Improving 2nd Place - Two-Stage Low Pressure Membrane Systems

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Outline

Why choose 2-stage MF/UF?

2nd Stage Design Considerations

- Membrane Selection
- Feed Water Quality
- Hydraulic Profile
- Redundancy
- System Controls
- LRV

Factors Driving High Recovery

Conserve potable water resources

High cost to discharge to sewer

Limited land area for drying beds

High cost per gallon of raw water

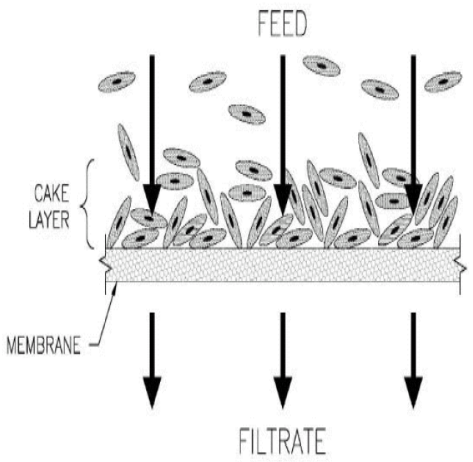
Influence of High Recovery
Single Stage MF/UF

Positive

- Increased feed water recovery
- Less waste/ smaller downstream processes
- Fewer equipment cycles

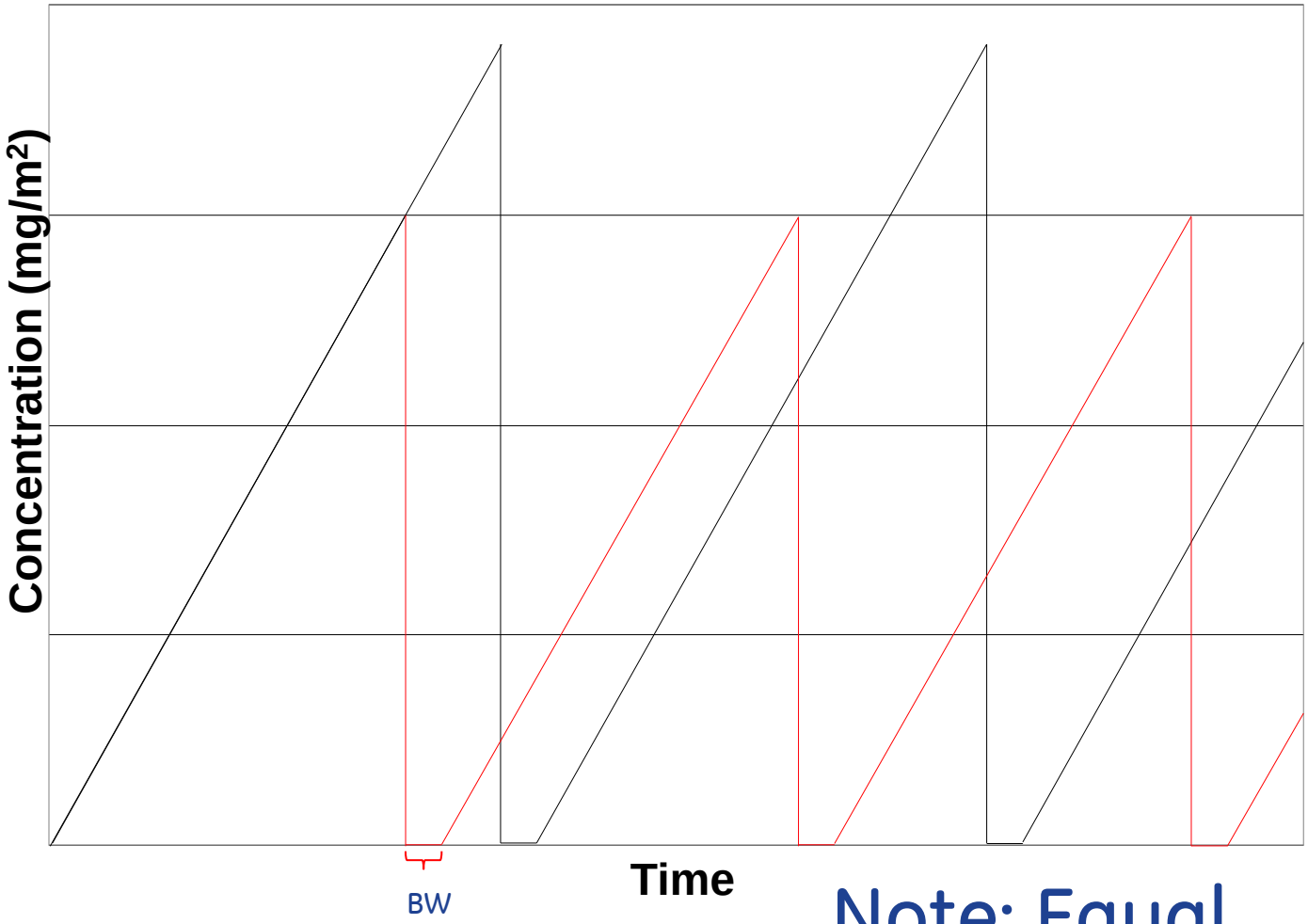
Negative

- Longer permeation cycle
- Thicker, more compact cake layer
- Higher Before Backpulse TMP
- Increased fouling risk due to solids and coagulant dewatering



Recovery

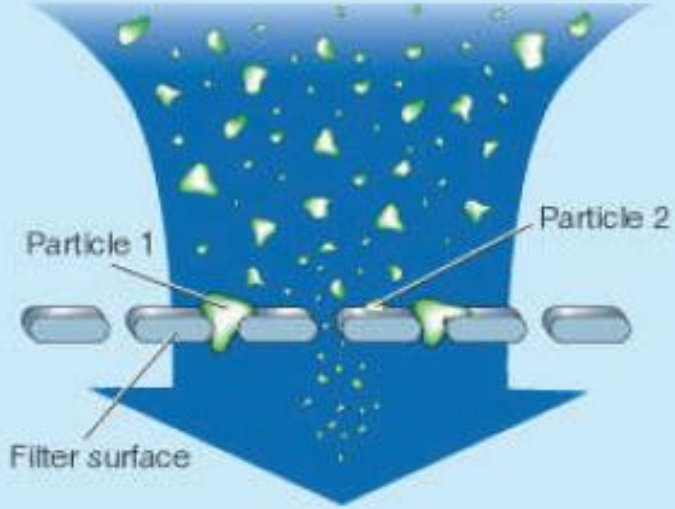
Solids Concentration vs. Time Simplified



Note: Equal flux assumed

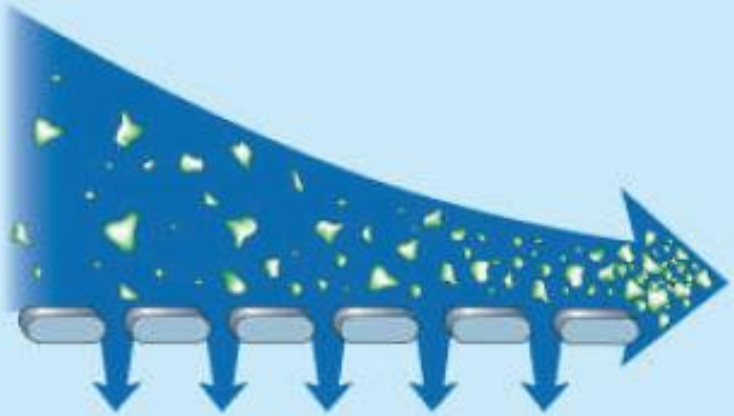
Managing the Cake Layer

Dead-end Filtration



Flow is perpendicular to the membrane surface

Cross-flow Filtration



Flow is **tangential** to the membrane surface

Why Choose 2-Stage MF/UF?

Compact Footprint compared to conventional

Consistent Treated Water Quality

Cost effective

Option to discharge to clearwell directly, reducing size/cost of 1st stage system

MF/UF Backwash Waste

"Concentrated raw water":

- Suspended solids (TSS, floc, pathogens) that have been rejected by the MF/UF membrane

$$CF = \frac{1}{1-R} \text{ where R = recovery}$$

1st @ 90-97% → CF = 10 – 50

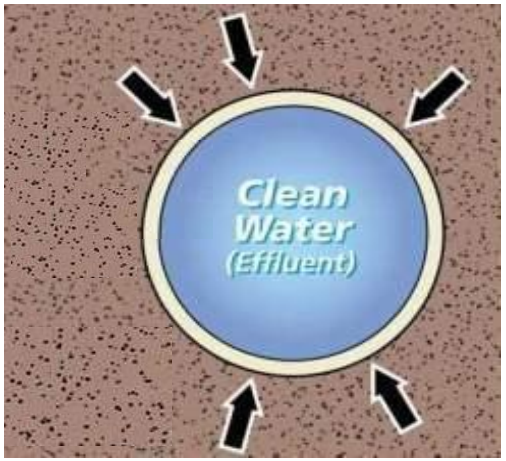
Overall CF 50-500

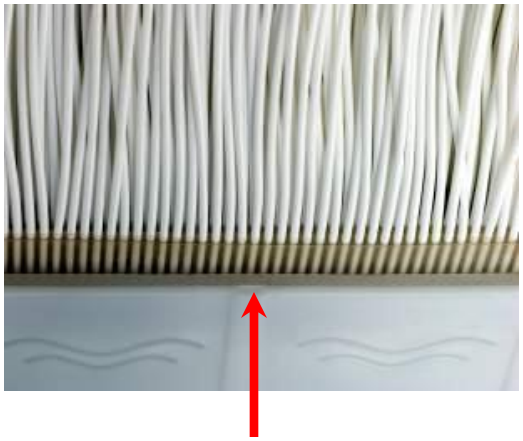
Membrane Selection

Outside-in flow

Appropriate fiber packing density & module spacing

Proven performance in high solids applications





Defined spatial distribution of fibers

Managing the Cake Layer

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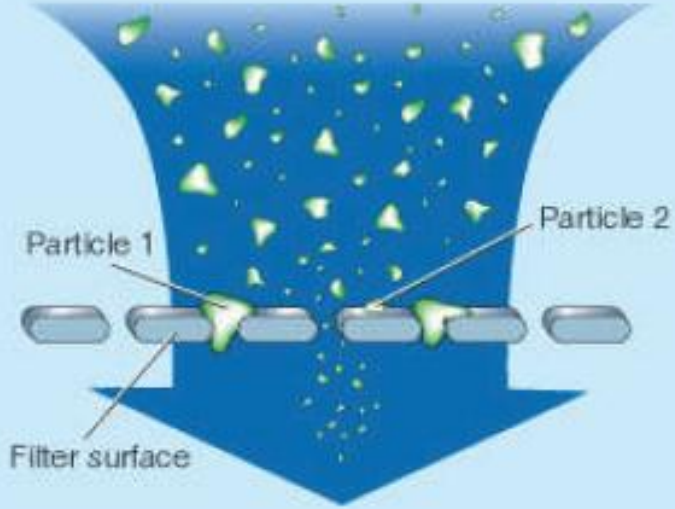

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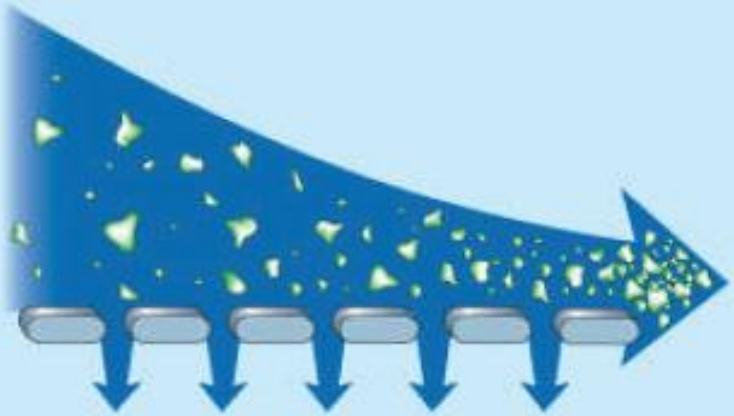
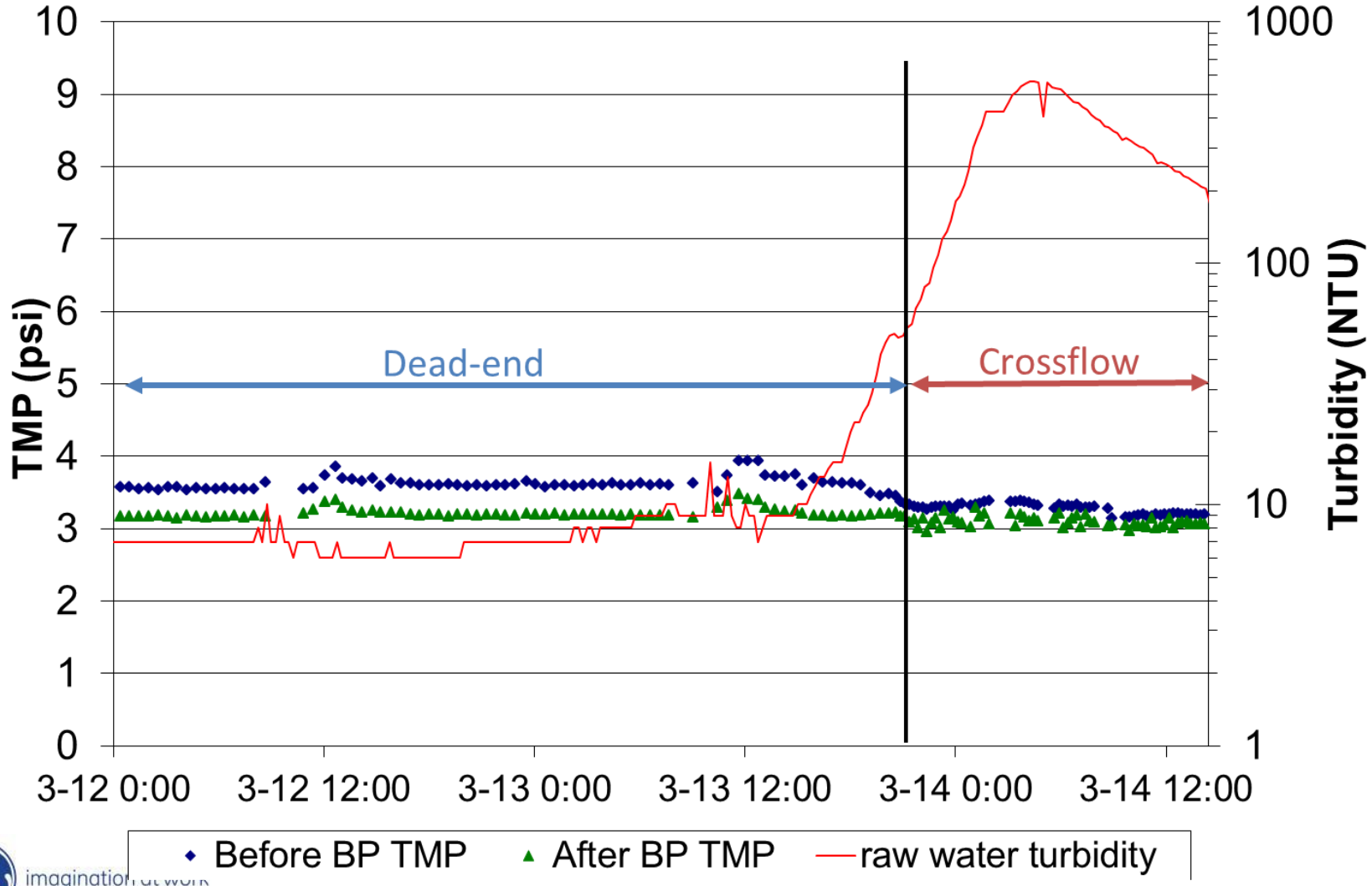


Flow is tangential to the membrane surface

Effect of Filtration Mode during Turbidity Spike



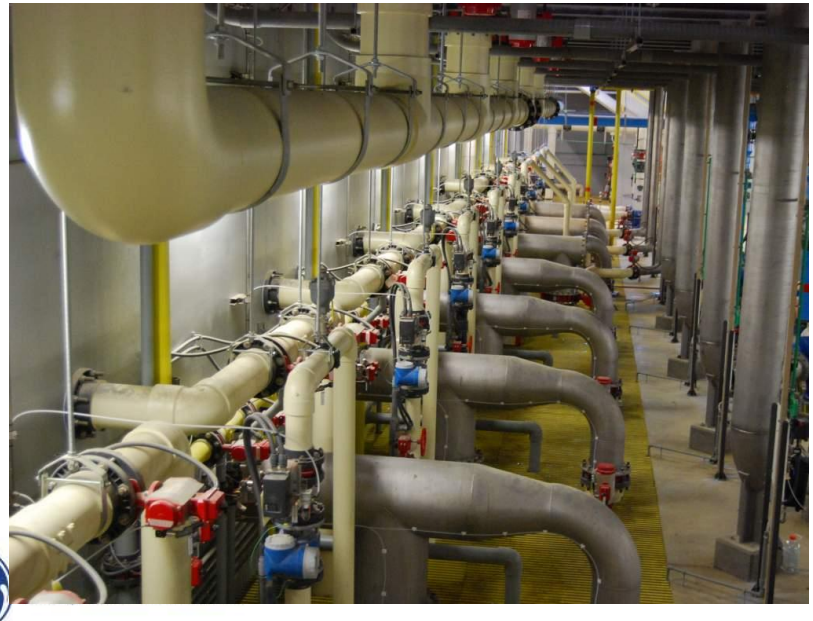
Conestoga WTP – Lancaster, PA

1st Stage: 11.147 MGD, 92%, ~34 gfd

2nd Stage: 0.853 MGD, 88%, ~21 gfd

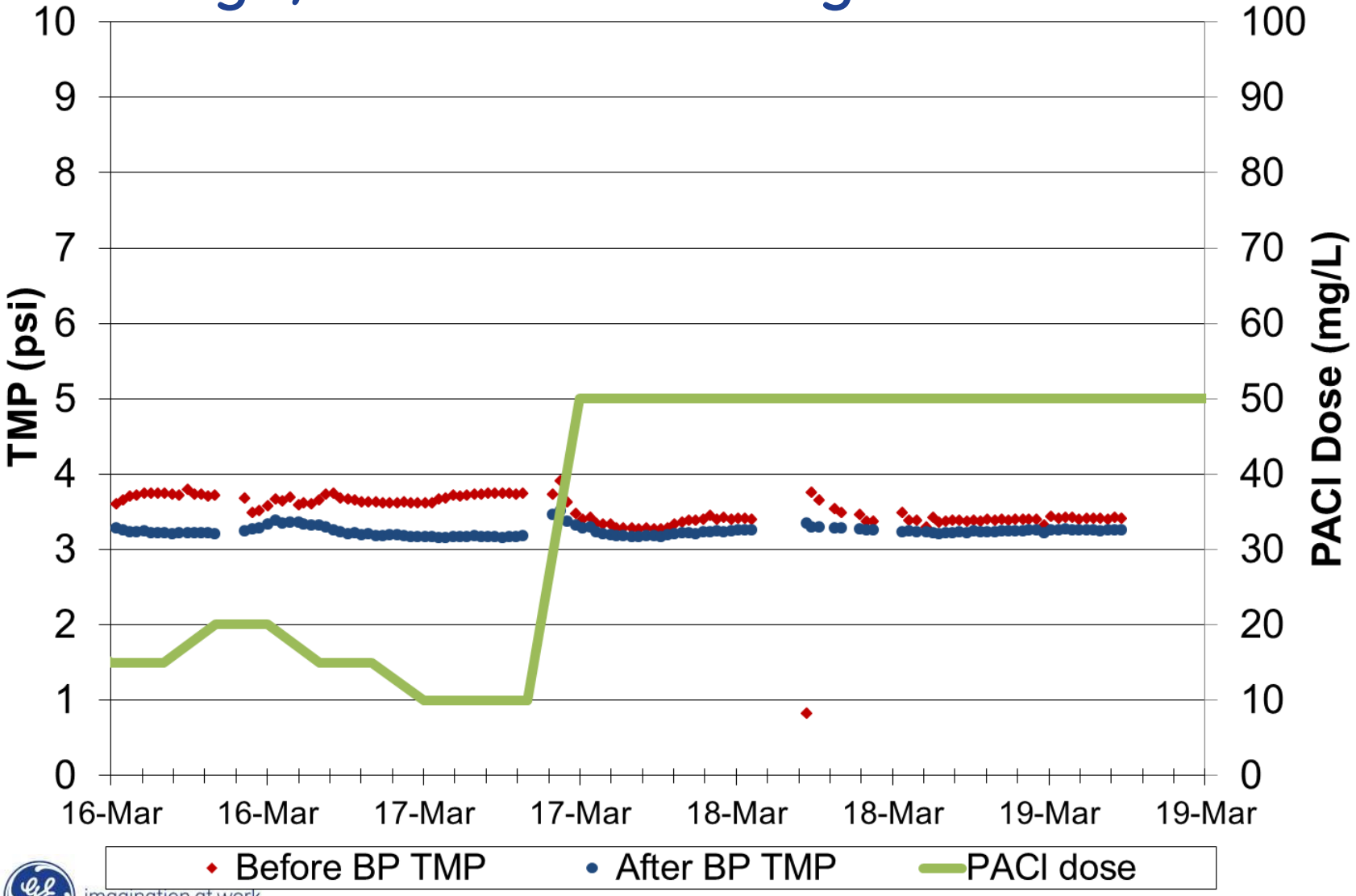
Turbidity ave 10-20 NTU, max >500 NTU

Coagulation for organics removal with PACl



Effect of Coagulant Dose on TMP

Conestoga, PA Plant – 1st Stage



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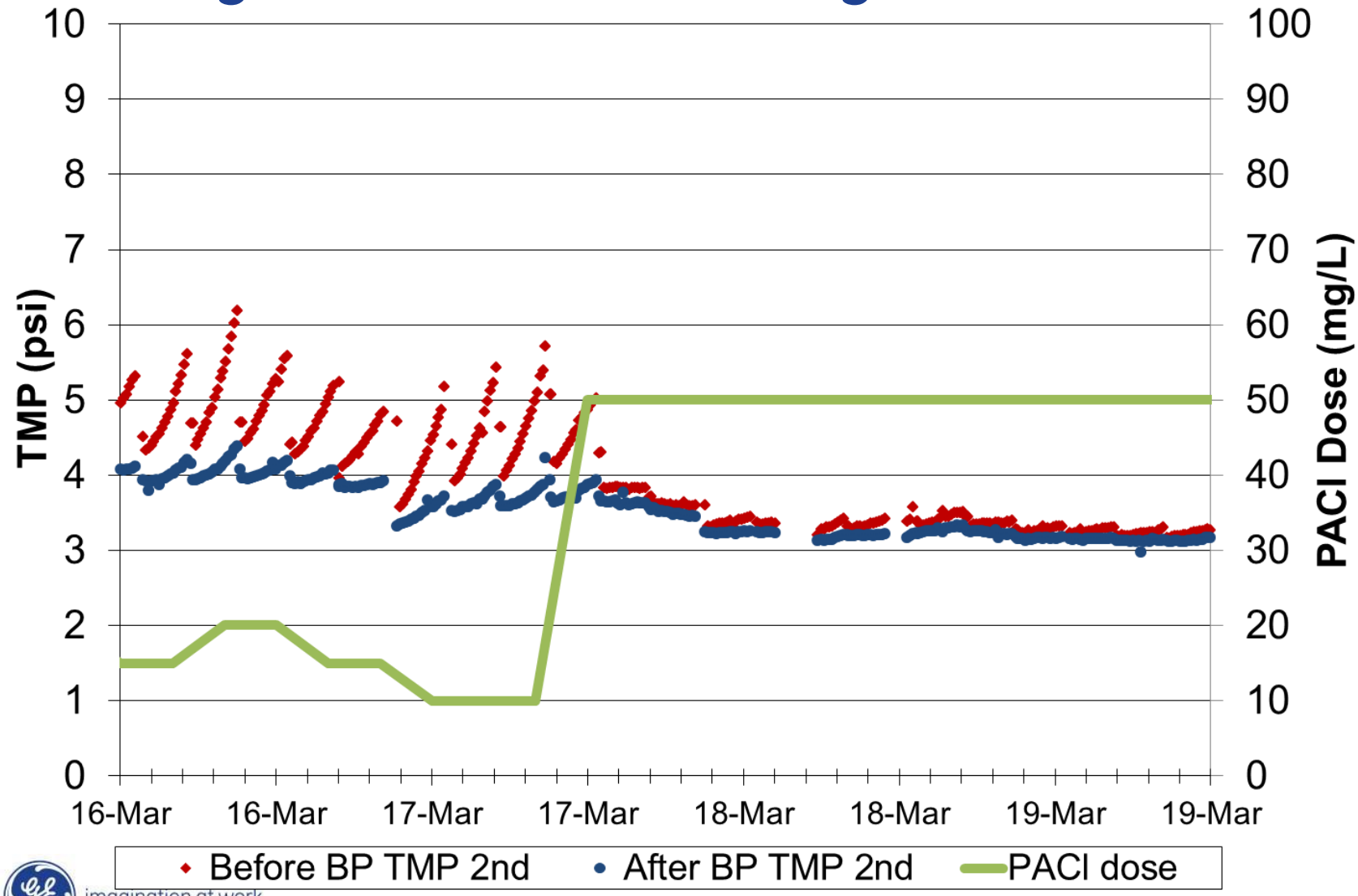
Effect of Coagulant Dose on TMP

Conestoga, PA Plant – 2nd Stage



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Scaling Potential

Controlling fouling layer in high solids applications requires agitation to keep solids in suspension

Aeration to agitate is common

But…

$$CO_2 \leftrightharpoons H^+ + HCO_3^- \leftrightharpoons H_2CO_3$$

pH may shift, depending on the HRT in the membrane tank

Scaling Potential

Langlier Saturation Index

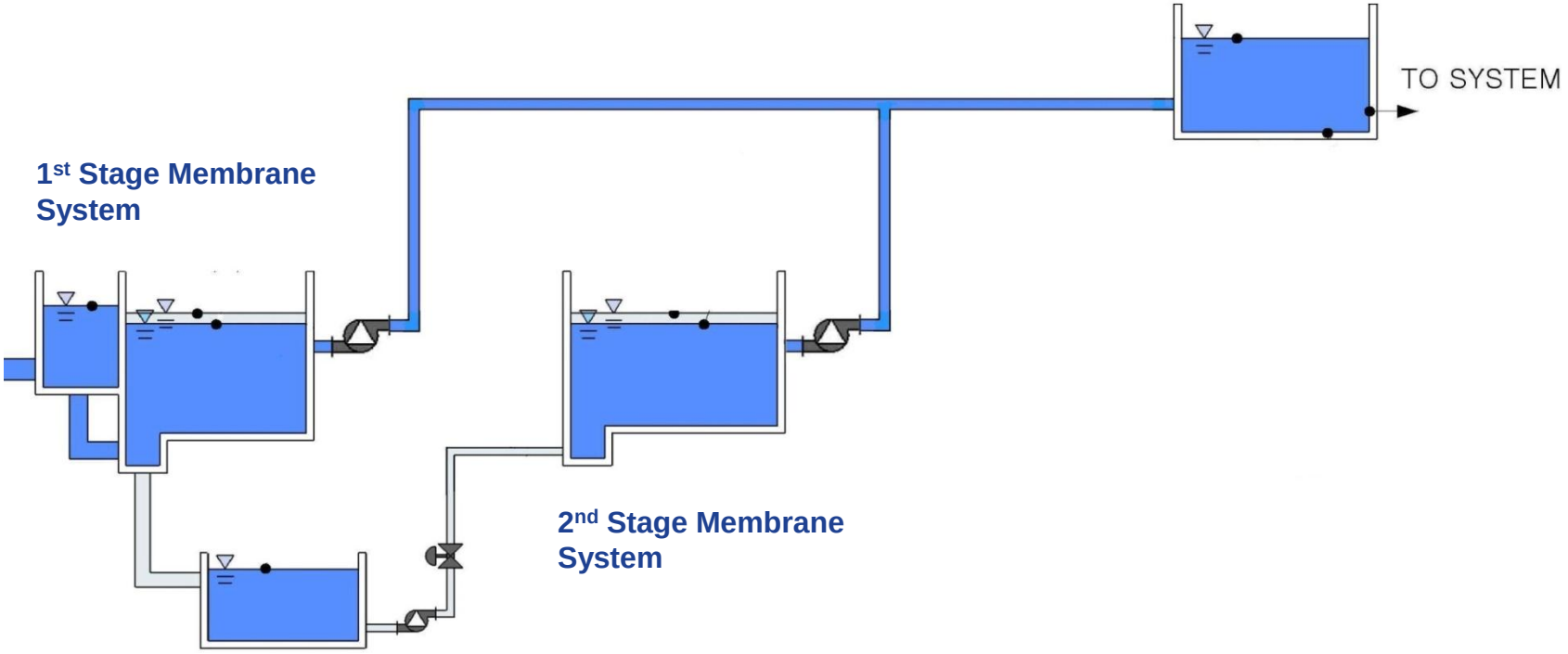
Scale may cause:

- Increased fouling rate
- Increased fiber damage

Solutions:

- acid/ anti-scalant addition to feed or acid maintenance cleans
- Reduce aeration frequency/duration

2-stage UF System - Hydraulics



Redundancy

Dependence of 1st stage on 2nd stage

Downtime for backwashes, MITs, cleans

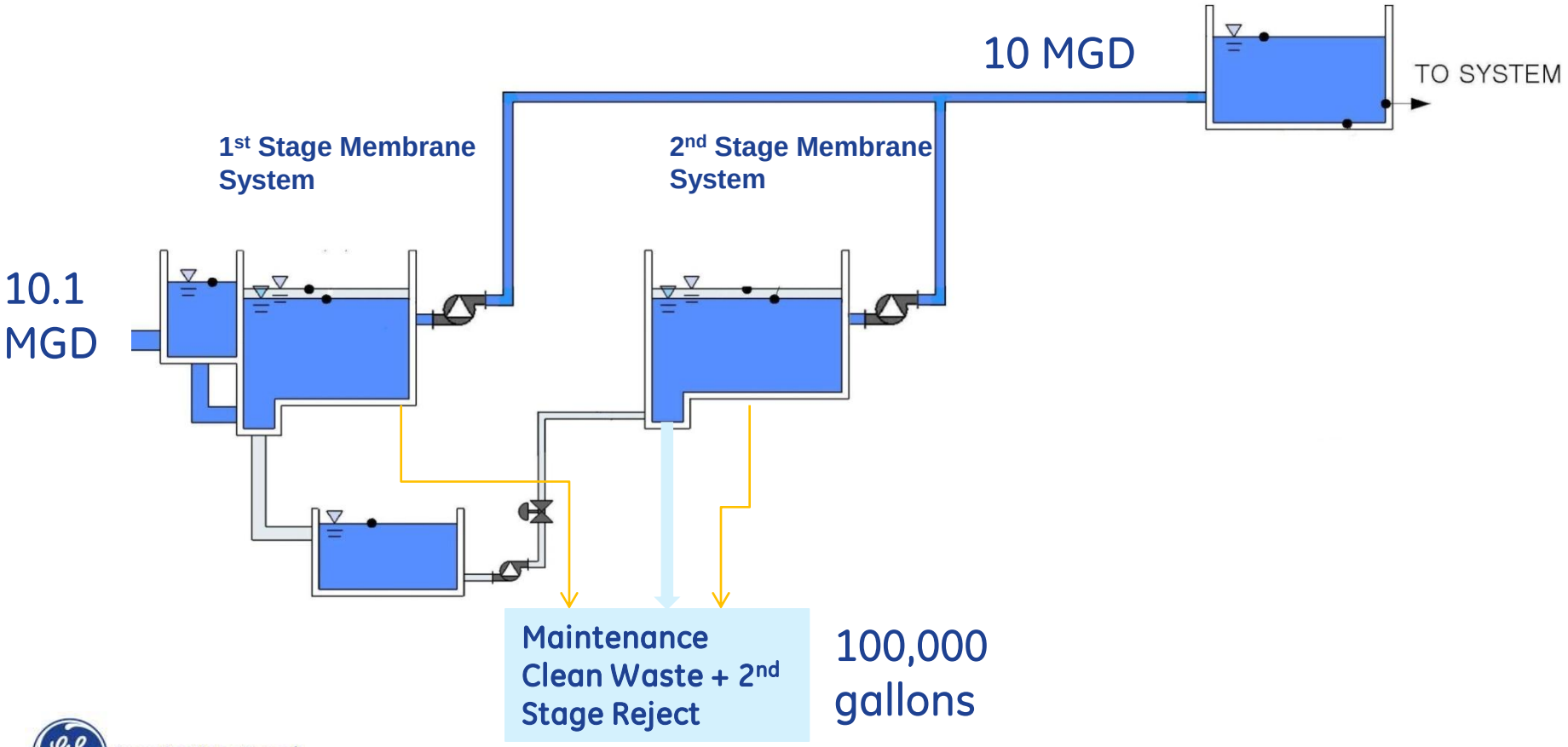
System Controls

Control 2nd stage recovery or overall system recovery

Maintenance clean waste is usually not directed to 2nd stage

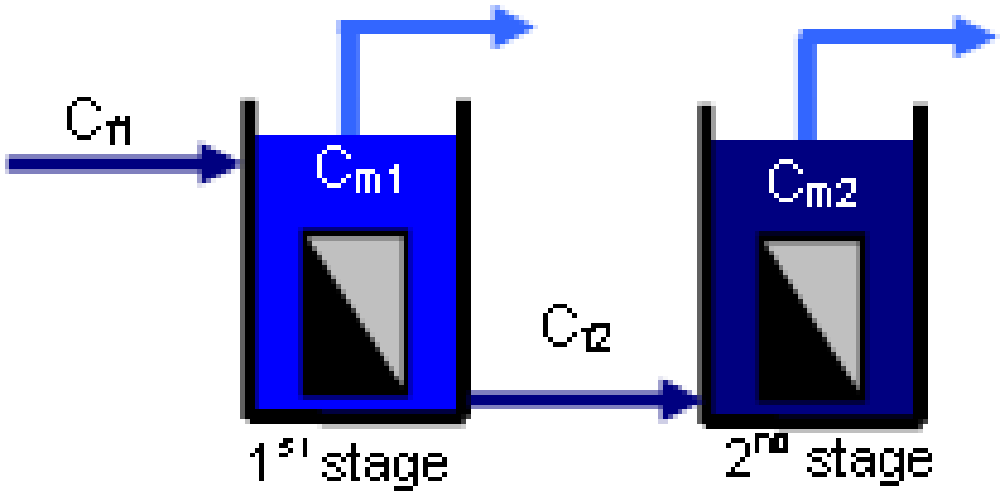
Operation at reduced capacity may be limited to maximum waste volume rather than overall recovery

Reduced Capacity Operation



Log Removal Value (LRV)

$$LRV = \log_{10}\left(\frac{Q_p \times ALCR \times P_{atm}}{\Delta P_{test} \times V_{sys} \times VCF}\right)$$



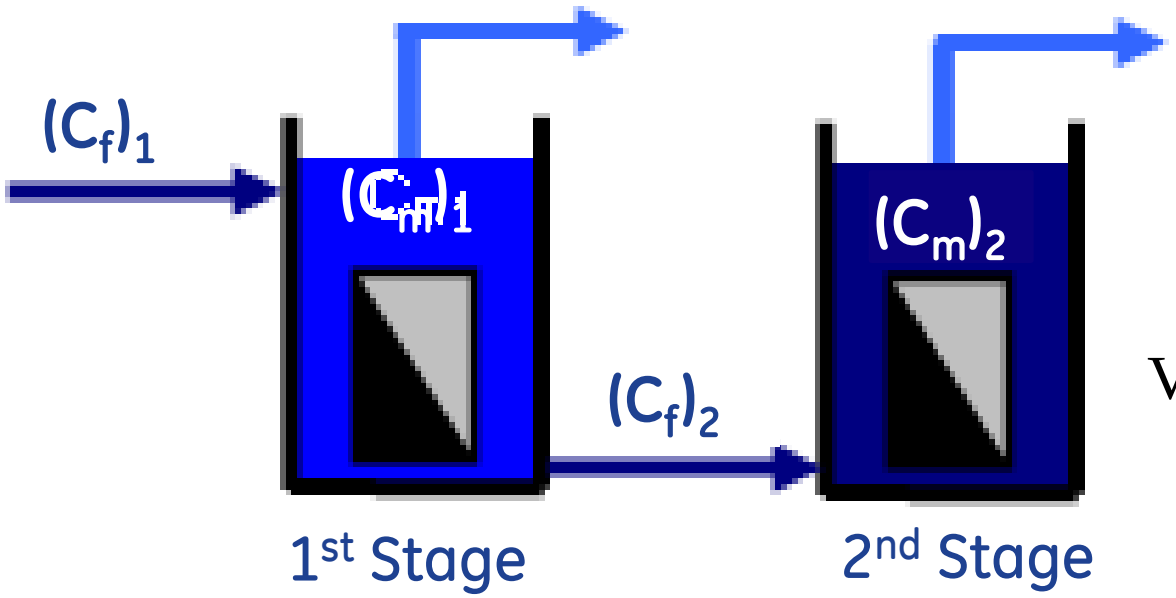
$$VCF_i = \frac{(C_m)_i}{(C_f)_1}$$

Equation 2.39 in MFGM for VCF of 2nd or subsequent (ith) stage

$(Cm)_i$ = concentration of suspended solids maintained on the feed side of the membrane associated with the stage (i)

Log Removal Value (LRV)

- VCF of each stage depends on operating mode



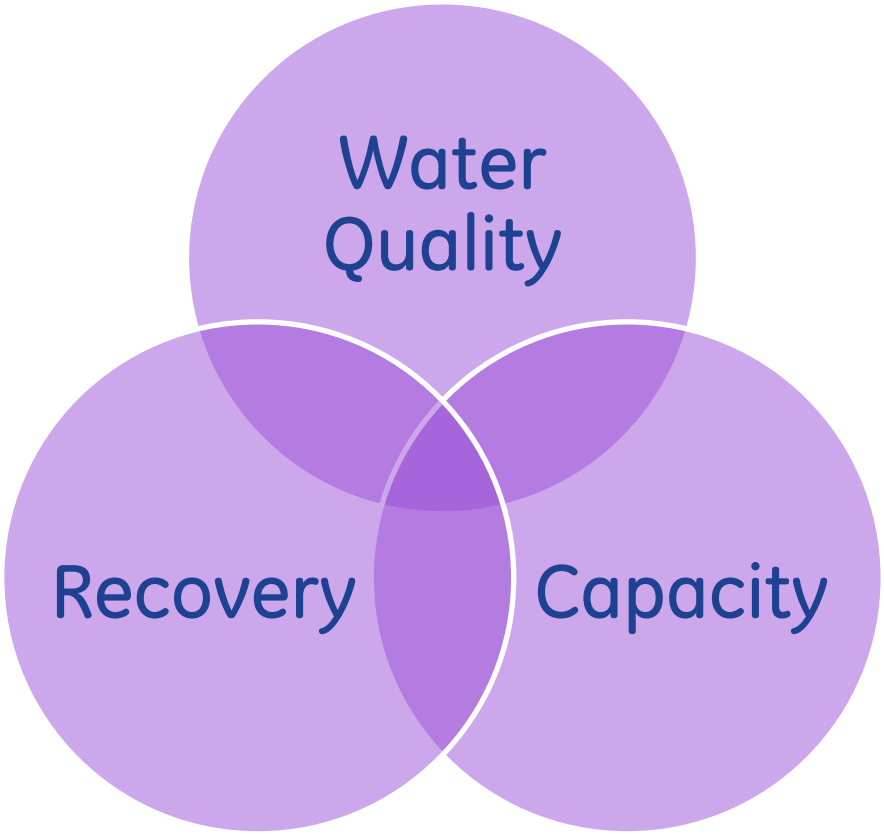
$$VCF_{2nd} = \frac{(C_m)_2}{(C_f)_2}$$

$$(C_f)_2 = (C_f)_1 \times (VCF_{max})_1$$

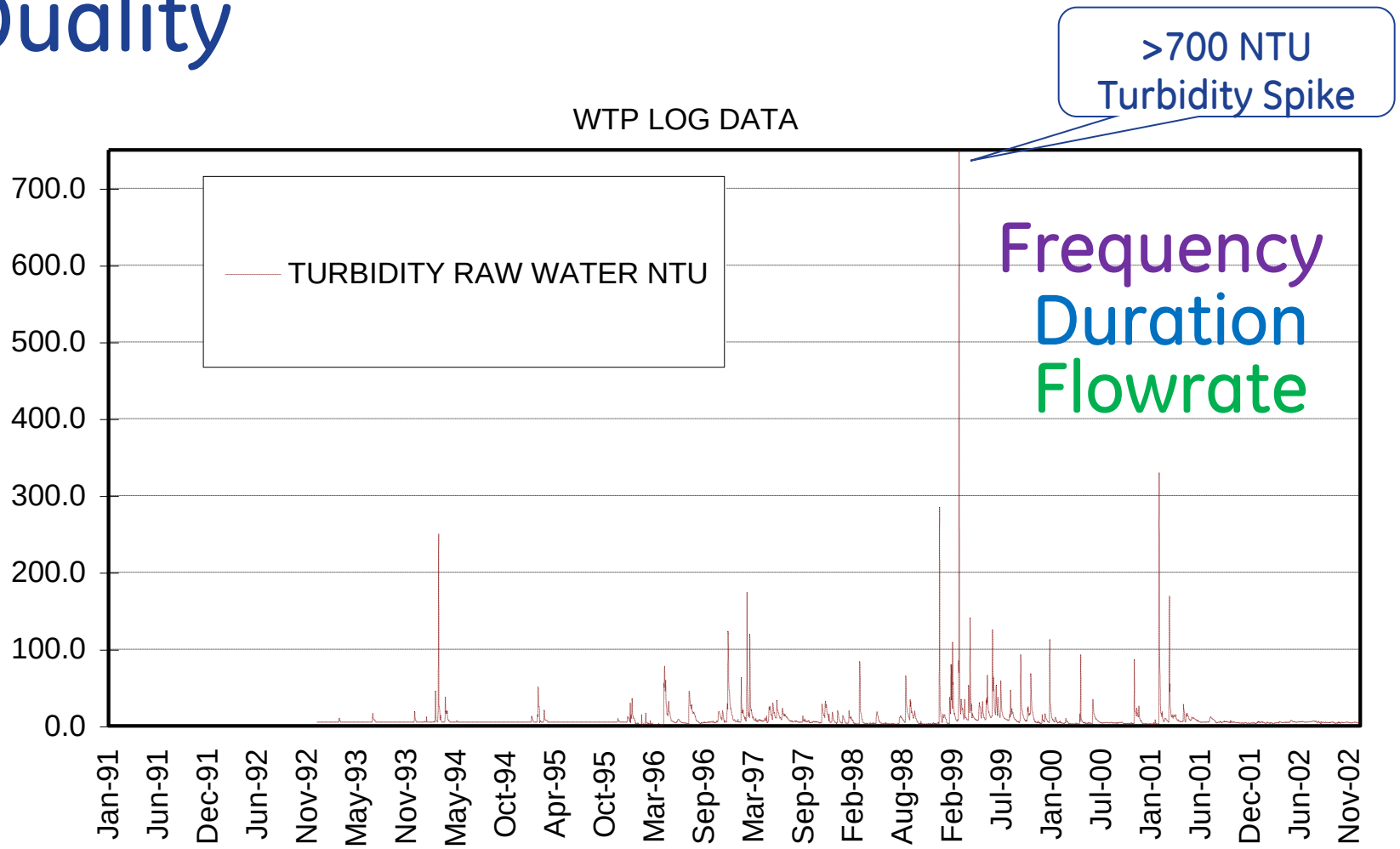
$$(VCF_{max})_1 = \frac{1}{1 - R_1}$$

$$(VCF)_2 = (VCF)_{2nd} \times (VCF_{max})_1$$

Design Considerations



Interpreting Variable Feed Water Quality



Thornton, CO Retrofit with Swing Train

28 MGD (106 MLD) Before

50 MGD (189 MLD) After

Barrie WTP, ON, Canada

15.85 MGD

Two Stage System

- Stage 1: ZW1000
- Stage 2: ZW500

ACH Addition

Online: May 2011

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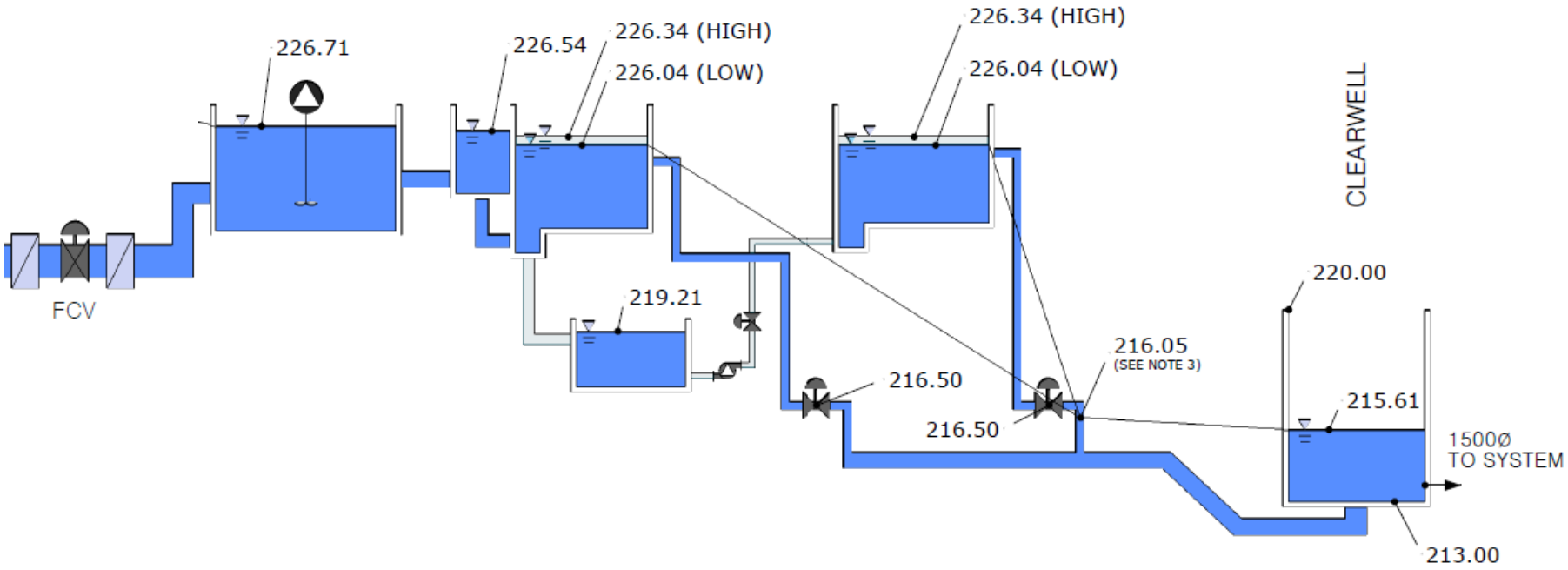
2-Stage Siphon Design



Thank You!

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