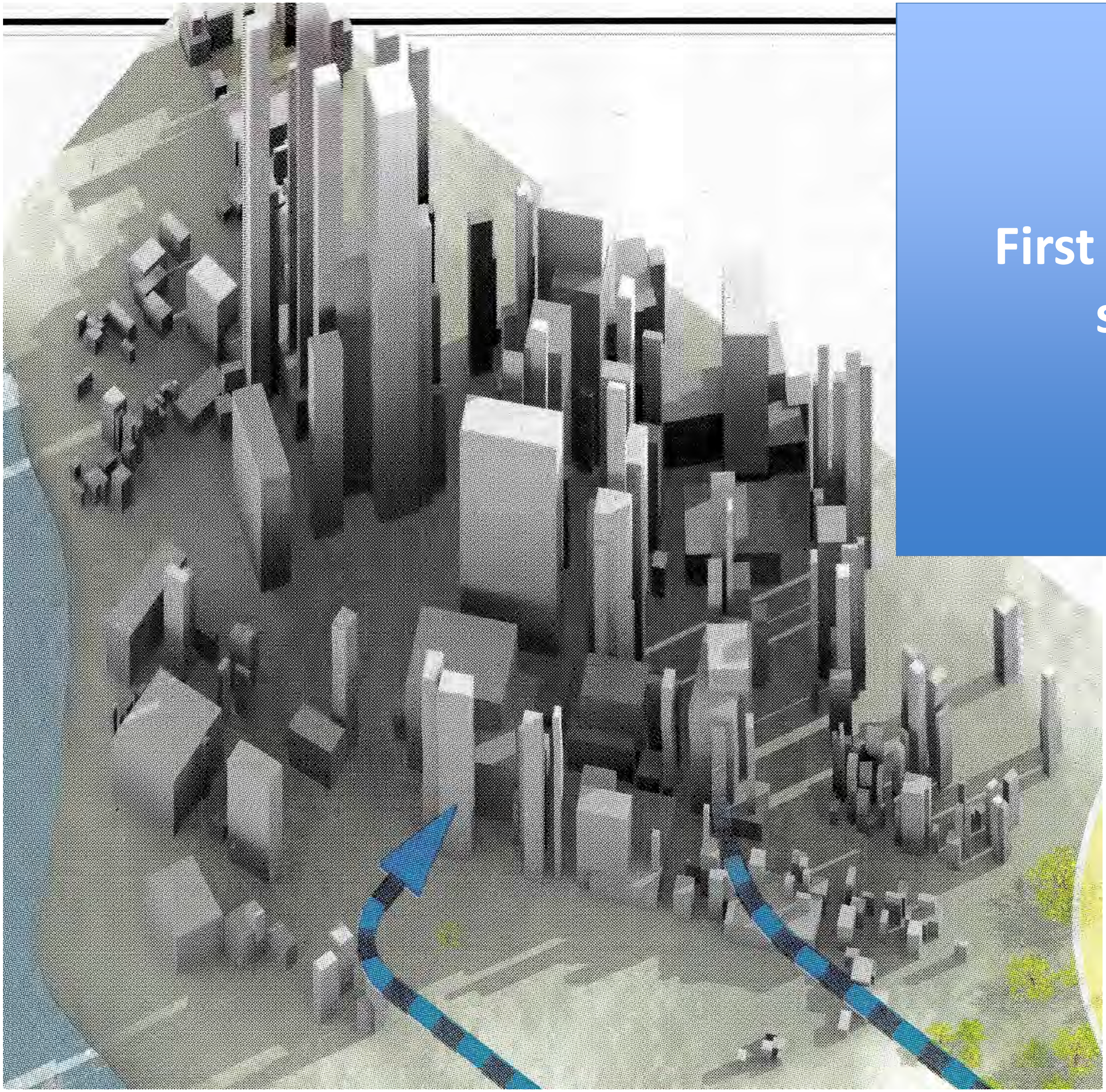
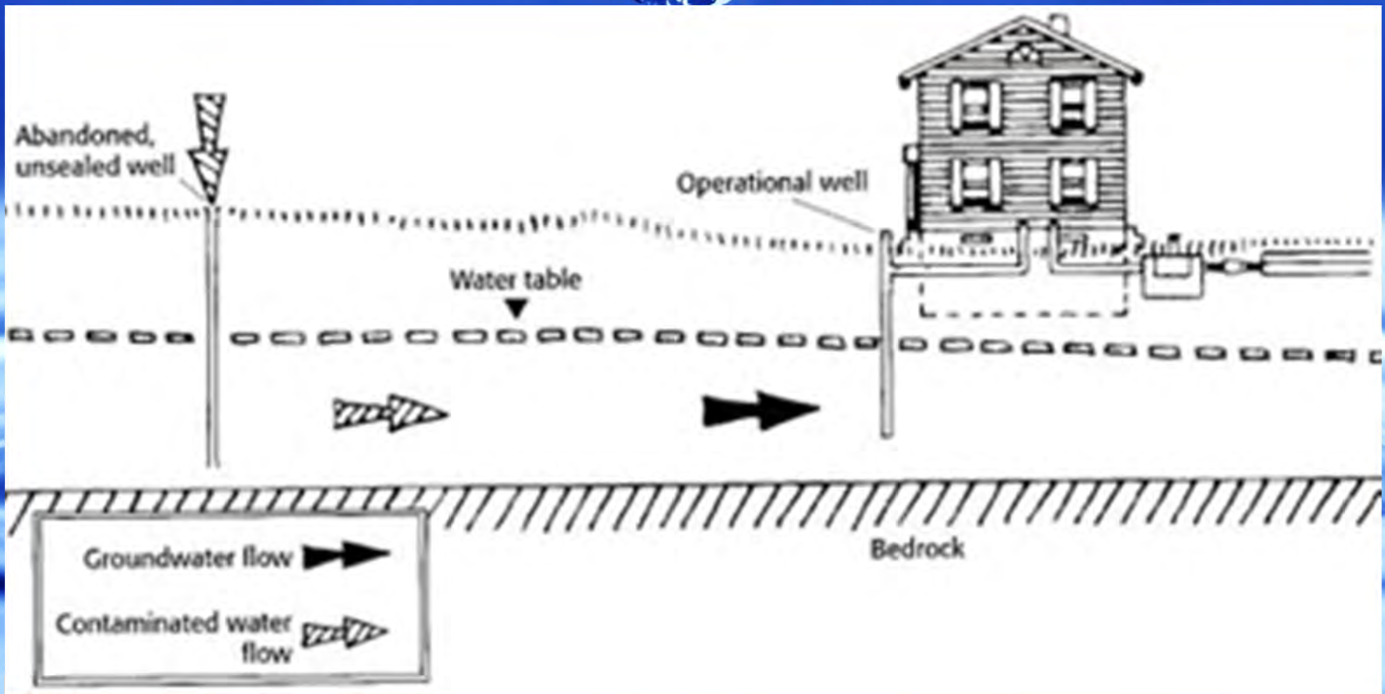


First Step is the source.

Big change in our water culture

Big change in our water culture

- *Old Culture: World of plenty, limited technology* – Focus on separating the collection of drinking water and the disposal of sewage to the maximum practical extent



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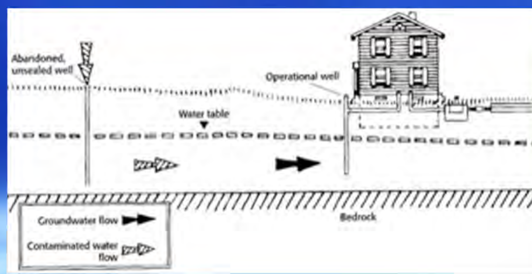


- *New Culture: World of Limits, One water*. *(resources are limited but technology is abundant)* Designing and operating urban water systems so that they share a common, recycled water supply

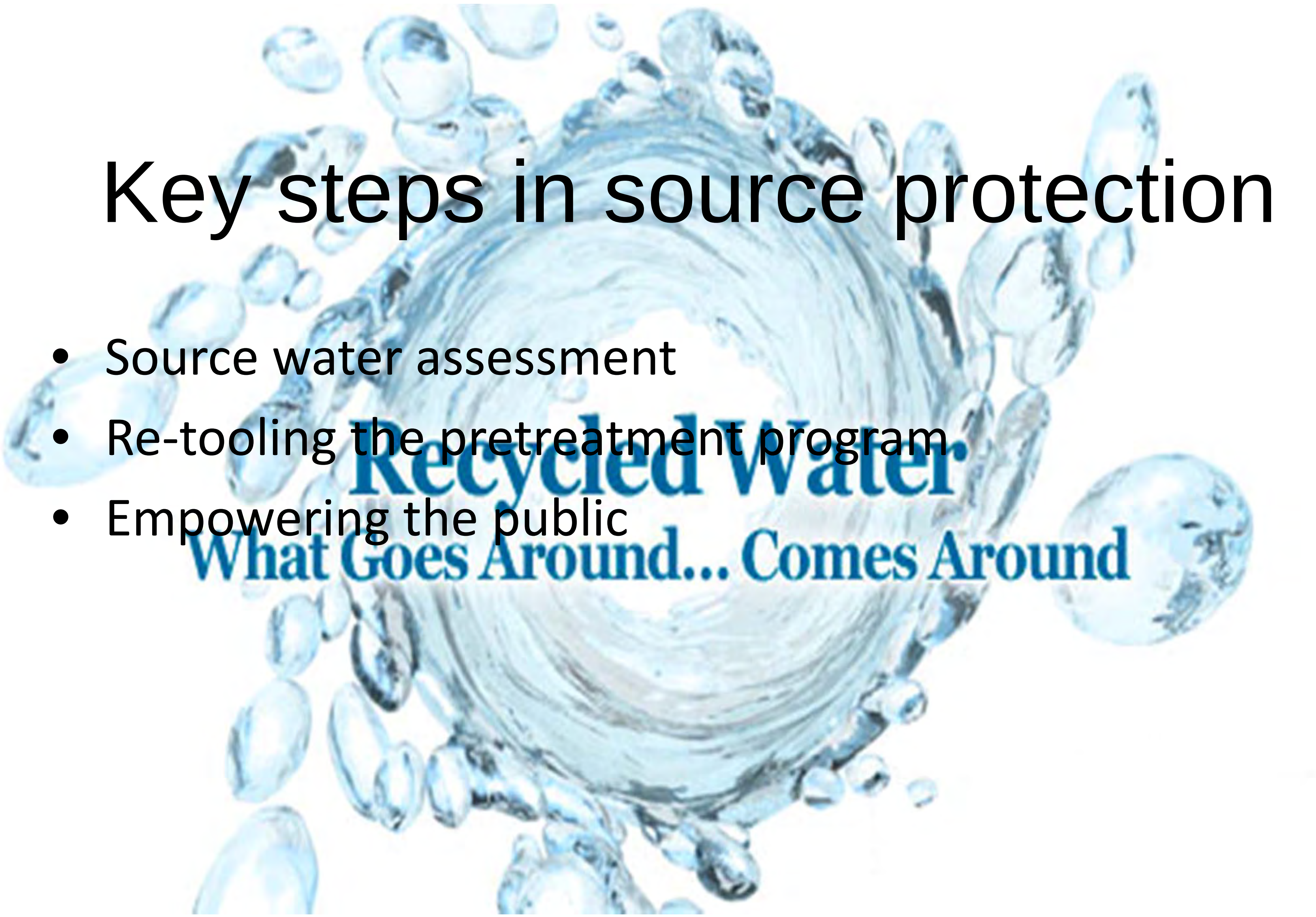
this photo as a symbol of that change … because this is the new water source we have to "protect"

Protecting our new water source

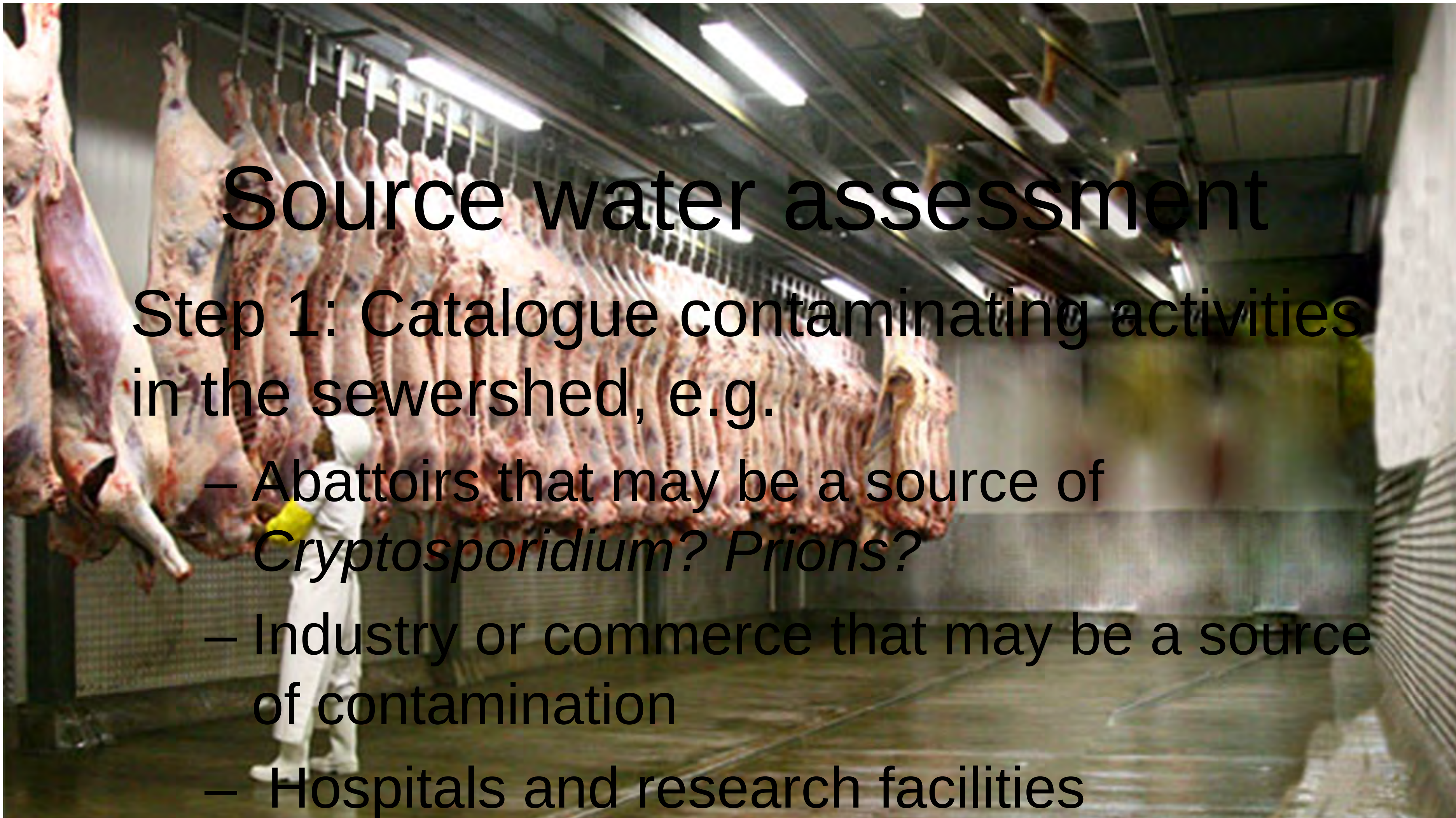
- We all understand potable reuse is a big change in perspective for drinking water utilities and public health regulators, but …
- Making potable reuse successful requires a big change in culture for wastewater utilities, too:
  - Old mission: conveying and disposing of waste; meetingenvironmental regulations
  - New mission: collecting and protecting an important new drinking water source

Key steps in source protection

- Source water assessment
- Re-tooling the pretreatment program
- Empowering the public



Source water assessment



Step 1: Catalogue contaminating activities in the sewershed, e.g.

- Abattoirs that may be a source of *Cryptosporidium? Prions?*
- Industry or commerce that may be a source of contamination
- Hospitals and research facilities
- Others?

Source water assessment

Step 2: Comprehensive characterization of water quality …

- Sampling for pathogens (bacteria, viruses, protozoa)
- Sampling for chemicals with MCLs, SMCLs or NLs
- Sampling for priority pollutants
- Sampling for contaminants identified in Step 1 (SWA)

Source Protection

Source Protection

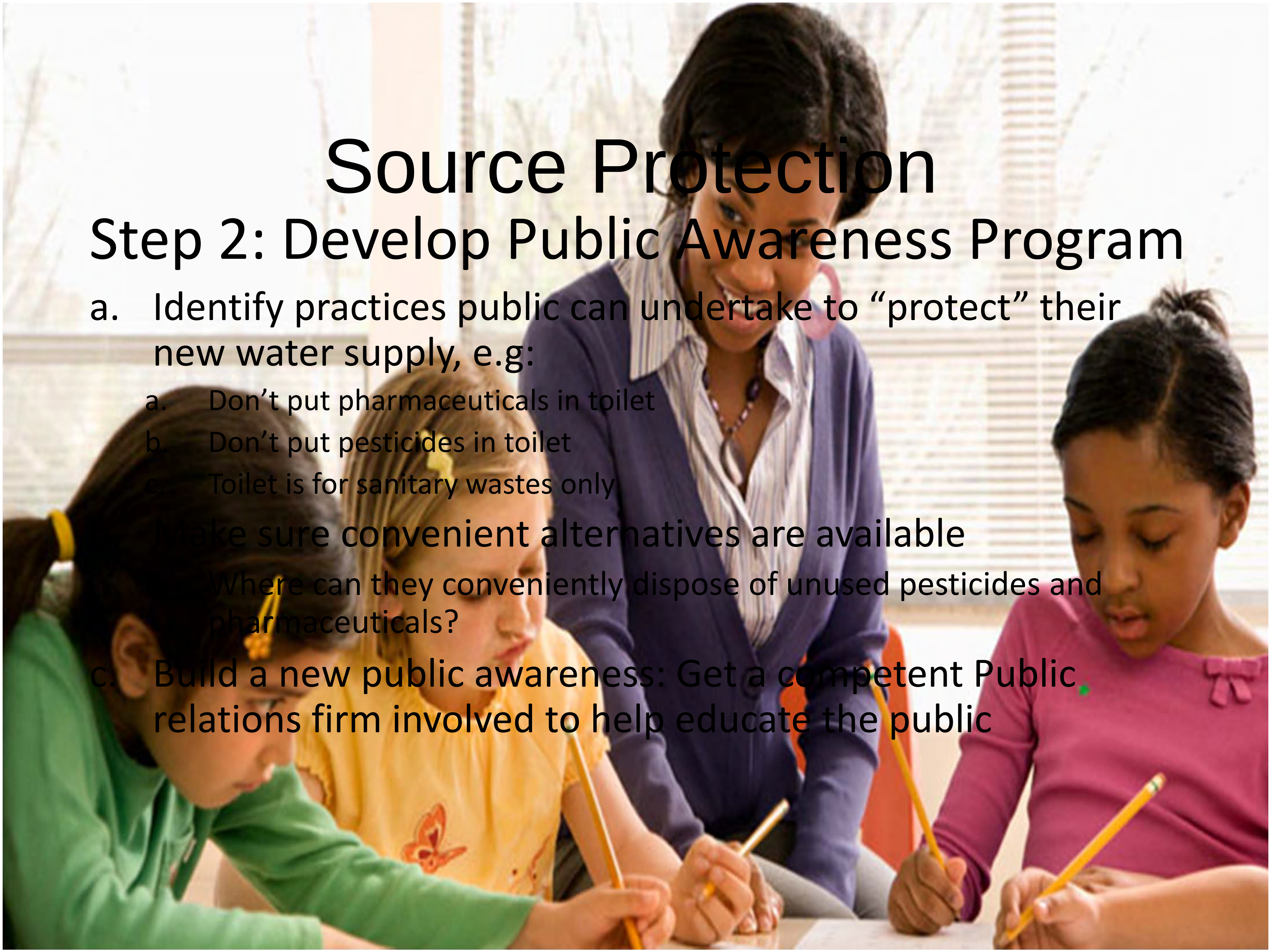
Step 1: Review industrial pretreatment program, for example:

a. Develop a list of chemicals, which may not be well-removed by biological treatment, ozonation, RO, UV or AOP

b. Review industries and compounds regulated in existing pretreatment program.

c. Add unlisted sources identified in SWAAdd local limits for compounds of concern identified in SWA and in item a. above.

d. Hold a public hearing and get citizen input



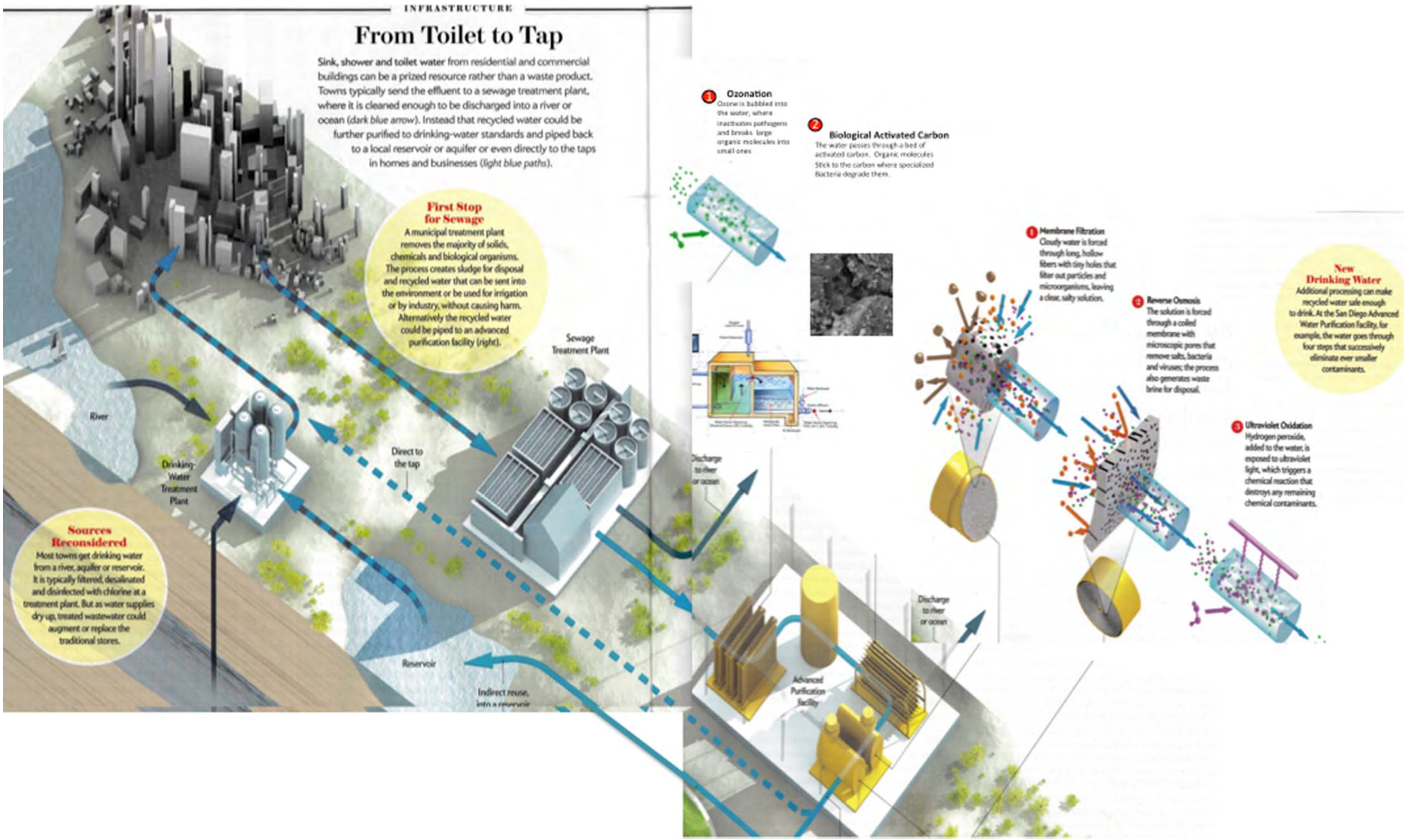
Source Protection

Step 2: Develop Public Awareness Program

a. Identify practices public can undertake to “protect” their new water supply, e.g:
  - a. Don’t put pharmaceuticals in toilet
  - b. Don’t put pesticides in toilet
  - c. Toilet is for sanitary wastes only

Make sure convenient alternatives are available
  - Where can they conveniently dispose of unused pesticides and pharmaceuticals?

c. Build a new public awareness: Get a competent Public relations firm involved to help educate the public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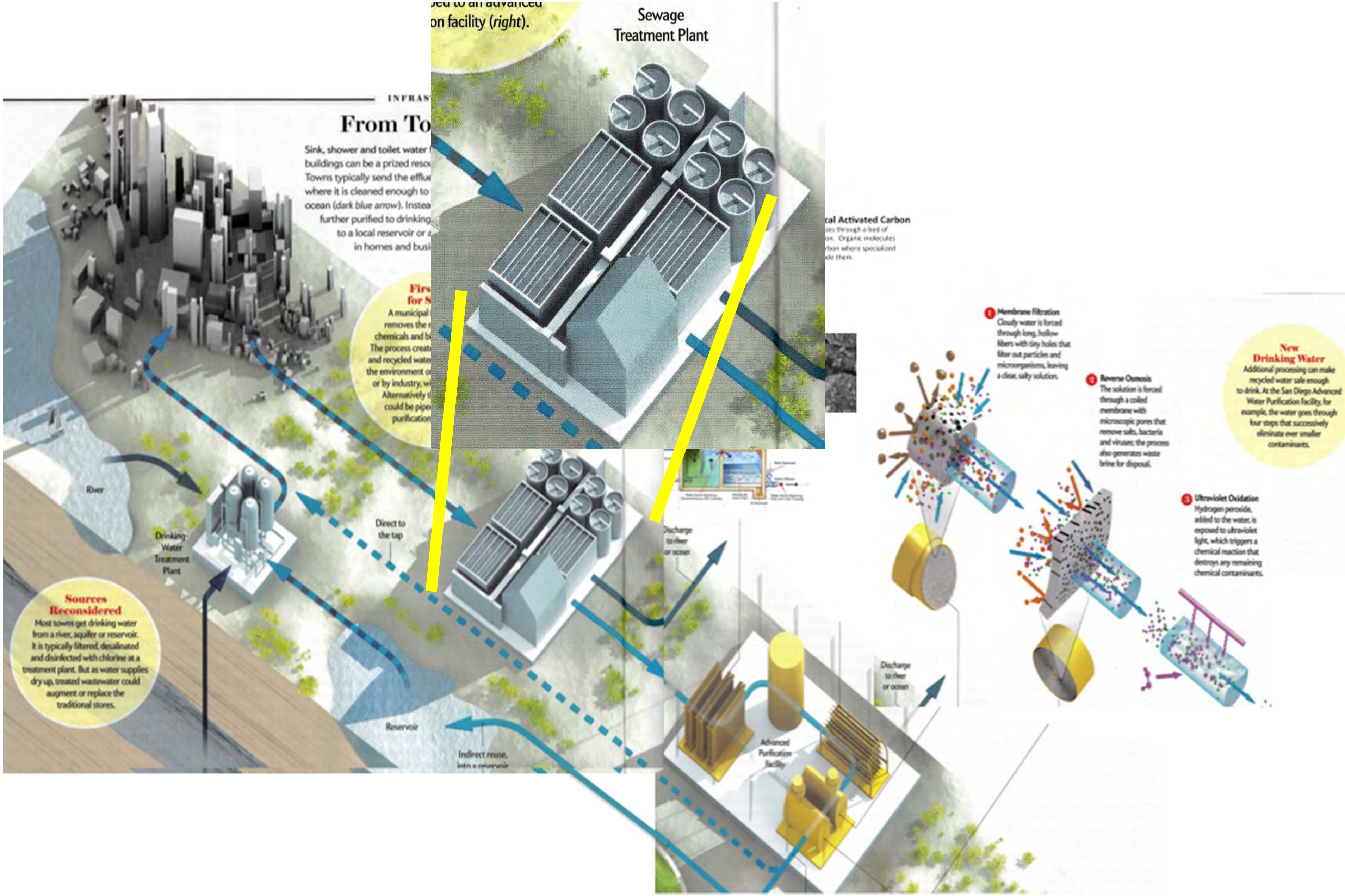

on facility (right).
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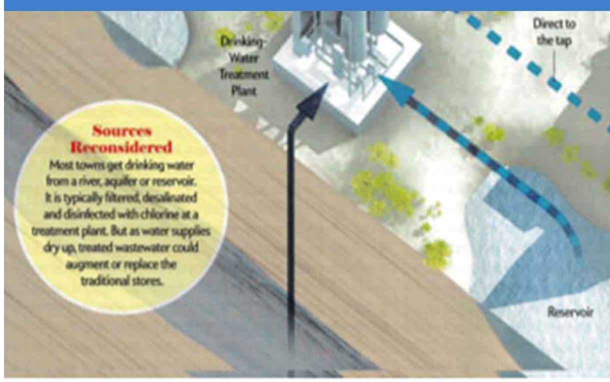
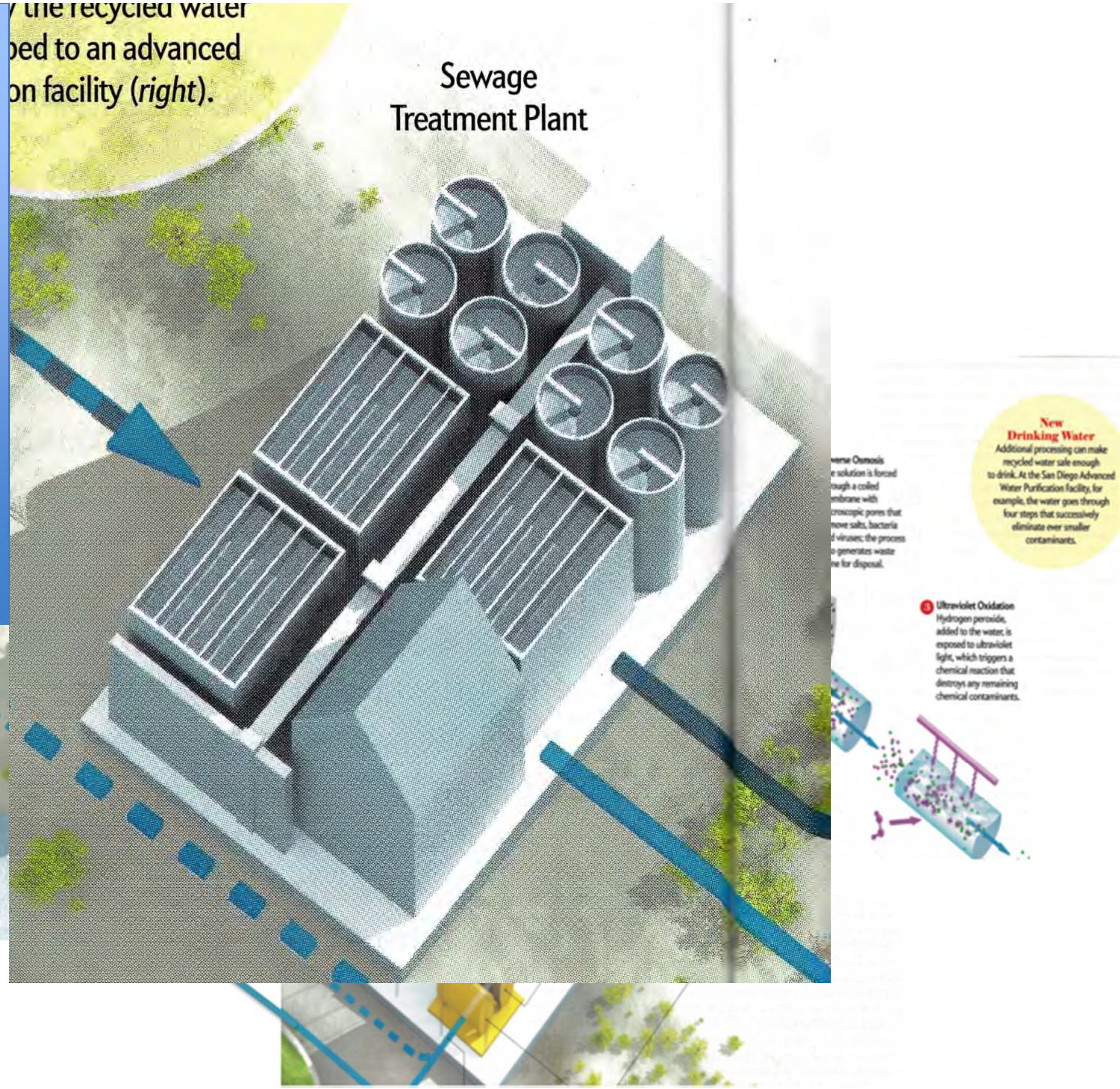
Second Step is biological treatment.





Once again change is needed in our water culture

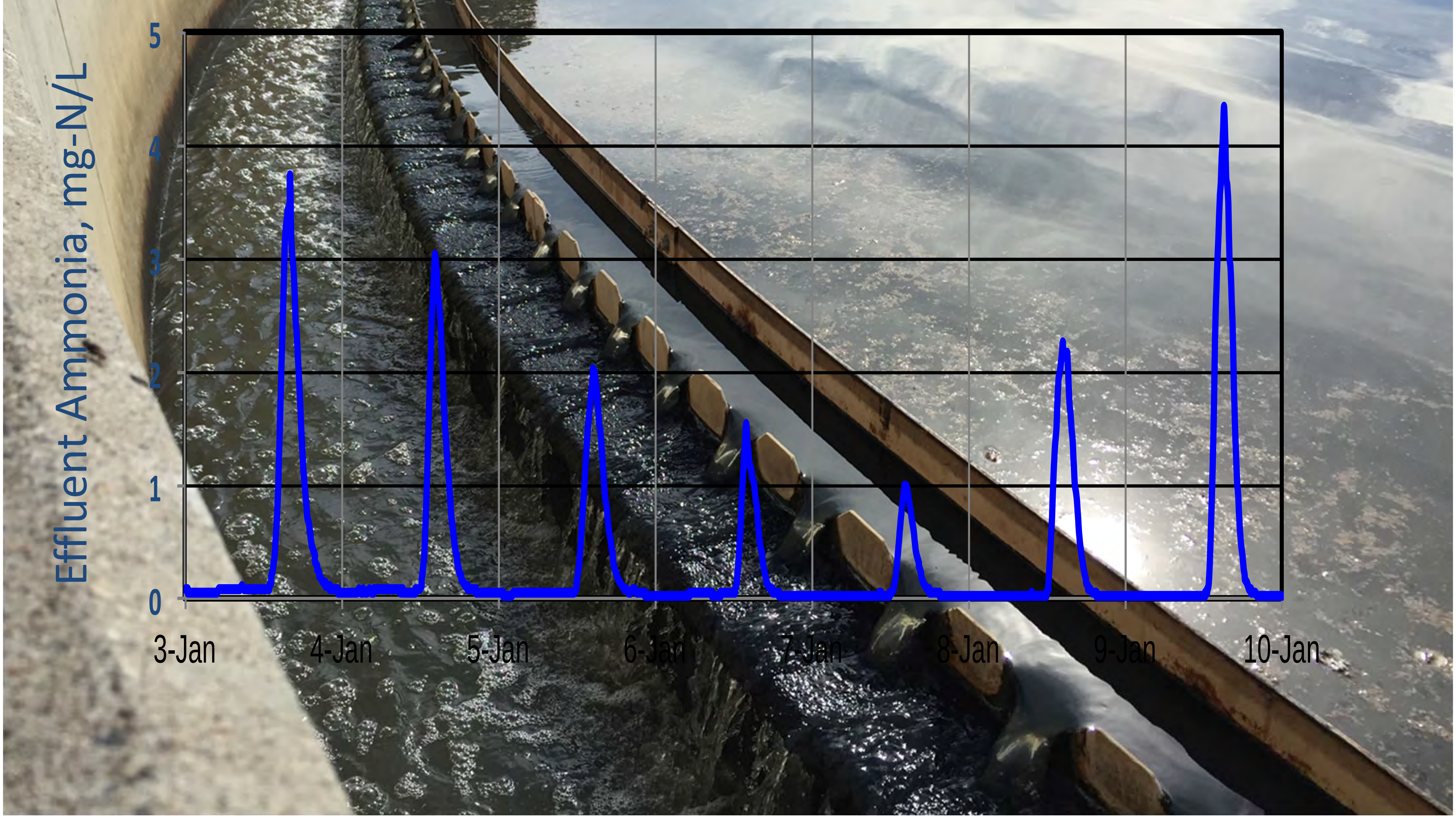
Biological Treatment

- Biological treatment can be an important barrier for both pathogens and chemicals (CECs):
  - Old mission: meeting requirements for environmental discharge
    - Oceans & estuaries – 30/30 BOD_5/SS
    - Inland – Often Title 22 + 10-mg-N/L
  - New mission: first stage of treatment for an important new drinking water source

Key features we need

- Flow equalization ahead of the biology
- Side streams: elimination, flow equalization, or separate treatment
- Maximizing biological treatment
- Bias toward including GMF to enhance stability

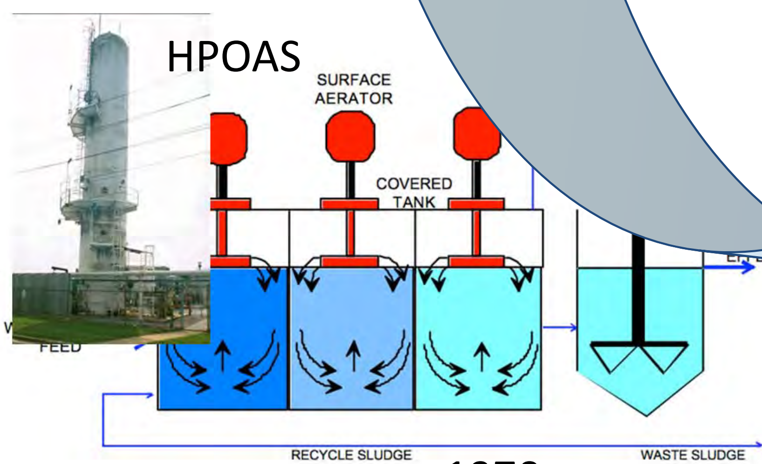
Sewage loads are cyclic, so flow equalization is necessary for steady biological performance



Side-stream flows must be actively managed

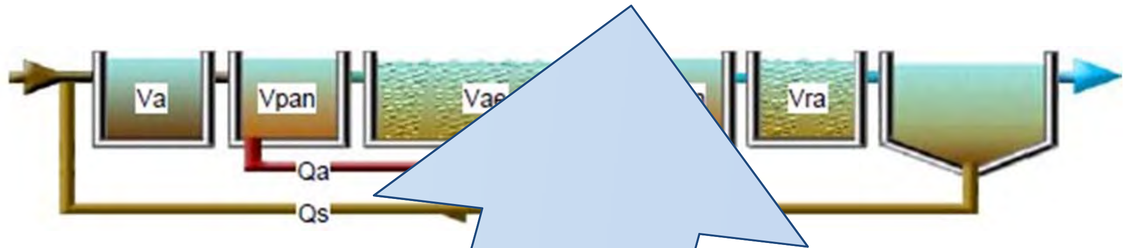
- E.g. water from solids processing
- Often has adverse impacts on performance
  - Messes with biological process, itself
  - Fouls downstream membrane processes
- Often includes precursors for transformation products (e.g. NDMA)
- Actions: divert, flow equalize and/or treat separately

Evolution of biological treatment



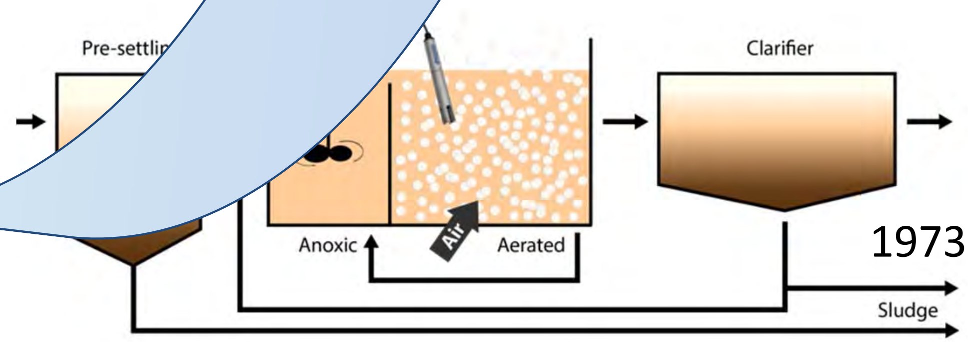
1970

5-stage Bardenpho



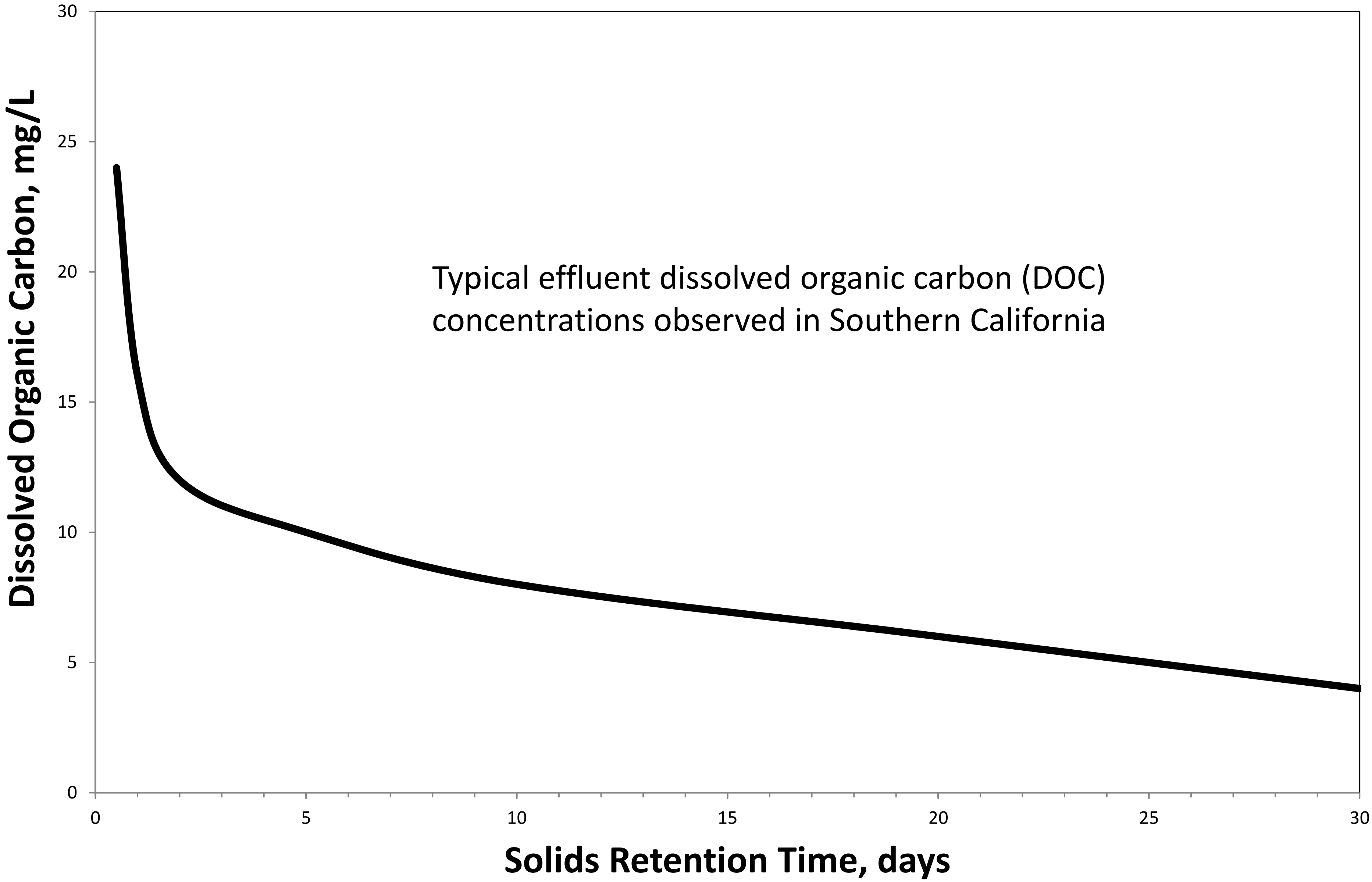
Ca 1980

Mod k-Ettinger Process



1973

Importance of Solids Retention Time



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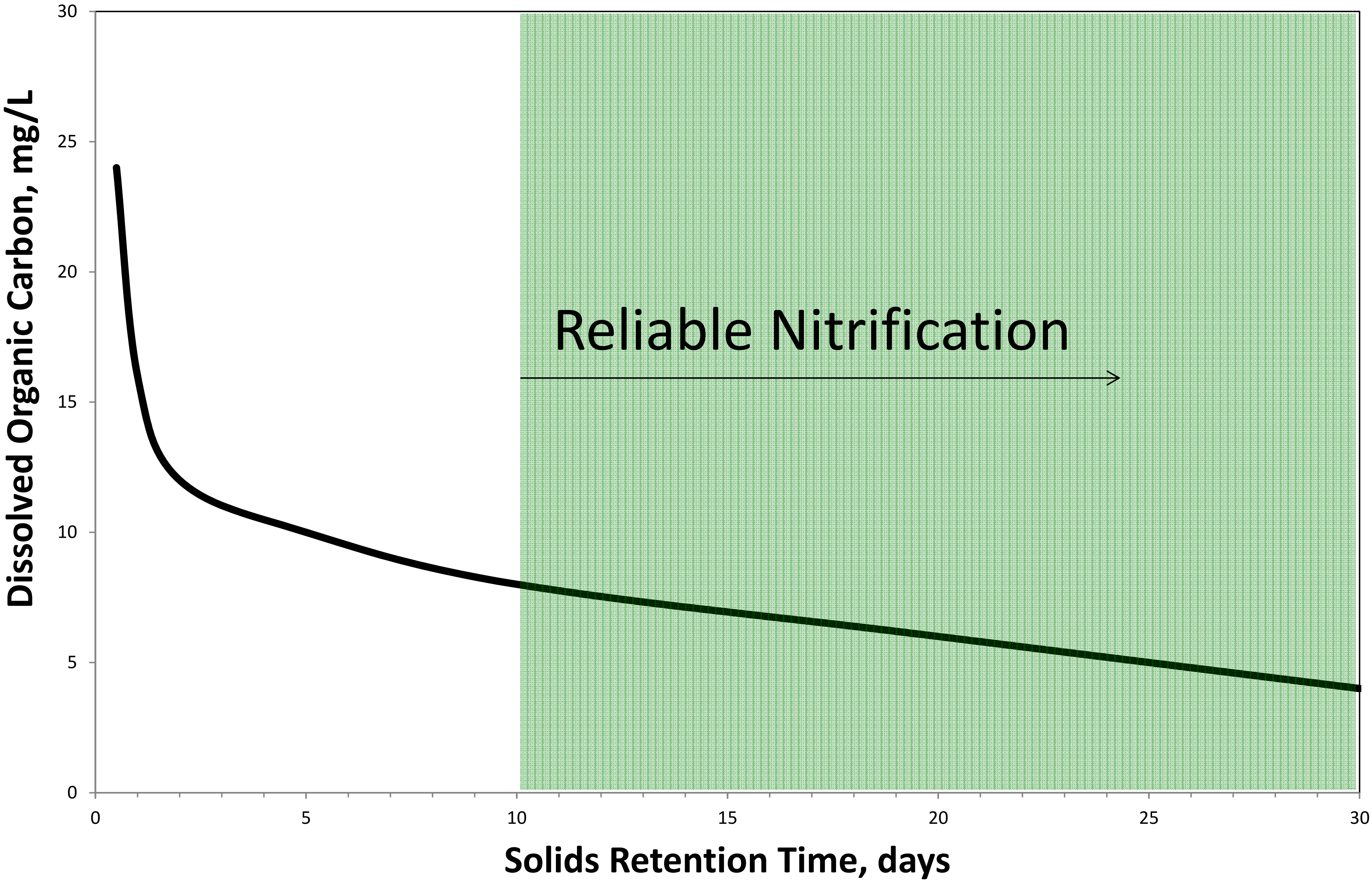

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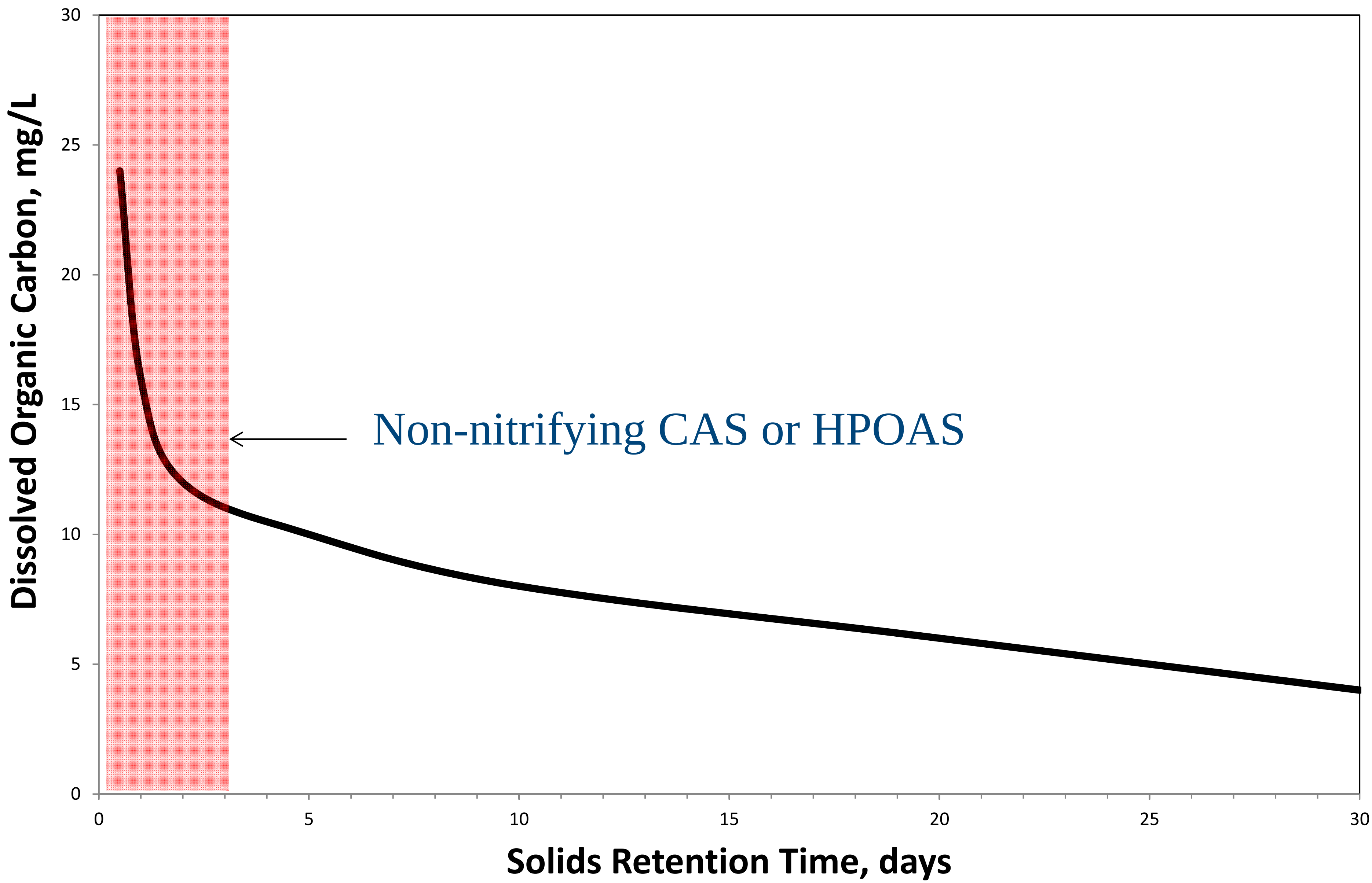

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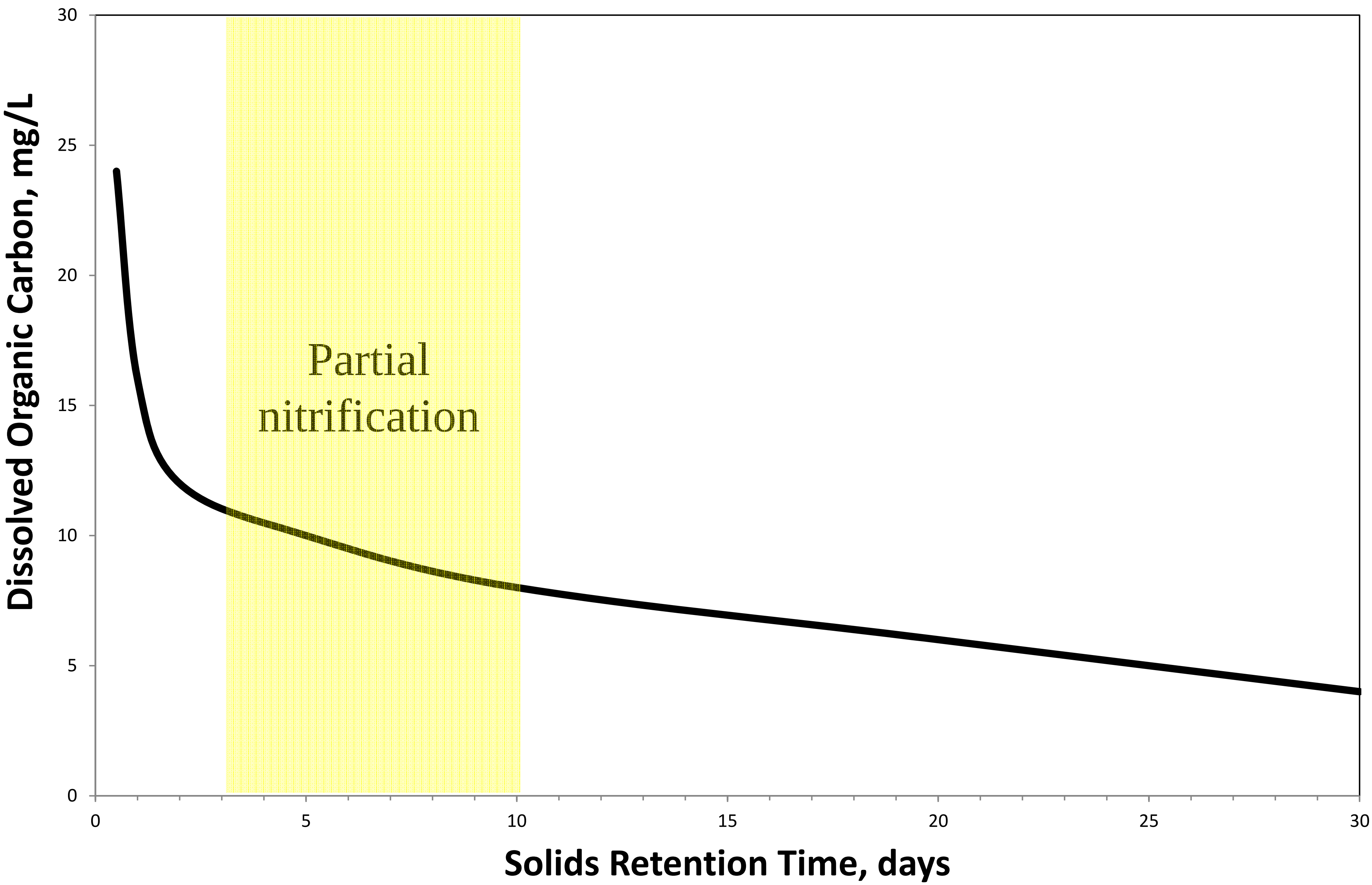
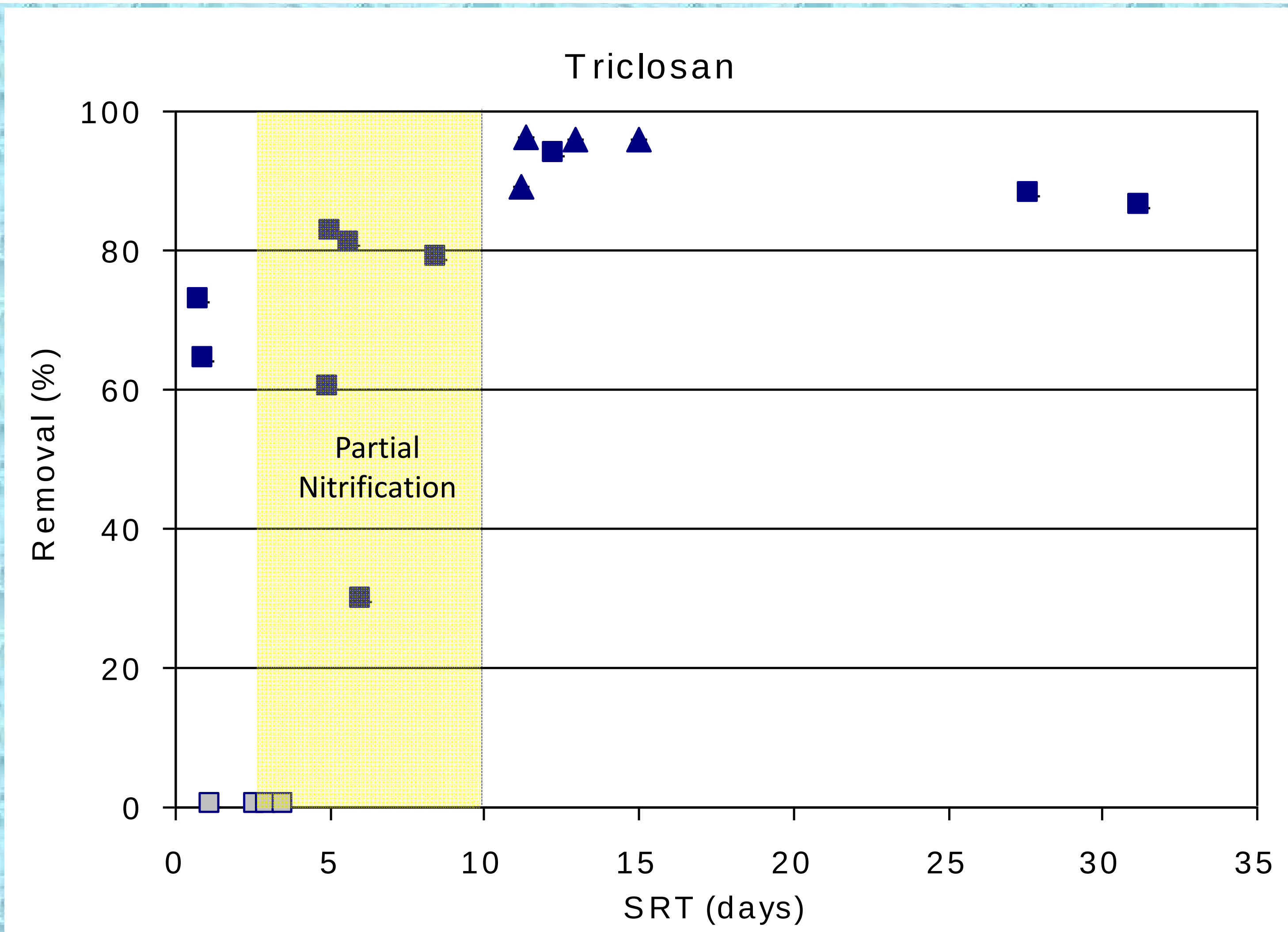


SRT is also important to CEC removal



■ = Actual Removal ▲ = Removal greater than percentage value □ = Effluent > Influent

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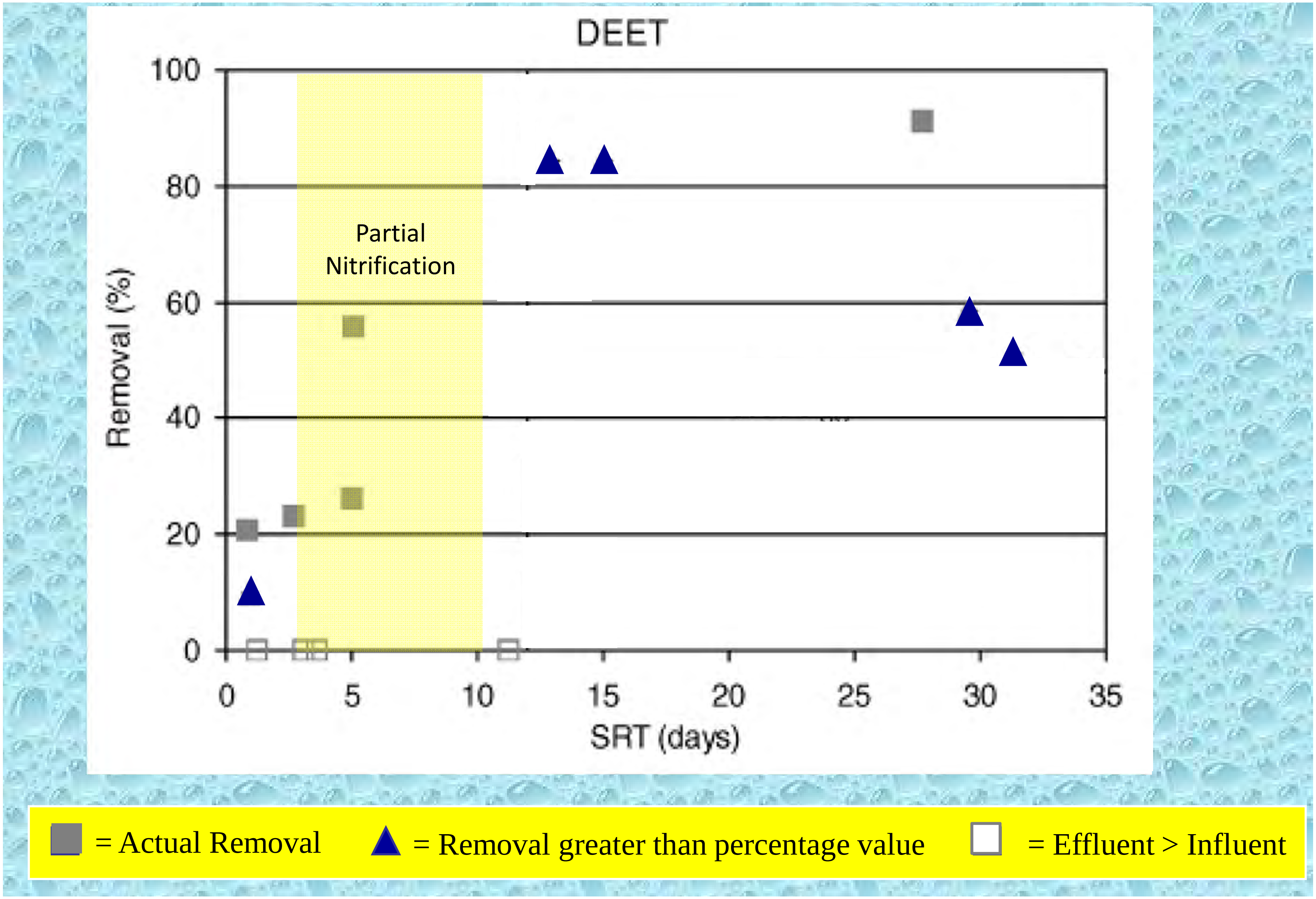

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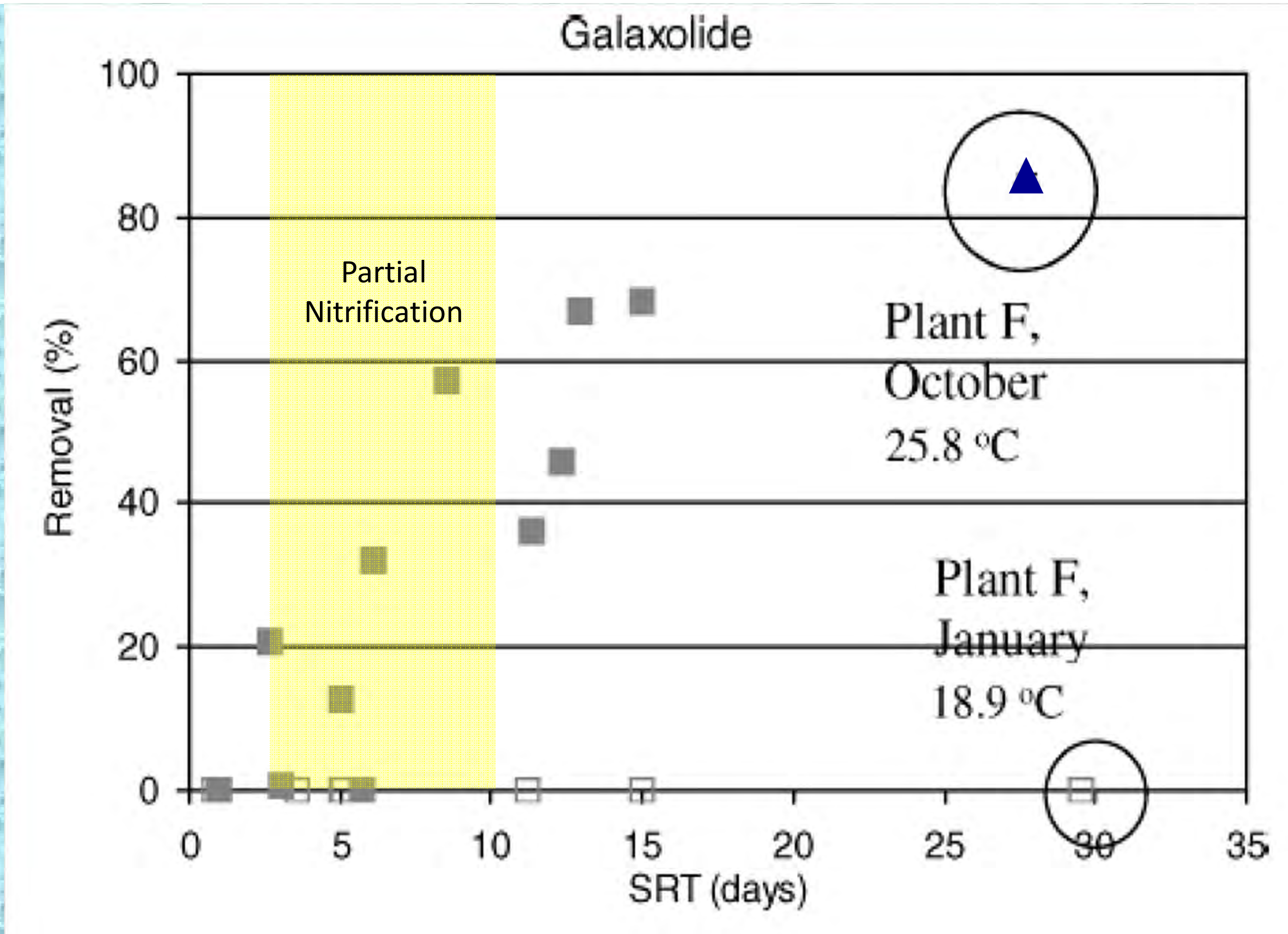

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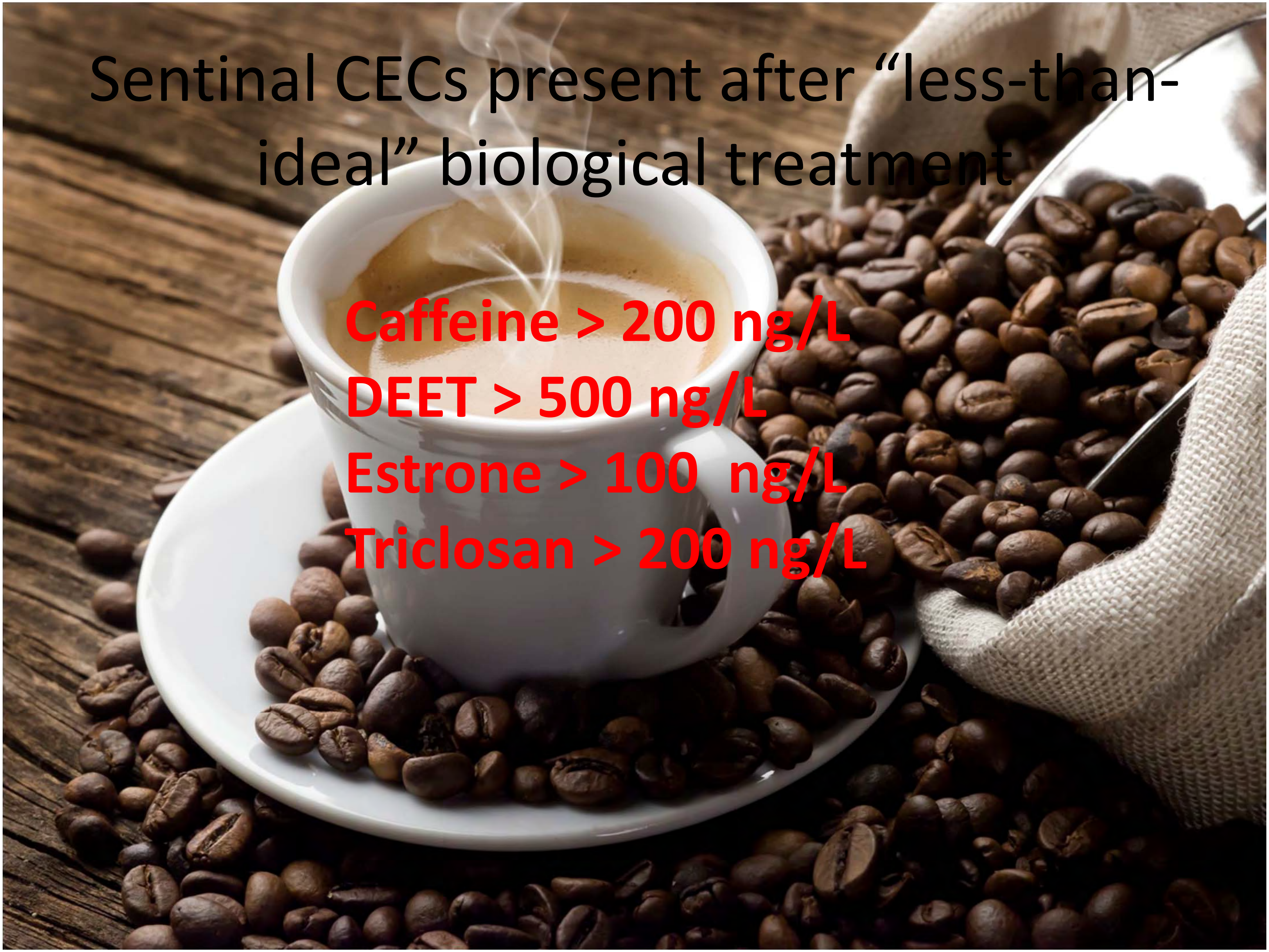
Sentinal CECs present after “less-than-ideal” biological treatment



Caffeine > 200 ng/L
DEET > 500 ng/L
Estrone > 100 ng/L
Triclosan > 200 ng/L

List of TOrCs in WRRF 11-02

Acesulfame K Diclofenac Meprobamate Simazine Atenolol Diphenhydramine Naproxen Sucralose Atrazine Ditiazem Norgestrol Sulfamethoxazole Benzophenone Estrone Perfluorobutyric acid (PFBA) TCEP Benzotriazole Fluoxetine Perfluorobutane sulfonate (PFBS) Tris(1-chloro-2-propyl) phosphate (TCPP) Bisphenol A Gemfibrozil PFOA Testosterone Caffeine Hydrocortisone PFOS Triclocarban Carbamazepine Ibuprofen Perfluorohexanoic acid (PFHxA) Triclosan Clofibric Acid Iohexol Prednisone Trimethoprim DEET Iopamidol Primidone Dexamethasone Iopromide Propylparaben

WATEREUSE

TOrCs that were ubiquitous

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TOrCs selected by NWRI panel

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Criteria from NWRI panel

DBPs	Criterion
Bromate	10 µg/L
Chlorate	800 µg/L
HAA5	60 µg/L
NDMA	10 ng/L
THMs	80 µg/L

Criteria from NWRI panel (cont’d)

Unregulated chemicals of interest	Criterion
Carbamazepine	10 µg/L
Estrone	320 ng/L
Meprobamate or Atenolol	200, 4 µg/L
Cotinine, primidone, or phenytoin	1, 10, 2 µg/L
PFOA and PFOS	400 , 200 µg/L

Criteria from NWRI panel (cont'd)

Other chemicals of interest	**Criterion**
Perchlorate	6 µg/L
1,4-dioxane	1 µg/L
Sucralose	150 mg/L
TCEP	5 µg/L
DEET	200 µg/L
Triclosan	2.1 mg/L

The 2° Effluents meet the NWRI Criteria

Constituent	NWRI Criterion	SJCWRP	El Paso	UOSA	SD AWPF	OCSD/GWRS
Atenolol	4,000	63	110	130	130	555
Carbamazepine	10,000	192	328	185	190	263
DEET	200,000	53	33	51	130	528
Estrone	320	NDL	< 36	< 46	< 4	41
Mebrobamate	200,000	351	174	115	125	401
PFOA	400	11	11.5	24	NM	NM
PFOS	200	< 14	NDL	< 13	NM	NM
Primidone	10,000	166	121	148	91	100
Sucralose	150,000,000	25,450	35,500	34.950	41,000	NM
TCEP	5,000	NDL	406	335	375	338
Triclosan	2,100,000	89	NDL	27	64	324

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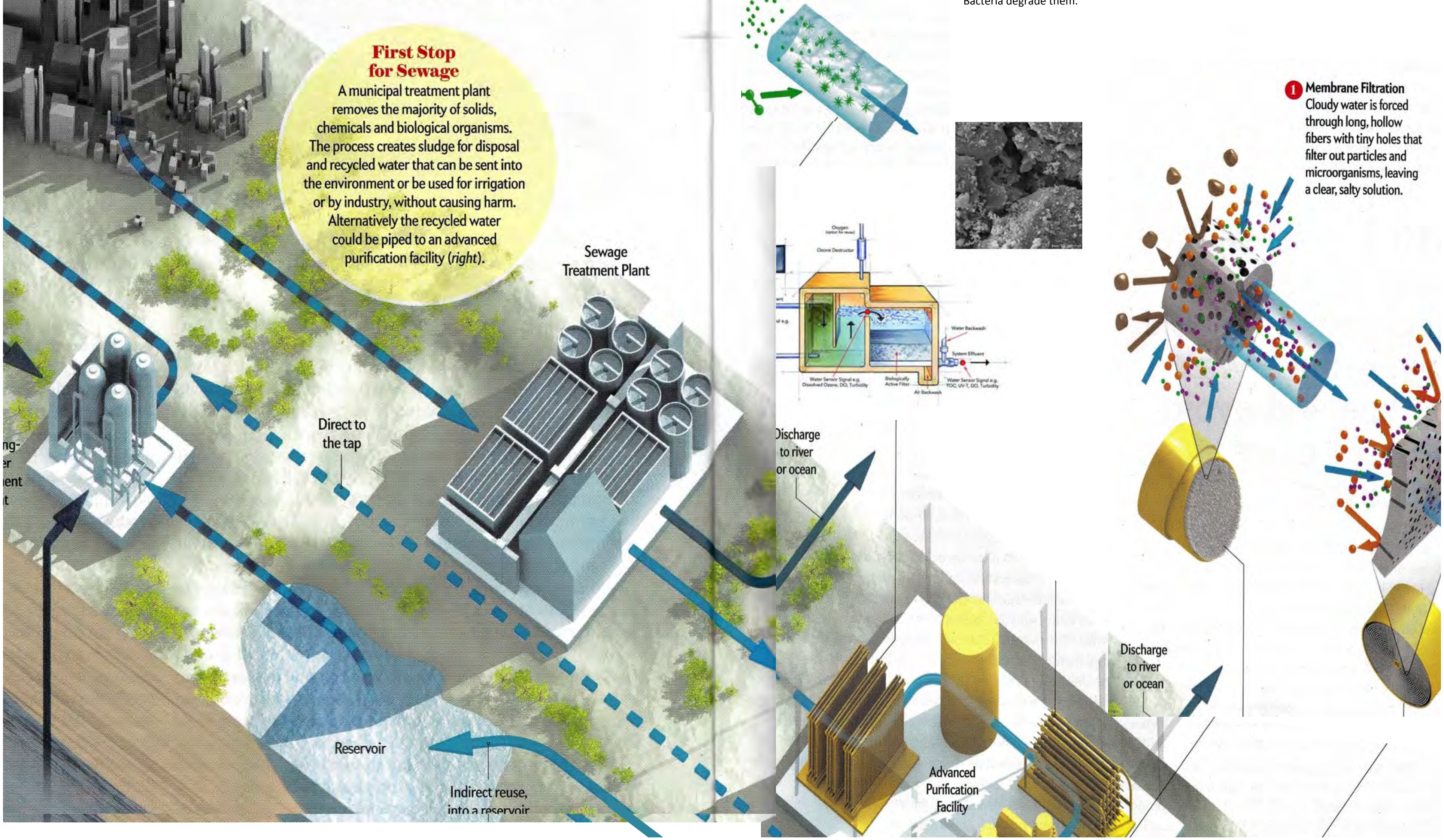
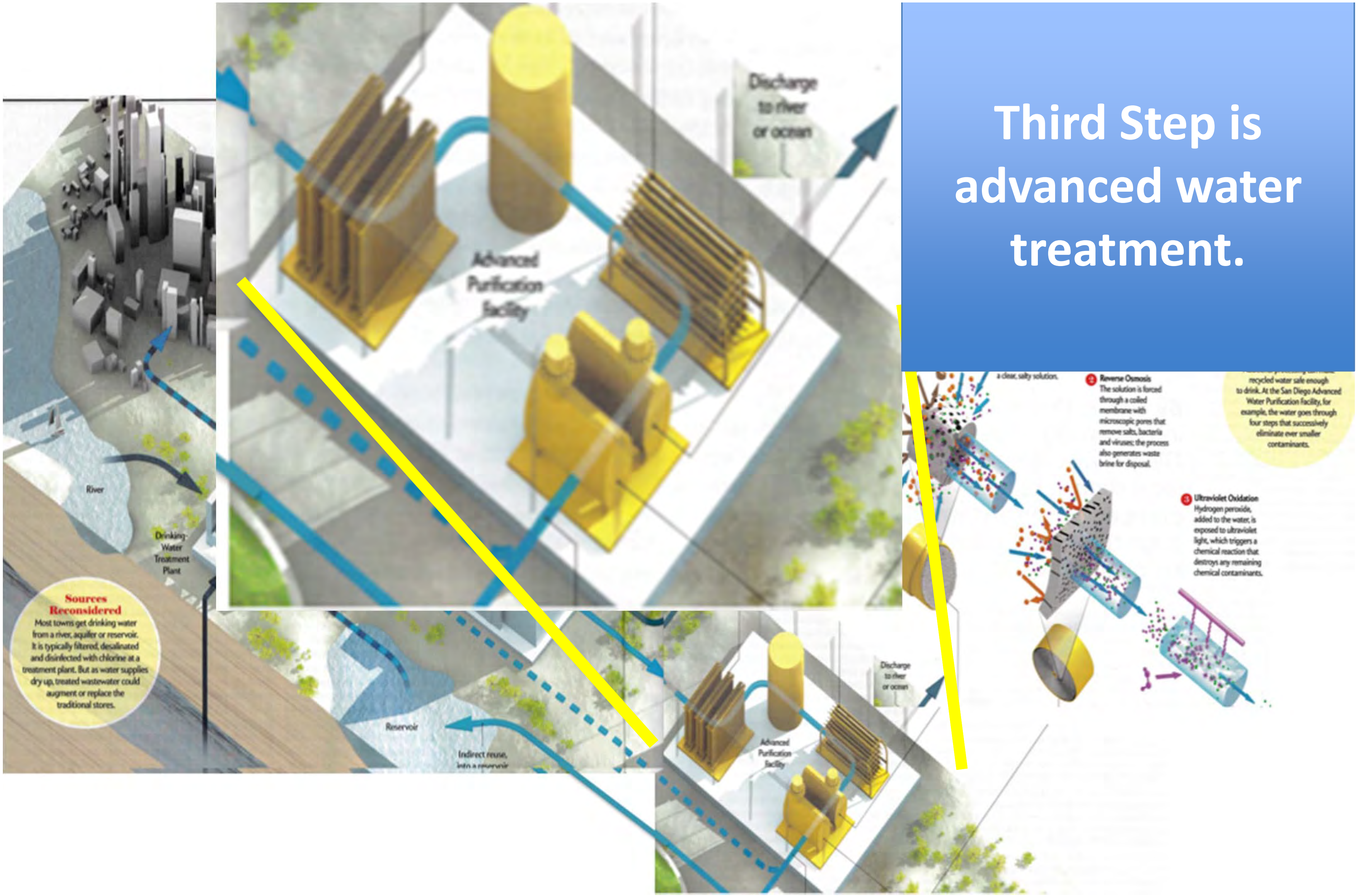


Third Step is advanced water treatment.

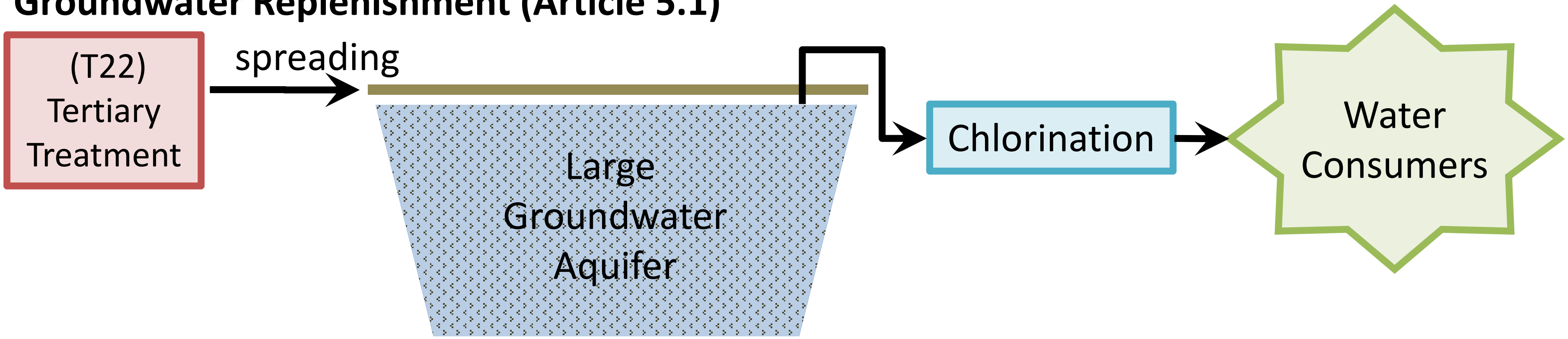


Some advanced processes of Interest

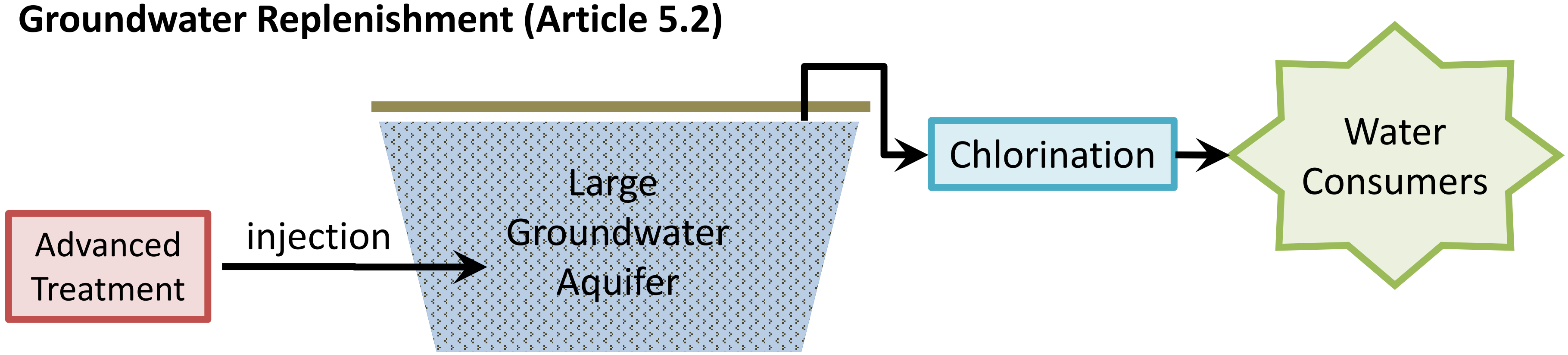
- Ozonation
- Biological filtration and biological activated carbon
- Adsorption on activated carbon (PAC and/or GAC)
- Anoxic or anaerobic filtration
- Membrane filtration
- Reverse osmosis/nanofiltration
- UV Photolysis
- UV/H_2O_2
- UV/Chlorine

Today we have two types of potable reuse projects in CA

Groundwater Replenishment (Article 5.1)



Groundwater Replenishment (Article 5.2)



Today we have two types of potable reuse projects in CA

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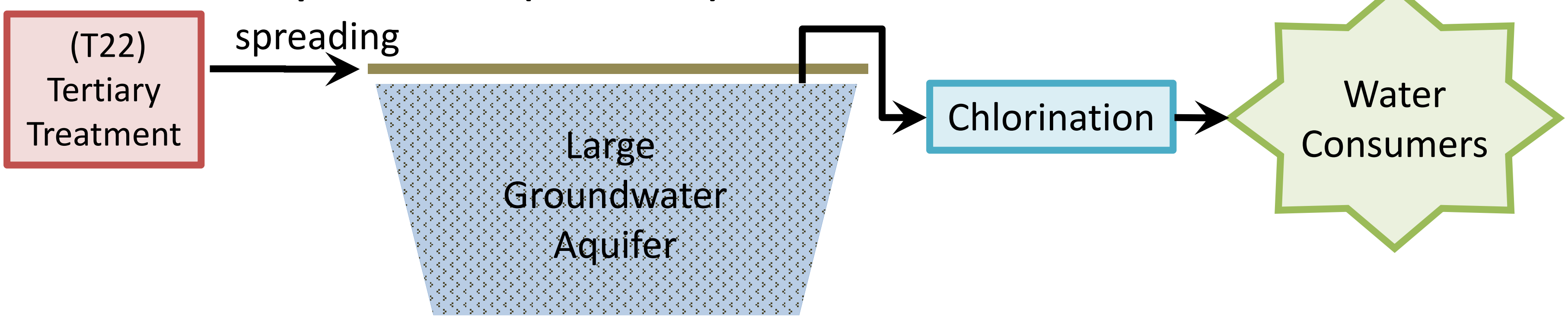
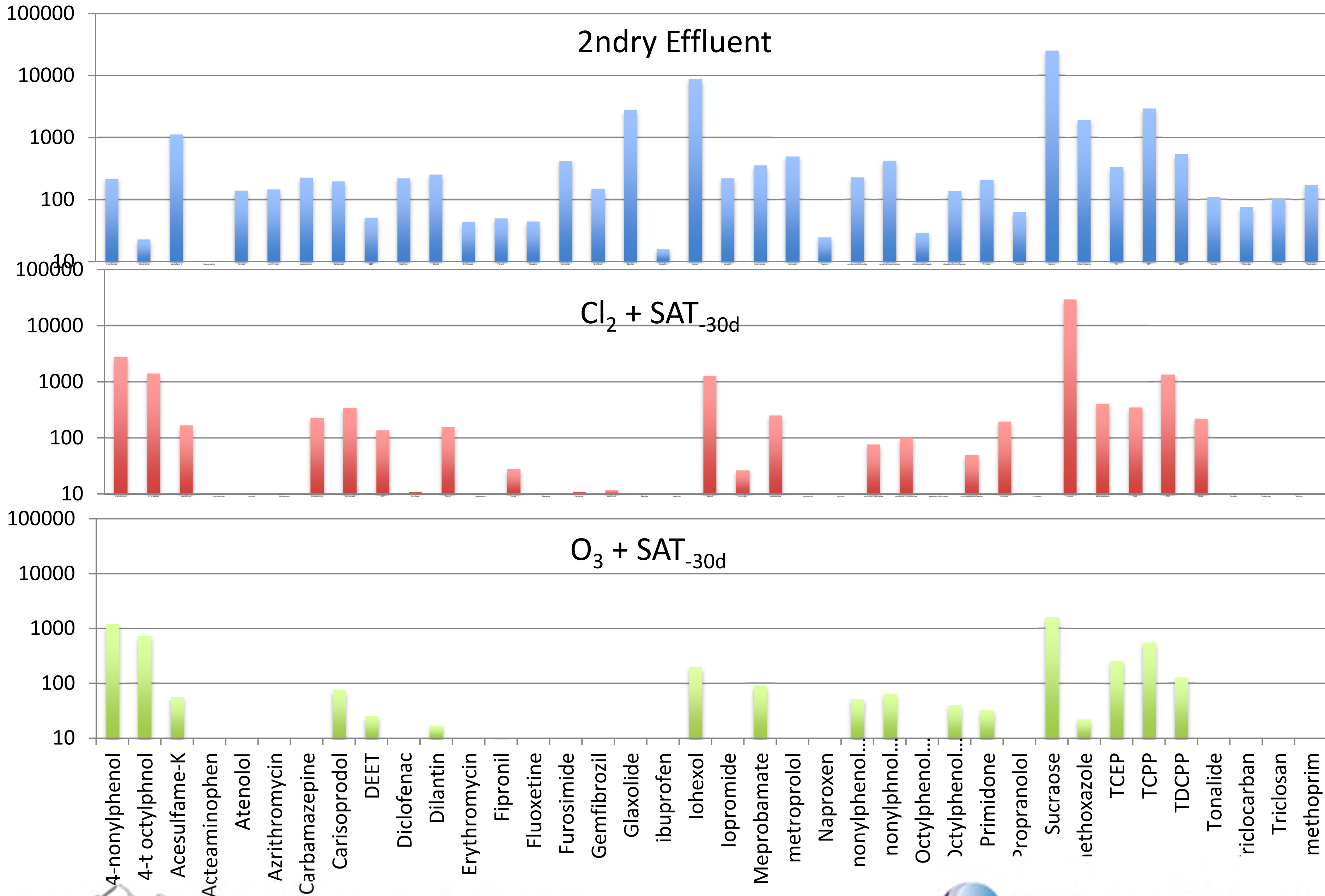


- These projects largely eliminate CECs but it seems likely that some, limited, CECs will be associated with them
- Ozone can reduce the number and level of CECs
- In return these projects offer lower costs and higher recovery of water but higher TDS



UPPER DISTRICT

WATEREUSE

The NWRI Criteria

TOrC	NWRI criteria	2°	Cl_2-SAT 30-d	O_3-SAT 30-d
Atenolol	4,000	140	< 10	< 10
Carbamazepine	10,000	230	232	< 10
DEET	200,000	52	140	25
Estrone	320	NM	NM	NM
Meprobamate	200,000	361	252	91
PFOA	400	NM	NM	NM
PFOS	200	NM	NM	NM
Primidone	10,000	211	196	32
Sucralose	150,000,000	25,200	29,388	1,600
TCEP	5,000	340	358	258
Triclosan	2,100,000	103	< 10	< 10

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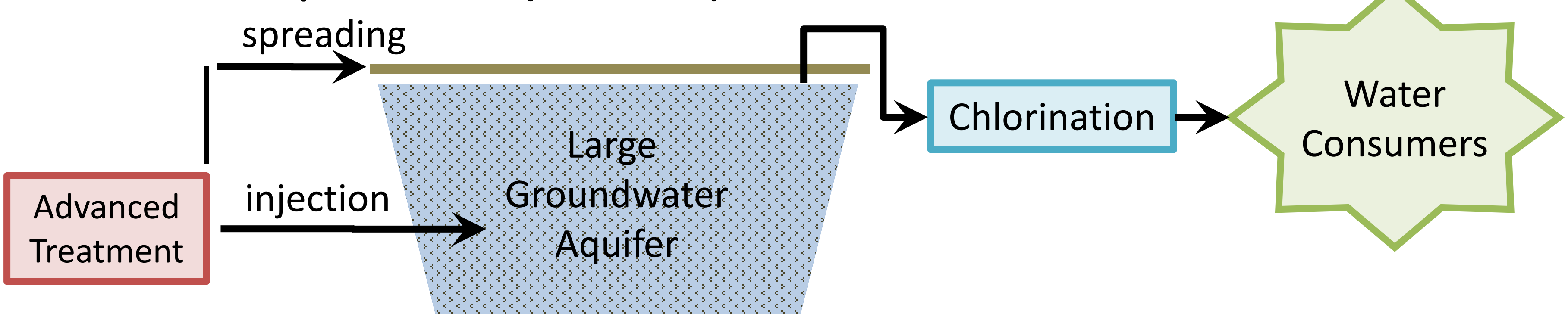

– These projects seek to reduce all the CECs below the limits of detection
– They encounter significantly more treatment cost and experience lower water recovery but the product has a very low TDS.

Does ozone ahead of RO make sense?

(Tale of two good labs)

TOrC	NWRI criteria	Full Scale	Pilot
Atenolol	4,000	1	< 3
Carbamazepine	10,000	< 0.08	<2
DEET	200,000	1	< 2
Estrone	320	< 0.2	< 4
Meprobamate	200,000	1	< 2
PFOA	400	NM	< 5
PFOS	200	NM	< 3
Primidone	10,000	1	< 2
Sucralose	150,000,000	37	< 150
TCEP	5,000	3	< 43
Triclosan	2,100,000	2	< 4

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Is money well spent on this extra sensitivity?

Each community has to make choices based on what is most important to them

- I’m certain more potable reuse is in our future
- I also think Shane is right … we cannot afford to let our talent in analytical chemistry drive us toward ever higher treatment costs that provide no real benefit
- It is the job of the scientific/technical community to lead the way … but we have to find a way to do it that the public is prepared to accept … and we have to do it soon.

Our Needs

- I think we need criteria like those from NWRI
  - We don't need them for every CEC in 2°
  - We need them for those that regularly show up after alternative treatments
  - They need to be updated regularly as we learn more (every 3-yr)
  - Standing committee?

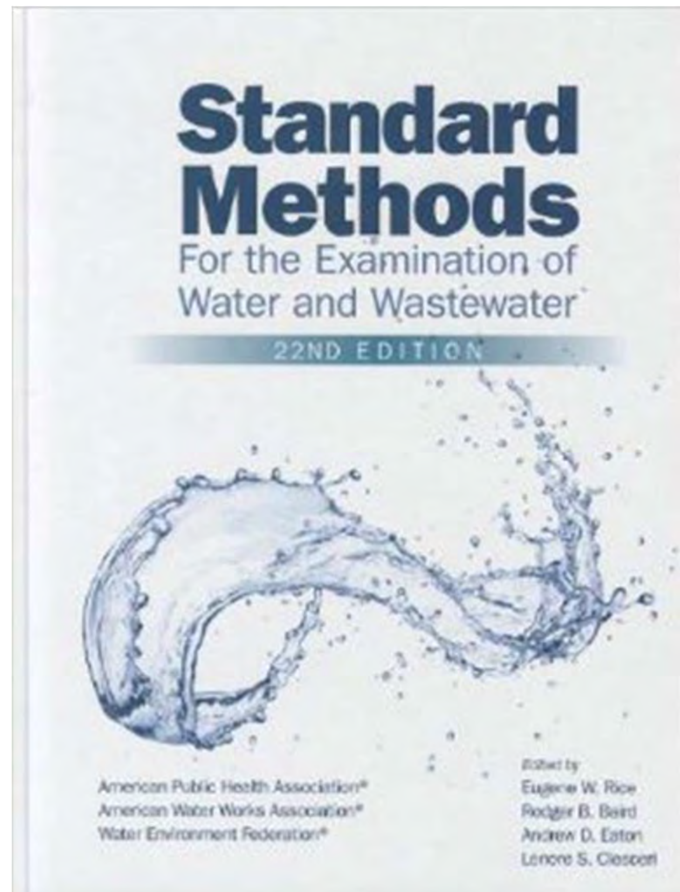
in partnership with:

NWRI National Water Research Institute

Our Needs

We need standard methods for the CECs with robust reporting limits

- Both should be in *Standard Methods*
- We should invest in developing these, doing round robin tests and getting them into SM
- The methods should include reporting limits
- We should end the race to the bottom



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