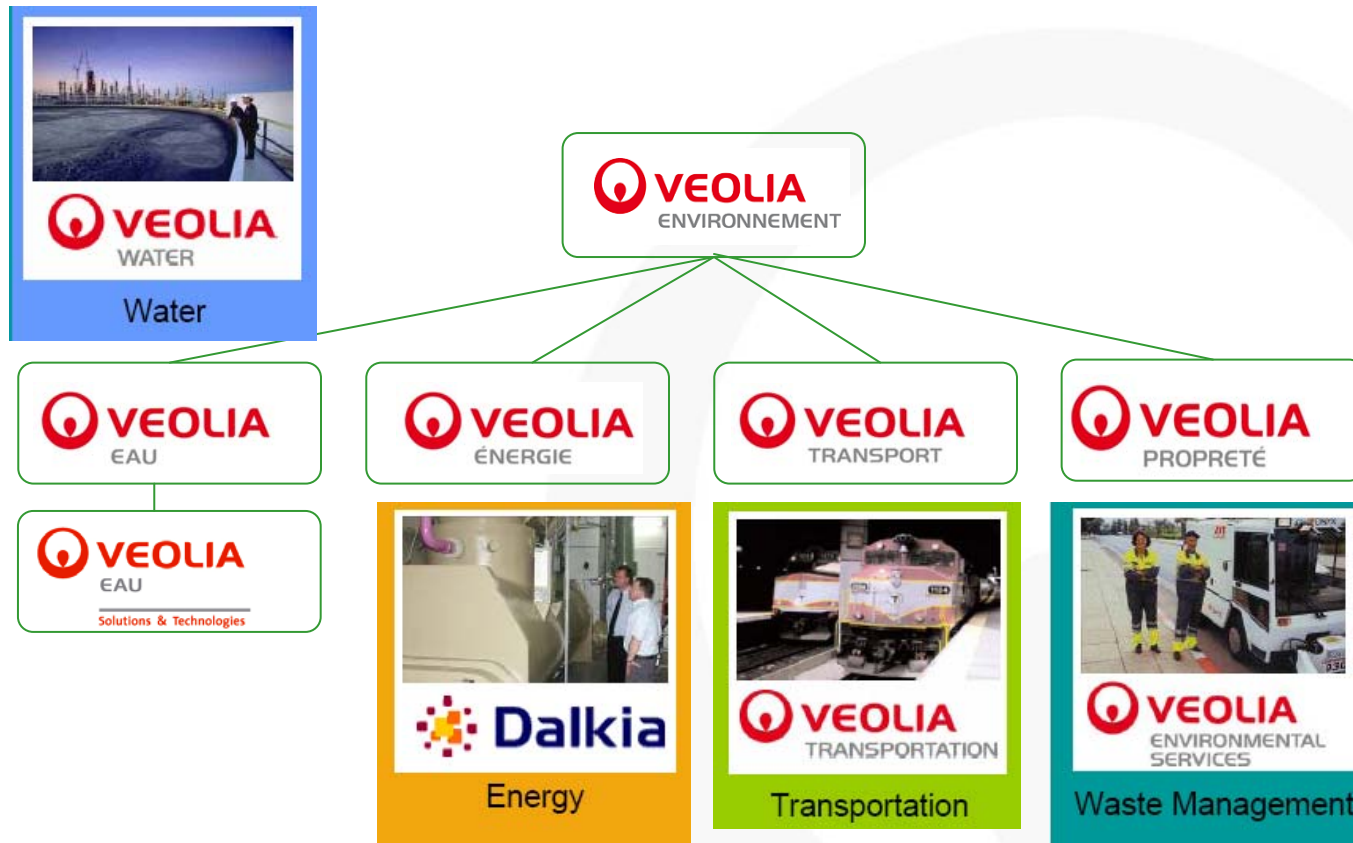


SGM FALL FORUM SERIES

KRÜGER

**Kruger's Ceramic Membrane
"KCM"
October 30, 2009**

The group



A World Leader in Innovation – 100+ Years

1903 – Krüger Systems starts up in Denmark

1989 – I. Krüger Inc. opens in Chicago

1991 – Krüger acquires Air Products WW patents, moves to Cary, NC

1996 – Vivendi/OTV acquires Krüger

2002 – Vivendi changes name to Veolia

2005 – Veolia \$38B in 2006

2007 – Acquired Anox/Kaldness

2009 – Veolia Acquired ZDD, inc technology

Leaders in Innovation

- **100+ years experience**
- **19 years in US**
- **> 120 employees**
- **500+ installations in the U.S.**
- **Integrated >20 solutions in US municipal market**





Kruger: Advanced Technologies

• Clarification

- **ACTIFLO® / Turbo**
- **MULTIFLO®**

• Biological

- **Oxidation Ditch**
- **BIOSTYR® BAF**
- **AnoxKaldnes™**
- **Oases**
- **NEOSEP MBR**

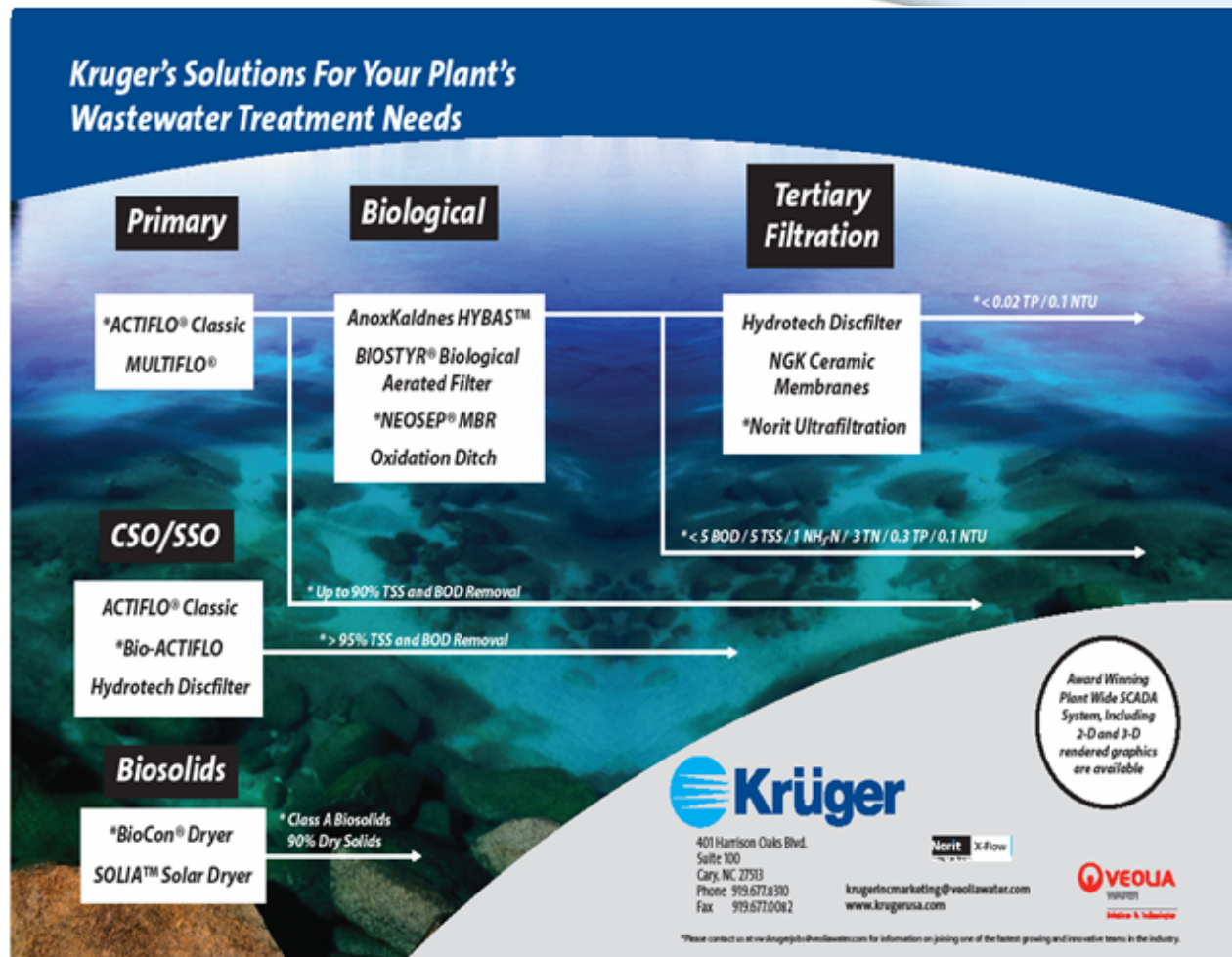
• Filtration

- **Hydrotech Discfilter**
- **KCM**
- **Norit X-Flow Membrane**

• Biosolids

- **BioCon®**
- **Solia™**
- **BioPasteur**

• Instrumentation & Controls

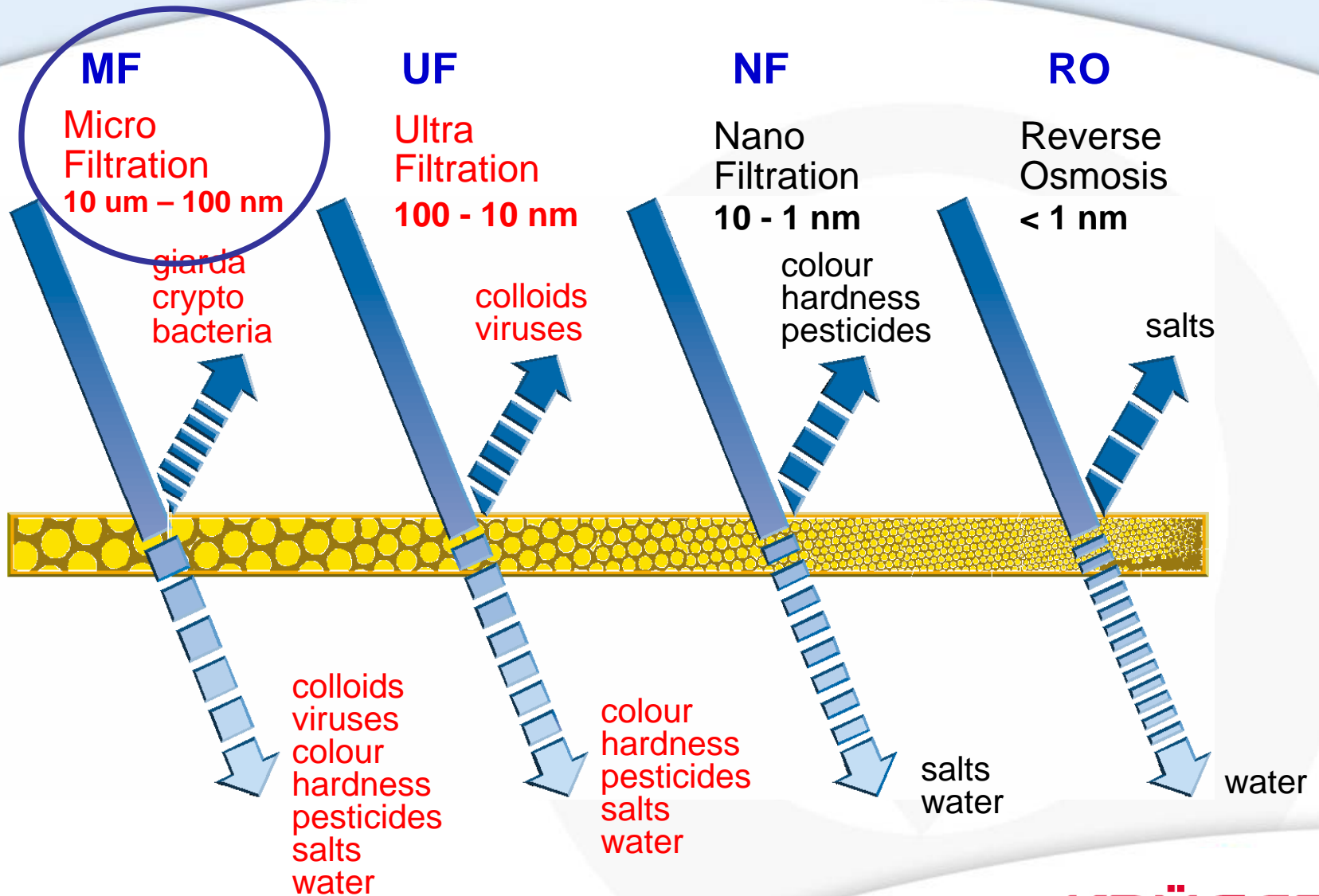


KRÜGER

Membrane Benefits

- ▶ Absolute barrier for removal of suspended solids
- ▶ Smaller footprint compared to conventional granular media filters
- ▶ Consistent filtered water quality < 0.1 ntu
- ▶ Fully automated system & remote access
- ▶ BAT to meet LT2 SWTR
- ▶ Certified for use in potable water, wastewater, reuse, and advanced purification
- ▶ Removal of micro-organisms:
 - bacterial
 - viruses

Membrane Rejection



Process Parameters

Flux

gal/sf-d or gfd

Yield per square foot of membrane surface area

TMP: Trans membrane Pressure

psi

Feed Pressure (P_f) – Permeate Pressure (P_p)



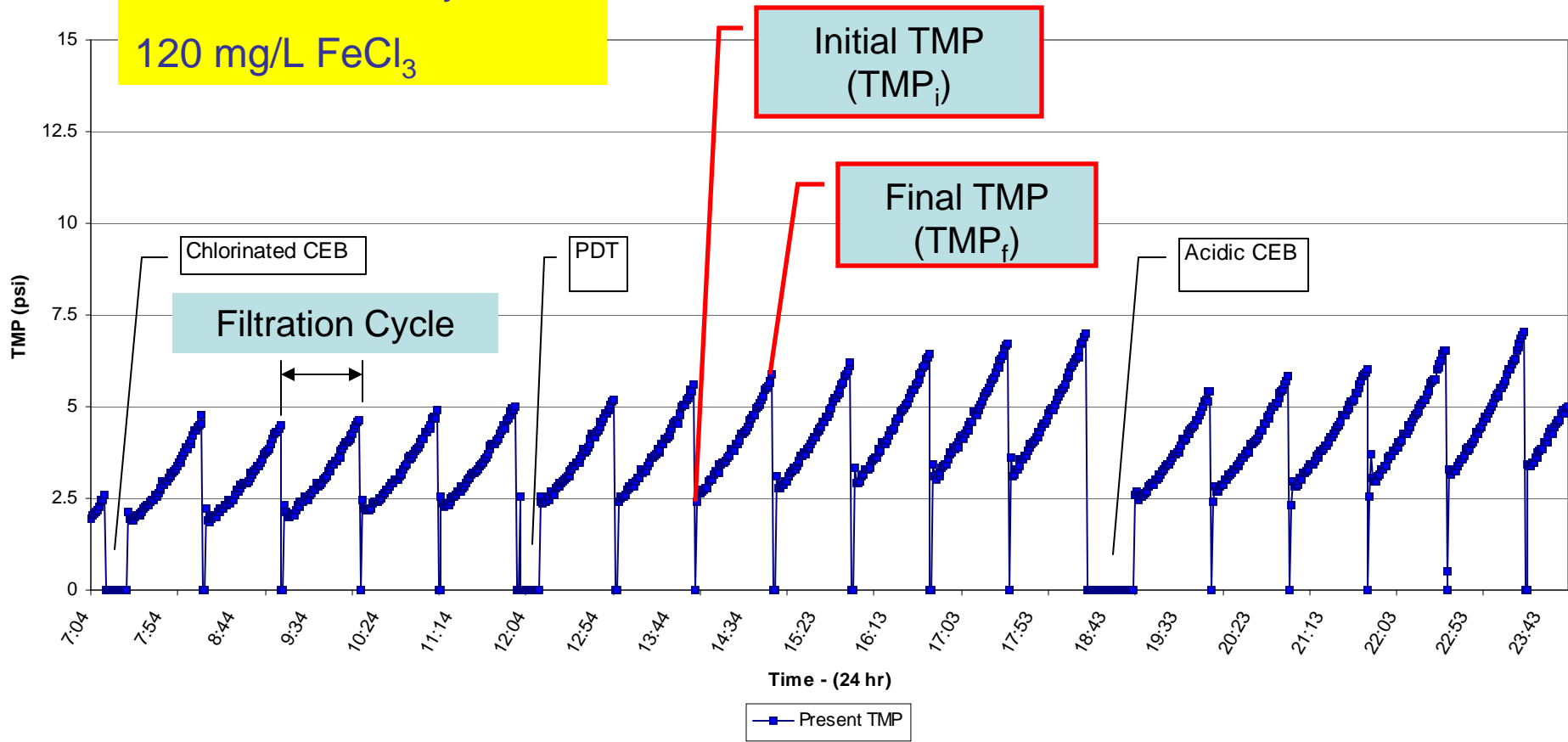
Daily TMP graph

100 gfd

60 min filtration cycles

120 mg/L FeCl_3

$$\text{Ave TMP} = \frac{(\text{TMP}_f - \text{TMP}_i)}{2}$$



Process Parameters

Permeability

gfd/psi

Flux divided by TMP;
ability of membrane to
allow the passage of a
substance

- Represents the amount of water that can be pushed per psi of pressure
- Used for comparison between membrane materials



KRÜGER

Ceramic Microfiltration System Overview

Ceramic Membrane Experience

As of March 2009,
there are currently 70 ceramic membrane systems installed world-wide



with an additional 12 under construction,
including 45 mgd in final design.



Ceramic Membrane - Element



Nominal Pore Size: 0.1 μ m (MF)

Dimension : 7'' (180 mm) D X 59'' (1500 mm) L

Membrane Surface Area: 269 ft² (25 m²)

Channel Size: 0.1'' (2.5 mm) d

Number of Channels: 2000/Element

Material: Ceramic

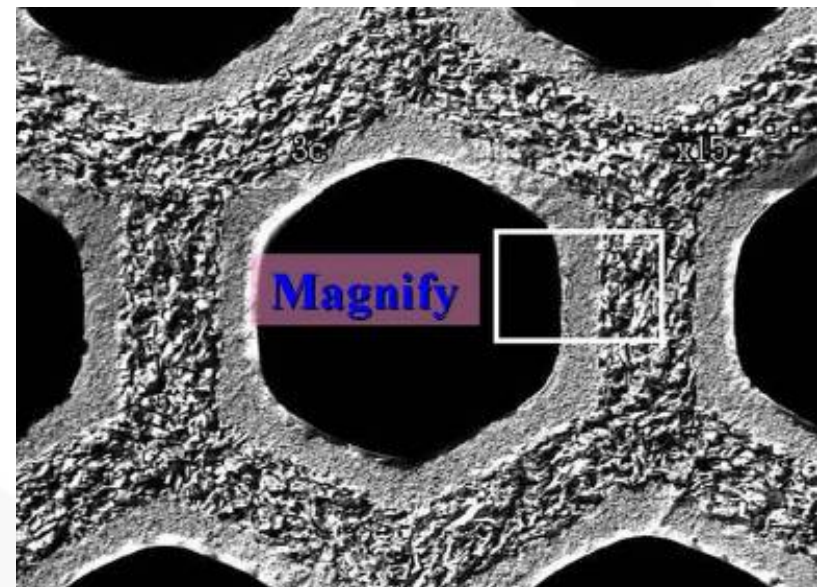
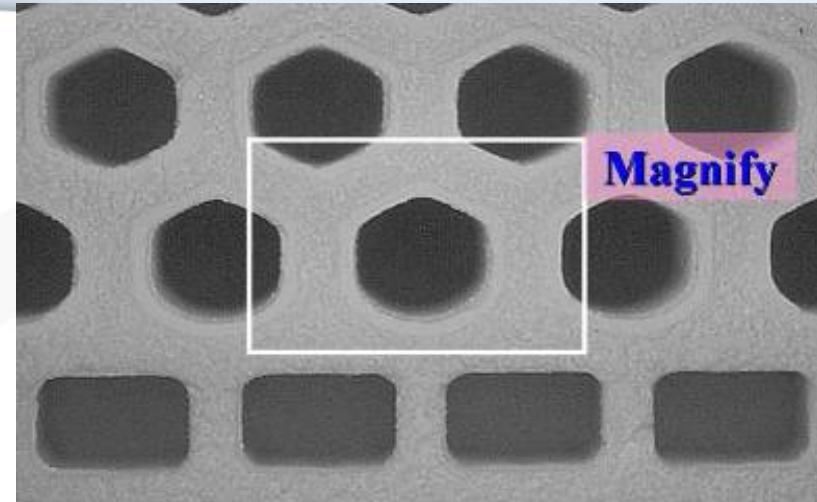
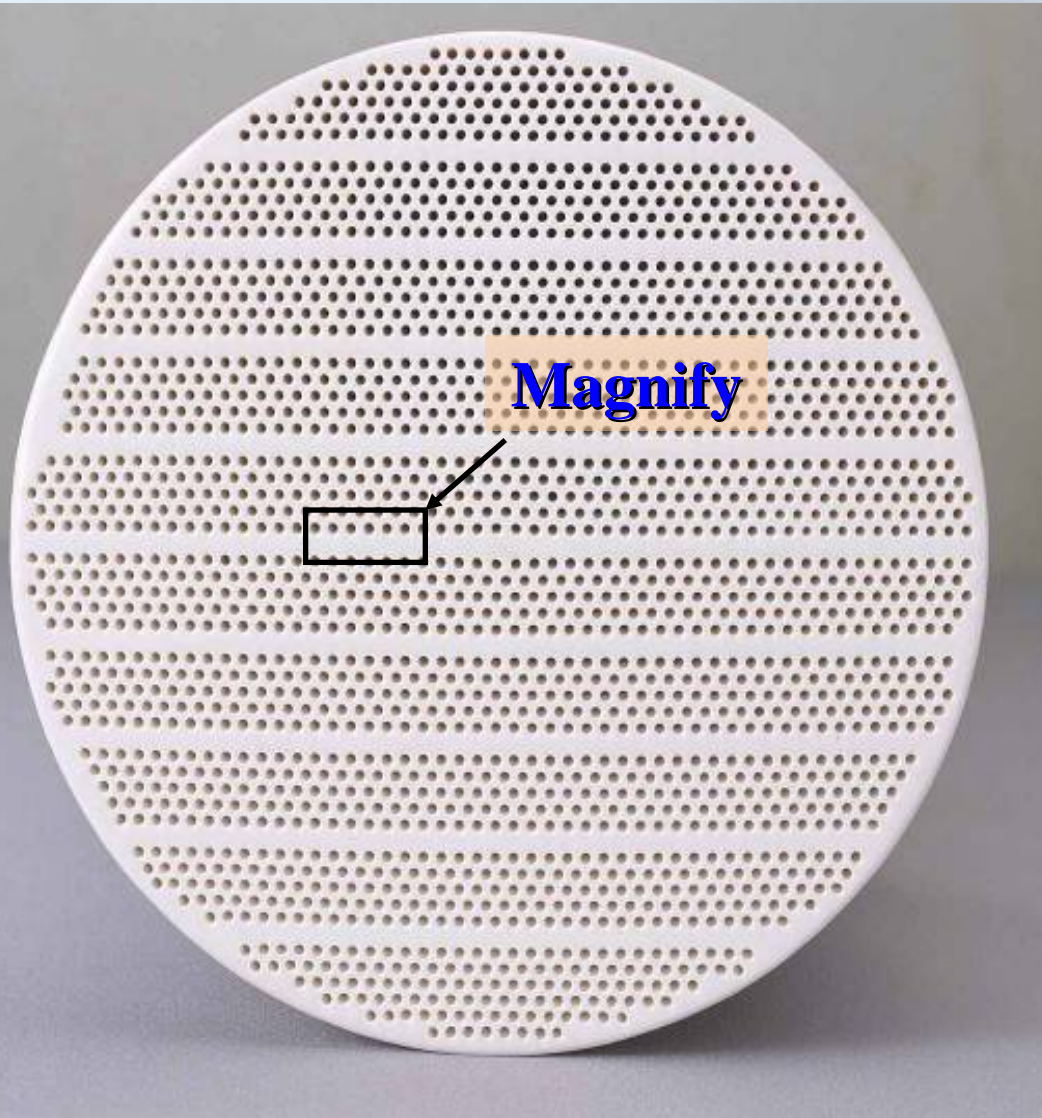


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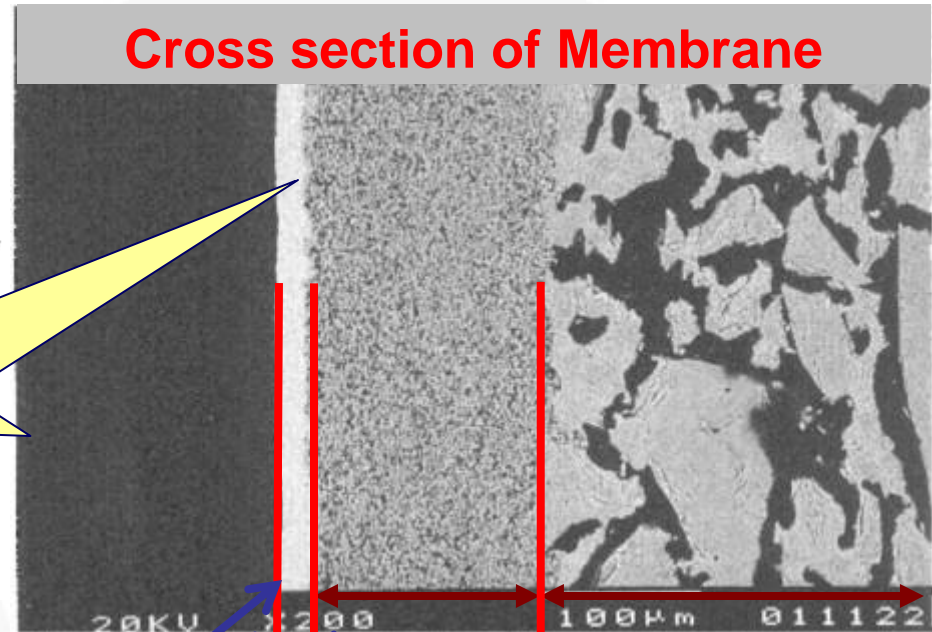
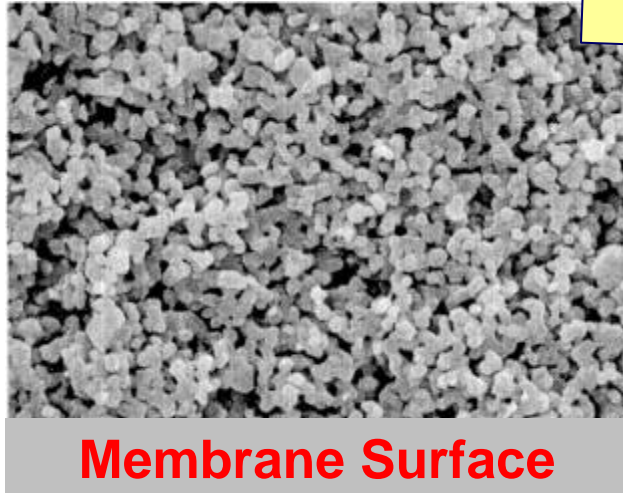
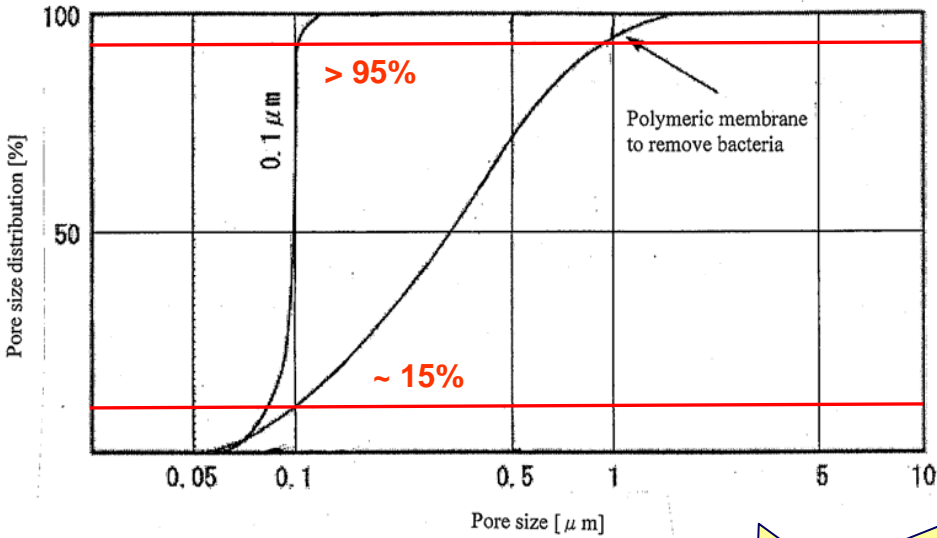
Ceramic Membrane – Module



Ceramic Membrane – Element



Ceramic Membrane - Element

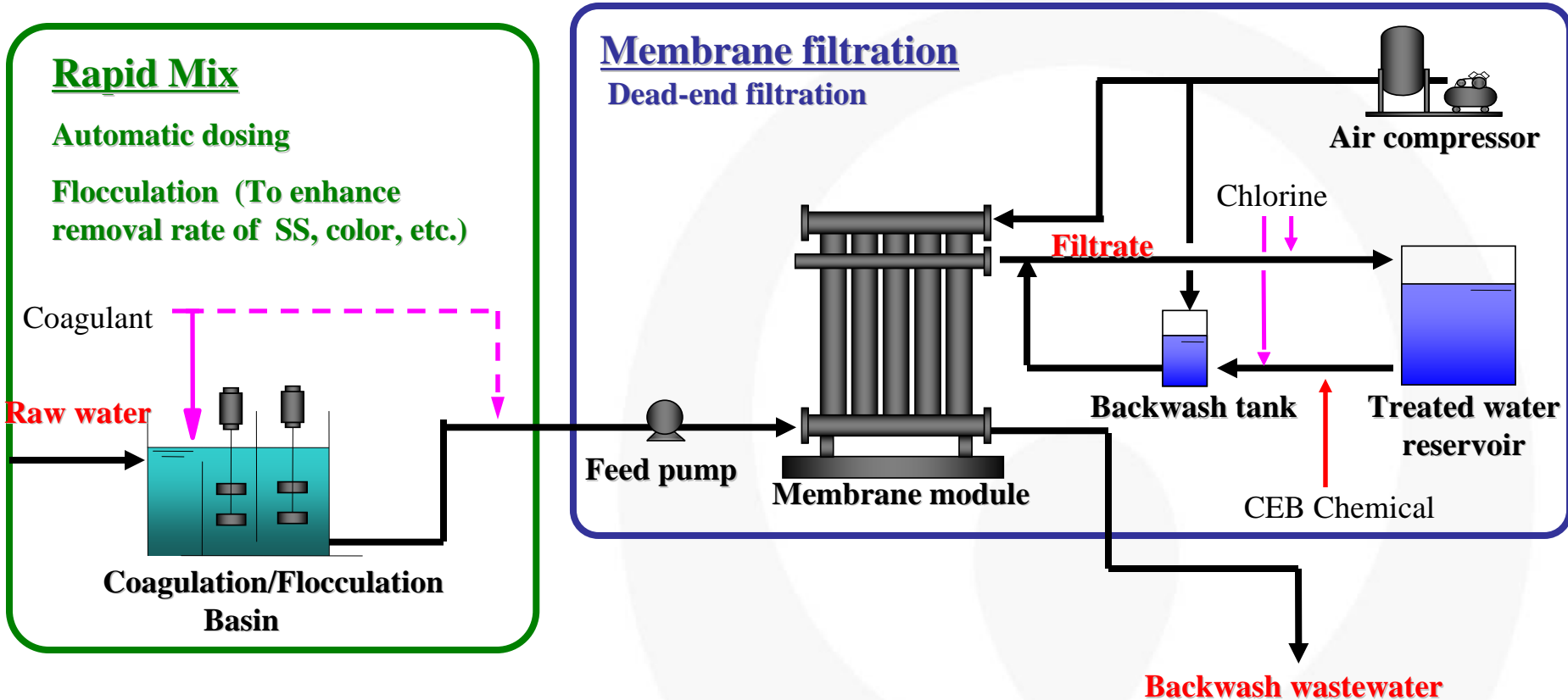


Intermediate layer

Membrane layer

Nominal pore size: 0.1 micron

Ceramic Membrane System



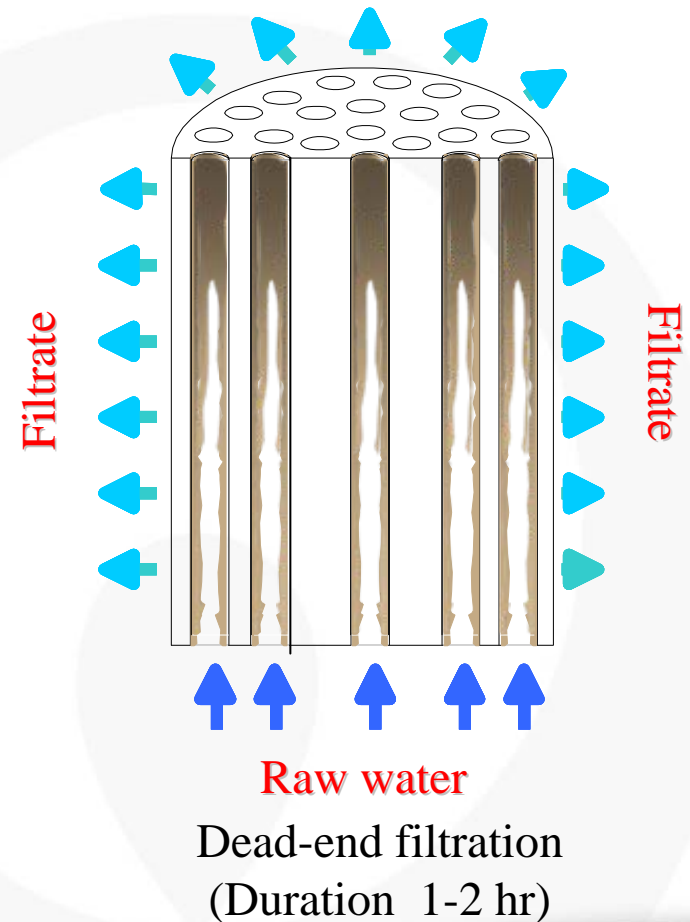
Modes of Operation - Filtration

Filtration process

Raw water is fed into the channels of ceramic membrane by feed pump.
Whole water is recovered as filtrate.
(Dead-end filtration)

Backwashing process (exfoliation)

Backwashing process (discharge)



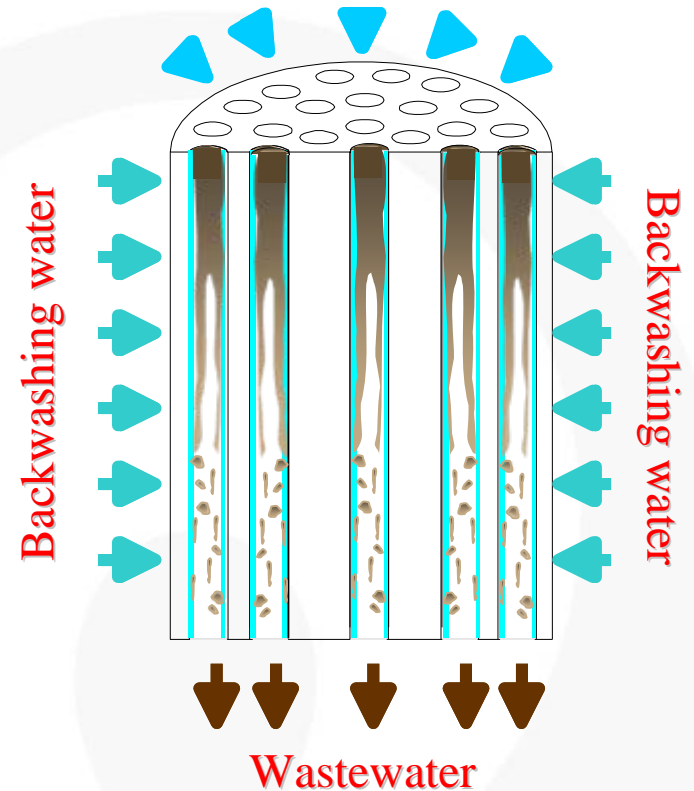
Modes of Operation – Backwash (Exfoliation)

Filtration process

Backwashing process (exfoliation)

Cake layer, formed on the membrane, is exfoliated from the surface by high pressure backwashing.

Backwashing process (discharge)



Applied pressure : max. 72.5psi
(Duration 20 sec)

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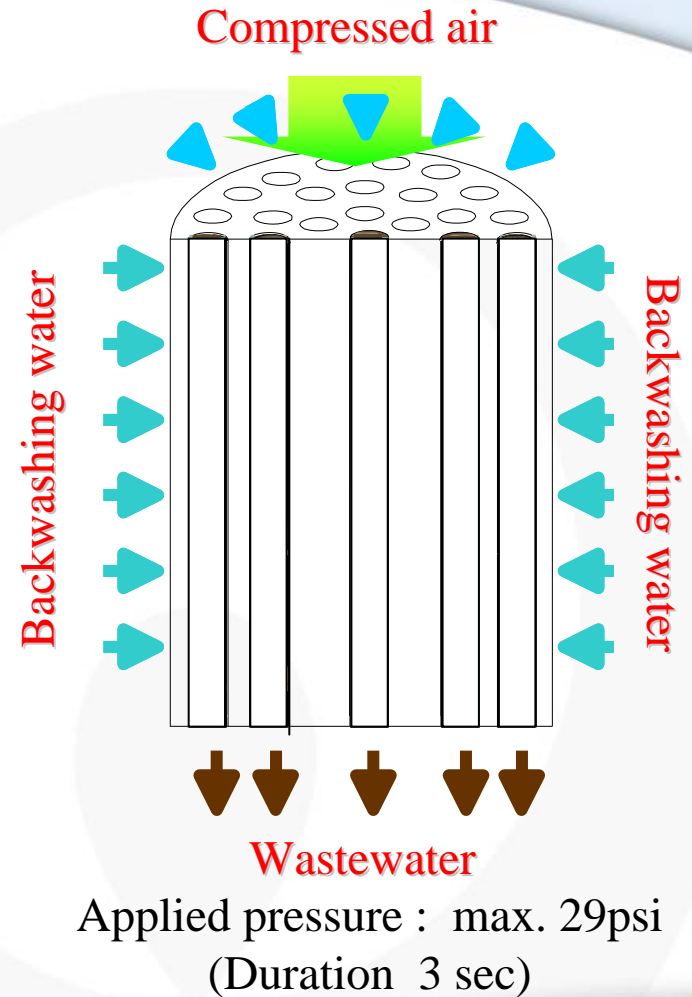
Modes of Operation - Backwashing (Air Scour)

Filtration process

Backwashing process (exfoliation)

Backwashing process (discharge)

Cake, exfoliated from the surface of membrane, is discharged completely by air blow.



Backwashing Example

Filtration Time:

2 hours

**Pressurized
Water Flush:**

6 seconds

**Pressurized Air
Flush:**

7 seconds



Filtration Process
/ Start

Modes of Operation – Chemical Cleaning

Chemically Enhanced Backwash (CEB)

- Sulfuric Acid to pH 2 (~ 500 mg/L)
- Sodium Hypochlorite (50-100 mg/L Free Cl)

Clean In Place (CIP)

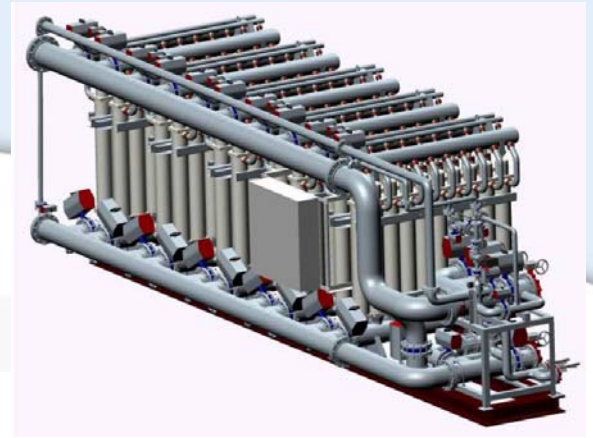
- Sodium Hypochlorite (Dosage 3,000 mg/L Free Cl)
- Citric Acid (1.0%)

**No heating of chemicals
required**

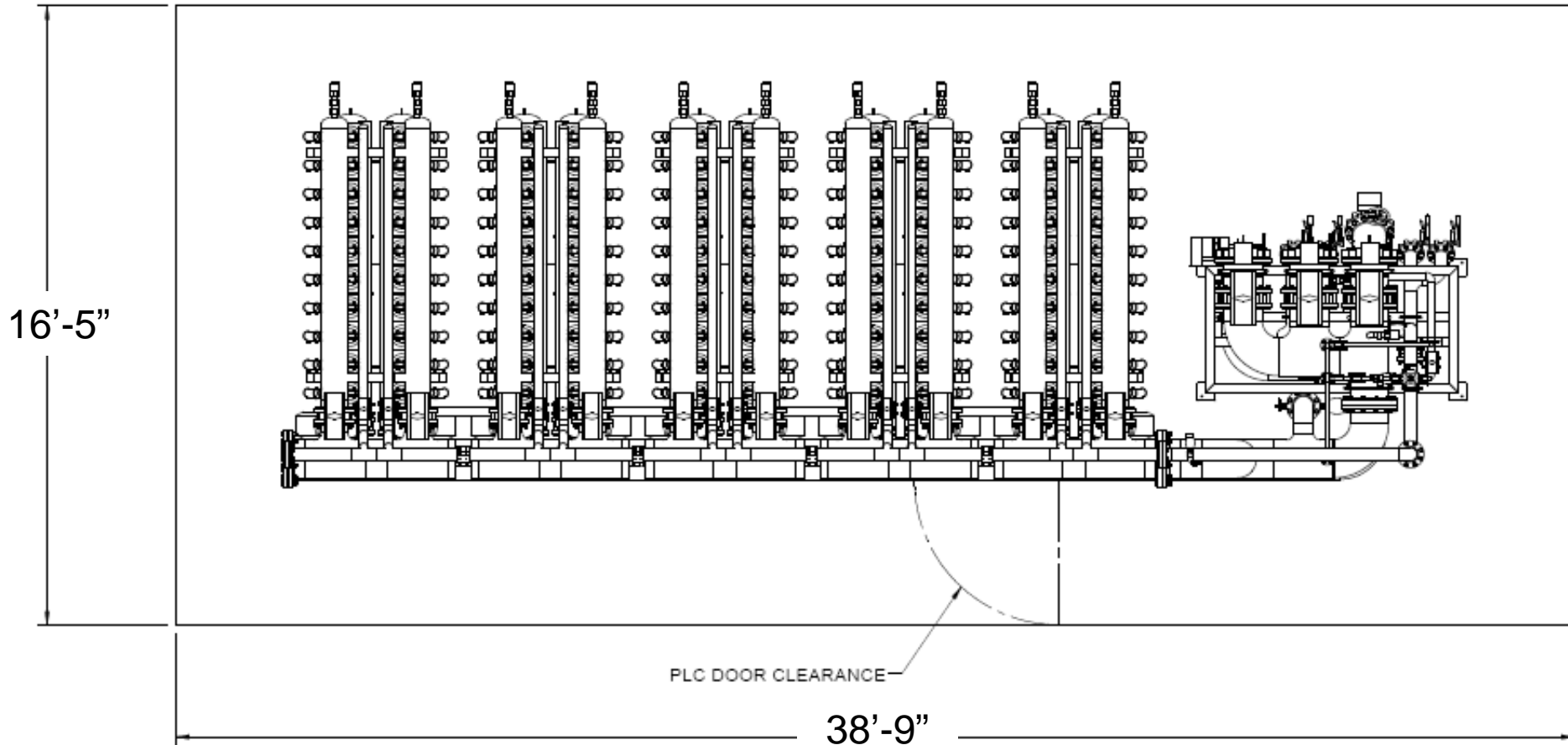
**However, if needed, CAN
HEAT chemicals**



Skid Layout



MINIMUM 3' CLEARANCE ALL AROUND



16'-5"

PLC DOOR CLEARANCE

38'-9"



KRÜGER

Ceramic Microfiltration The Engineering Marvel

Optimize **Operation** of Membrane

Keeping the membrane clean

- Ability to build a significant filter cake
- Ability to withstand more effective hydraulic backwashes

Make a stronger element; make a **ceramic** element

Extend Cleaning Frequencies

- Extend filtration cycle
- Extend CEB cleaning frequency
- Extend CIP cleaning frequency

Increases overall filtrate recovery

Optimize **Maintenance** of Membrane

What is largest maintenance issue of membranes?

- Membrane failure
- Membrane identification and pinning

Make a stronger element; make a **ceramic** element

Guarantee reduction of fiber breakages

- 20 year warranty
- 10 year 100% warranty
- NO PINNING involved; eliminates identification time

Superior product reliability



KRÜGER

Ceramic Microfiltration Water Treatment

Upland, CA (January 2006 to February 2006)

Conditions

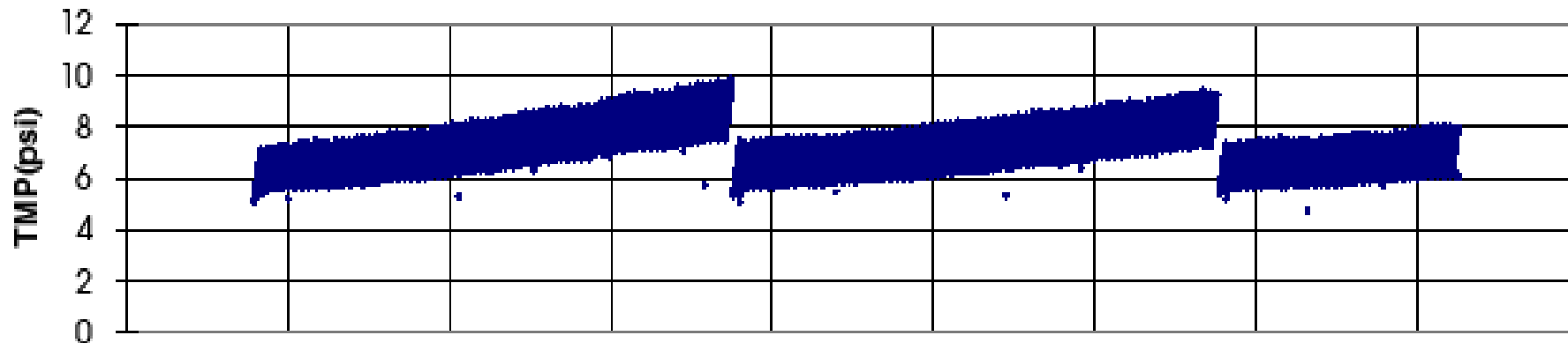
- Flux → 100 gfd
- Backwash Interval → 120 min
- Coagulant / Dose → PACl / 40 mg/L
- Inline Coagulation
- CEB Interval → Every 6 days – 30 min soak with Sulfuric Acid at a pH of 2

Parameter	Unit	Raw Water	Filtrate
Turbidity	NTU	4 (5-3)	<0.1 (<0.1)
TOC	mg/L	2.4 (2.4)	1.22 (1.22)
pH	--	7.4 (7.4)	
Alkalinity	mg/L as CaCO ₃	75	
Temp	°C	10.2 (11.5-10.2)	

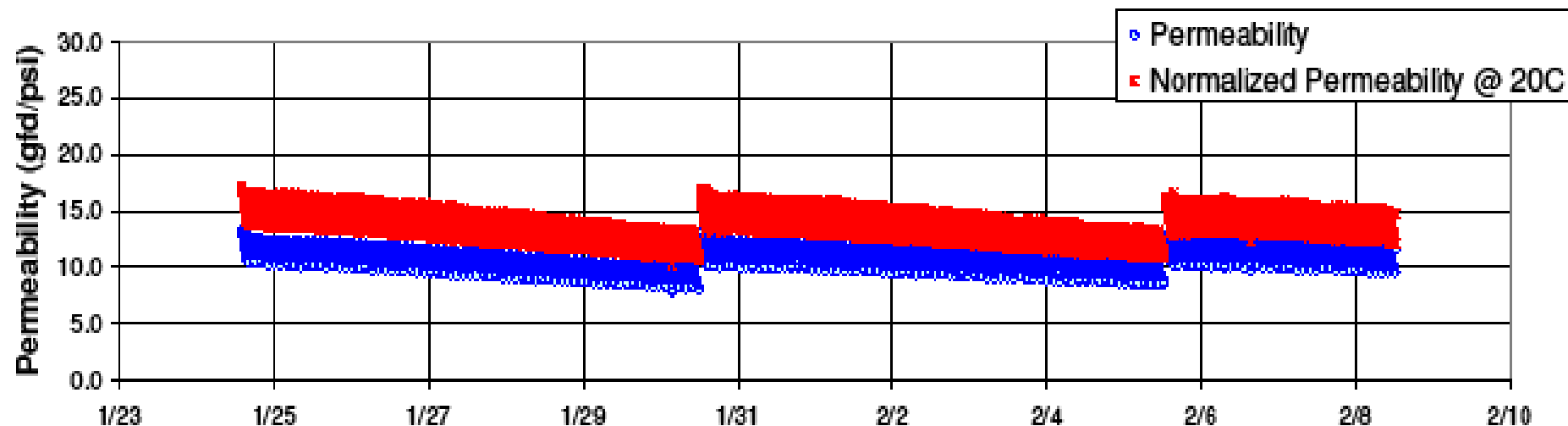
Average (max–min) Average (max–min)

Upland, CA

TMP(actual)



Permeability vs. Normalized Permeability @ 20C



Siler City, NC

- Study conducted by Kruger and NGK
- First type of study to be conducted in the US treating Surface Waters with High Organic Content
- Optimization of Operating Parameters



Raw water (left) Filtrate (right)



Mixing tank

Siler City, NC

February 2007 to Present

Condition 1

- ▶ Flux → 100 gfd
- ▶ Backwash Interval → 60 min
- ▶ Coagulant / Dose → PACl / 100 mg/L
- ▶ CEB Interval → 2 days - 30 min soak with Sulfuric Acid (H₂SO₄) at a pH of 2

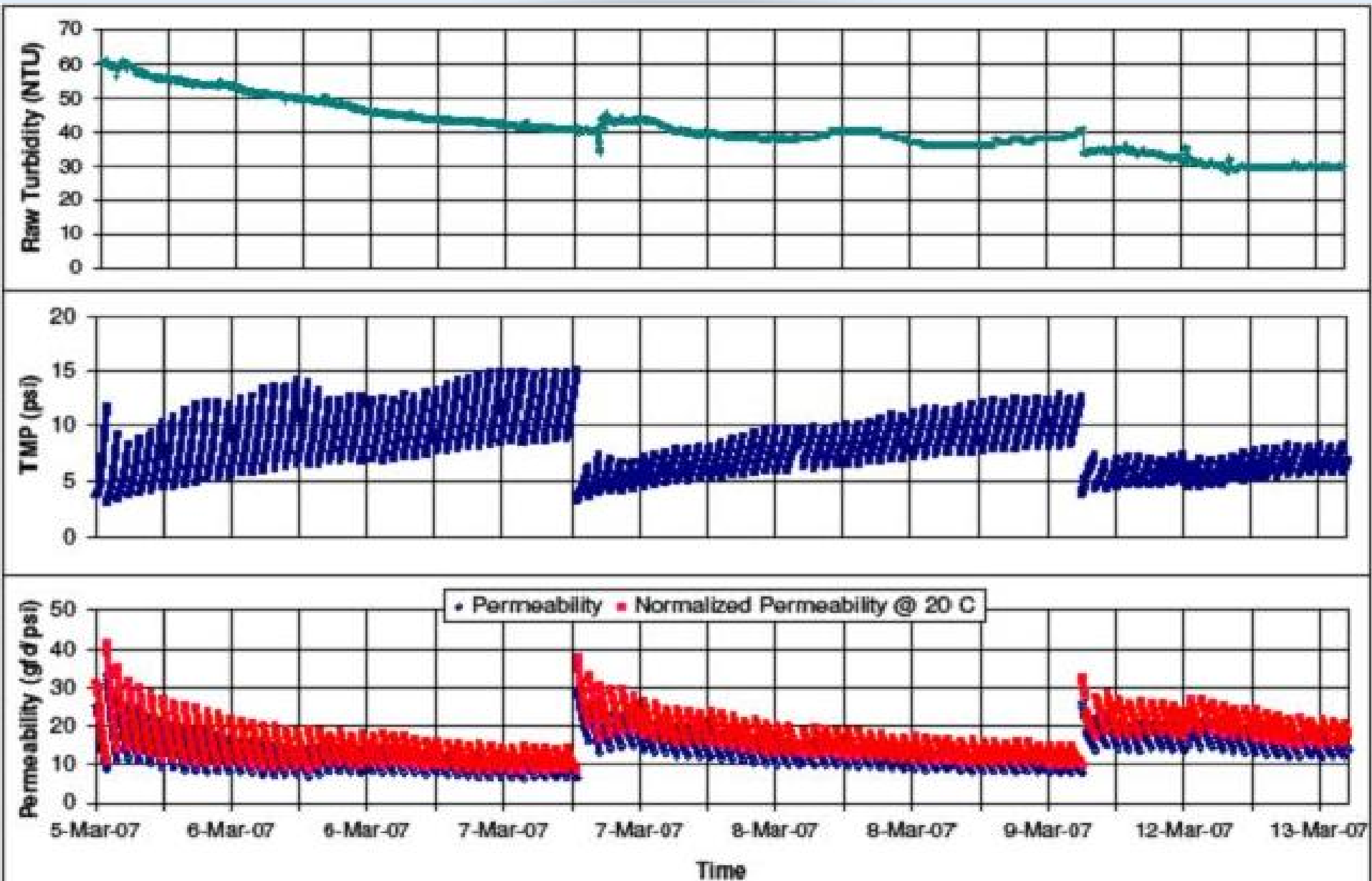
Condition 2

- ▶ Flux → 75 gfd
- ▶ Backwash Interval → 120 min
- ▶ Coagulant / Dose → PACl / 100 mg/L
- ▶ CEB Interval → 4+ days - 30 min soak with Sulfuric Acid (H₂SO₄) at a pH of 2

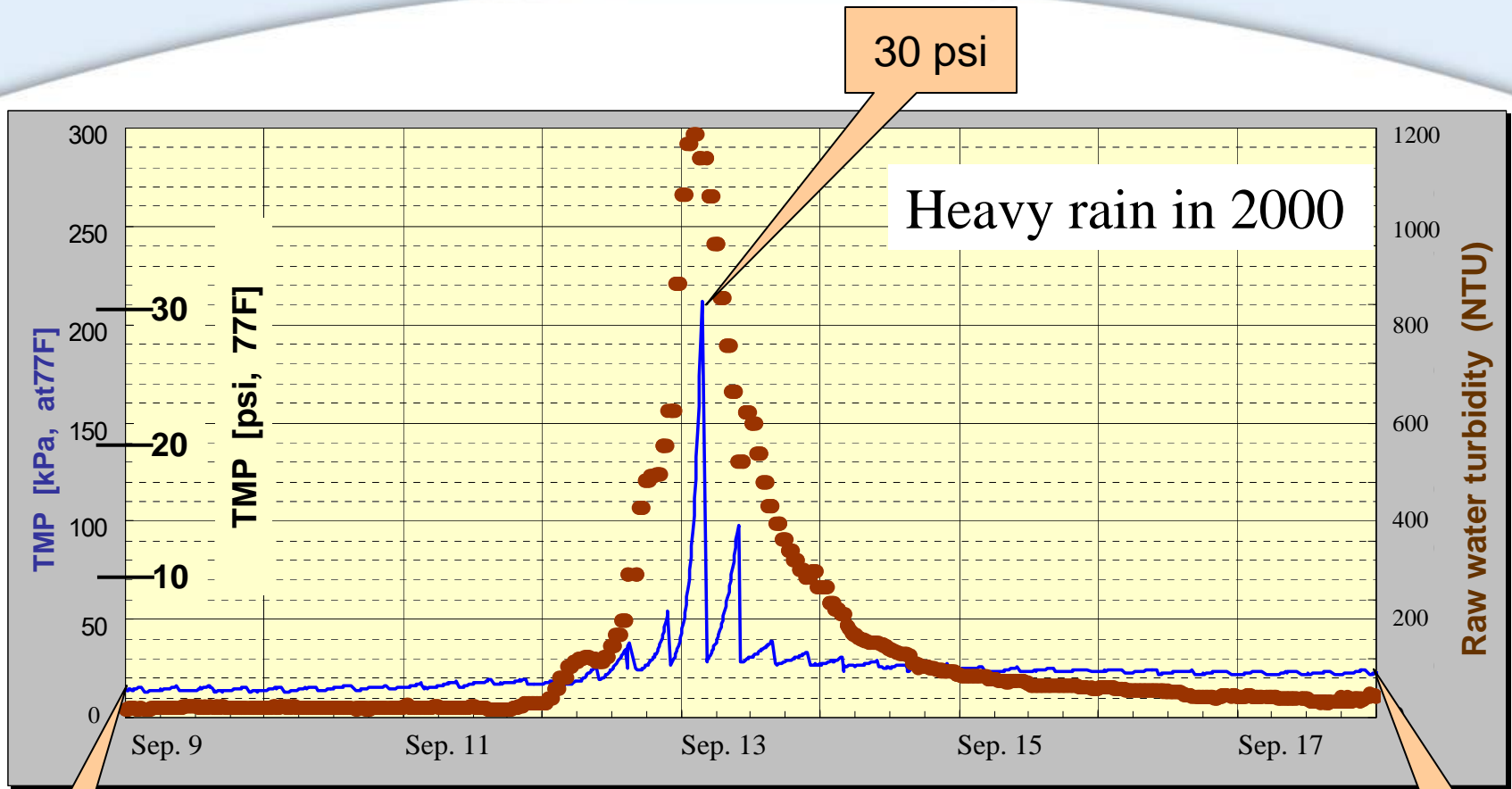
Parameter	Unit	75 gfd		100gfd	
		Raw Water	Filtrate	Raw Water	Filtrate
Turbidity	NTU	20	< 0.1	41	< 0.1
TOC	mg/L	N/A	N/A	10.1	4.2
Color	PCU	360	< 3	280	< 3
Manganese	mg/L	0.647	0.006	0.743	0.027
pH	--	6.9		6.9	
Alkalinity	mg/L (CaCo3)	23		24	
Temp	oC	13		11	



Siler City, NC



Stable Operation



**TMP increased during filtration period; however
TMP was recovered by backwashing only.**

2 psi

30 psi

Heavy rain in 2000

3 psi



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Ceramic Microfiltration Filter Backwash Treatment

Filter Backwash Study (June – December 2007)

	FBW	FBW w/ coag	FBW + Thickener solids	FBW + Thickener solids + CL
Variable	Run 6	Run 7	Run 13	Run 14
Flux (gfd)	100	100	50	50
Turbidity (NTU)	86.4/0.1		718/0.1	
TOC/DOC (mg/L)	9.35/1.5		95/1.95	
True Color (PCU)	1.5/0.4		2.3/1.4	
Fe (mg/L)	1.32/0.01		18.6/0.01	
Mn (mg/L)	0.233/0.005		1.6/0.005	
Al (mg/L)	5.6/0.06		68/0.03	
Filtration Interval (hrs)	2 - 3		0.5 – 1	
CEB Interval (day)	--	--	--	--
CIP Interval (month)	4	4	2	3

Run 6: Filter Backwash (sand filter)

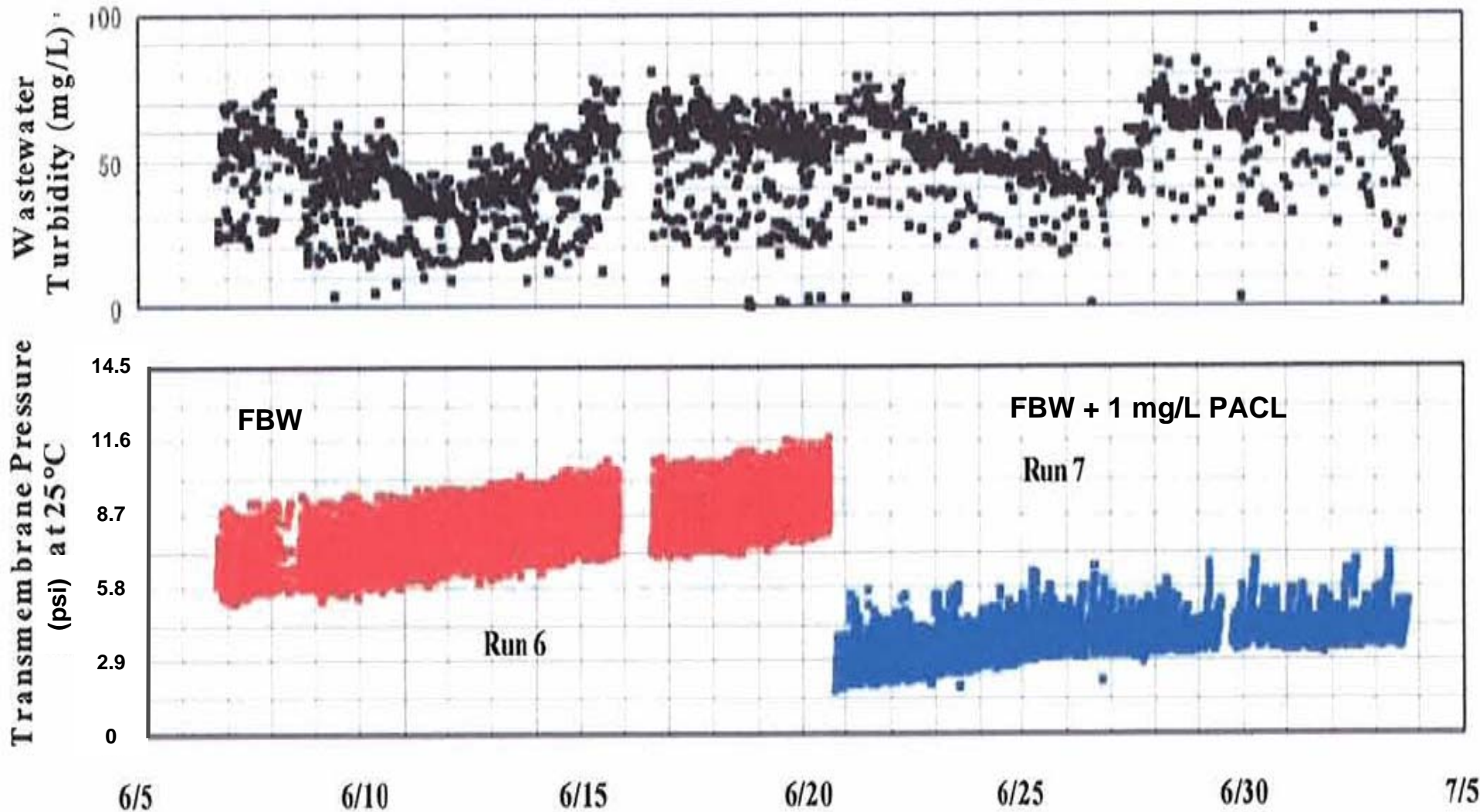
Run 7: Filter Backwash (sand filter) with 1 mg/L coagulant (as PACL)

Run 13: FBW + Solids Return from Thickener

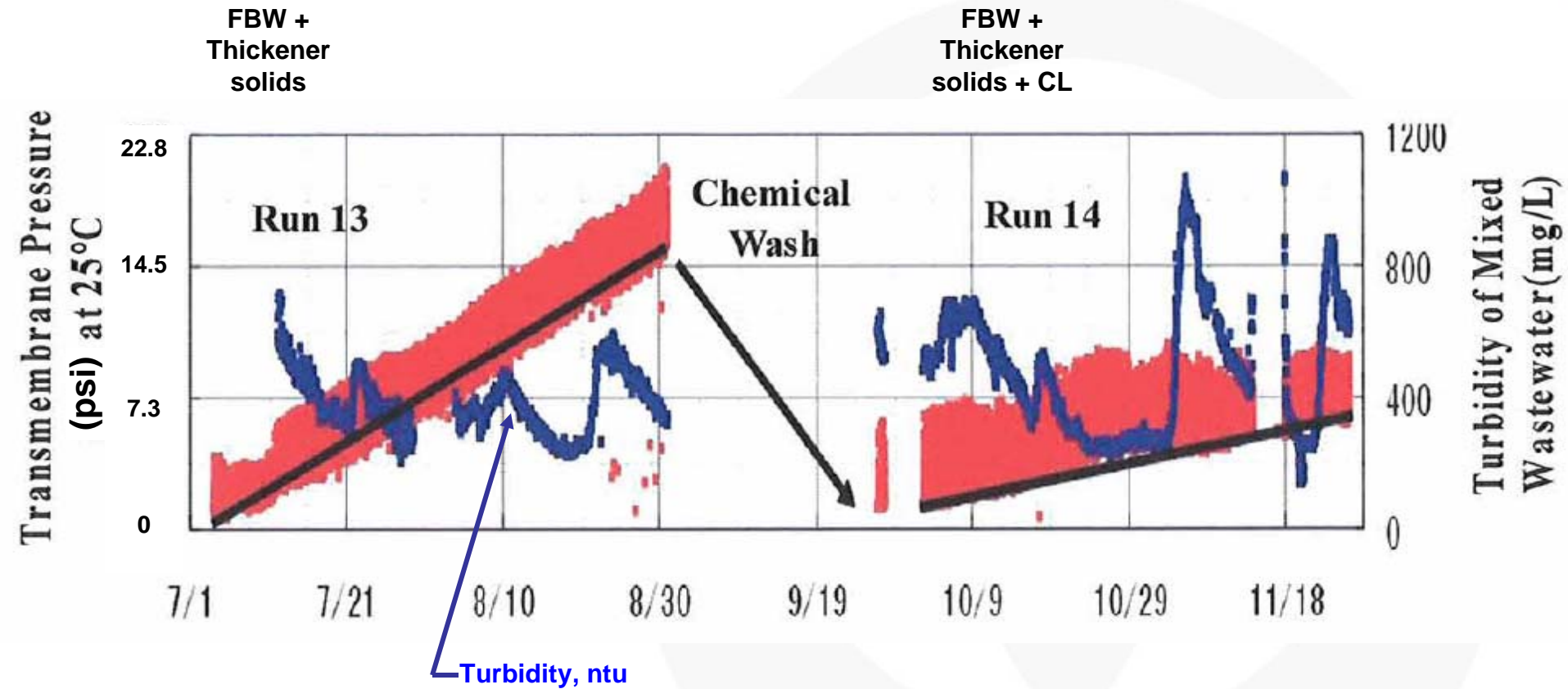
Run 14: FBW + Solids Return from Thickener with 2 – 5 mg/L of Hypochlorite (as Cl₂)

Filter Backwash Study (June – December 2007)

Operation: 100 gfd; 120 min to 180 min filtration cycles



Filter Backwash Study (June – December 2007)





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Ceramic Microfiltration Benefits

Ceramic versus Polymeric



Variable	Ceramic	Polymeric
Flux (gfd)	100 - 220	30 - 85
Turbidity (NTU)	< 1,500	<100
TSS (mg/L)	< 3,000	< 200
TOC/DOC (mg/L)	< 100	< 30
Coagulant (mg/L)	< 200	< 30 (need sedimentation)
Recovery (%)	> 98	96
Filtration Interval (hrs)	1 - 2	0.25 – 0.67
CEB Interval (day)	2 – 4	1
CIP Interval (month)	6	1

Ceramic Membrane Benefits

- ▶ Reliability with 11 years of installed experience, with no breakages (>17,000 elements)
 - No pinning required
- ▶ Twenty-year warranty
- ▶ Consistent operation on “flashy” water
- ▶ Backwash Interval 1-2hrs, CEB 1/day, CIP 4/yr
 - Recovery >98%
- ▶ Low TMP (5-15psi) at high flux (175gfd)
- ▶ Operational Flexibility
 - PAC or Ozone directly onto membrane
 - Membranes can be stored dry





KRÜGER

For questions please contact:

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rowena.patawaran@veoliawater.com