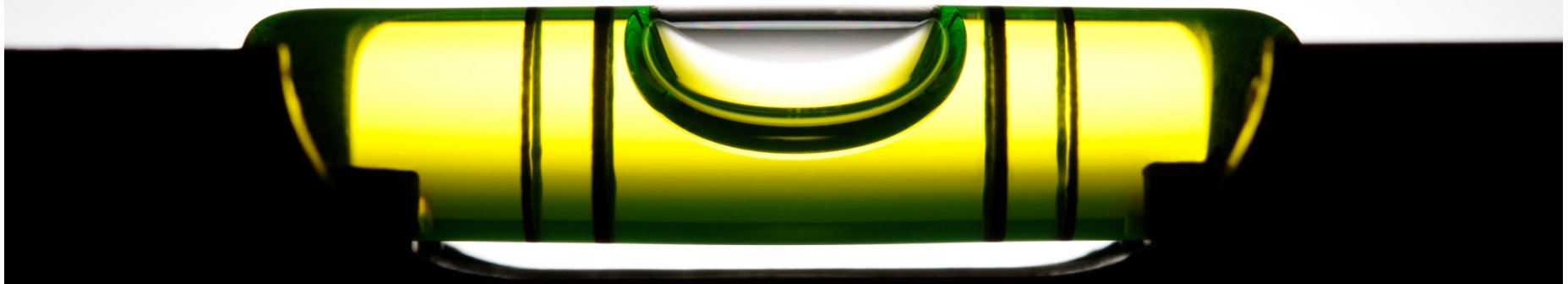
Managing the Delicate Balance between Wastewater Discharges and Groundwater Aquifers

Case Studies from New England



Marc Drainville | GHD

November 2016

Agenda

Background

- Typical Drivers (Why discharge to the ground)
- Permit limits

Methods of Land Disposal

Technologies used to remove CECs

New England Case Studies

- Rindge, NH
- Foxwoods Casino, CT
- Chatham, MA
- Oak Bluffs, MA

Questions

Background

Typical Drivers (Why discharge to the ground?)

- Limited or no viable surface water discharges
- Unable to discharge to the ocean
- NPDES permitting
- Regulatory requirement to evaluate
- Desire for reuse and reclamation

Concerns: groundwater aquifers, receiving water bodies

Permit Limits

- TSS/Turbidity
- Nitrogen
- Contaminants of Emerging Concern (Total Organic Carbon, etc)
- Disinfection

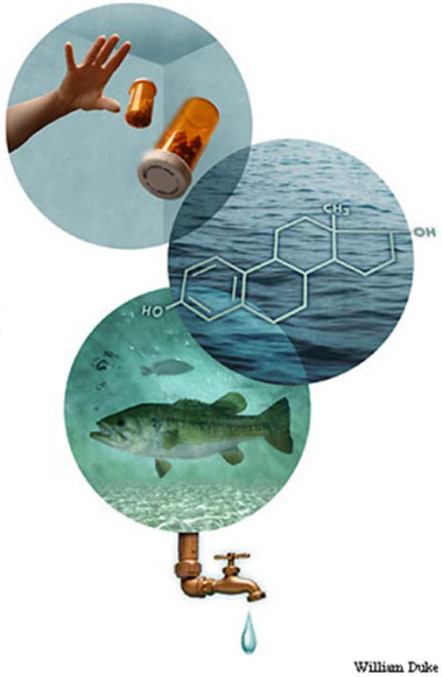
Leonardo Disposal Area

Effluent Characteristic	Discharge Limitations	
Flow	250,000 gallons per day maximum to Leonardo Property*	
Total Daily Flow**	not to exceed 370,000 gallons per day	
Oils & Grease	15	mg/l
Total Suspended Solids	10	mg/l
Biochemical Oxygen Demand, 5-day @20c	30	mg/l
Total Nitrogen (NO_2 + NO_3 + TKN)	10 mg/l	daily max
Nitrate Nitrogen	10	mg/l
Fecal Coliform Bacteria	200/100	ml
Turbidity	5	NTU
Total Organic Carbon (TOC)	3	mg/l

Nitrogen

- Primary drinking water standard – Nitrate 10 mg/L (TN of 10 mg/L)
- Lower limits if required by receiving water – TN as low as 3 mg/L

Contaminants of emerging concern



- 31 million organic and inorganic substances documer
- 14 million commercially available
- < 250,000 inventoried or regulated
- Domestic, Industrial & Agricultural compounds:
  - Pharmaceuticals: Prescription & Non Prescription
  - Personal Care Products
  - Industrial & Commercial Products (Detergents & metabolites, Plasticizers, Flame retardants, Pesticides)
- Potential Health Effects
  - EDCs
  - Carcinogens
  - Developmental Toxicants

Contaminants of Emerging Concern (CECs) and Total Organic Carbon (TOC)

- Requirements released by State of Massachusetts in March, 2009 include limitations for TOC
  - 3.0 mg/L for discharge within a Zone II drinking water protection area and >2-year travel time to source
  - 1.0 mg/L for discharge within a Zone II area and <2-year travel time to source
  - 1.0 mg/L for discharge within a Zone II area without soil aquifer treatment
- TOC limit is a daily limit (24 hour composite sample)
- TOC is a surrogate for many CEC
- Studies have shown that Pharmaceuticals & Personal Care Products (PPCPs) adsorb on to particulates of organic carbon, hence removal of TOC provides for removal of PPCPs.

Methods of Land Disposal

Land Disposal: The Challenges

- Sufficient land available?
- Suitable soil and groundwater conditions?
- Sensitive ecologic receptors?
- Compatible land use?
- Distance from plant?
- Reclamation reuse component?
- Drinking water aquifer?

Investigate the land

- Find land
- Review soils - desktop
- Investigate soils (borings, test pits)
  - Depth to groundwater
  - Characterization of soils
- Hydrogeologic Study (mounding)
- Percolation Tests
- Hydraulic load tests

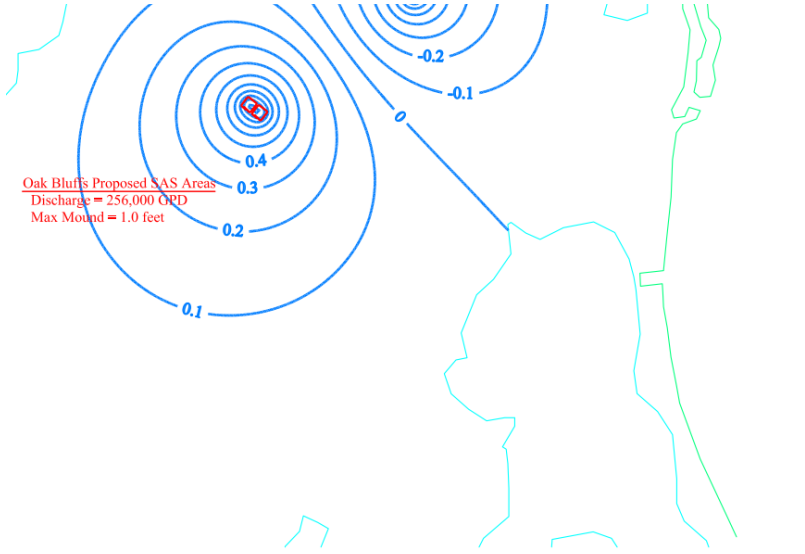


Figure 5. Simulated Groundwater Mounding and Drawdown - Proposed Sand Beds and Farm Neck Well Field.

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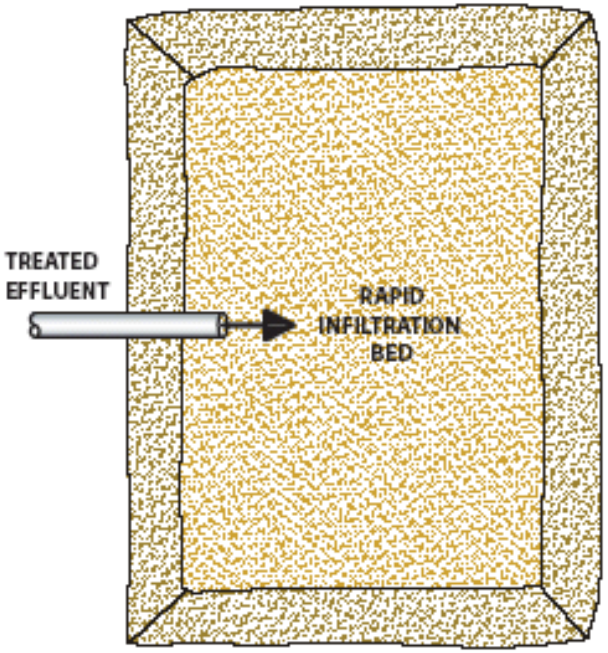
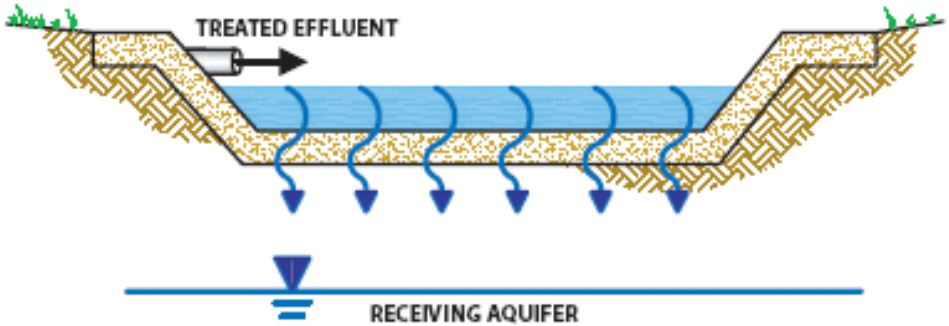
Technology Review: Introduction

- Rapid Infiltration Beds (RIBs)
- Subsurface infiltration (including drip irrigation)
- Spray irrigation
- Injection wells
- Wick systems
- Wetland restoration
- Reuse - reclamation

Technology Review: RIBs



PLAN VIEW



CROSS SECTION VIEW

Technology Review: RIBs

Chatham, MA WPCF

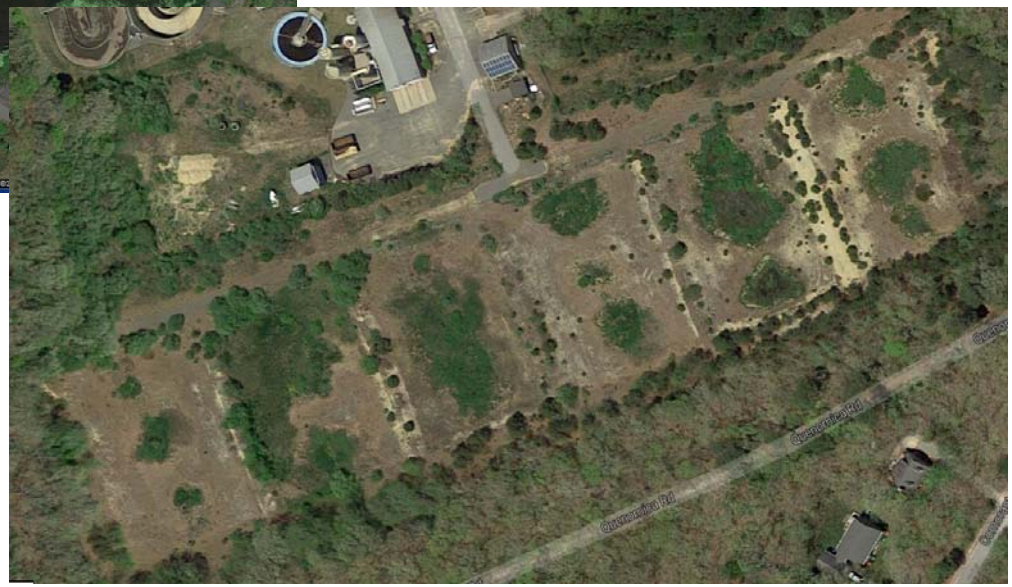
Barnstable, MA WPCF

Falmouth, MA WWTF

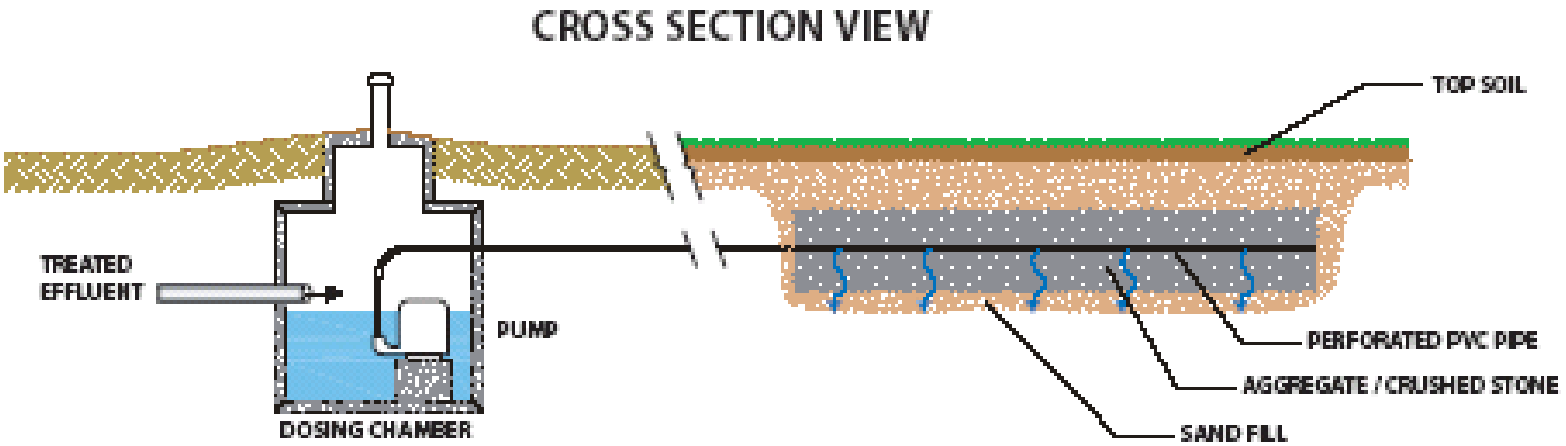
Technology Review: RIBs

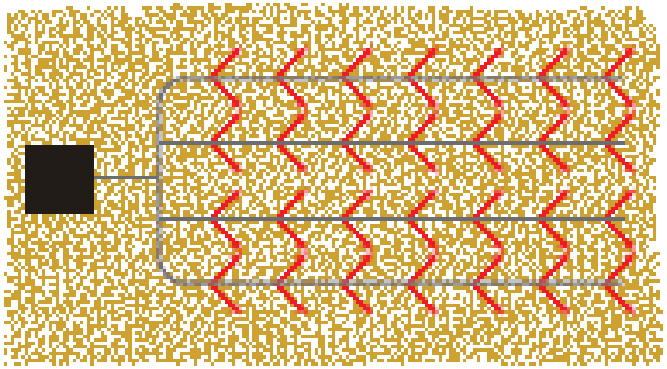
- Probably the simplest
- Easy maintenance (raking)
- Typically multiple beds and rotate use of beds
- Typically higher loading rates than other methods (up to 5 gpd/sq ft or more)
- Low public acceptance if visible
- Land intensive

RIB – Why is maintenance needed?



Technology Review: Subsurface Infiltration





PLAN VIEW

Technology Review: Subsurface Infiltration

- Allow secondary land use (parking, playing fields, parks)
- Higher public acceptance
- Larger area requirements than sand beds due to lower application rate
- 3 gpd/sq ft (trench) = 18 gpd/LF = 1.8 gpd/sq ft (field)
- Typically multiple beds and rotate use of beds
- Difficult to service if plugging occurs

Subsurface Infiltration

Oak Bluffs is on the Island of Martha's Vineyard

Ocean Park, Oak Bluffs, MA (disposal area for Oak Bluffs WWTF)

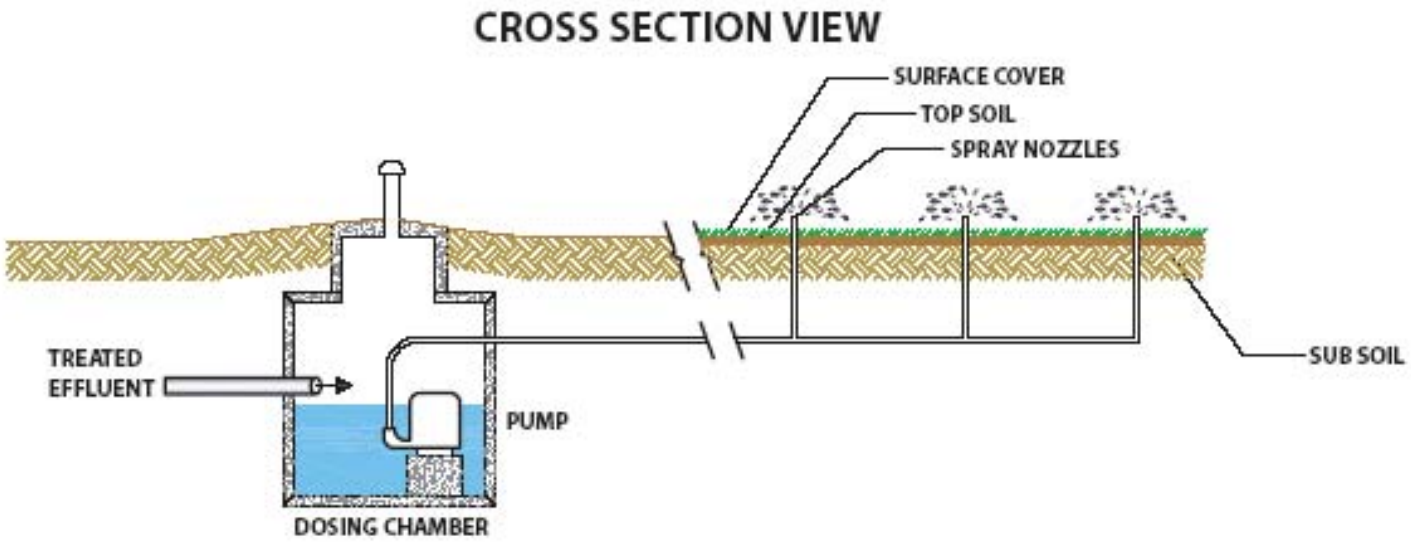
Technology Review: Subsurface Infiltration

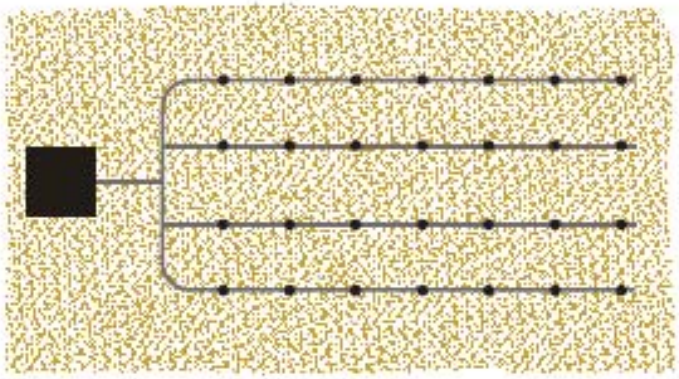
- Variation of subsurface infiltration: drip irrigation
- Can be used in rolling terrain conditions.
- Is associated with water reuse because water is recharged into the root zone of plants or crops.
- Low delivery rate to minimize water table impacts.
- Effluent must be highly treated to minimize plugging.
- Difficult to monitor emitter performance.
- Facilities must be protected from damage from heavy vehicles.

Technology Review: Subsurface Infiltration

Oakson Inc. drip dispersal system

Technology Review: Spray Irrigation



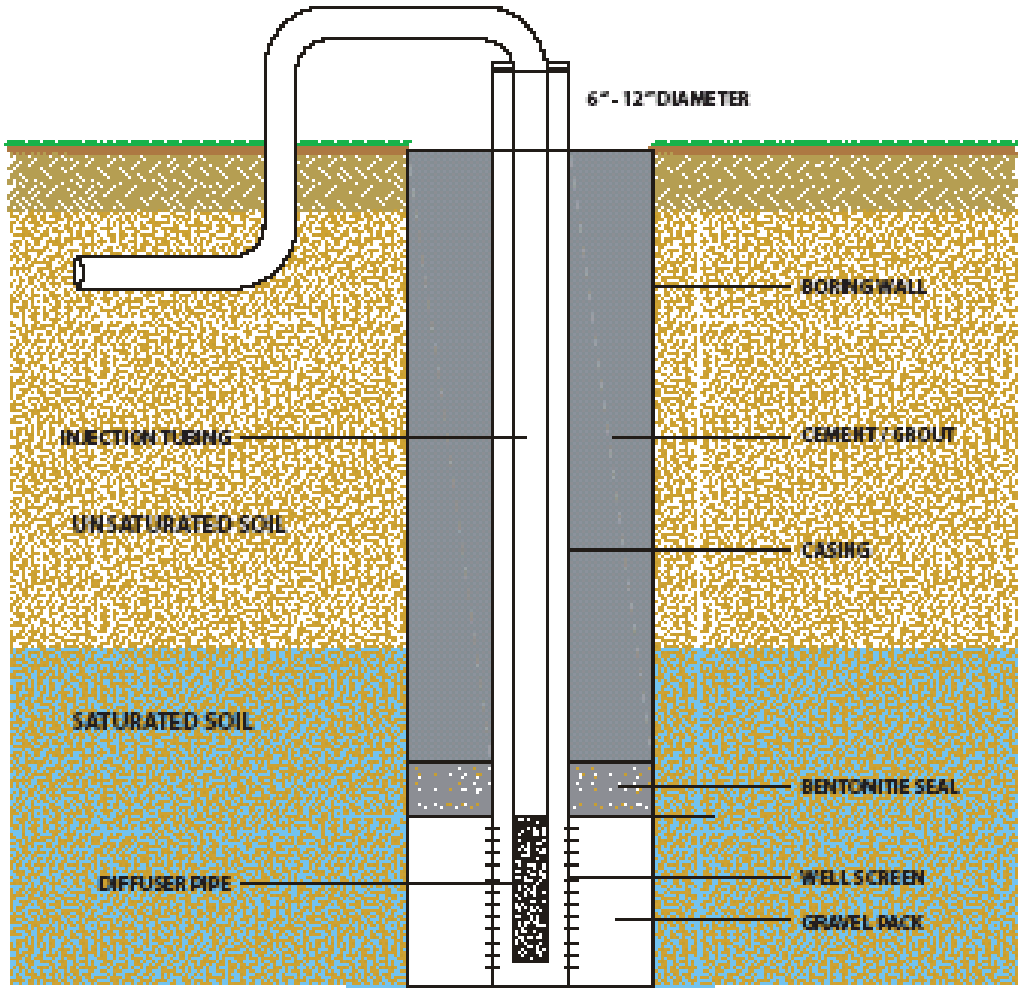


Technology Review: Spray Irrigation

- Beneficial reuse of water in the form of irrigation
- Volume attenuation (through evapotranspiration) and Nitrogen attenuation (through plant uptake)
- Allows secondary use of land
- Reduces demand on water system
- Requires storage or alternative method
- Land intensive (2 in/wk = .17 gpd/sq ft)

Spray Irrigation

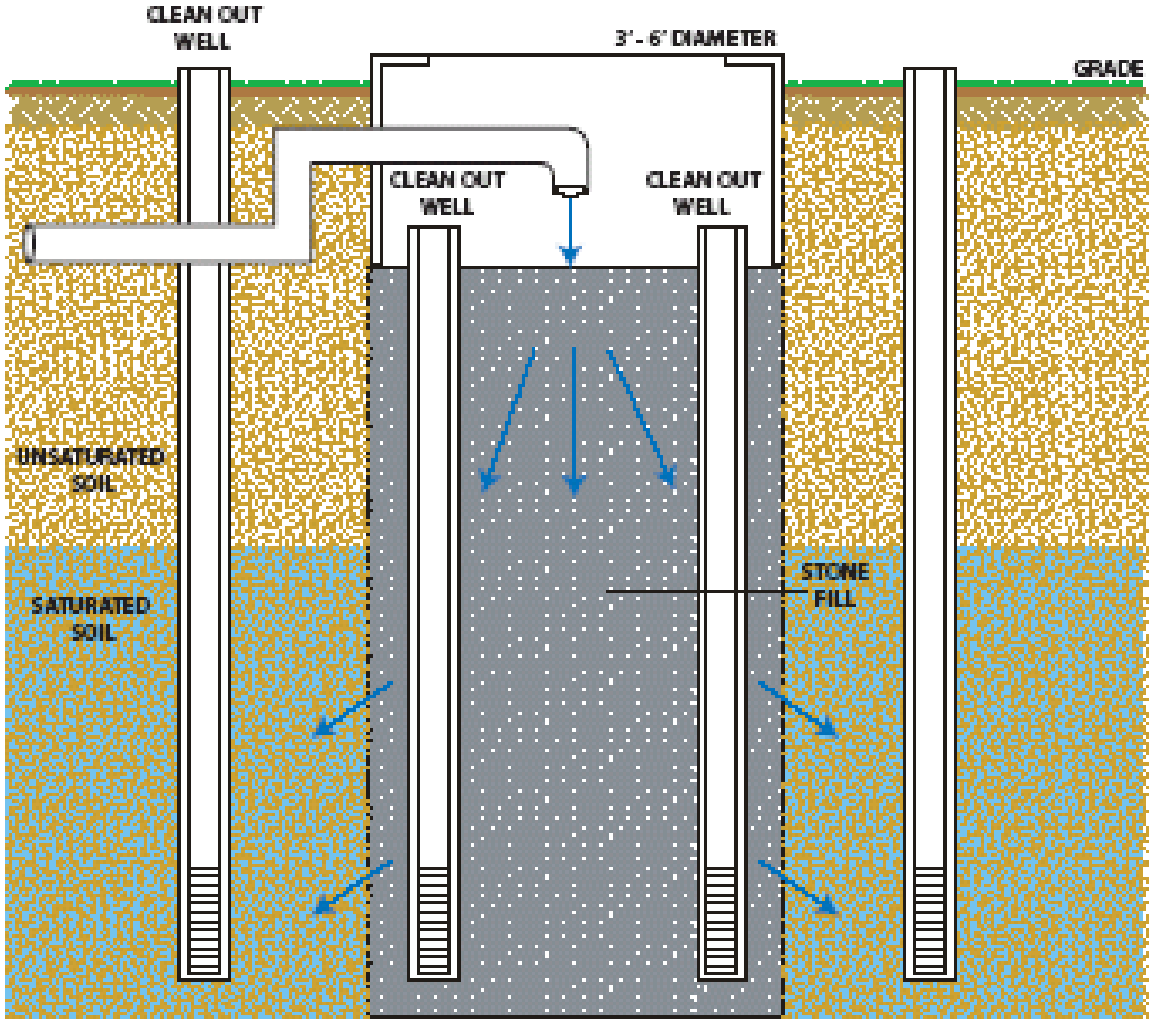
Technology Review: Injection Wells



Technology Review: Injection Wells

- Long history of use in CA and FL
- Low land area requirements
- Aesthetic impacts (sight-odor) are minimal
- Operation and maintenance can be challenging
- Regulatory hurdles, especially with regard to higher levels of chlorination, needed to mitigate biological fouling

Technology Review: Wick Systems



Technology Review: Wick Systems

- Low land area requirements (some states require 100% reserve area)
- Aesthetic impacts (sight-odor) are minimal
- Very limited long term operation and maintenance experience
- Plugging possible with high solids
- Typically multiple wells and rotate use of wells

Technology Review: Wetland Restoration

- Hybrid system
- Comparable to created wetlands for stormwater treatment
- In conjunction with conventional land recharge
- Regulatory hurdles to direct discharge
- Benefits ecosystem by restoring hydrologic balance (in areas of high groundwater withdrawal)
- Significant nitrogen attenuation

Technology Review: Reuse and Reclamation

- Follow state reuse policy (treatment)
- Recharge in zone of contribution of water supplies
- Recharge and associated withdrawal for irrigation
- Spray irrigation
- Purple pipe systems (toilets, irrigation, cooling water, etc.)

Technology Review: Conclusions

Multiple technologies, variables include:

- Public acceptance
- Area
- Regulatory comfort
- Treatment and maintenance
- Reuse benefits

Pick which one best suits your needs

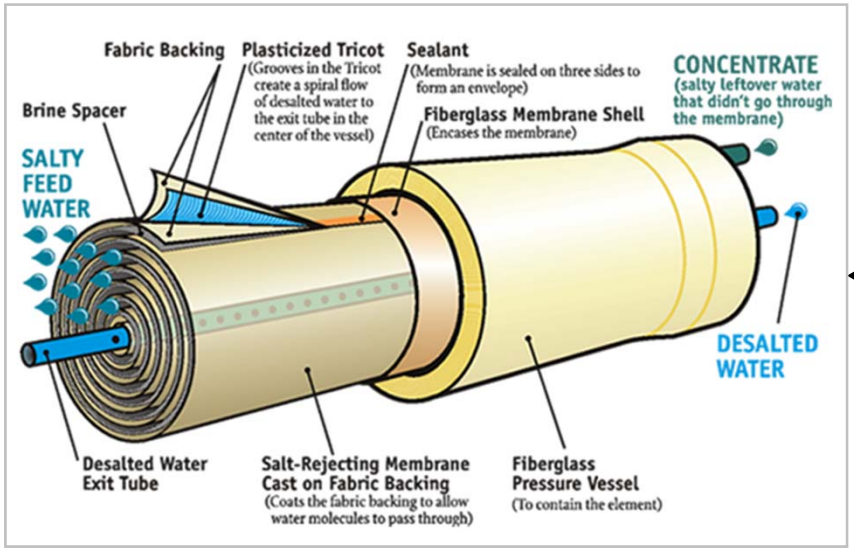
Technologies used to remove CECs

Technologies to achieve less than 3.0 mg/l TOC (post-tertiary) – alone or in conjunction with others

- Membrane Filtration
  - Nanofiltration, Reverse Osmosis, Ultrafiltration
- Ion Exchange
- Adsorption Granular Activated Carbon (GAC)
- Advanced Oxidation Processes (AOPs)
- Coagulation and Filtration

Membranes

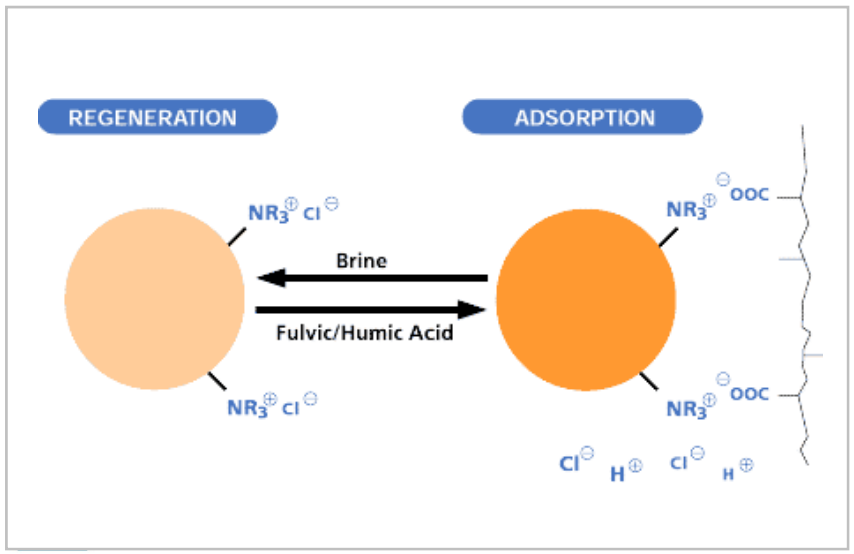
- Requires pretreatment to minimize fouling
- May require post-treatment for water chemistry stabilization
- Concentrate disposal required (high salinity RO concentrate)
- Excellent TOC and CEC removal

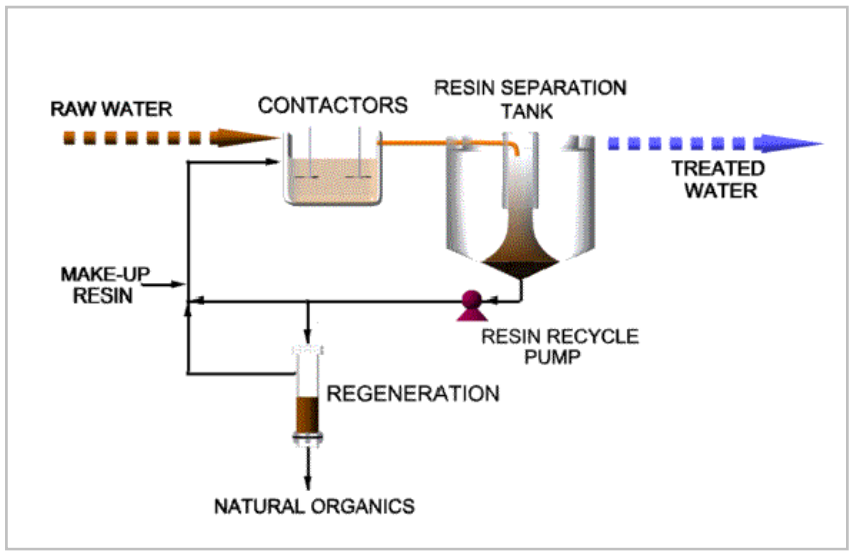


Reverse Osmosis Membrane Element inside a Pressure Vessel

Ion exchange

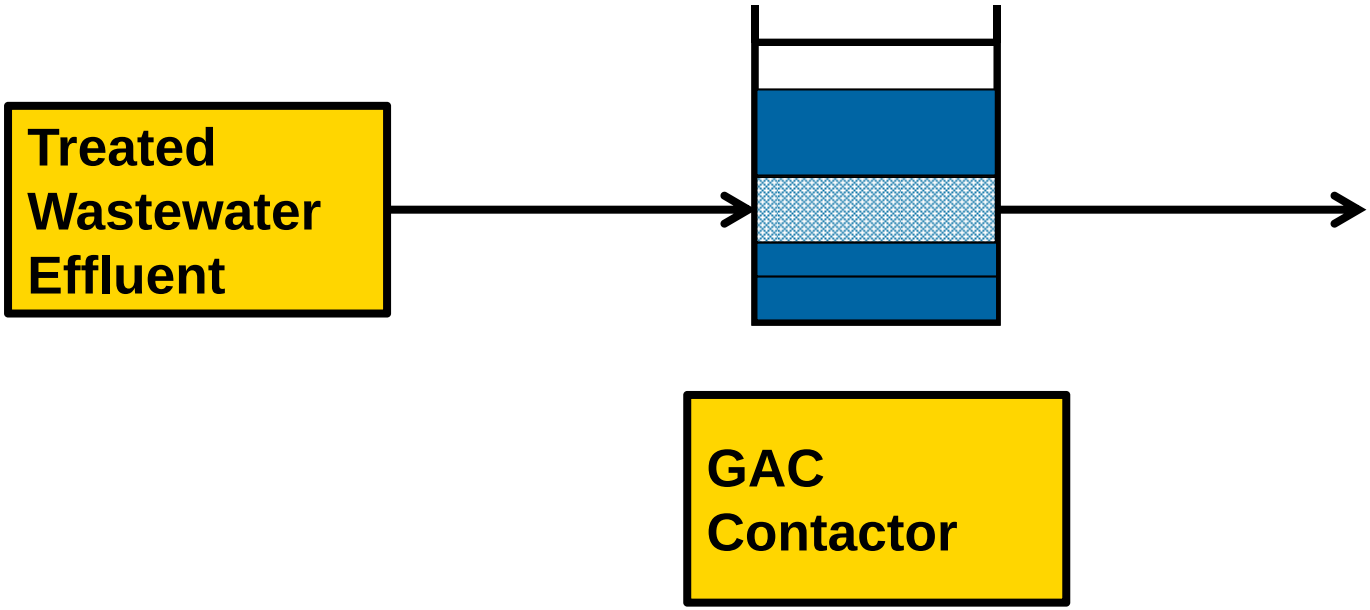
- Continuous process with magnetized anionic exchange resin designed for Dissolved Organic Carbon (DOC) removal
- DOC exchanged with chloride ions on the MIEX resin surface, resin has to be regenerated
- Brine disposal required
- Potential for good DOC and CEC removal





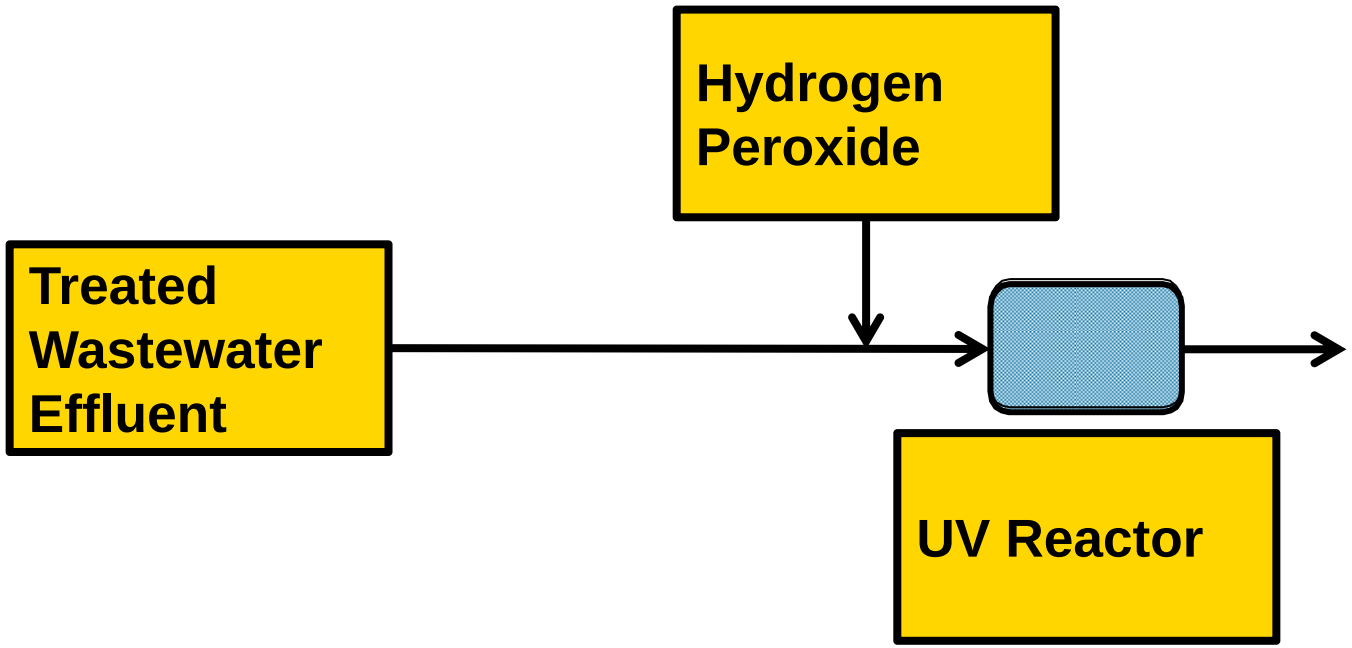
Adsorption GAC

- TOC adsorbed in a downflow or upflow contactor
- Requires pre-treatment and disposal / regeneration of spent GAC once breakthrough occurs
- Good TOC and CEC removal



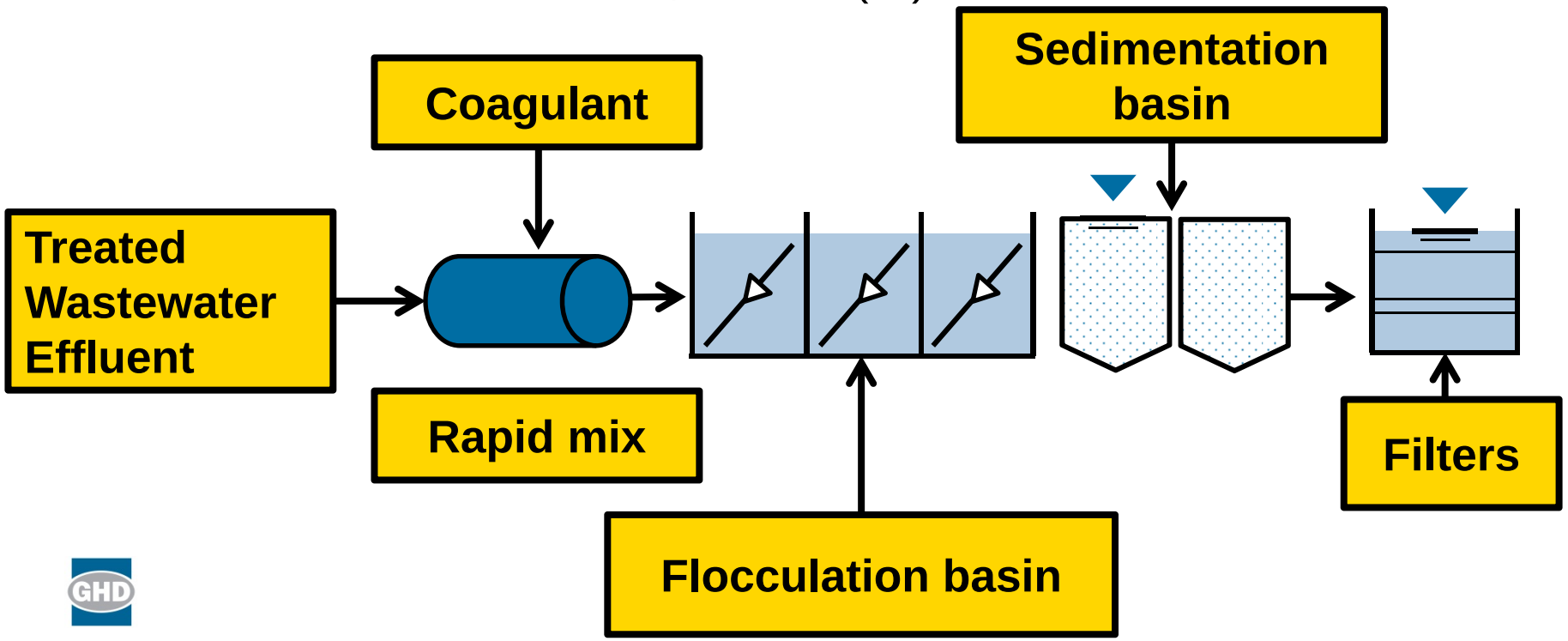
Advanced Oxidation

- Oxidation by hydroxyl radicals
- Typically used as polishing step following membrane filtration
- Good CEC destruction

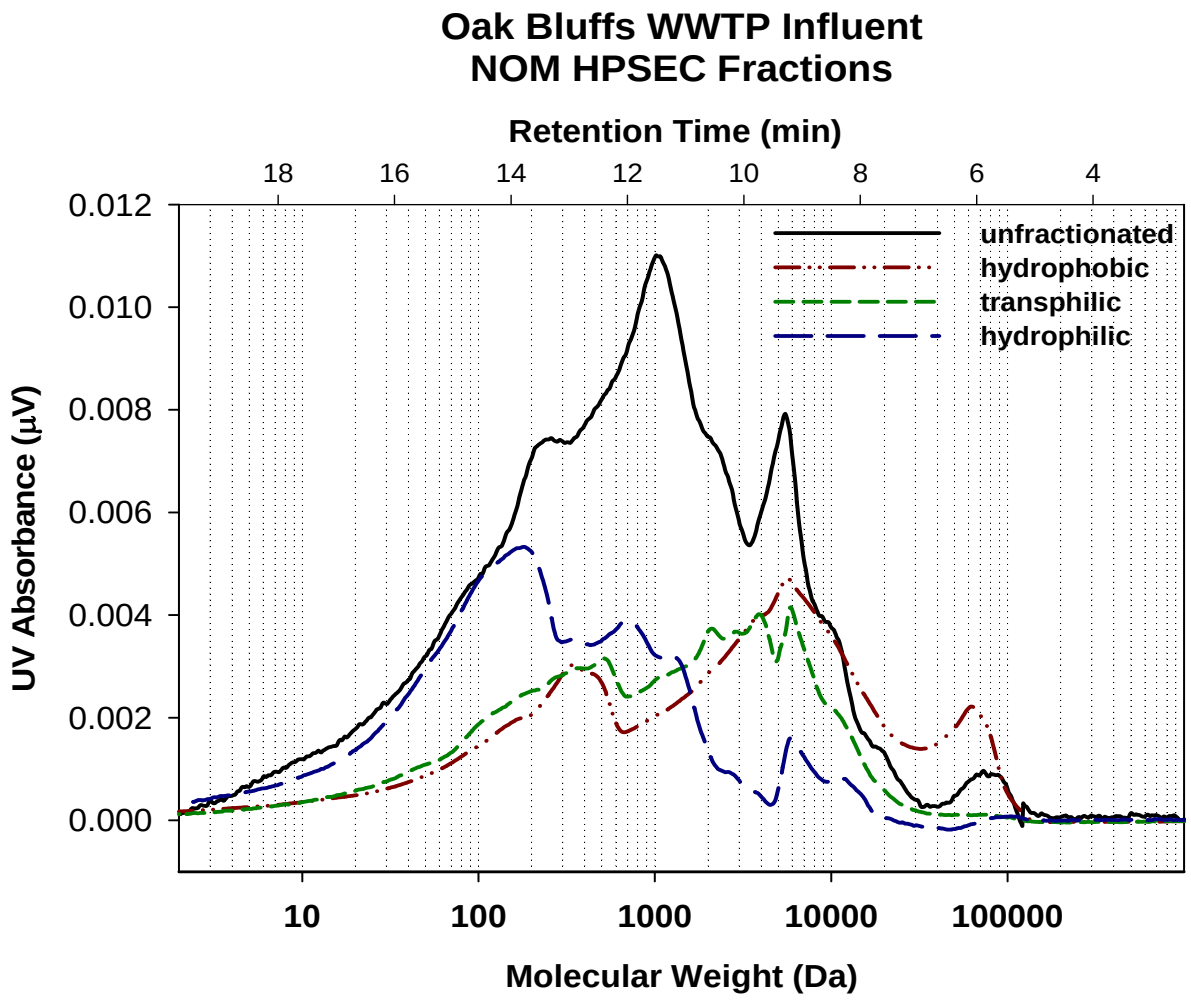


Pre-Treatment

- Alter physical / chemical properties of suspended particles to increase agglomeration (create larger flocs)
- Chemical coagulants include aluminum sulfate (alum), ferric chloride, and ferric or ferrous sulfate, Ferrate (VI)



Influent organic matter characterization



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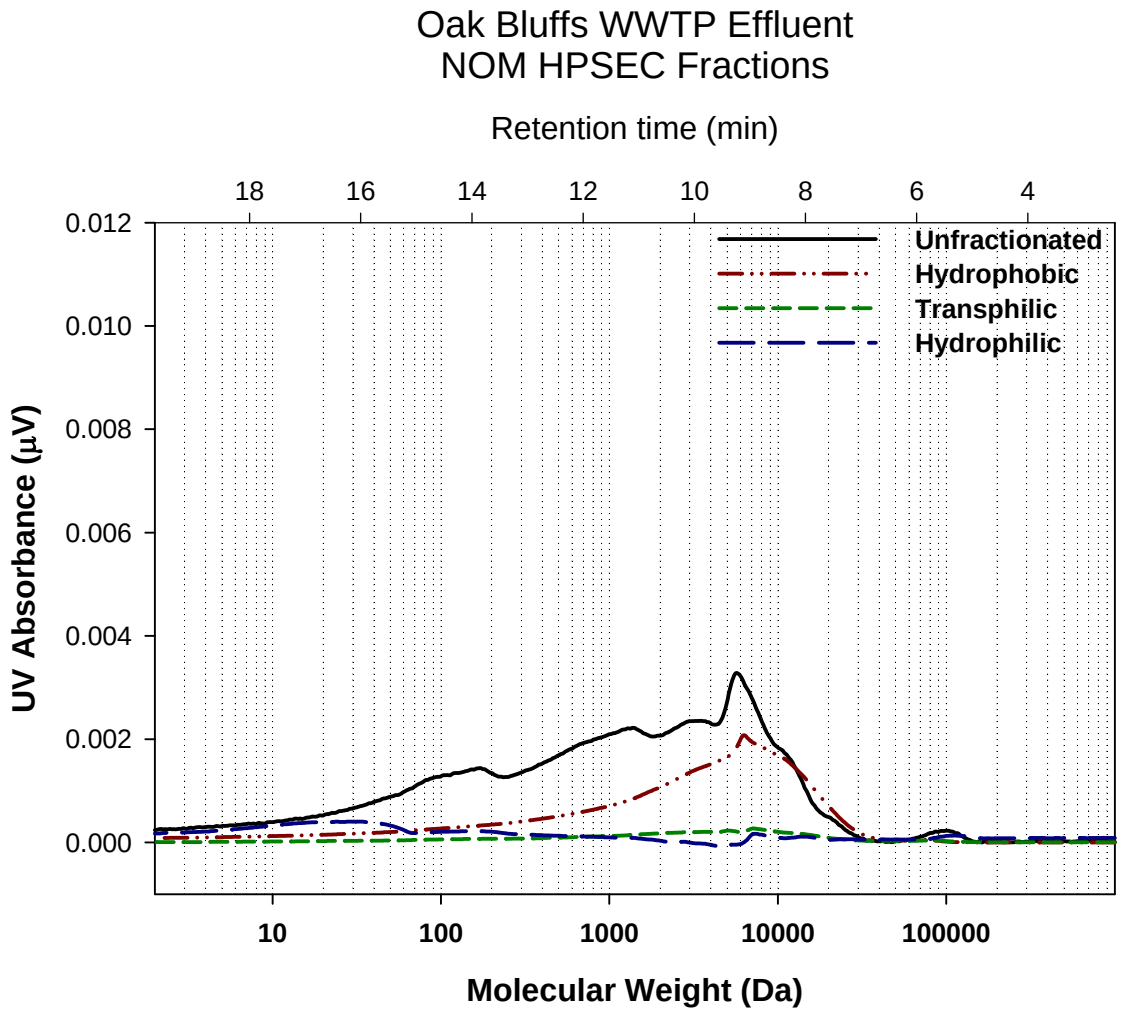


New England Case Studies

Franklin Pierce University; Rindge, NH

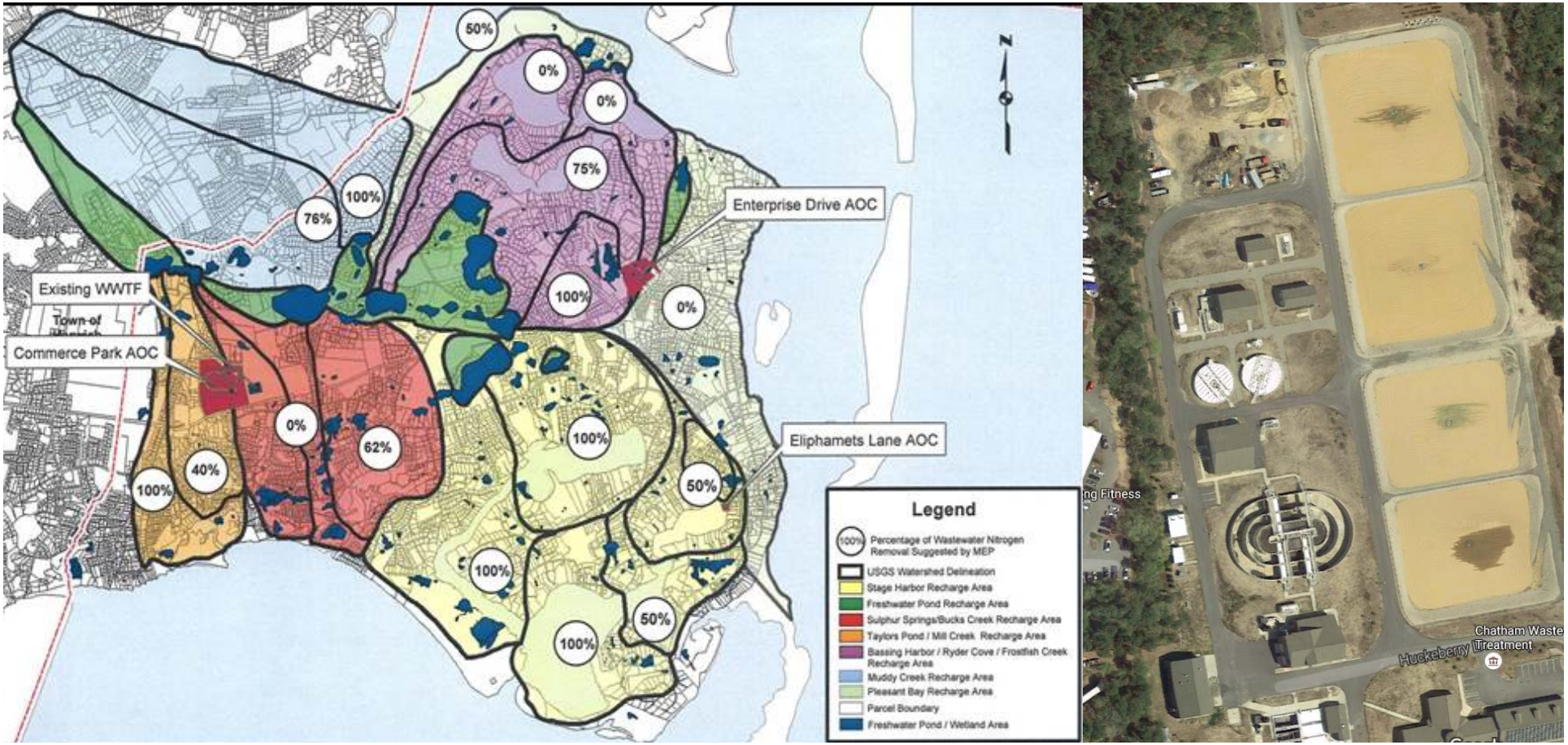
- Former wetland discharge (surface water)
- Transitioned to groundwater discharge – encouraged by EPA
- Infiltration beds
- Several drinking water wells downstream of discharge (rural area)
- Nitrate and TN of 10 mg/L

Foxwoods Casino, CT

- Native American Casino (no permit for normal discharge)
- Infiltration Beds (normal discharge)
- Voluntarily remove nutrients
- Golf Course (permitted water reuse application) including disinfection

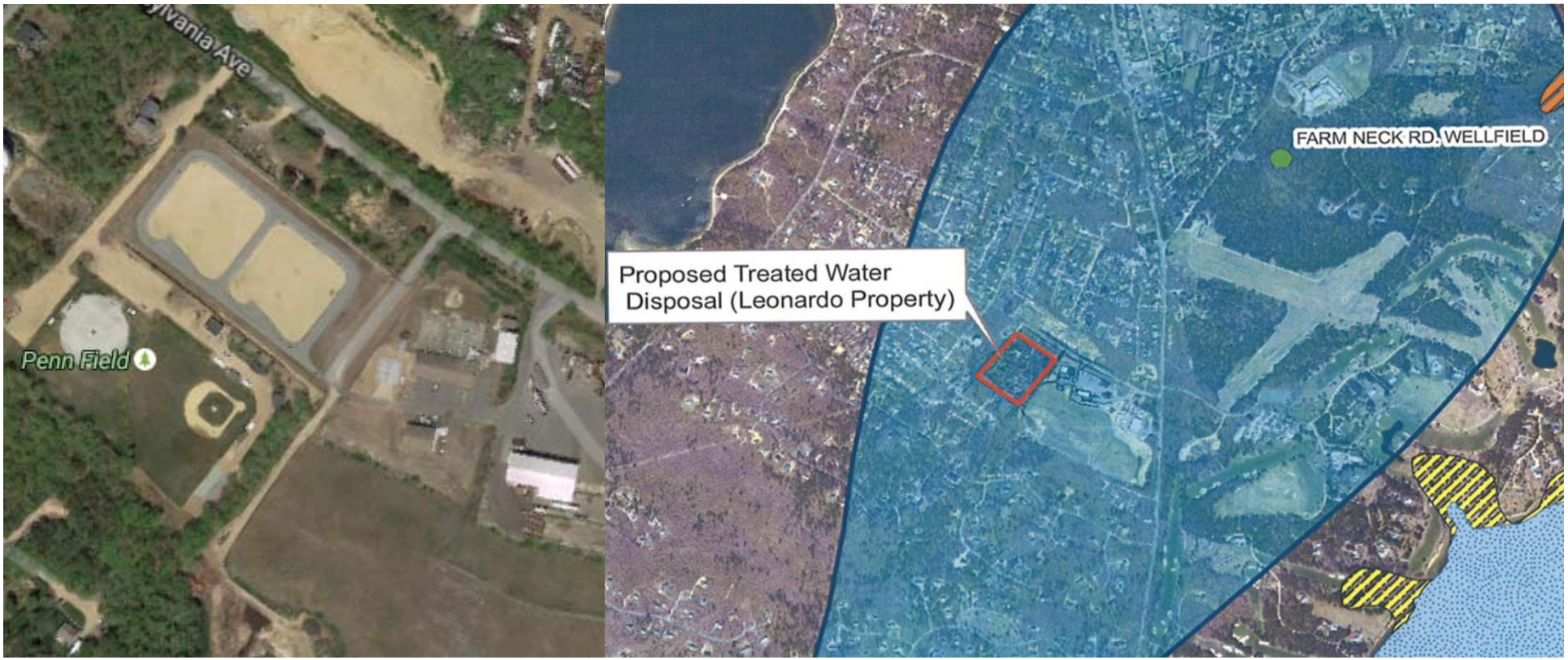
Chatham, MA

- Discharge to groundwater (abandoned drinking water supply)
- Special action from state
- TN of 3 mg/L



Oak Bluffs, MA

- Discharge to groundwater (drinking water supply)
- Original permit required TOC limit of 3 mg/L
- Negotiations with State required to allow discharge without treatment beyond filtration (only nitrate and TN of 10 mg/L)



Summary cost comparison for TOC removal

Town	Treatment Costs (project costs in $/gpd)	Other options	Final Decision
Chatham, MA	$10 *	Replace well, treat at well, waiver	Abandoned well in drinking water supply area and sought waiver
Falmouth, MA	$9 *	Alternative site	Sought alternative disposal site
Oak Bluffs, MA	$16**	State negotiations	Permit was negotiated to eliminate TOC req't

* Incremental increase above ENR

** No backup facilities due to the presence of a backup disposal area

Thank you

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