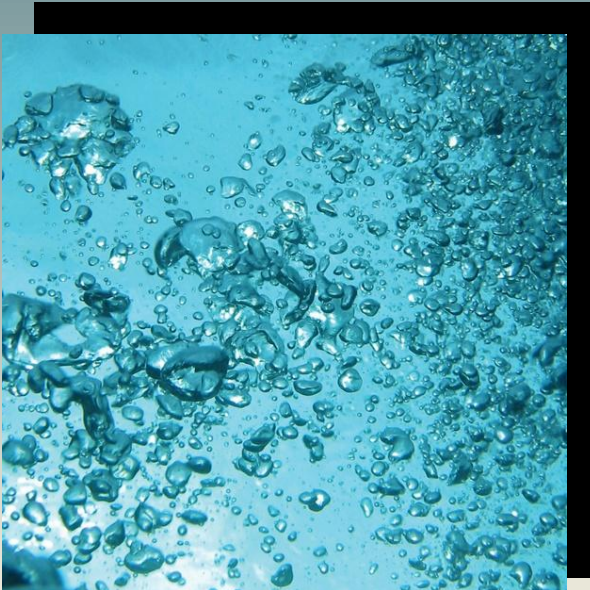


Exploring a Low Profile Aeration Technology

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Presentation Overview

- **Gas Transfer Technologies Review**
- **New Membrane Contactor Technology**
- **Case Study**
- **Future Research**

Gas Transfer Approaches

■ Aeration

- Spray (nozzle)
- Mechanical
- Cascade
- Diffused bubble
- Packed Tower

All aeration processes
require exposure to
atmospheric pressure

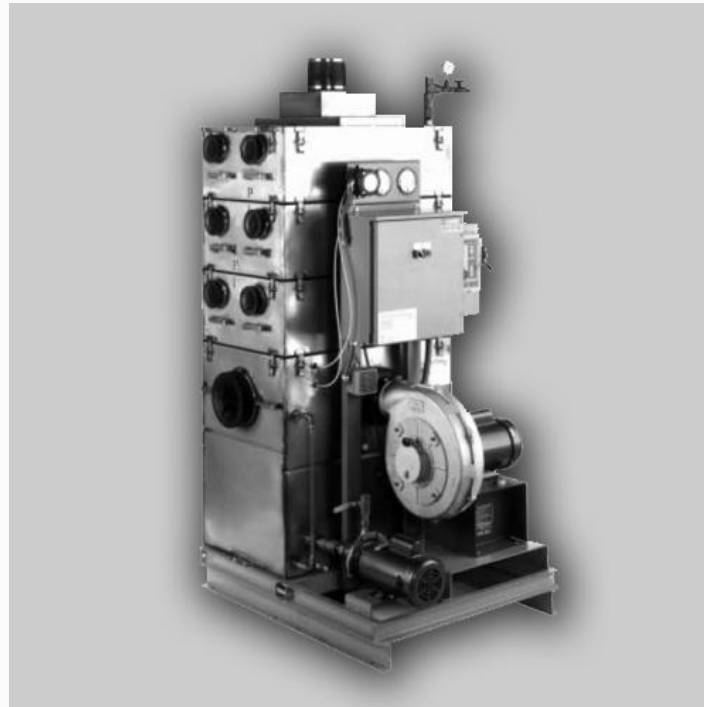
■ Degassing

- Membrane Contactor
- Centrifugal/Vortex

Degassing can occur under
system pressure or using
vacuum

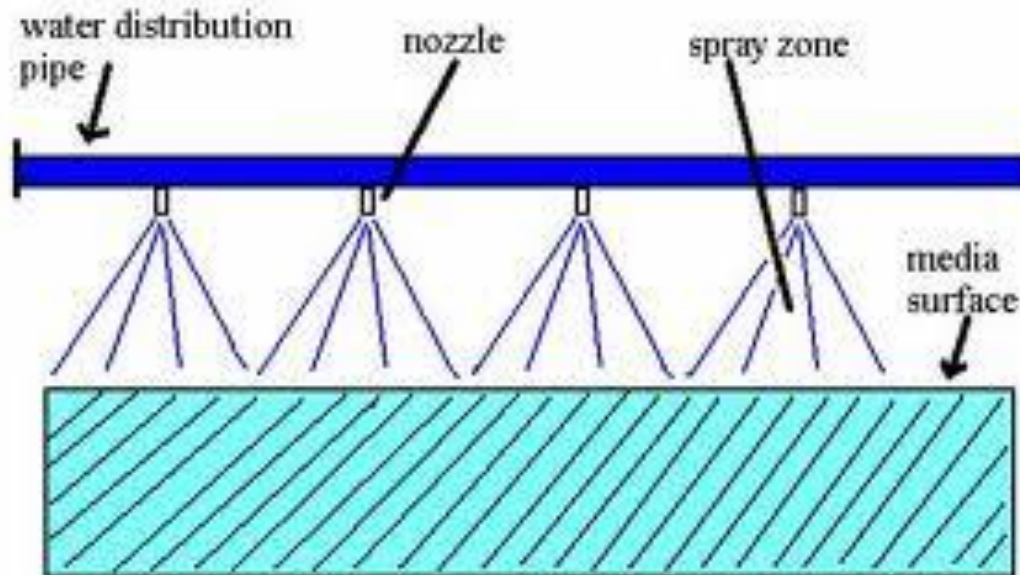
Tray Aeration

- Can use forced air or natural draft
- Must collect treated water and re-pump

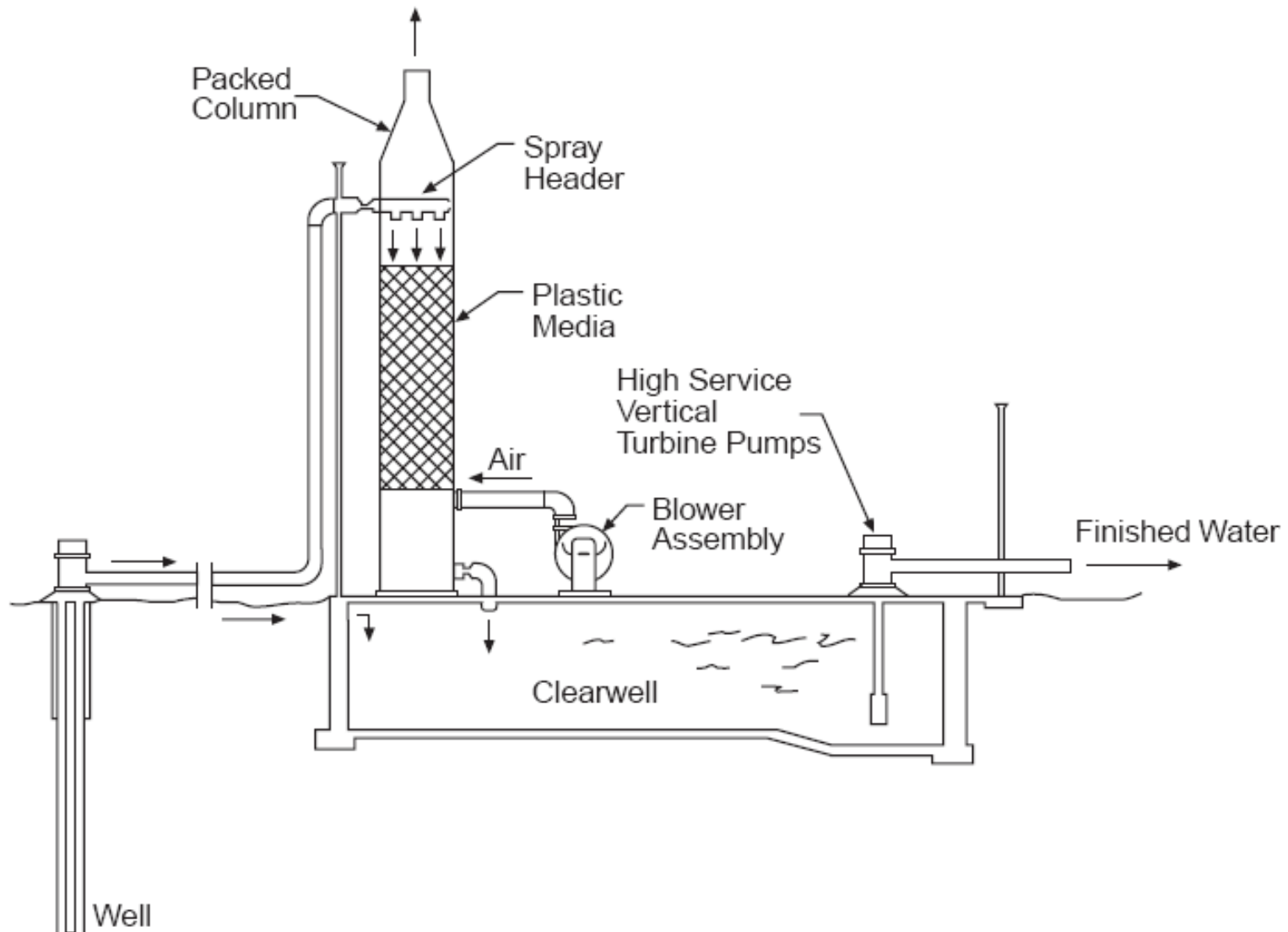


Spray (Nozzle) Aeration

- Low cost and simple
- Low efficiency ($\leq 50\%$)
- Can be installed in reservoirs



Packed Tower Aeration



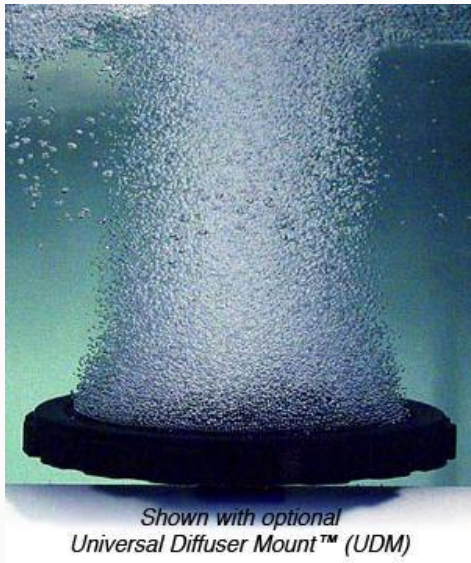
Packed Tower Aeration

- **Highly efficient (>95%)**
- **Must collect treated water and re-pump**

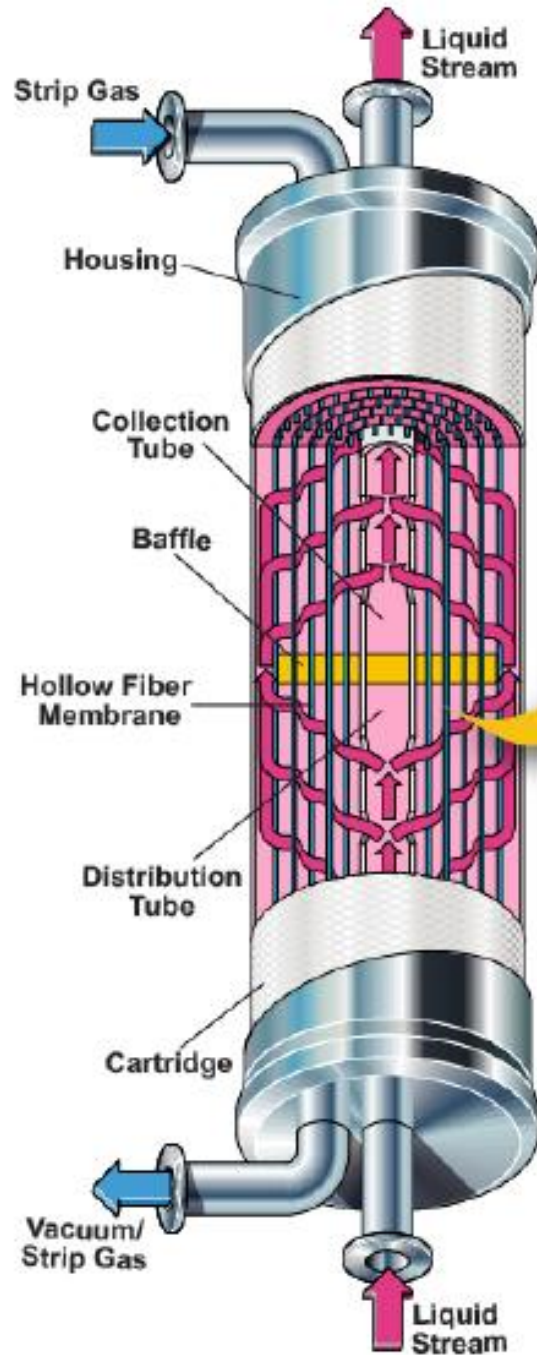


Diffused Bubble Aeration

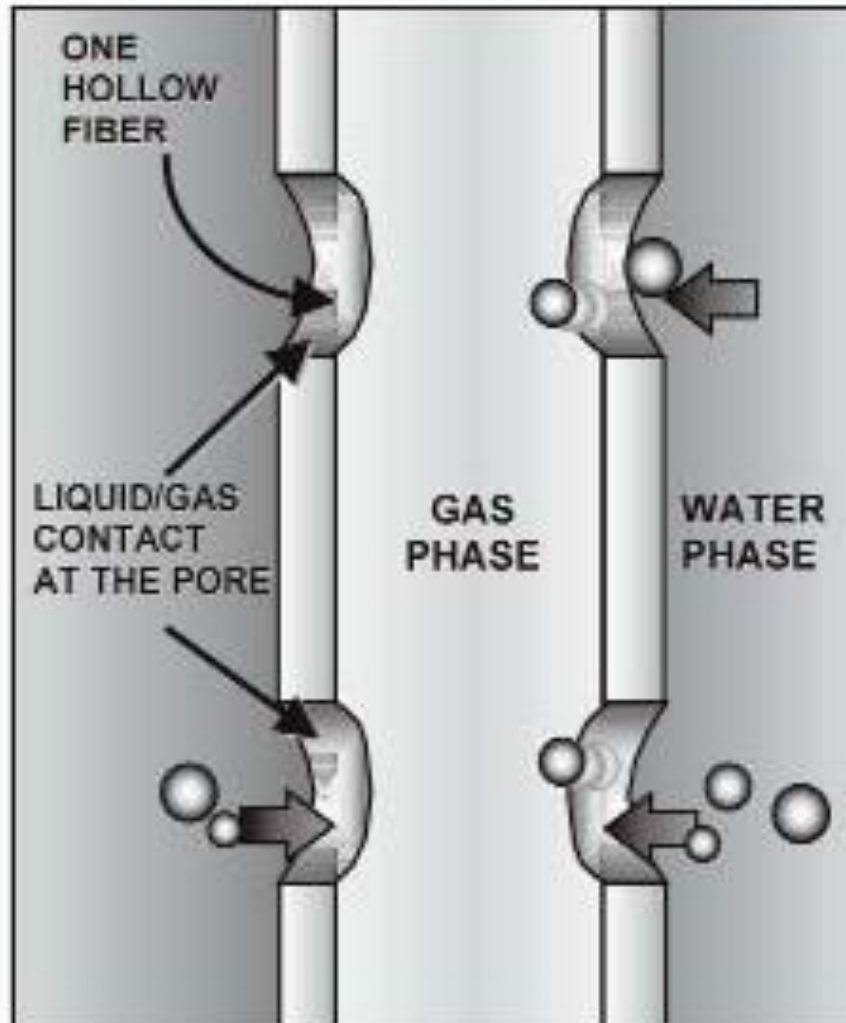
- Can be installed in reservoirs



Degassing Membrane Contactor (Liqui-Cel)



Liqui-Cel Treatment Technology

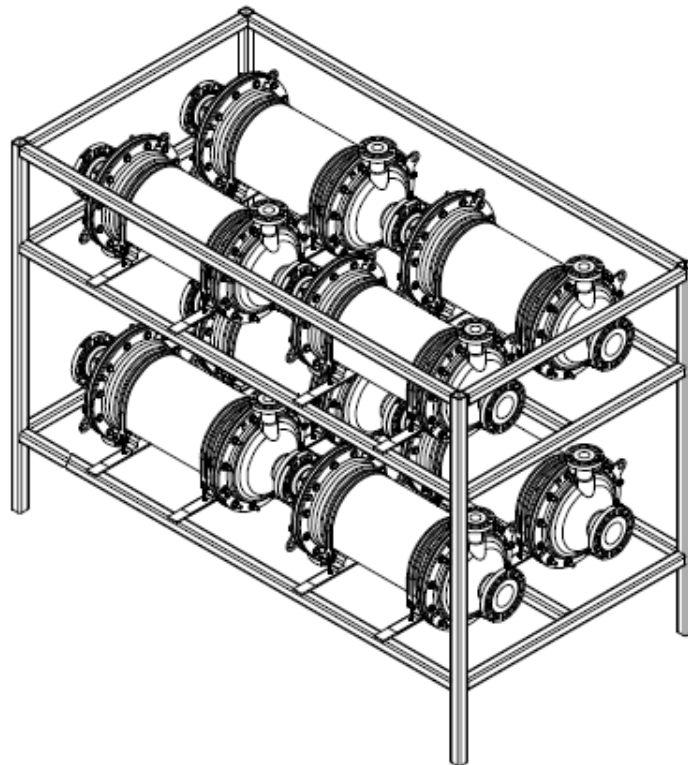


Installation at United Water New York



Operational Modes

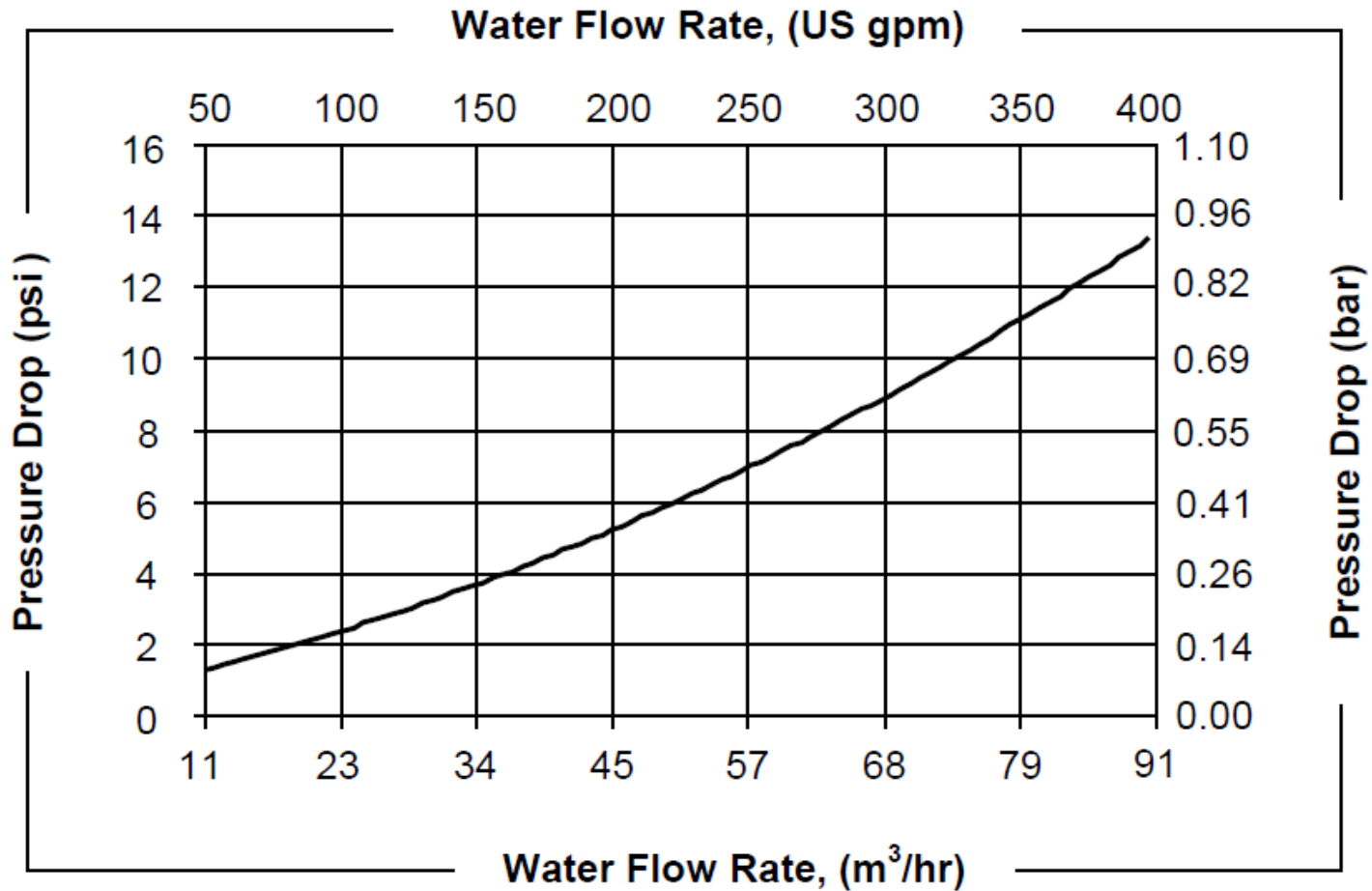
- **Series – to improve treatment (% removal)**
- **Parallel – to meet total flow capacity needs**



Fouling and Cleaning

- **Membrane surface/pores can become coated or blinded:**
 - **Organics**
 - **Minerals**
 - **Metals**
- **Chemical cleaning to remove (CIP)**
- **Site-specific pilot testing**
 - **1 to 2 months recommended**

Contactors Head Loss (14x28-inch unit)



Aeration Process Attributes Summary

Process	Effectiveness	Energy Use	Capital Cost	Space Required
Diffused	Med	Varies	Med	Low
Packed Tower	Very High	High	High	High
Spray Nozzle	Low/Med	Low	Low	Low
Tray	Med/High	Med	Low/Med	Low
Mechanical	Low	Varies	Low	Low
Membrane Contactor	Very High	Low	Med/High	Very Low

Case Study: United Water Idaho

- **PCE contamination**
- **2,000 gpm capacity**
- **Comparison to GAC**
- **Piloting performed by United Water**
- **Planning and data analysis: Murray Smith & Associates and Confluence Engineering**



Well site in residential area

Raw Water PCE Data

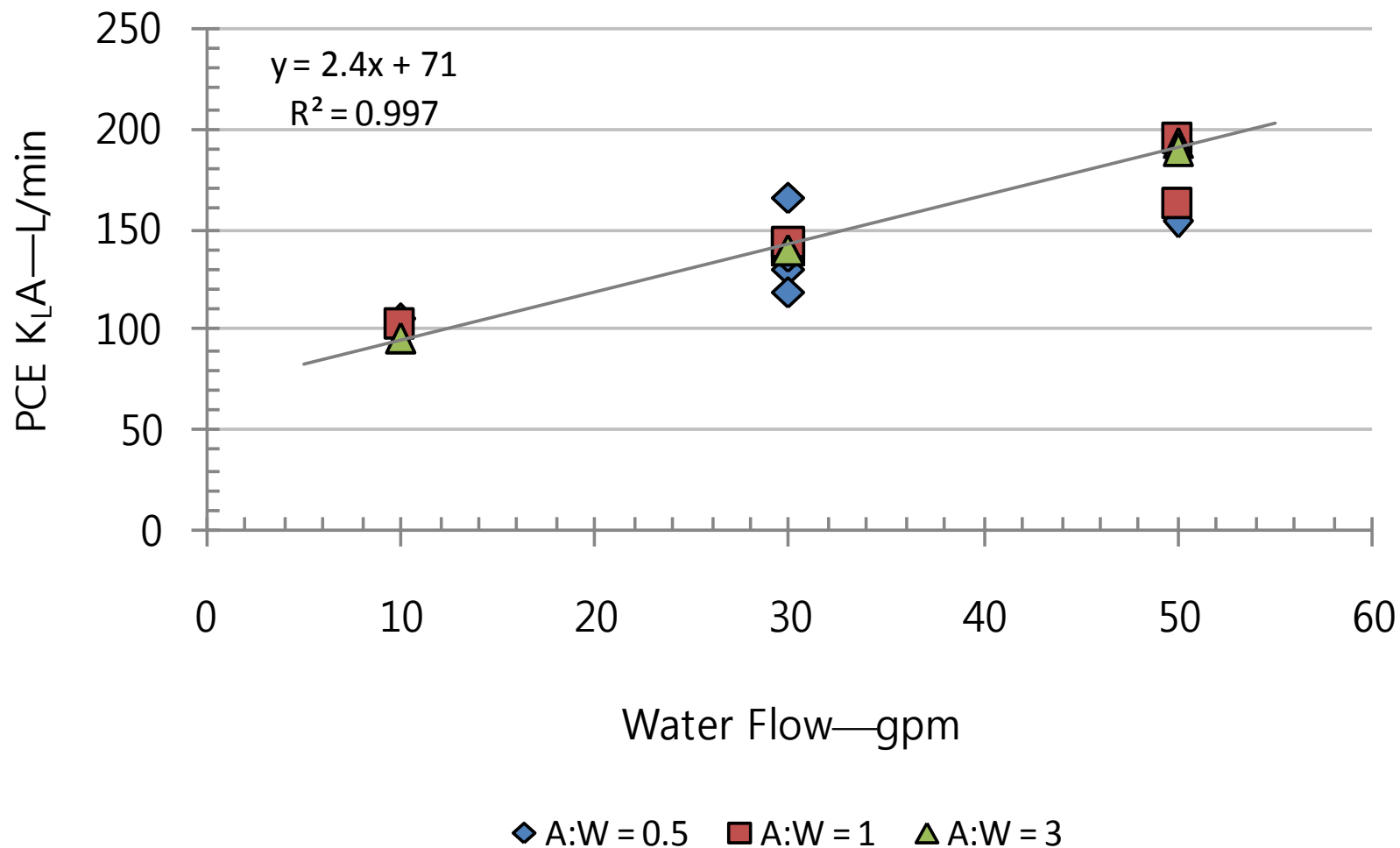
Raw Water Sample ($\mu\text{g/L}$)	Sample Date
4.6	7/9/10
6.1	9/2/10
6.6	9/2/10
6.1	9/14/10
7.0	9/14/10
7.3	9/21/10
7.8	9/21/10
7.9	9/21/10

LIQUI-CEL Pilot Test Setup

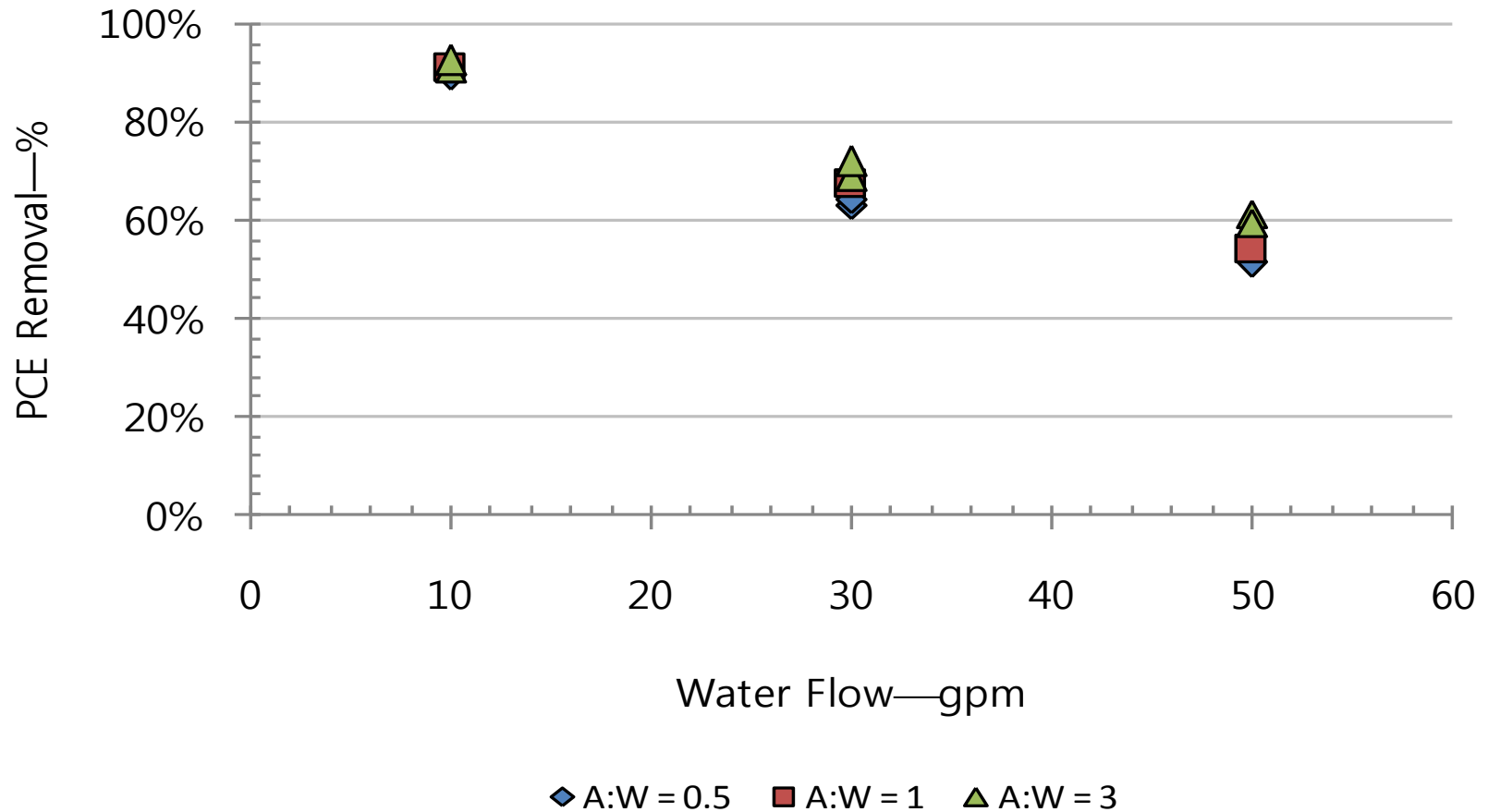


Liqui-Cel 6x28 Pilot Membranes (5-50 gpm)

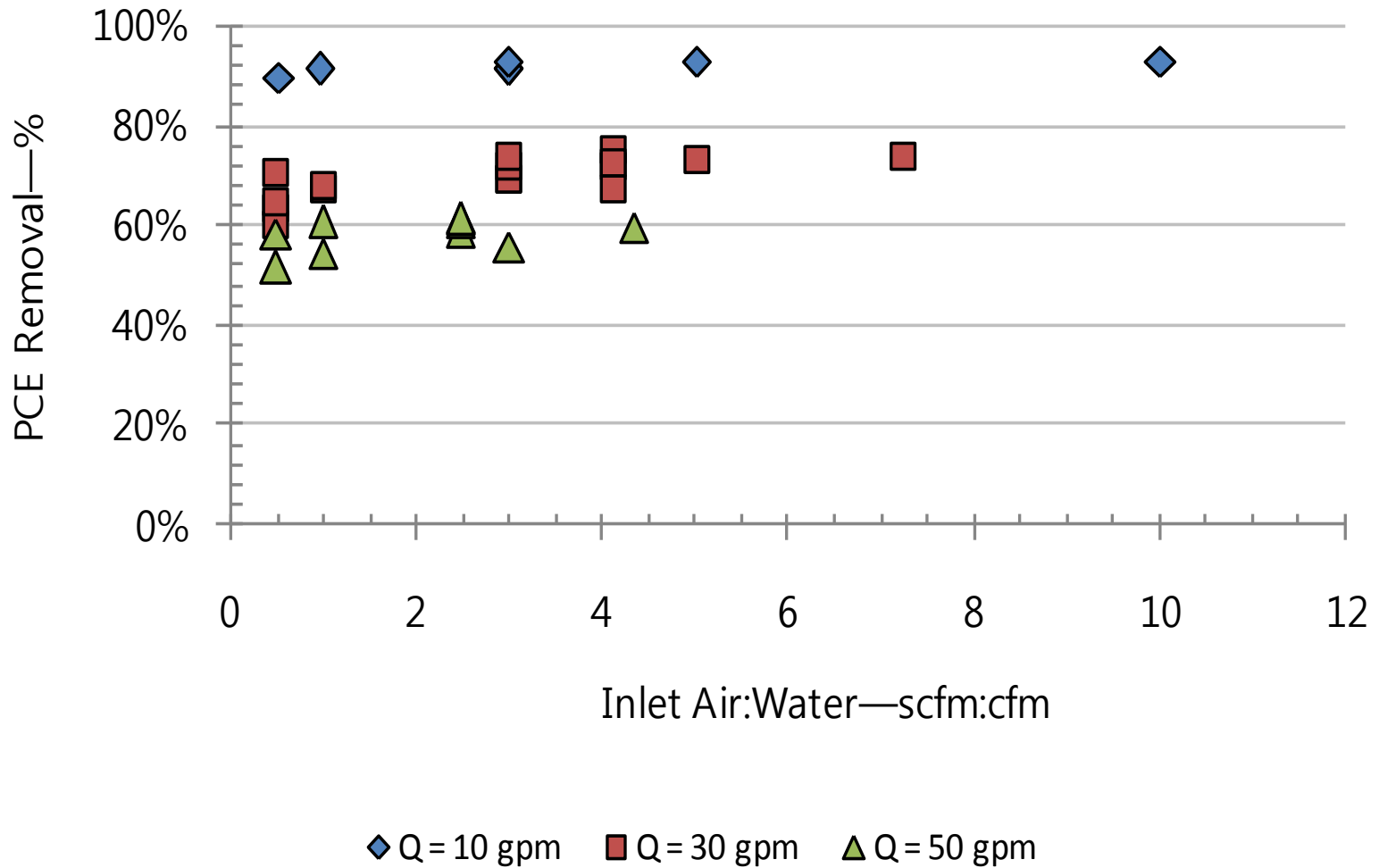
Impact of Water Flow Rate: Mass Transfer



Impact of Water Flow Rate: Percent Removal



PCE Removal vs. Inlet Air:Water Ratio

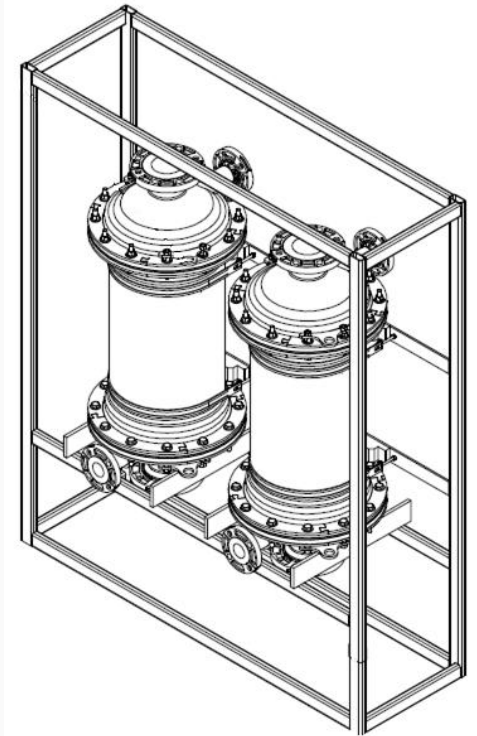


Full-Scale Concepts: Membrane Contactor

■ 9x2 Membrane Contactor System

- 80% Removal Total
- Parallel Trains: 225 gpm each
- Total Vacuum Pump: 75 hp
- Pre-filtration (10 μm)

■ Expand existing well facility



GAC Contactor Comparison

- **Budgetary quote for package system**
- **Four treatment vessels, each containing 20,000 lbs GAC (80,000 lbs total)**
- **Empty-Bed-Contact-Time = 9 minutes**
- **Estimated head loss 12-15 psi (no re-pumping)**
- **New Building**

Life-Cycle Cost Analysis

- **Capital cost**
- **Comparative O&M**
- **Pump 24 hours/day**
- **GAC Replacement:**
 - Replace 80,000 lbs every 4 years
- **Membrane Contactors:**
 - Membrane life: 6.5 years

Cost Comparison

Item	Membrane Contactors	GAC
Capital Costs	\$1,461,000	\$2,076,000
Replacement Costs	\$472,000	\$415,000
Annual O&M Costs	\$25,000	\$4,000
Total NPV	\$2,170,000	\$2,529,000

Membrane Contactors: Other Contaminants

■ Other VOCs:

- TCE
- cis-1,2,-DCE
- MTBE
- ETBE

■ Radon

■ THMs

■ Carbon dioxide

Other Applications

■ VOCs from CCL3:

- 1,1-dichloroethane
- 1,2,3-trichloropropane (TCP)

■ Carcinogenic VOC Rule

- Regulating VOCs in groups
- Possibly Lower MCLs

■ Stage 2 D/DBP Compliance

- THM “Hot Spots”

■ Long-Term LCR Revisions

- New construction with copper pipe
- Sensitive subpopulations: day cares and schools

Future Planned Research

■ **Water Research Foundation Tailored Collaboration Project**

- ❑ Led by United Water and Confluence
- ❑ Pilot tests to evaluate removal of volatile compounds
- ❑ Development of a mathematical model of membrane contactor performance
- ❑ Compare membrane contactor to other technologies

Summary

- **Membrane contactor is new alternative for aeration and volatile contaminant removal**
- **Has several attractive features**
- **Site-specific pilot testing recommended**
- **Future research to model performance and compare costs to other technologies**

Questions?

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Series and Parallel Operation

