Membrane Applications for Wastewater Re-use in the Middle East

Enviro Arabia 2007

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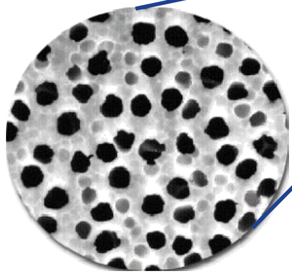
Presentation Outline

- ZeeWeed® UF Technology & Products
- ZENON MBR
- Regional MBR Drivers
- Overview of MBR Developments
- Regional Case Studies

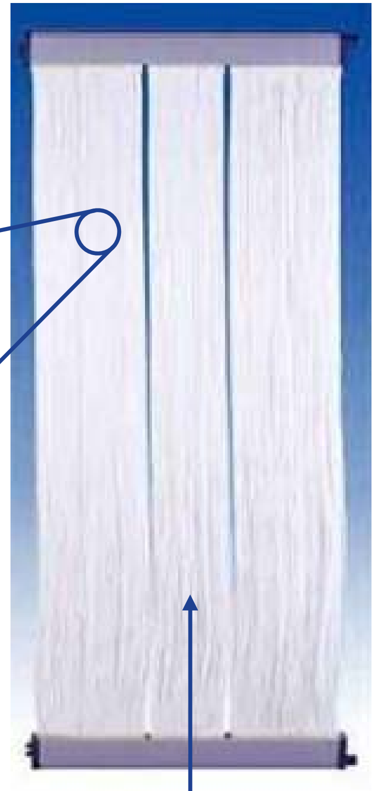
UF Technology

How Membranes Work

- Membrane fibers have billions of microscopic pores on the surface
- The pores form a barrier to impurities, while allowing pure water molecules to pass
- Water is drawn through the pores using a gentle suction

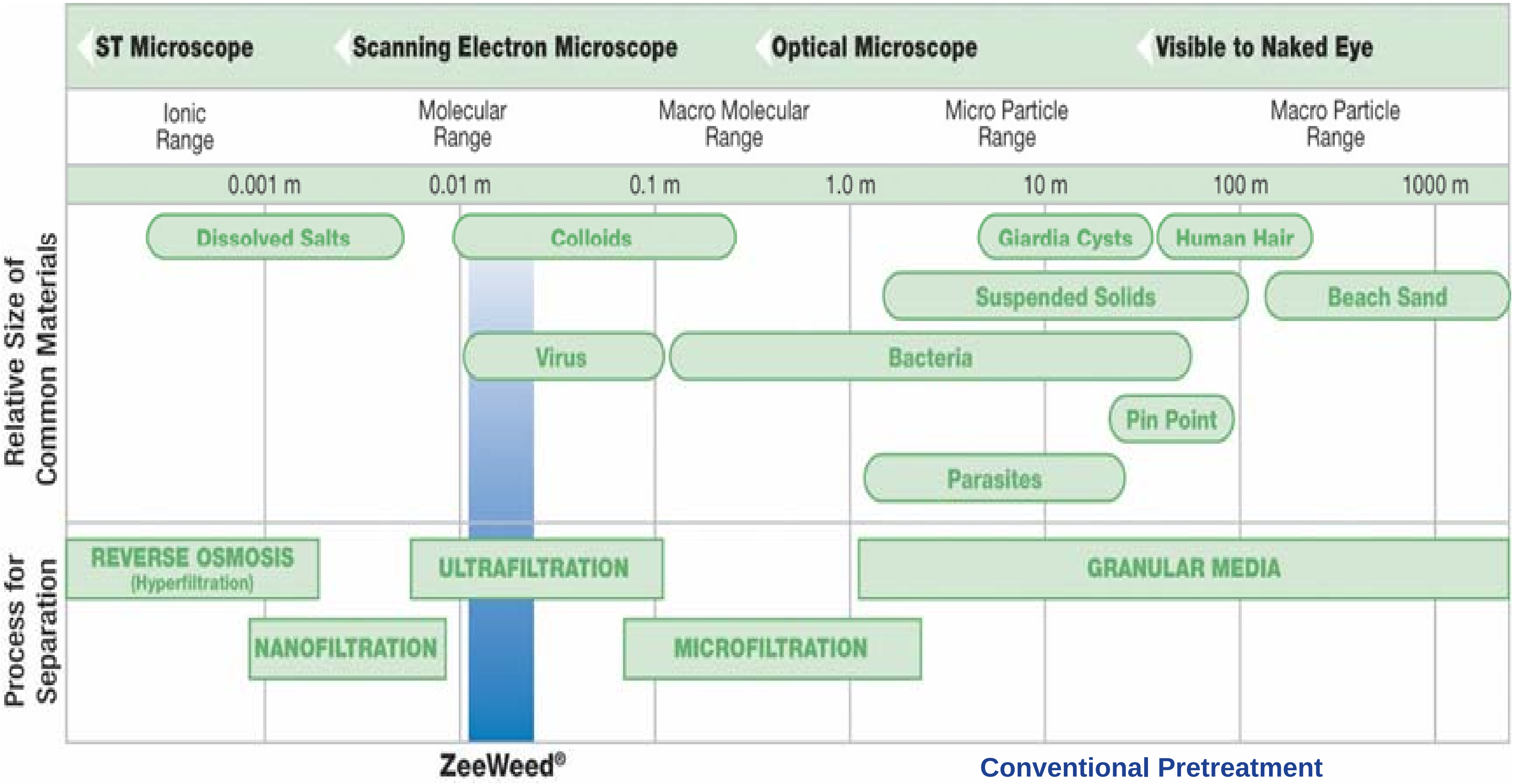


Electron microscope view of membrane surface



ZeeWeed® Membrane Fibers

Membranes for Water Treatment



0.04 µm

ZeeWeed® Products

ZeeWeed® 500d

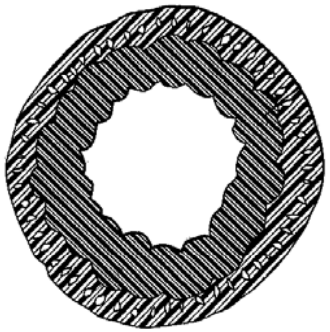
Reinforced Membranes™

ZeeWeed® 1000

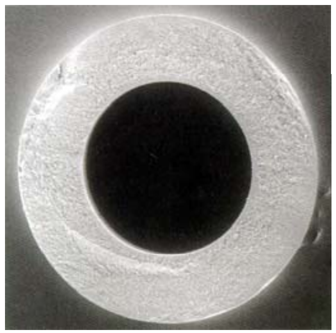
Membrane Filter Media™

ZeeWeed® Hollow Fibre Membranes

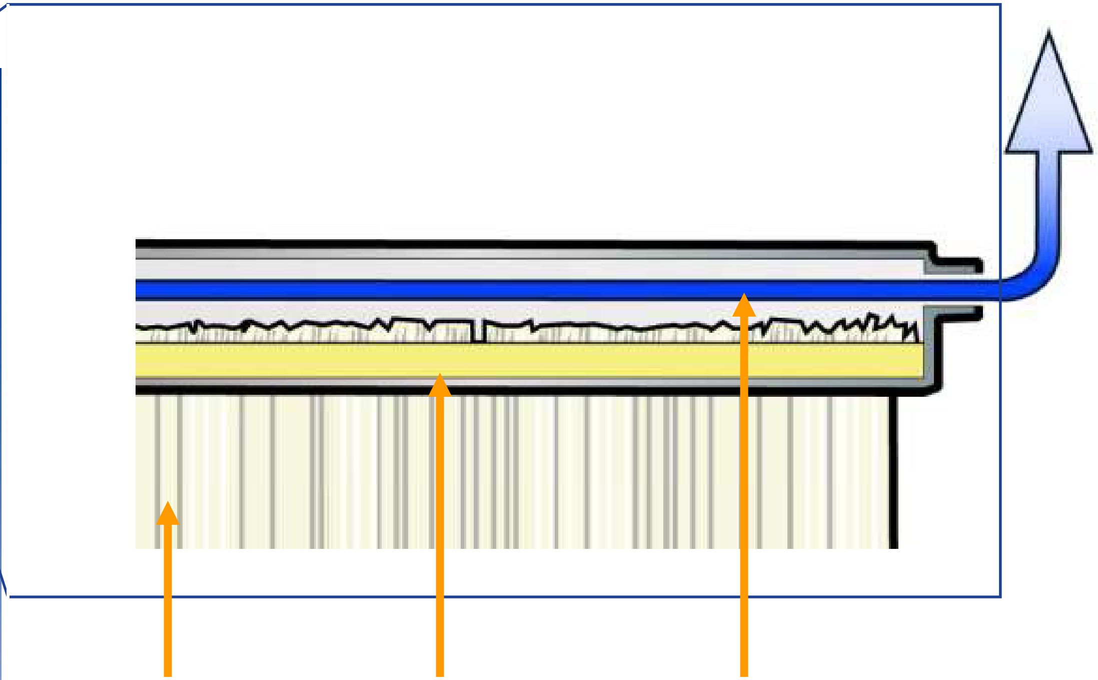
ZeeWeed® 500
Diameter (1.9/0.8 mm),
Extremely solids tolerant



ZeeWeed® 1000
Diameter (0.8/0.47 mm),
High packing density



ZeeWeed® 500d Module

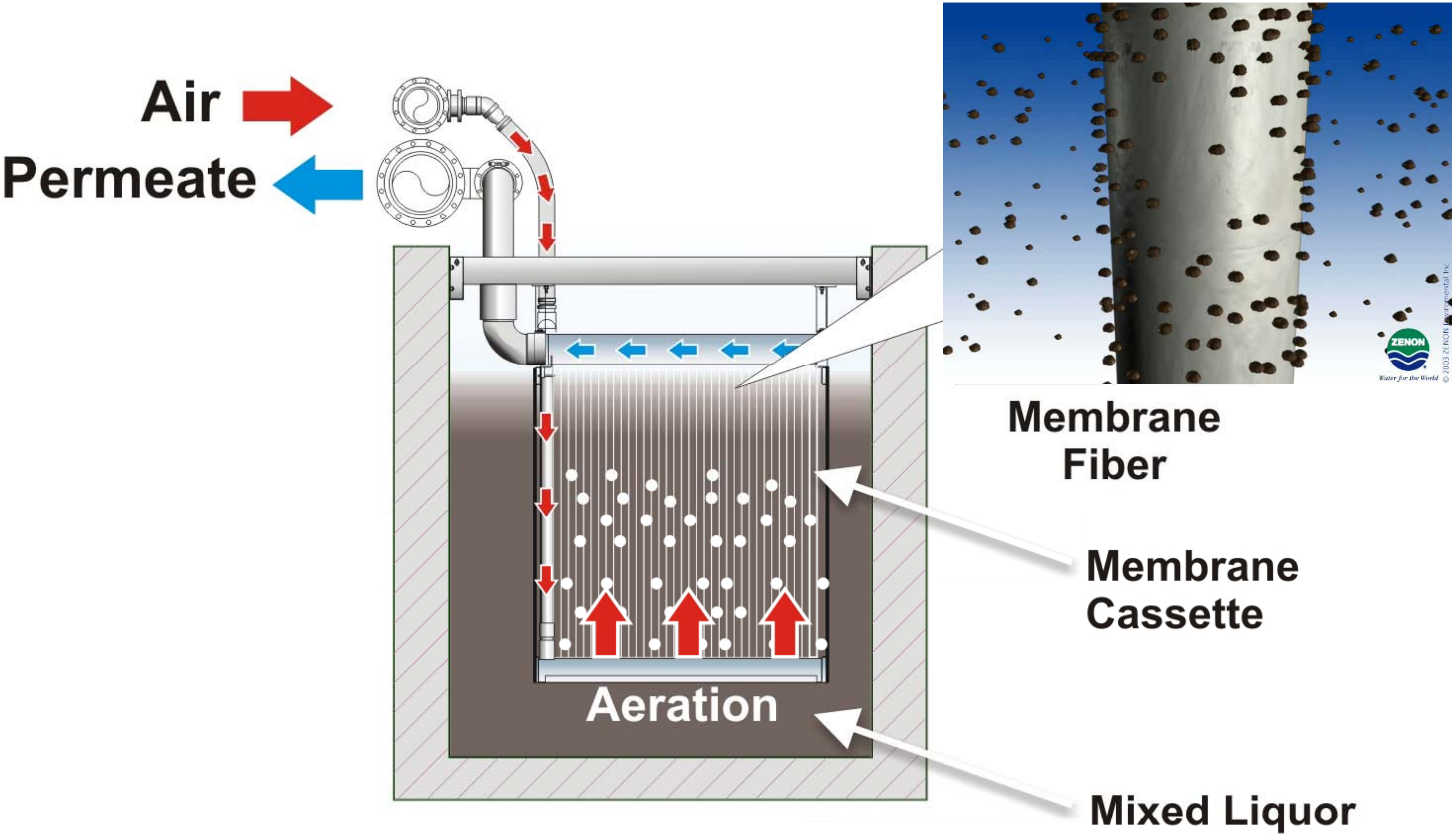


Modules are composed of thousands of membrane fibers

ZW 500 Membrane System

ZW 1000 Membrane System

Principles of ZeeWeed® Immersed Membranes

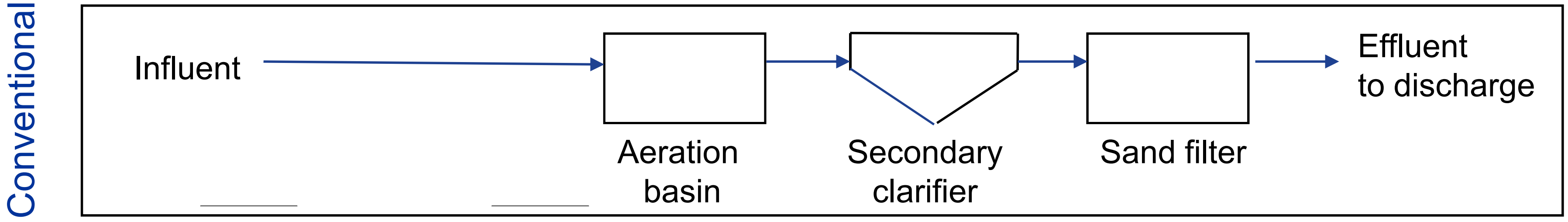


Wastewater Treatment

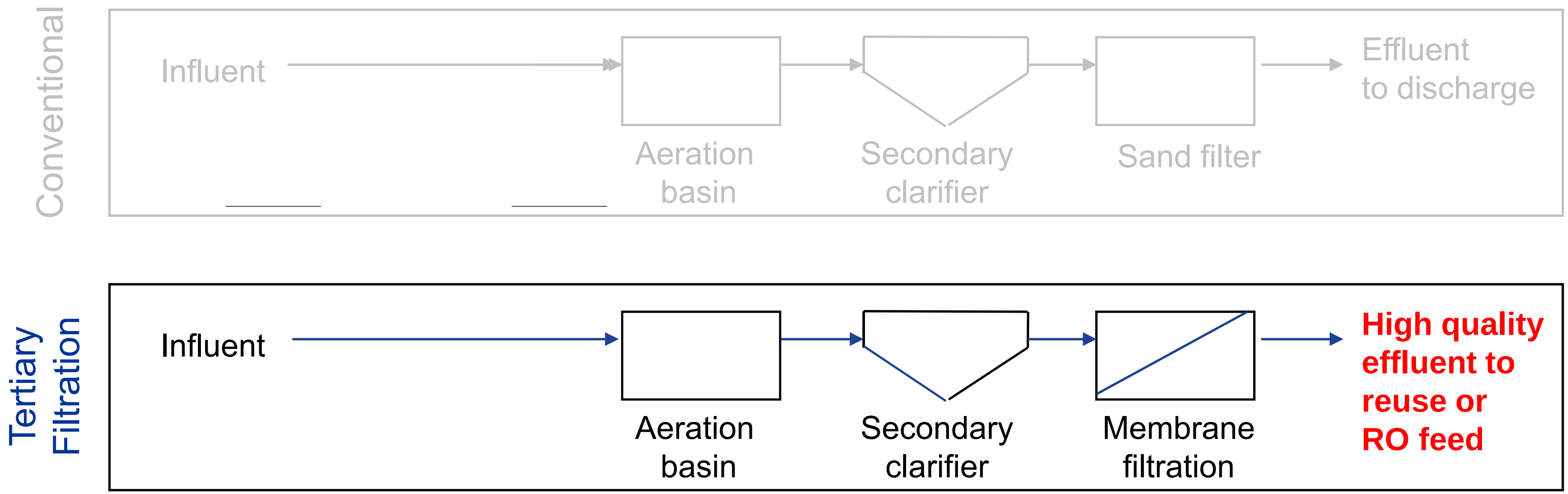
For Water Reuse

MBR or Tertiary

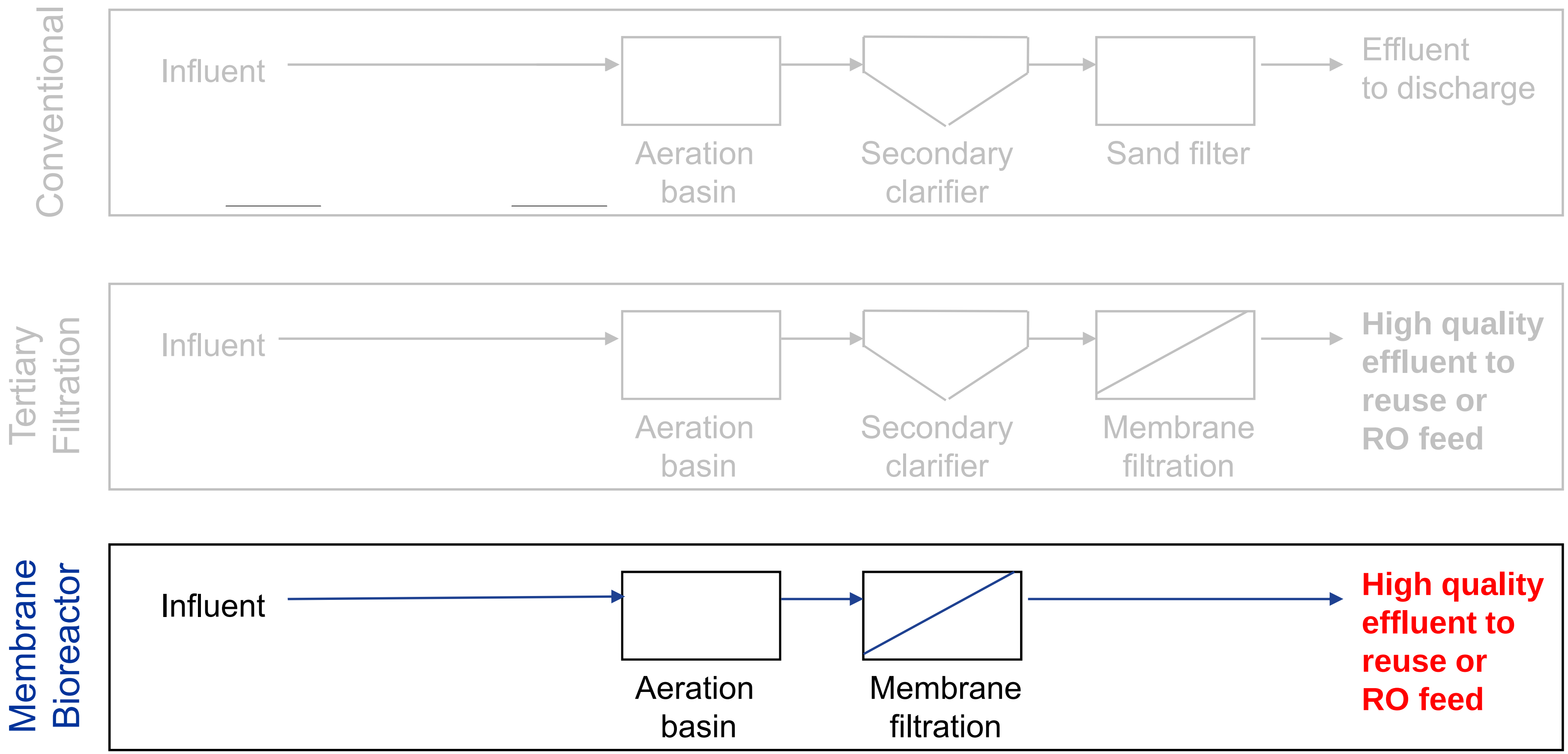
Tertiary Filtration vs. MBR



Tertiary Filtration vs. MBR



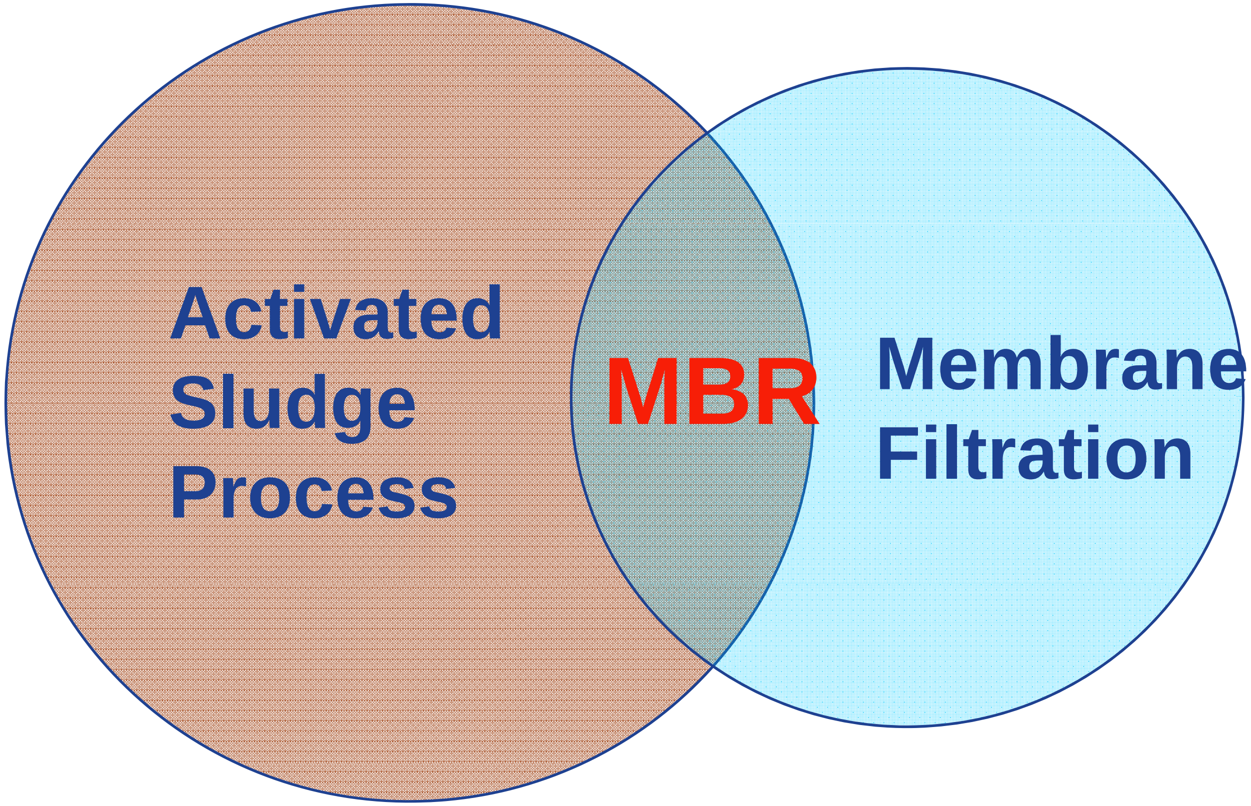
Tertiary Filtration vs. MBR



Membrane Bioreactor (MBR)

For Water Reuse

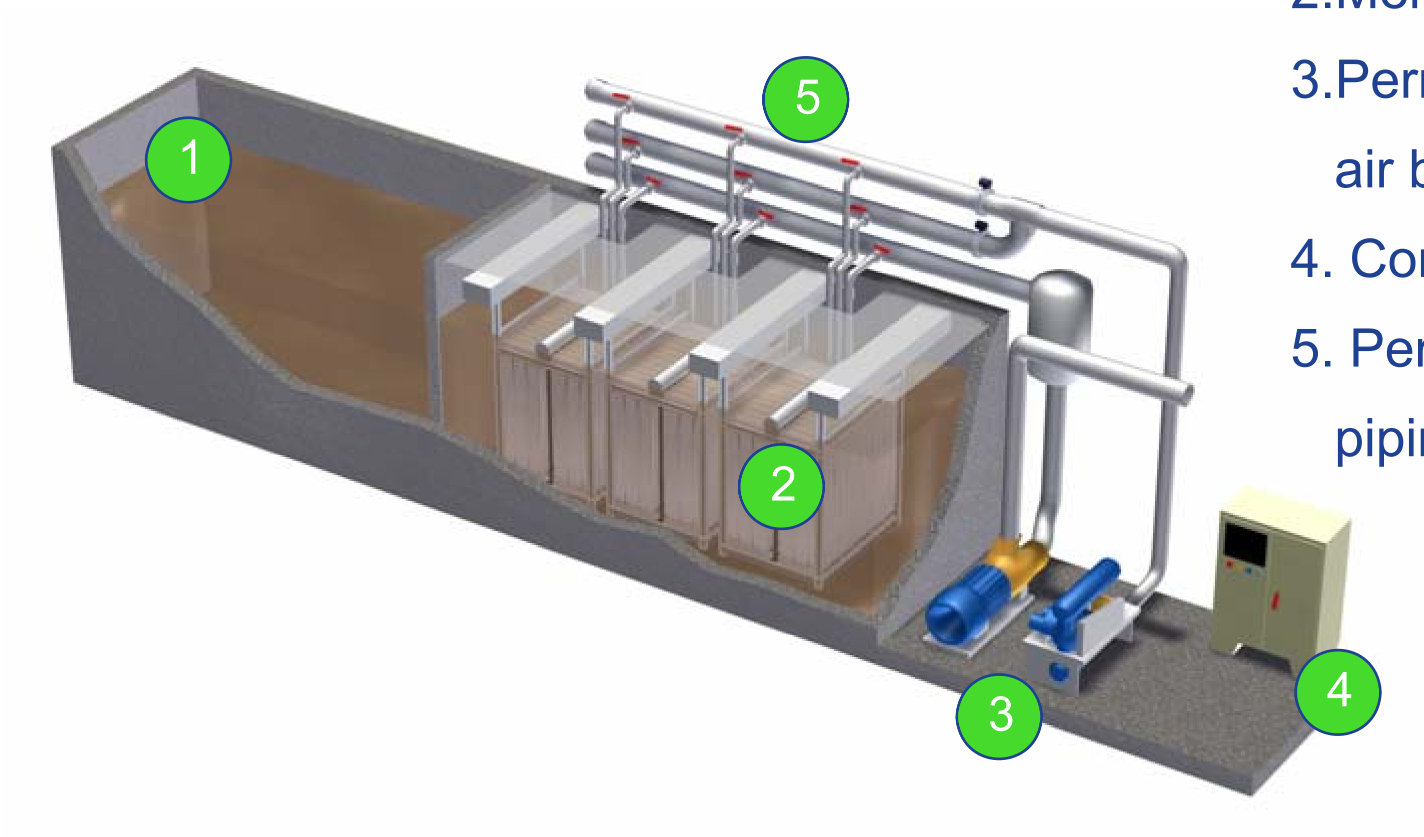
Membrane Bioreactor (MBR)



Stable Biological Treatment Process

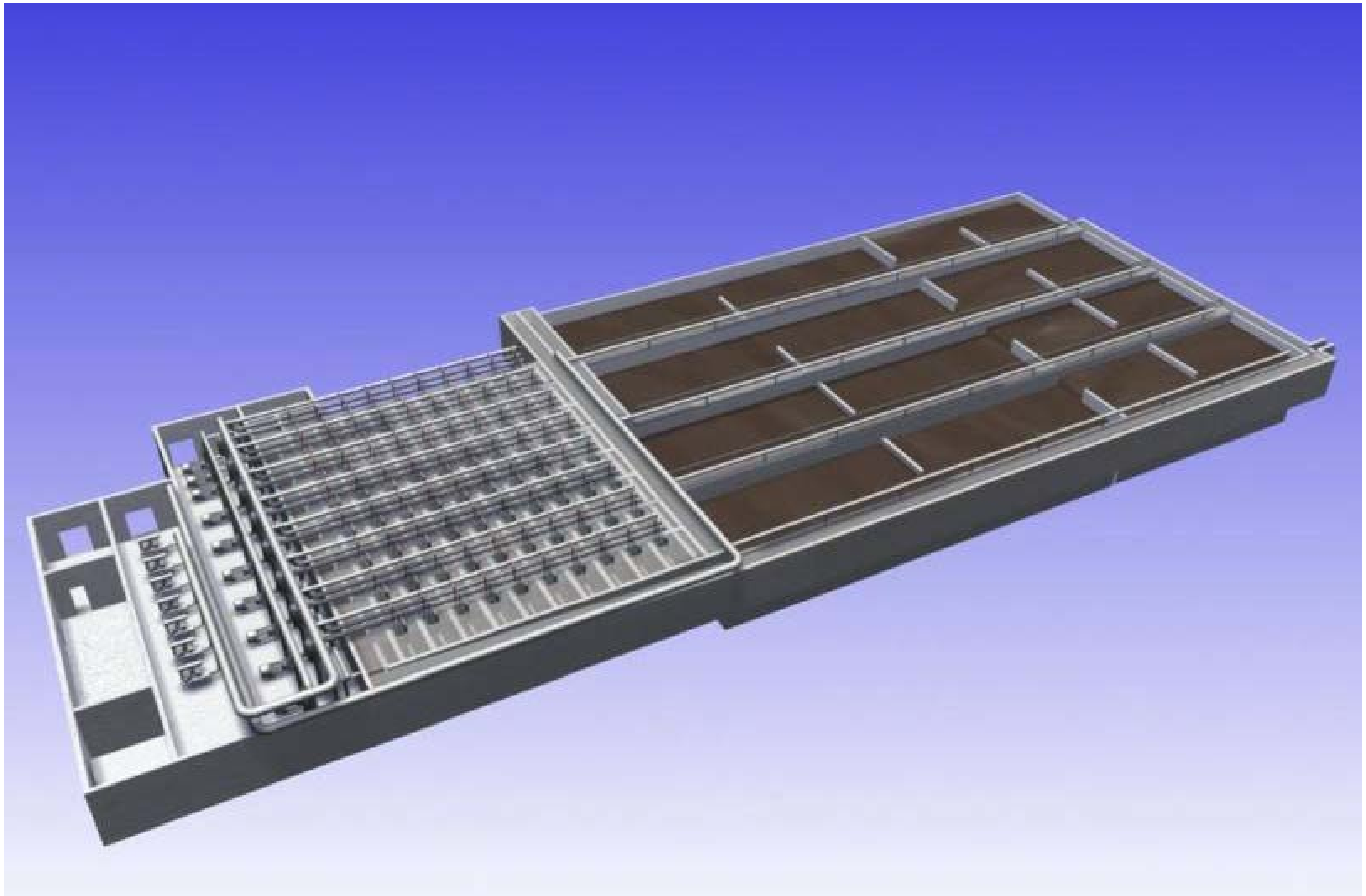
Absolute Solids Separation

A Basic MBR Production Train



1. Biological reactor
2. Membranes
3. Permeate pump & air blower
4. Control panel
5. Permeate & air piping

Overall ZeeWeed® MBR Design



Regional MBR Drivers

- Effluent Quality
- Reduced Plant Footprint & Lower Civil Costs
- High Cost of Alternative Water Sources
- Process Advantages:
  - complete control of sludge age
  - does not depend on sludge settling characteristics

Advantages of UF membranes
High-quality effluent

Effluent Parameters	Typical Values	Achievable Levels
BOD_5	< 2 mg/L	Typically n.d.
TSS	< 2 mg/L	Typically n.d.
NH_4 - N	< 1 mg/L	< 0.5 mg/L
TN	< 10 mg/L	< 3 mg/L
TP	< 0.3 mg/L	< 0.1 mg/L
Turbidity	< 0.3 NTU	< 0.1 NTU

… and physically disinfected!

Advantages of UF membranes
Compliance with global standards

UF permeate in compliance with:

WHO standards for unlimited irrigation

International Maritime Organization bacteriological limits

EU bathing Water Directive

California Title 22 Code of Regulations

UF: the best approach to meet the tightest effluent quality requirements

California Title 22, Chapter 4 Compliance with global standards

State of California—Health and Human Services Agency
Department of Health Services

California Department of Health Services

SANDRA SHEWRY
Director

ARNOLD SCHWARZENEGGER
Governor

The most stringent standards for wastewater reuse across the U.S. (and possibly the world)

Regulations adopted in 1978 by CDHS (California Department of Health Services)

- Recycled water quality standards
- Reliability & redundancy of recycled water treatment plants
- Tertiary treatment + disinfection

Standards

- Strategy favoring the beneficial reuse of water to the maximum extent practical
- Bacteriological standards based on the expected degree of public contact with recycled water

	Average	Maximum	Tolerance
Turbidity (NTU)	< 2	< 10	< 5 (5% of time in any 24 hr period)
Total coliforms (ufc/100 mL)	< 2.2	< 240	< 23 in any 30 day period
Fecal coliforms (ufc/100 mL)	0	0	0

Key MBR Driver - Reduced Footprint

ZeeWeed® MBR Upgrade
(11 MGD)

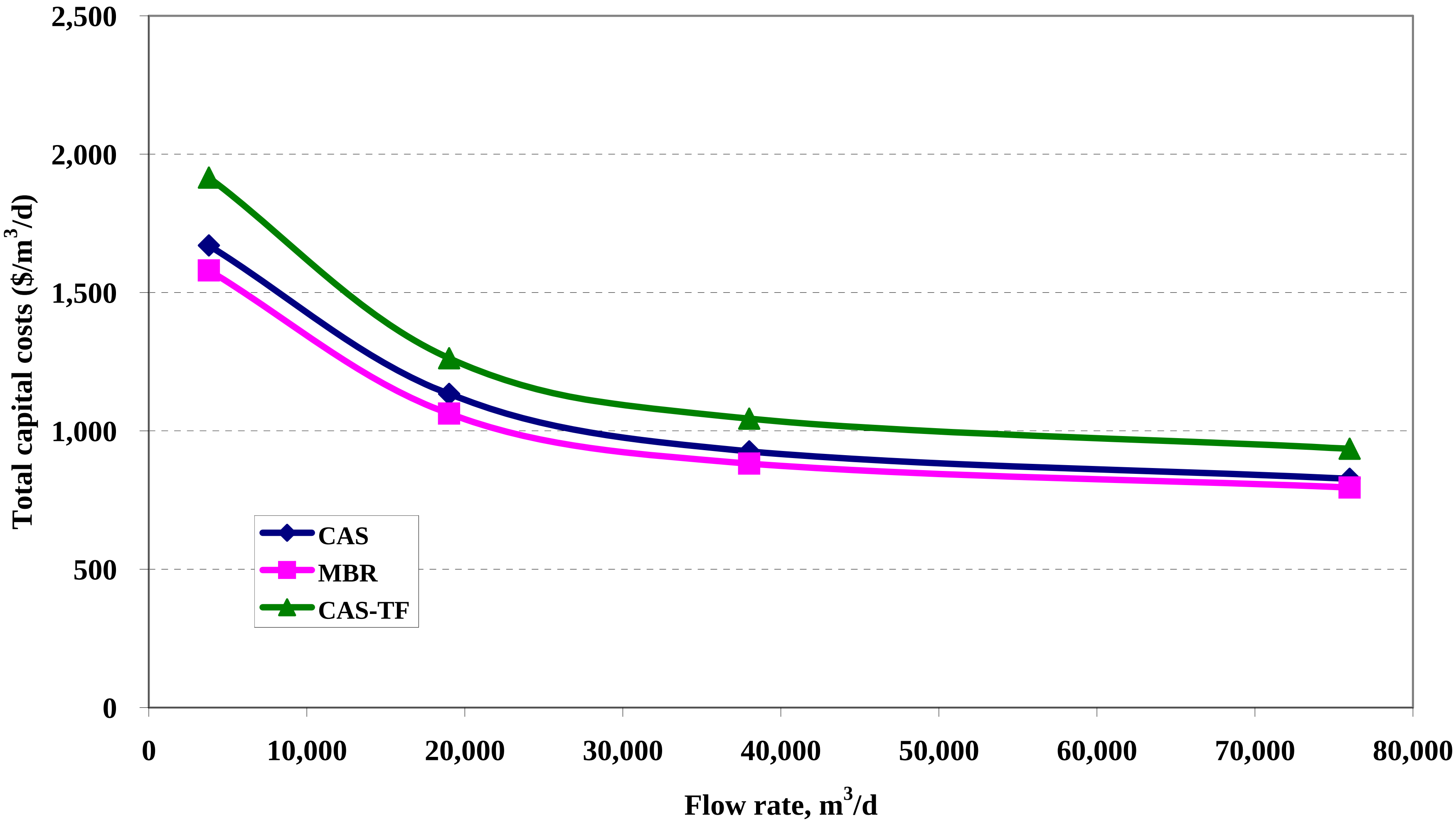
Existing Line A
(6.3 MGD)

Costs of Producing Water from Secondary Effluent and from Seawater

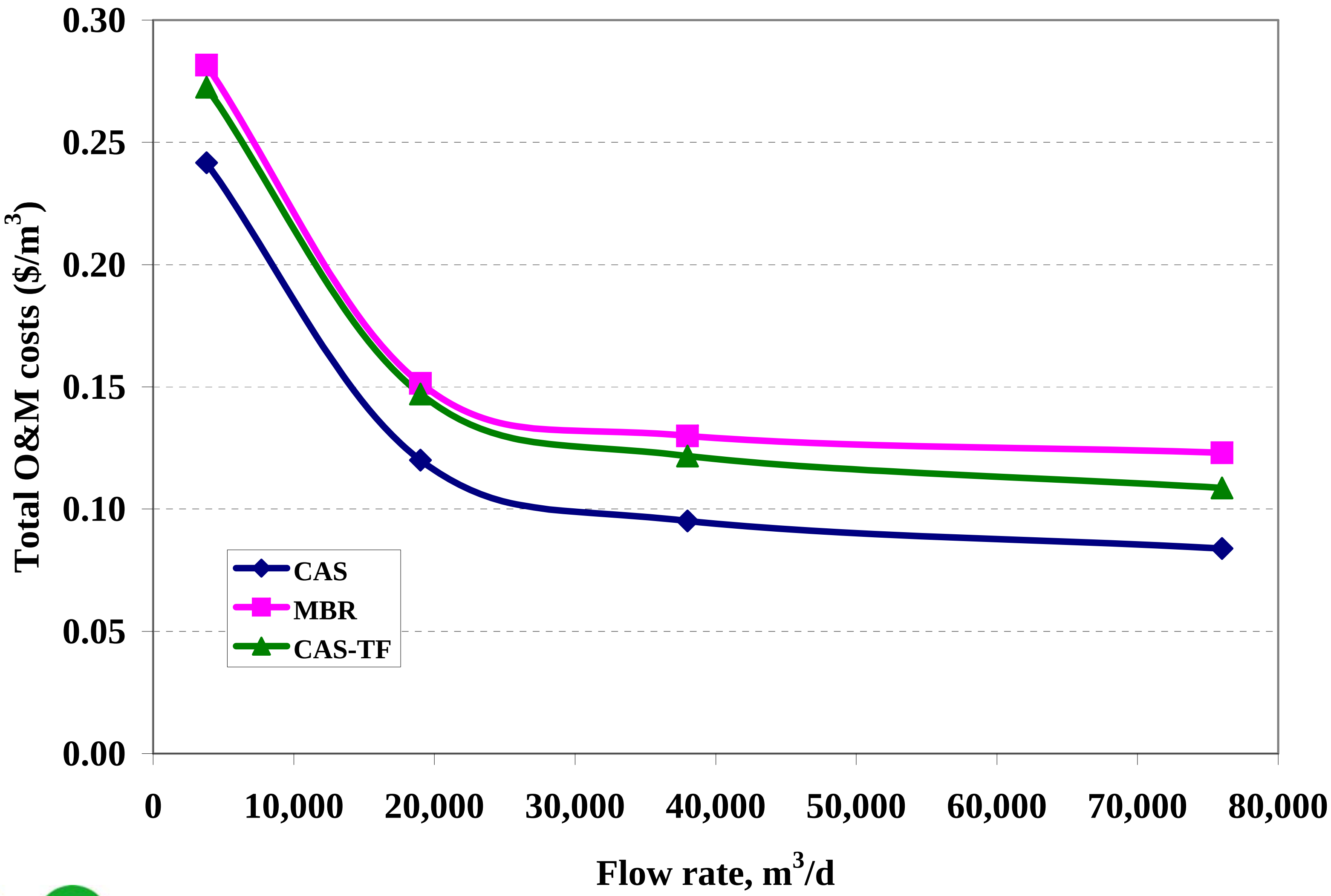
Component	Units	A: from CAS effluent	B: from seawater	Ratio (B/A)
Capital costs				
Infrastructure & pretreatment	$\$/m^3/d$	161	320	1.99
RO	$\$/m^3/d$	321	624	1.94
Total	$\$/m^3/d$	**482**	**944**	**1.96**
Total Life cycle costs				
Capital	$\$/m^3$	0.07	0.24	3.43
O&M	$\$/m^3$	0.21	0.38	1.81
Total	$\$/m^3$	**0.28**	**0.62**	**2.21**

Developments In MBR

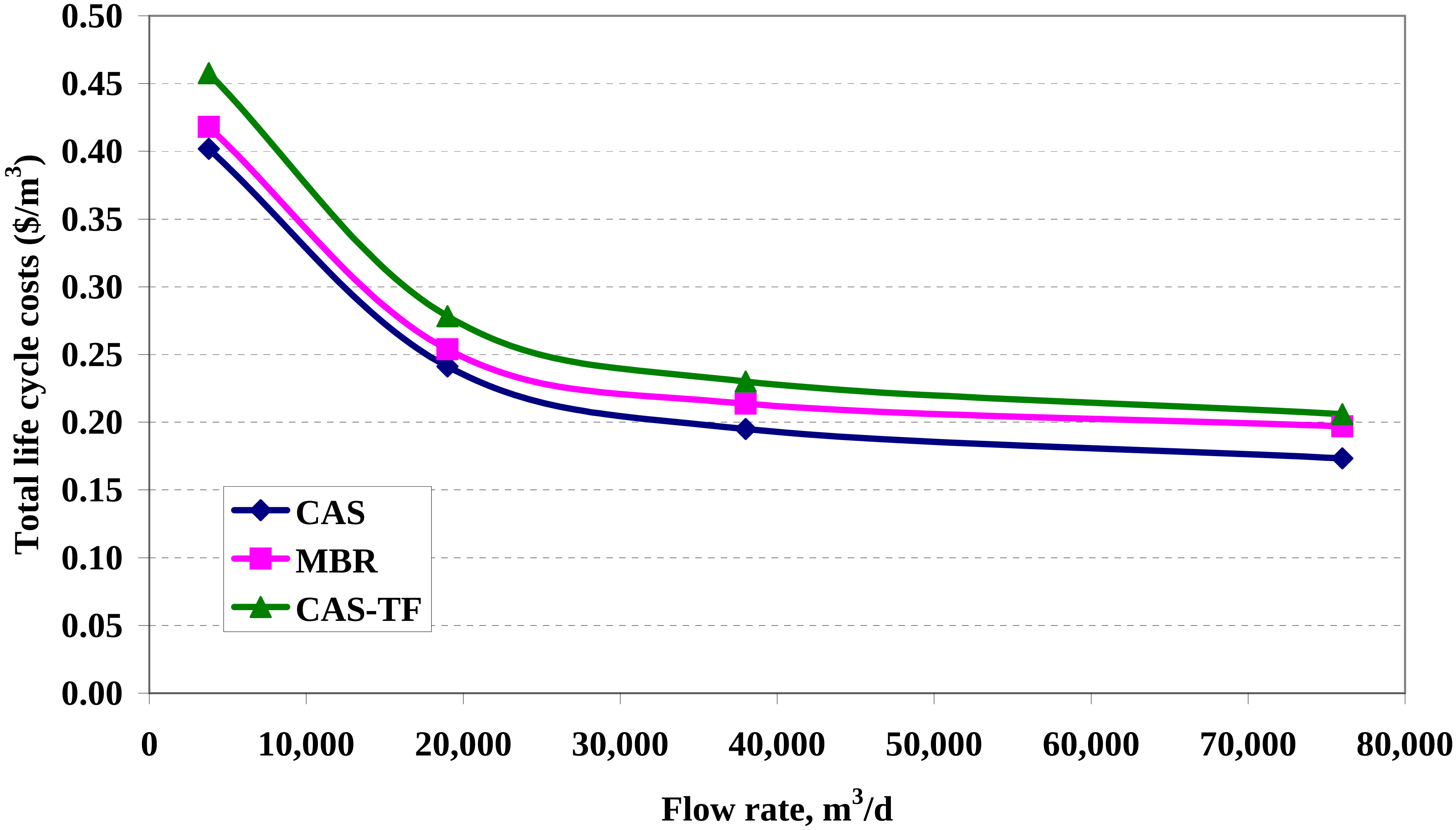
Total Capital Costs



Total O&M Costs



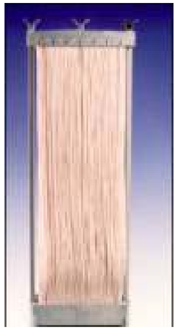
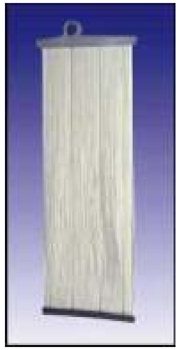
Total Life-Cycle Costs



Capital Cost Developments

ZeeWeed® 500 Cassette Evolution



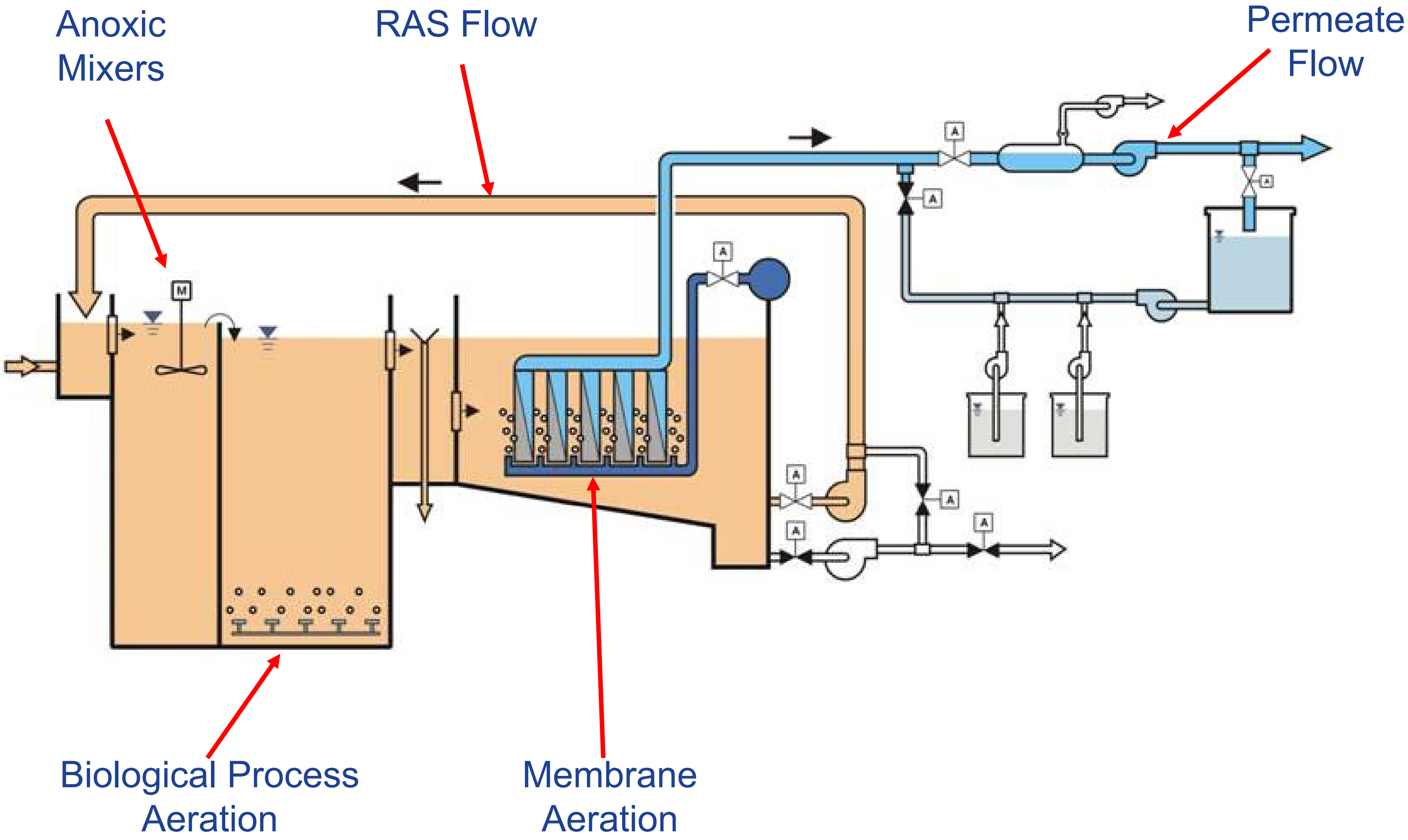

ZW-145 **ZW-150** **ZW-500a** **ZW-500c** **ZW-500d**

1993 **2003**

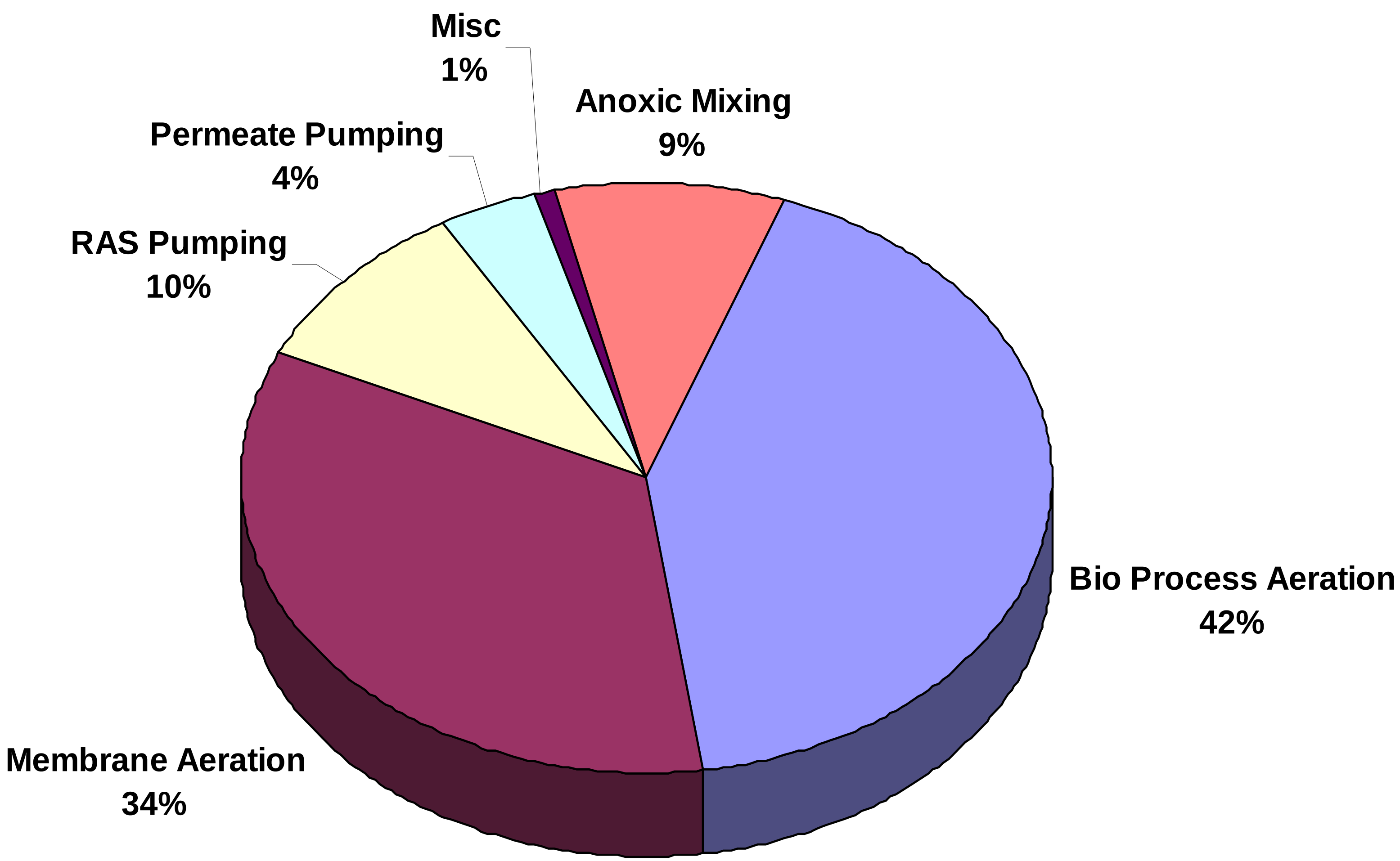



Operational Cost Developments

MBR Energy Users



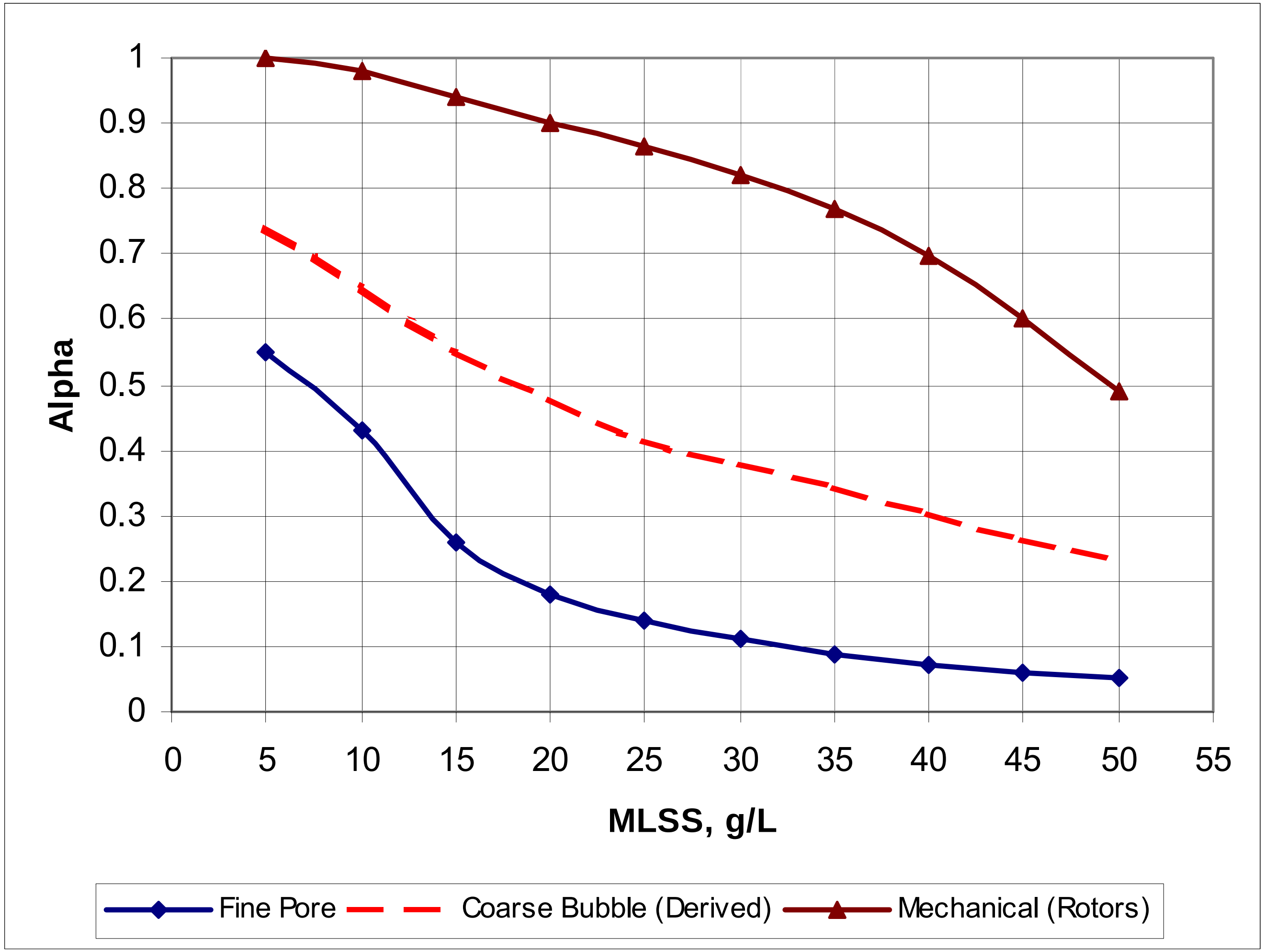
MBR Energy Users



Reduction of Aeration Energy

- Effect of MLSS - Optimize Footprint & Energy
- Reduction of Membrane Air Scour Power – Cyclic Aeration

Effect of MLSS on Alpha Factor

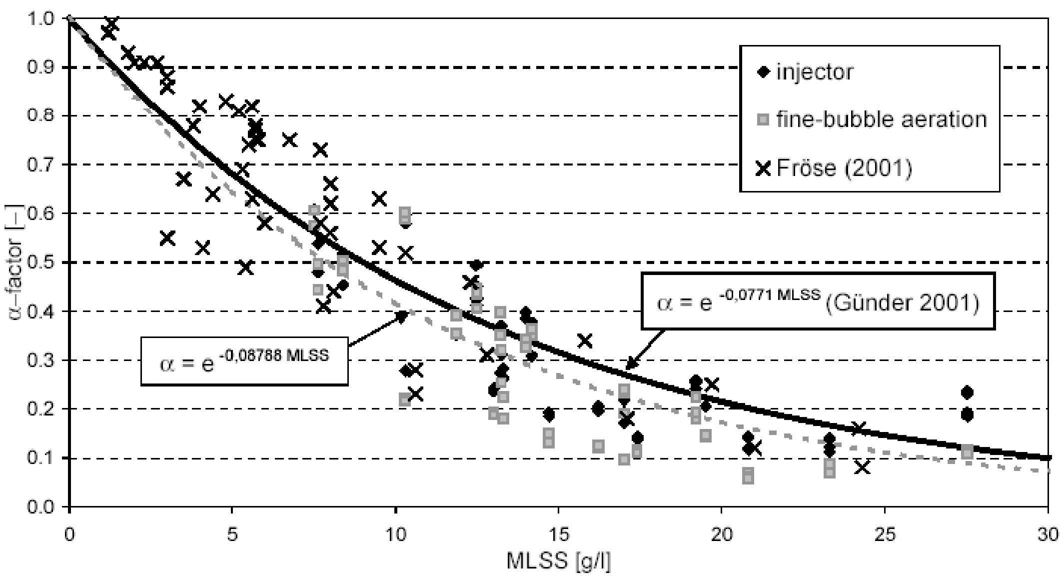


Reference: **Bratby, John R. et al, *Merits of Alternative MBR Systems,* WEFTEC 2002.**

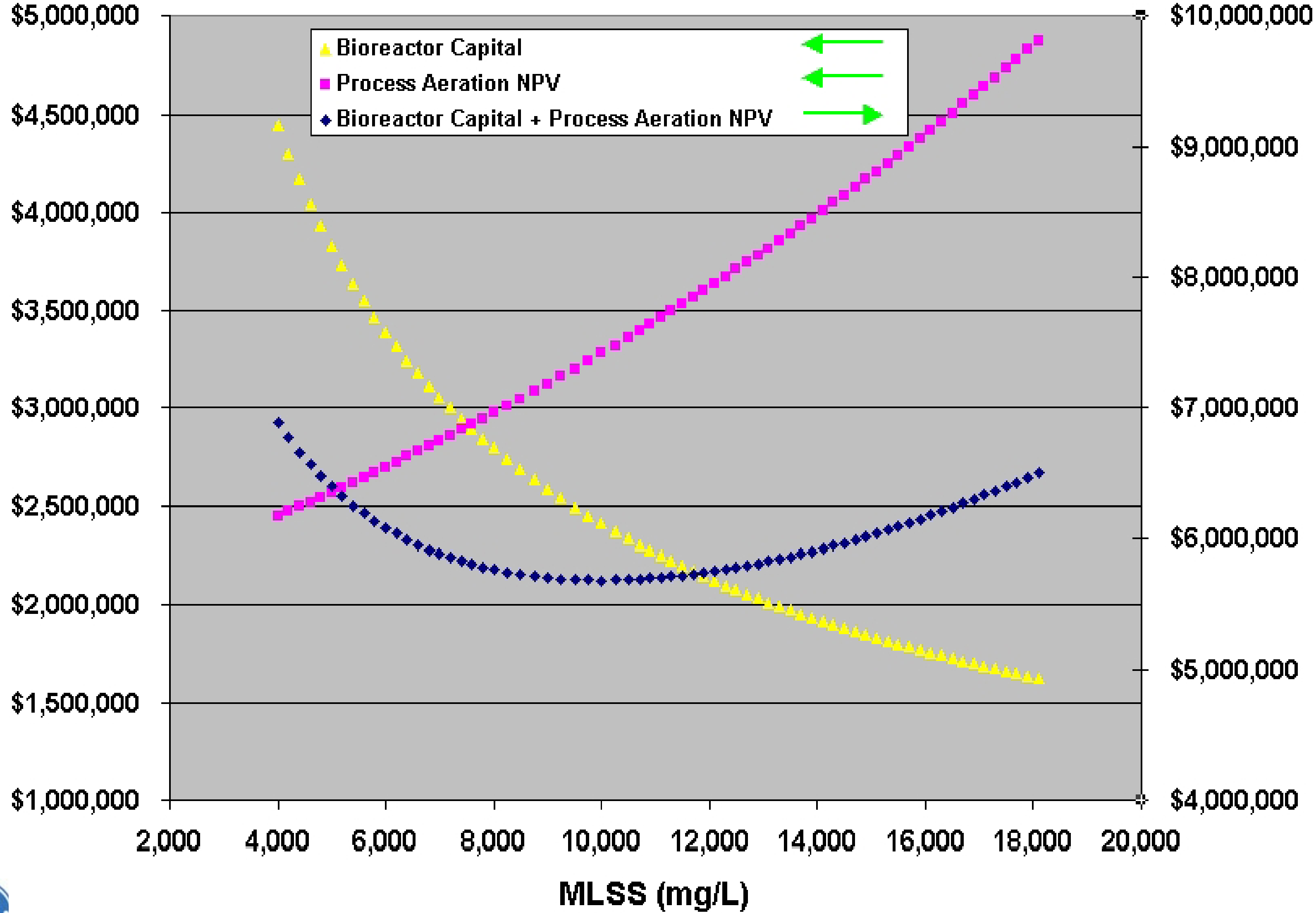
Optimizing Energy Efficiency

Biological process aeration

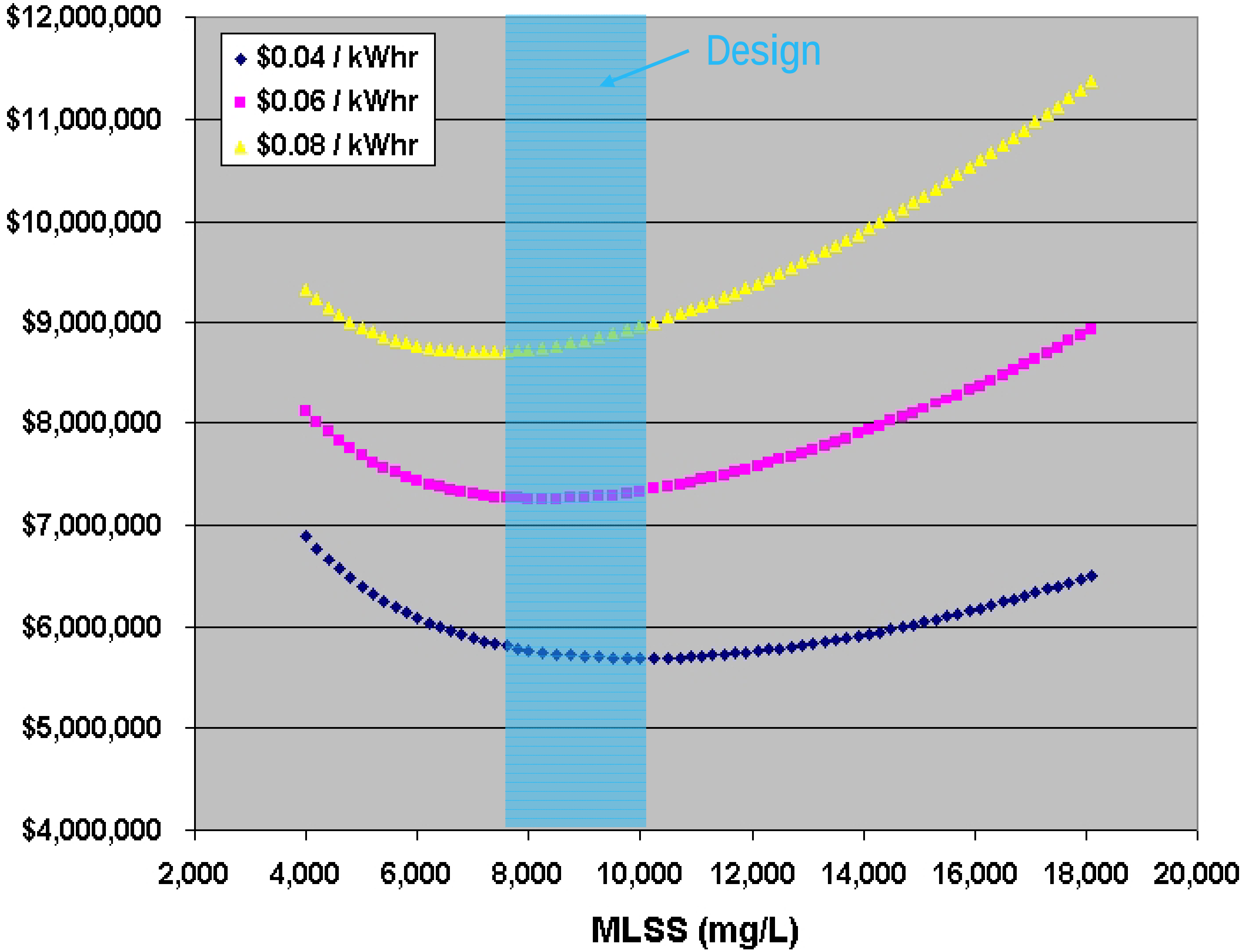
- Select MLSS to optimize OTE
  - Alpha factor decreases at higher MLSS
  - Limitation on OUR at higher MLSS
- Fine bubble aeration in bioreactor



Bio-Process NPV vs. MLSS Concentration

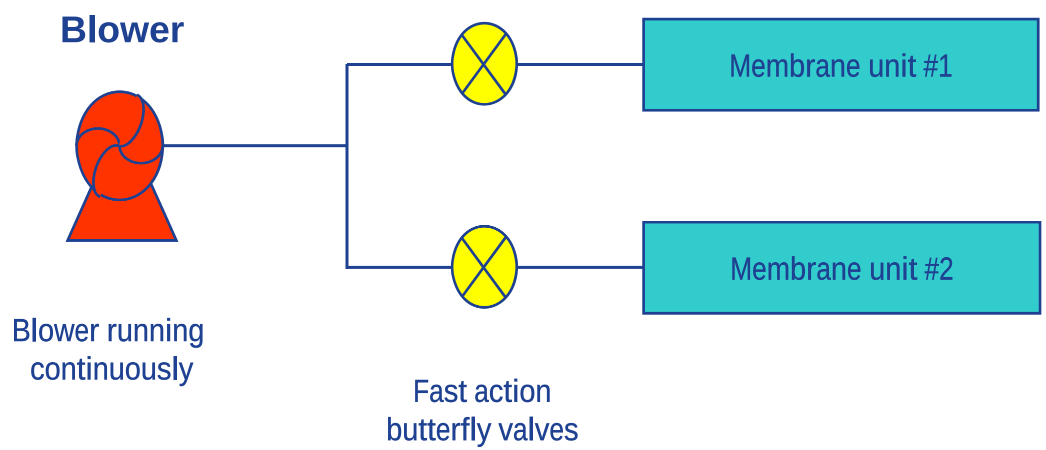


Bio-Process NPV vs. MLSS Concentration



Membrane Aeration

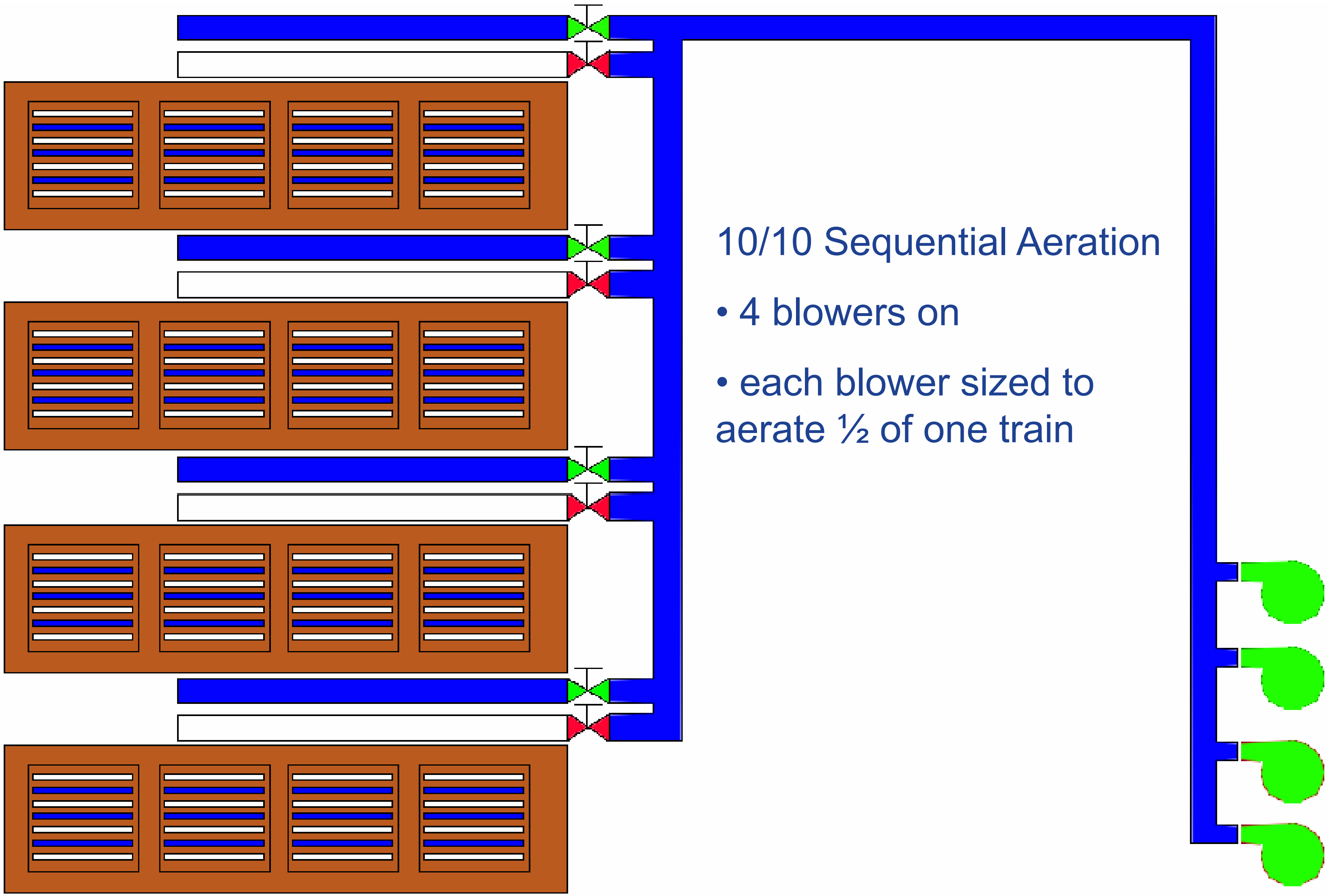
- Optimize membrane submergence to reduce blower discharge pressure
- Effective scouring with course bubble aeration
- Optimized cyclic aeration based on flow



US Patent 6,245,239

10/30 Aeration at ADF

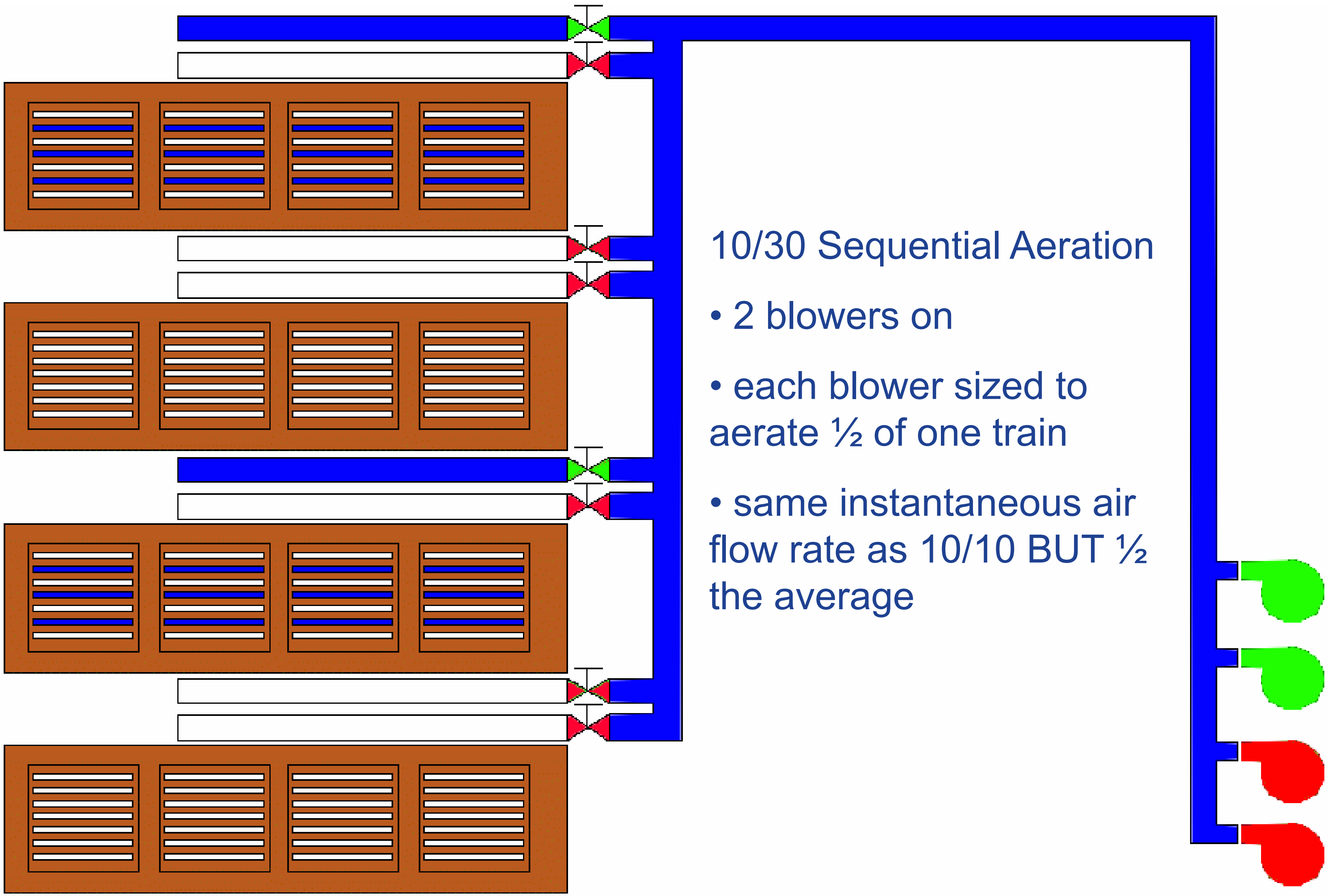
- Optimized cyclic aeration based on flow
- Maintain 10/10 Aeration at or above ADF
- Run at 10/30 Aeration below ADF
- 50% Savings compared to 10/10 = 7-10% LCC



10/10 Sequential Aeration

- 4 blowers on
- each blower sized to aerate ½ of one train

Note – Airflow is blue



10/30 Sequential Aeration

- 2 blowers on
- each blower sized to aerate ½ of one train
- same instantaneous air flow rate as 10/10 BUT ½ the average

Note – Airflow is blue

Main Reference Plants in the Middle East

List of Main Plants

- Buraida Upgrade, KSA (Fe/Mn Filtration)
- Jeddah Industrial City, KSA (Tertiary Treatment)
- Doha West, Qatar (Tertiary Treatment)
- Lusail, Qatar (MBR)
- Dubai Sports City, UAE (MBR)

Buraida Upgrading, Qassim, KSA Water Treatment Plant

- Capacity

  - 100,000 m^3/day (26.4 MGD) Ultimate Capacity

  - 85,000 m^3/day (22.5 MGD) Initial Capacity

  Plant is designed for Iron/Manganese & Radium Removal for RO Pre-treatment

- Effluent Quality:
  - Turbidity < 0.1- 0.3 NTU -SDI < 2-3

Buraida Upgrading-Cont'd

System Configuration:

- Seven trains each with seven ZW 1000 V3 Cassettes
- Total number of elements Initial: 2,142; Ultimate 2,499
- End User: Qassim Water Authority
- Expected Commissioning Date: June 2007

Jeddah Industrial City, KSA - Tertiary Treatment

- Capacity

  - 14,640 m^3/day (3.86 MGD)

- Feed Water Quality:

  - BOD/TSS 10/10 mg/l Turbidity 2-3 NTU

- Effluent Quality:

  - Turbidity < 0.2 – 0.5 NTU -SDI < 3.0

Jeddah Industrial City, Cont'd..

- System Configuration:
  - Three (3) Membrane Trains, Two (2) Cassettes in Each Train
  - Each Cassette has 51 Zee Weed 1000 V3 Elements
  - In operation since January 2006

DOHA WEST-Doha, Qatar
Tertiary Treatment

Capacity

- 135,000 m^3/day (35.7 MGD)

Feed Water Quality :

- TSS 5-10 mg/l (Weekly Max)

Effluent Quality:

- Turbidity < 0.1 – 0.5 NTU
- Nematode Eggs >4 Log Removal

DOHA WEST, Cont'd…

- System Configuration:

  - Seven (7) Membrane Trains, Six (6) Cassettes per Train

  - Total number of Membranes is 3,528

  - Inst. Design Flux: 45 lmh (N Mode), 53.6 lmh (N-1 Mode)
- UF Effluent is used for Irrigation
- End User: PWA-Drainage Dpt.
- Expected Commissioning Date: December 2007

LUSAIL MBR System
Doha, Qatar

- (Ultimate) Design Flow
    - 61,300 m^3/d wastewater flow
- Feed Water Quality:

  \- Sanitary Waste
- Effluent Quality:
    - Irrigation Water Quality

Lusail MBR System, Cont'd...

Bioreactor

- 4 (four) bioreactors @ 3250 m^3 each (for final stage)

Membrane Tanks

- Staged expansion of plant with 3/4/7/8 membrane trains
- Each train equipped with 5 (five) ZeeWeed 500d trains, using 64 Element Cassettes

LUSAIL, Cont'd…

- System Configuration (Phase 4)
  - Eight (8) Membrane Trains, Five (5) Cassettes per Train
  - Total number of Membranes is 2,456
  - Net design flux: 32.9 lmh (N Mode), 37.6 lmh(N-1 Mode)
- UF Effluent is used for Irrigation
- End User: Qatari Diyar Real State
- Expected Commissioning Date: December 2007 (Phase 1)

Dubai Sports City STP

ADF: **25,000 m³/d** Commission Date: **Expected Jan 2008**

- Partnership with local contractor
- MDF is 30,000 m^3/d
- Phased approach with 2/3 capacity installed
- 6 trains at buildout
- Effluent used as TSE for irrigation
- Evaluated Bid

Thank You!............. Questions?