

# Evolution of Membrane Filtration

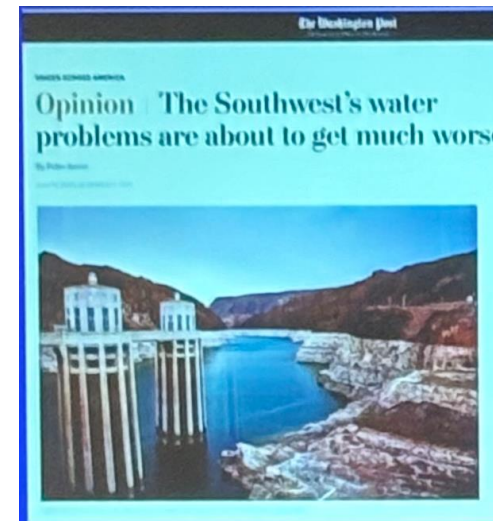
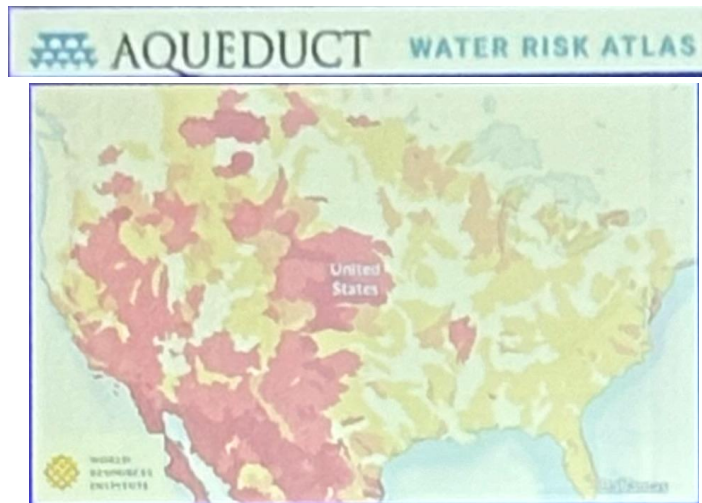
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# The Need for Innovation

- Global demands for freshwater will exceed the supply by 40% in 2030



- Membrane Supply options: Desalination, Reuse

# Reuse vs Desal Metrics

## **Cost**

- Wastewater Reuse <50% of Sea Water Desalination

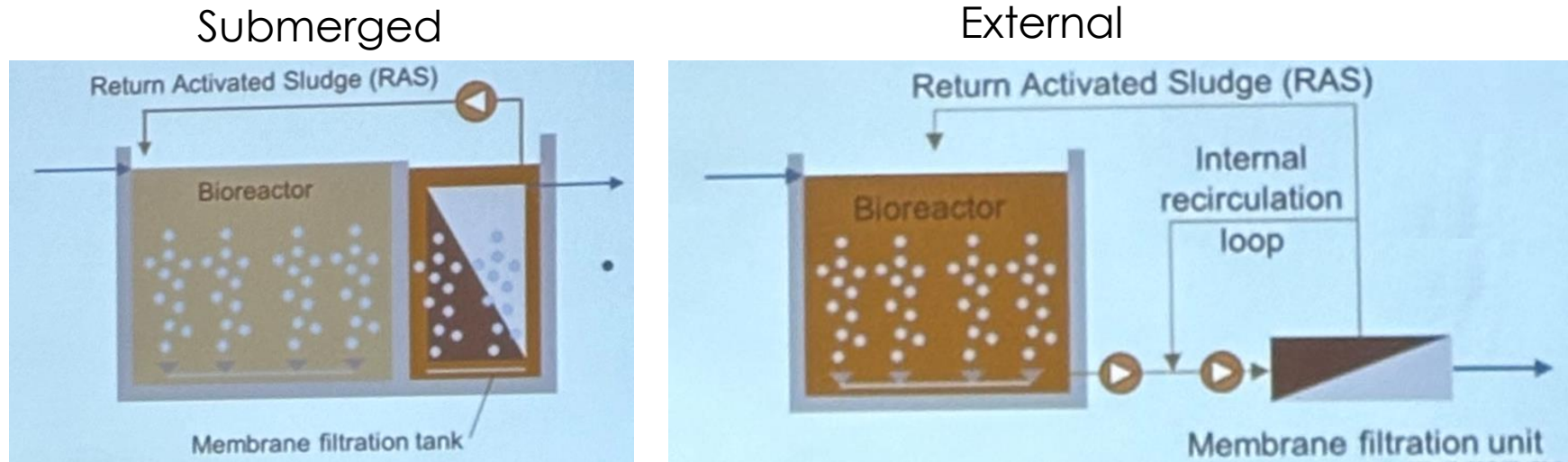
## **Energy**

- Wastewater Reuse <50% of Sea Water Desalination
- Reuse is Booming in Many Areas

# Membranes in Wastewater

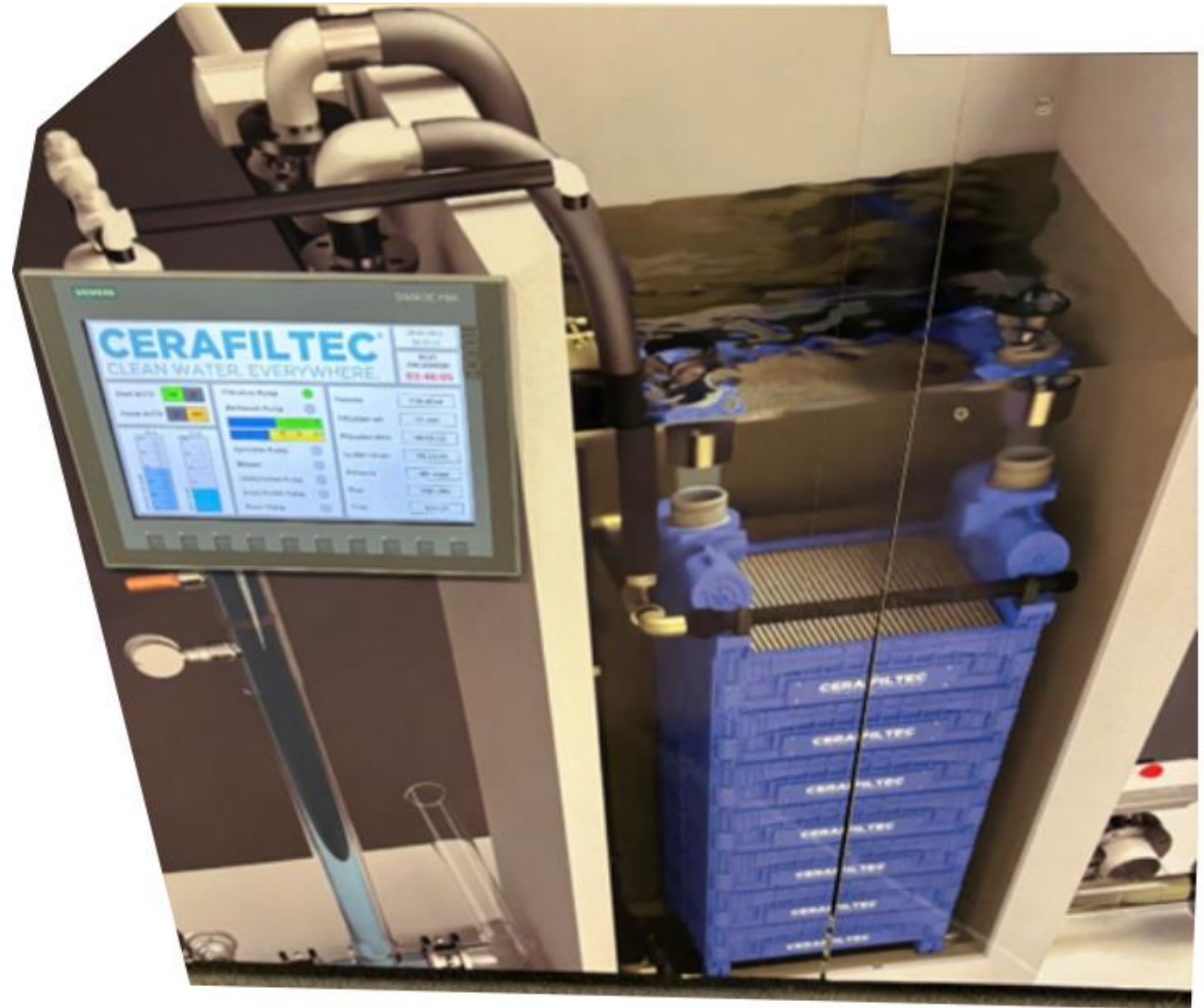
- Tertiary Membrane Filtration
  - MF, UF post CAS
- WWRO
  - Post MF, UF (IMS)
- Membrane Bioreactor (MBR)
  - MBR-WWRO (+UV) → Direct Potable Reuse

# Membrane Bioreactor MBR



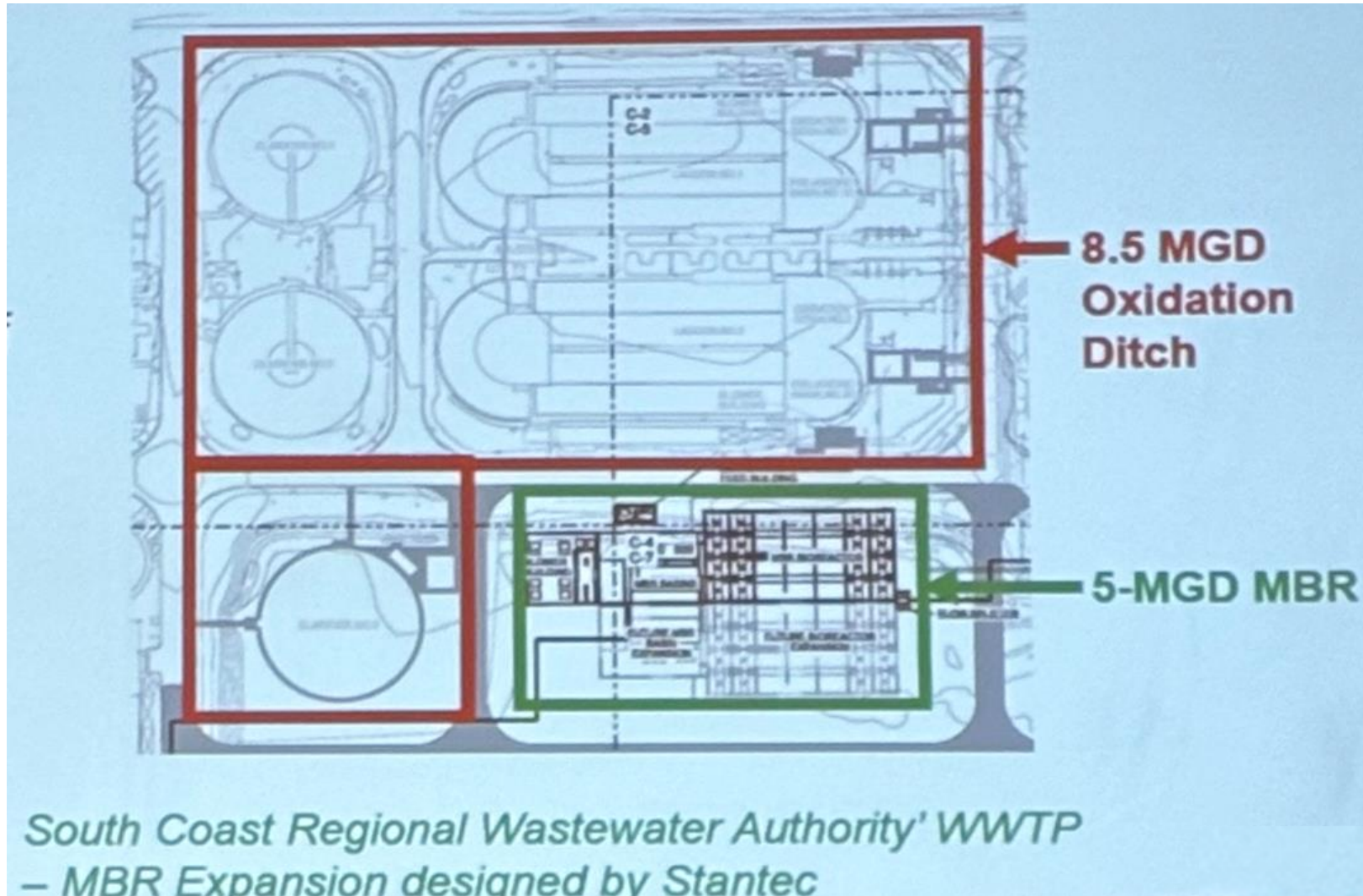
- High quality effluent

# Submerged Ceramic Membrane

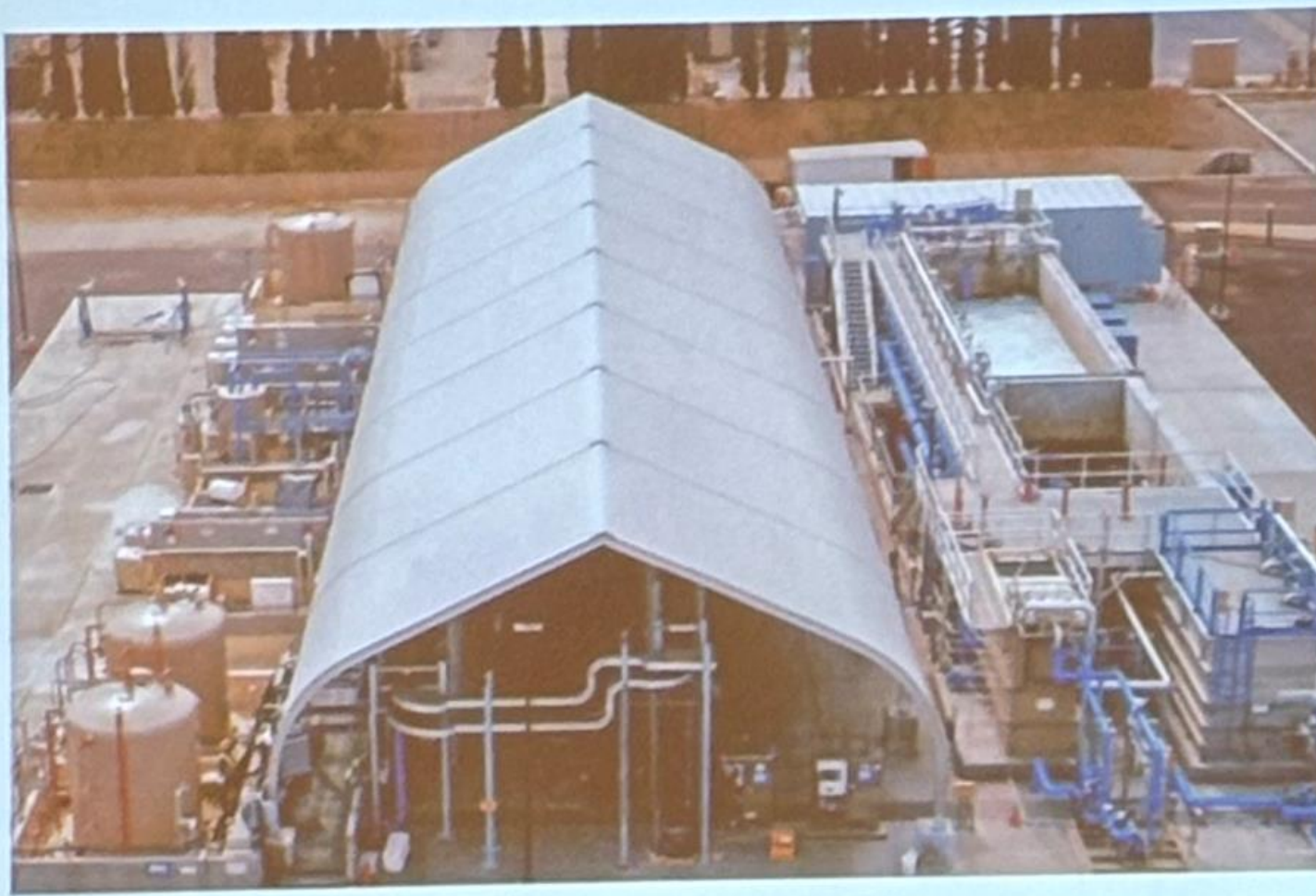




# MBR – Small Footprint



# MBR Pretreatment for RO + UV in Potable Reuse



*MBR-based AWT Demonstration Facility Designed by Stantec  
(Metropolitan Water District of Southern California, CA)*



# Reuse vs Desal Metrics

- Cost Favors Reuse
- Energy Favors Reuse
- Palate?



RO-AOP Porter Beer



# Los Angeles



Late Night TV, 1990

**You thought it  
was bad when  
just the air was  
brown in L.A.”**

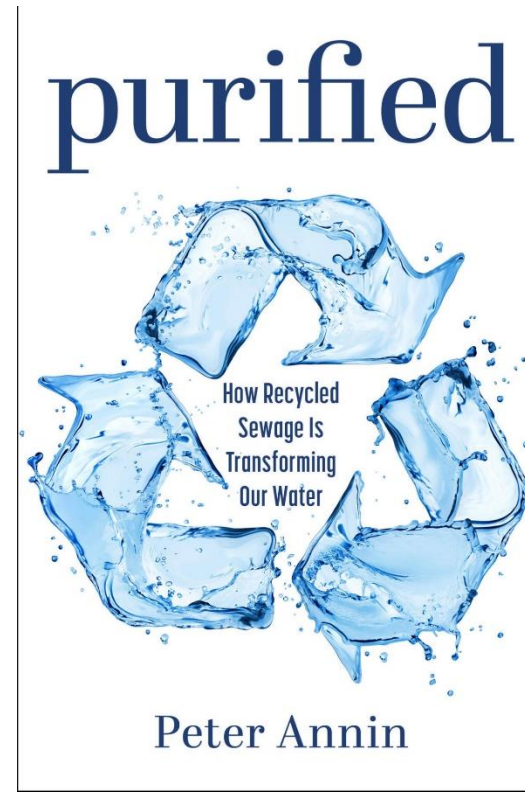
Headline, 2019

**Mayor Garcetti: Los Angeles Will Recycle  
100% of City’s Wastewater by 2035**

# TX-Big Spring, Wichita Falls



T Shirt Promoting DPR



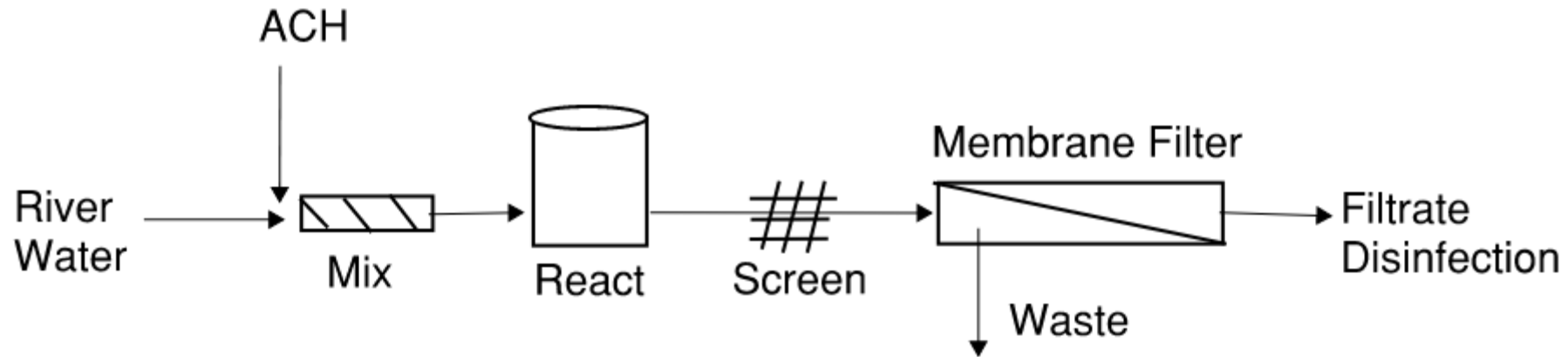
Find Out More!  
Entertaining and Informative



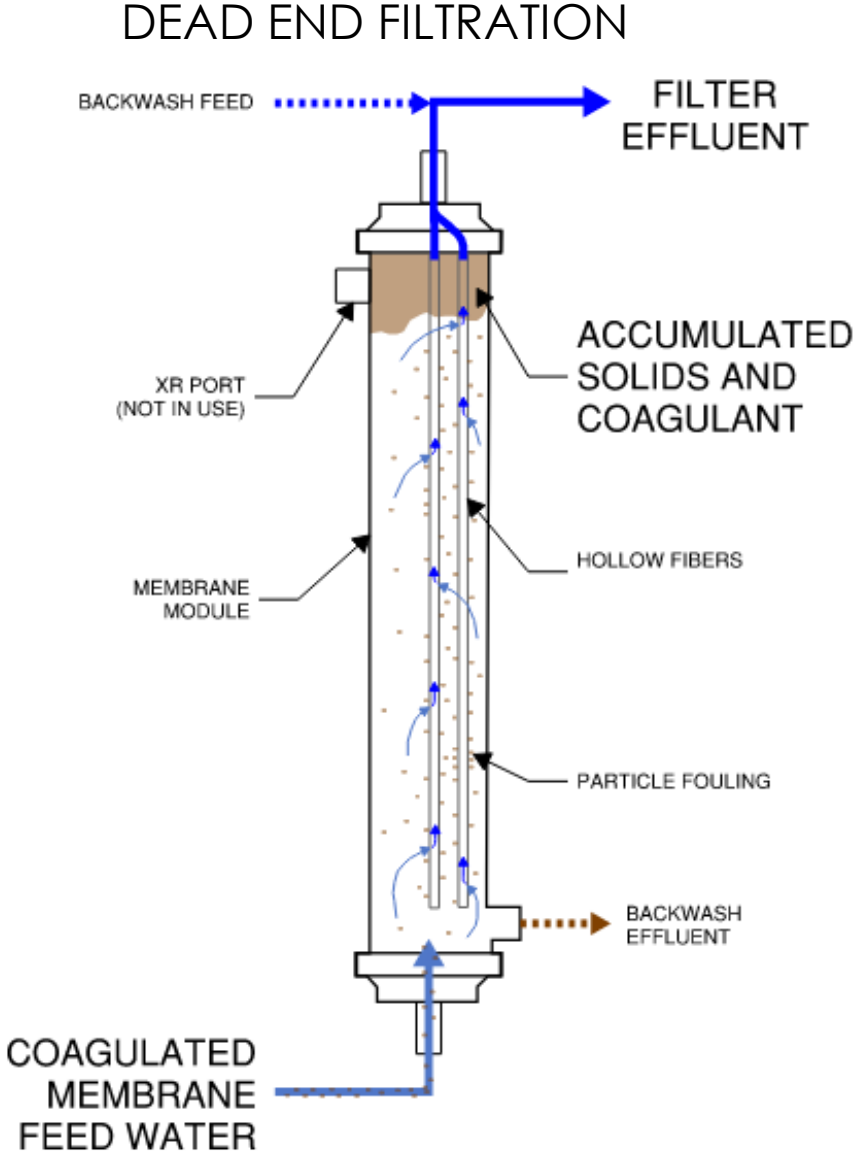




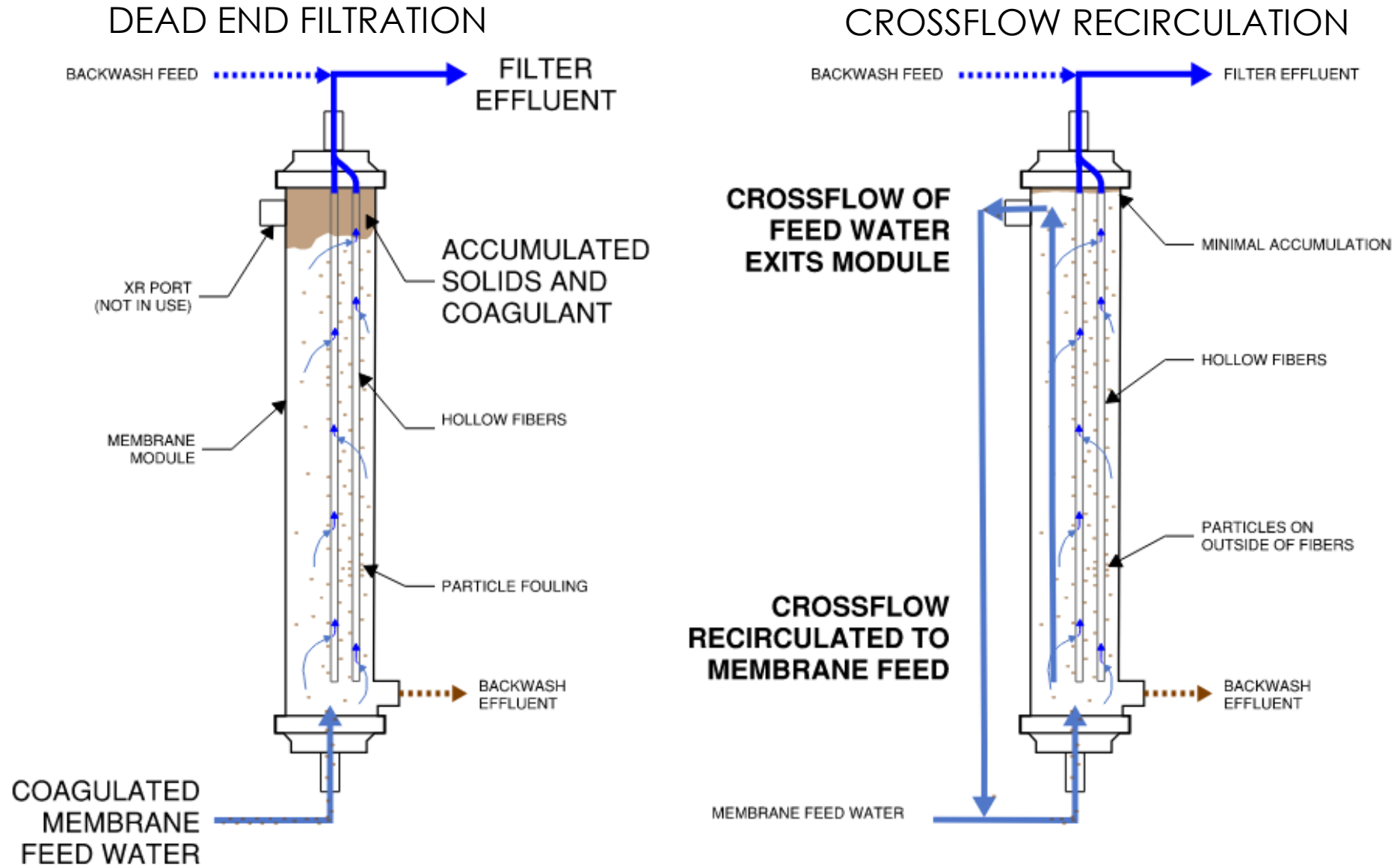
# In-Line Coagulation



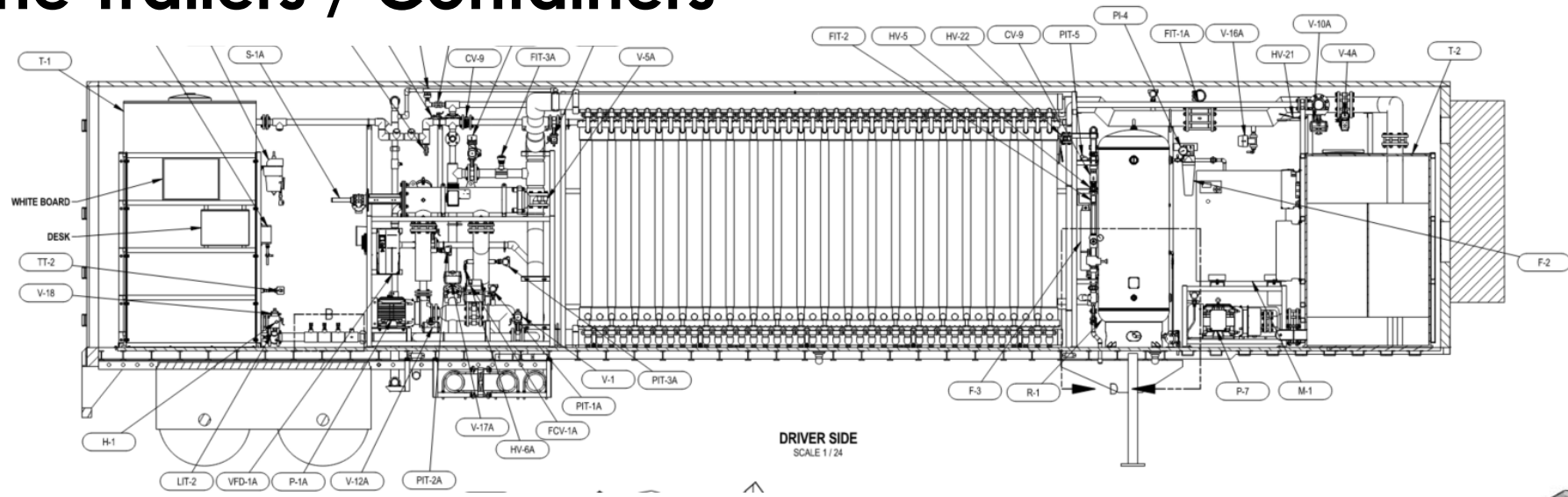
# Dead End Filtration - Solids Can Accumulate

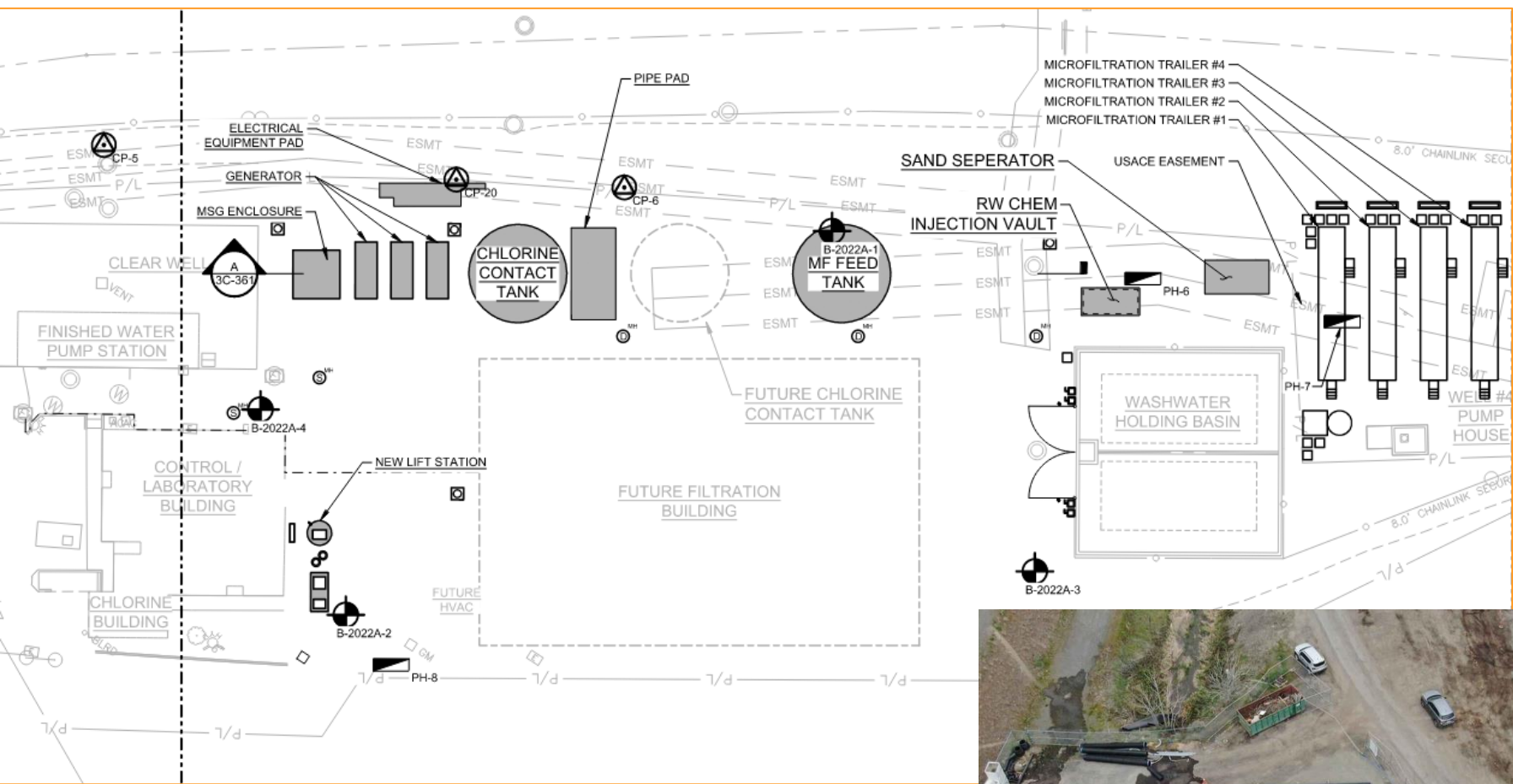


# Cross Flow Can Reduce Solids Accumulation



# Membrane Trailers / Containers







# Proprietary vs Open Platform

## Proprietary

- Pall-Aria
- Suez
- Memcor

## Open Platform

- H2O Innovations
- WesTech
- Toray, others

## Marketplace Solution



# Low Pressure Membranes (MF, UF)

- Polymeric (PVDF, PES), Ceramic (Aluminum Oxide), hybrids
- Hollow Fiber (Polymeric) vs. Tubular or Monolith (Ceramic)
- Dead-End vs Cross-Flow, Back-Washable
- Pressure vs. Submerged



# Nanofiltration (NF)

- State of the Art
  - Softening
  - Micropollutants (Organic / Inorganic)
  - Color
  - Low MW Natural Organic Matter (NOM)
- Evolution
  - Backwashable Hollow Fiber NF Membrane
  - Charged NF Membrane + & -
  - NF Barrier for PFAS and Microplastics?
  - Selectivity through pore size and charge



# Potential Future Trends

- Bioinspired membrane materials
- Enhanced selectivity
- 3-D Printing of Module Components
- AI/ML Driven Membrane Operation
- Zero Liquid Discharge Approaches
- Renewable Energy Driven Membranes

# Questions?

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