

# Zero-liquid Discharge Made Affordable with Minimal Liquid Discharge Technology and a Circular Economy Mind Set

Singapore International Water Week

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# Agenda

- Introduce MLD
- Textile MLD/ZLD process
- Stage 3 MLD Innovations

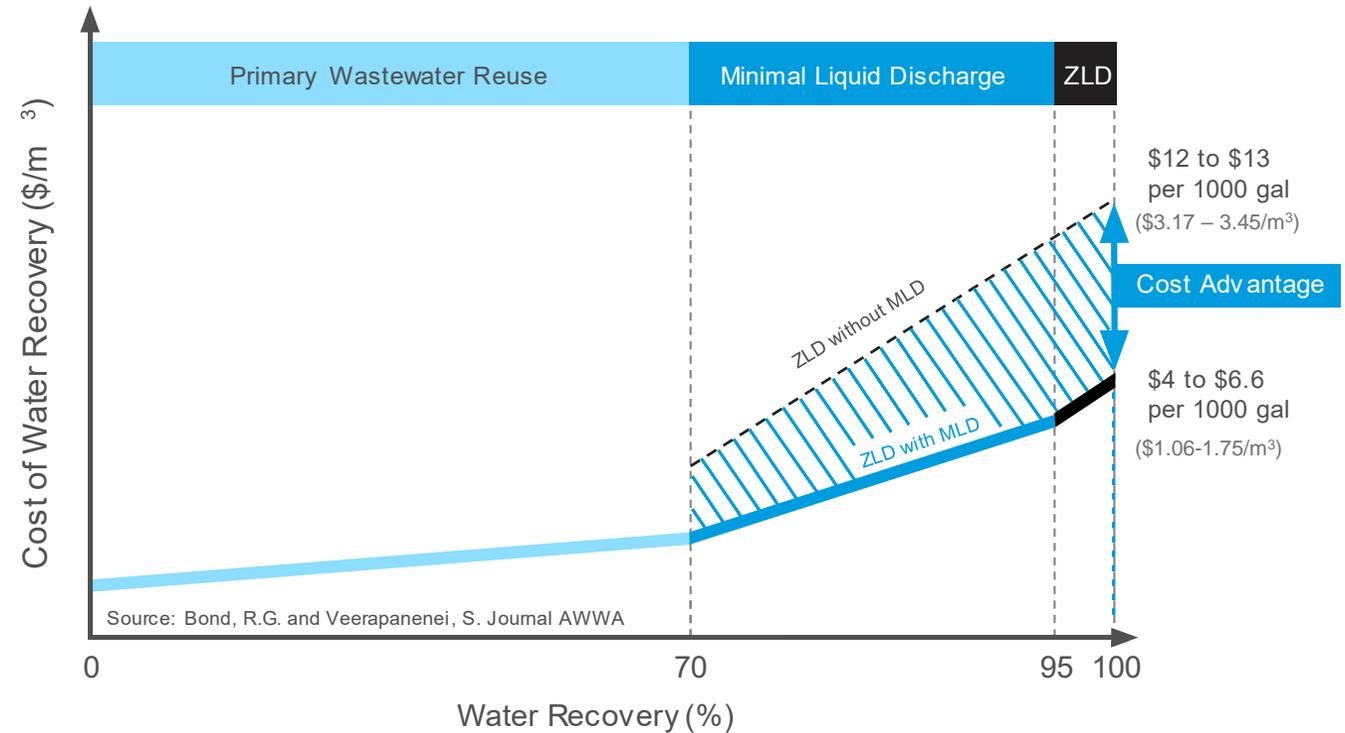


# 1. Introduce MLD

# The MLD value proposition

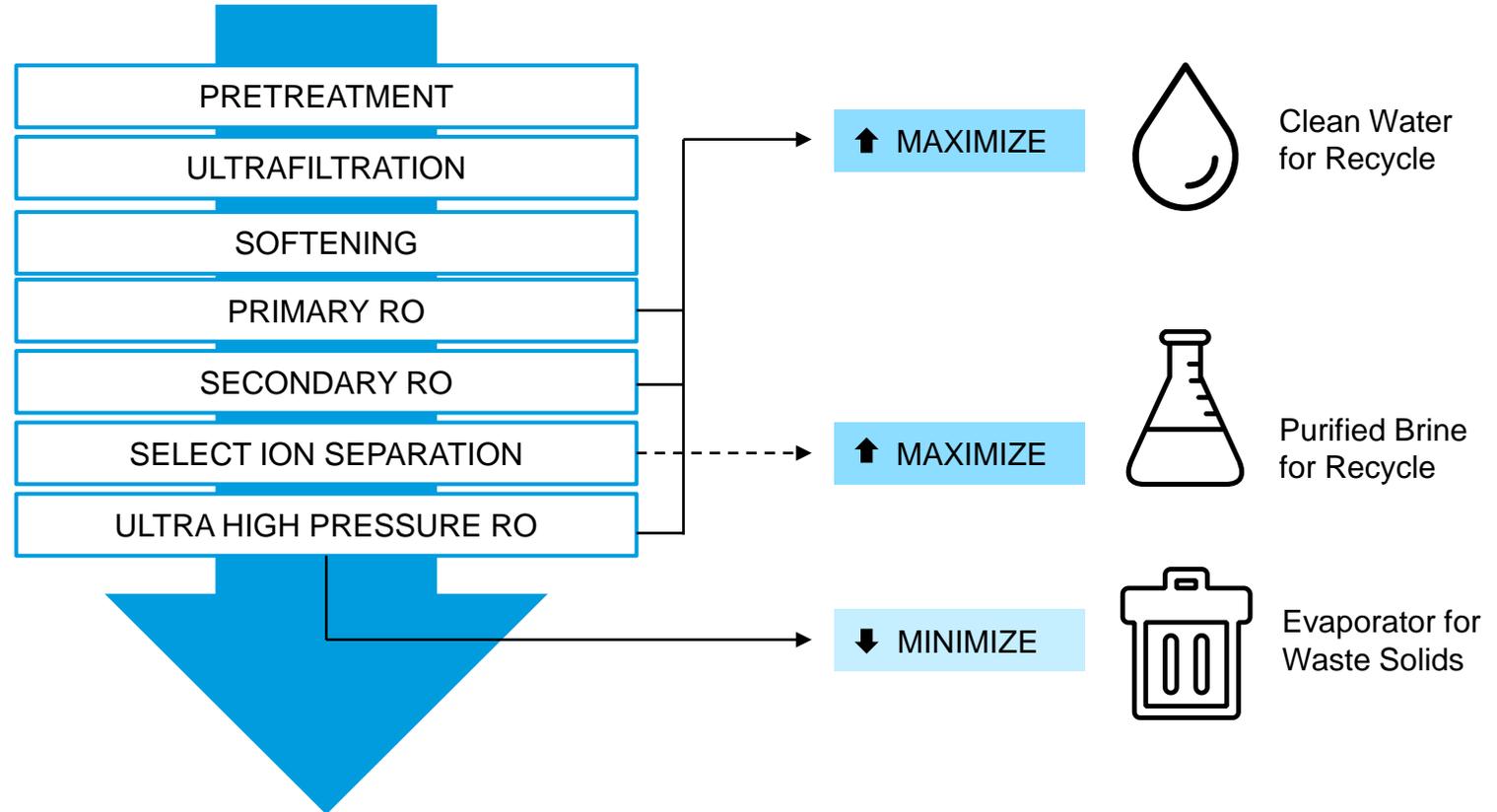
Minimal Liquid Discharge (MLD) utilizes proven separation technologies that enable a breakthrough process, recapturing resources that would otherwise go untapped, at a cost savings that allows businesses to thrive.

Employ a compatible solution that enables **capture of more than 95% of liquid discharge and save 60% of the cost.**



# Minimal Liquid Discharge (MLD)

A **tailored systems** approach allows for stronger emphasis on the water goals most important to *the problem on hand* → **treat for purpose**



## 2. MLD/ZLD in Textiles

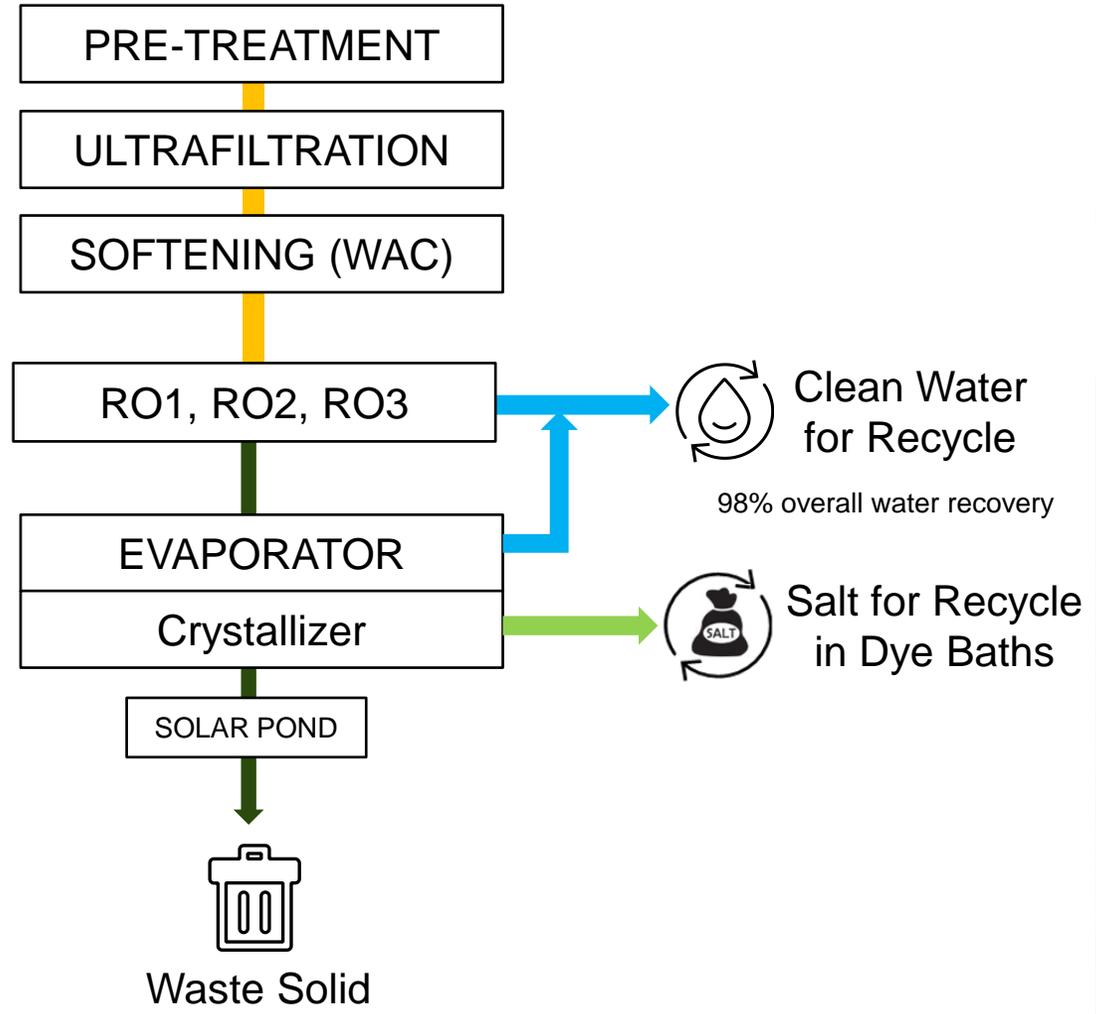
# Textile MLD-ZLD WW Treatment Process

Tamil Nadu, India

**Raw Textile Wastewater:**  
TDS: ~8000 mg/L  
COD: 1000-2000 mg/L  
Hardness: 100-300 mg/L

**Water after Pretreatment:**  
TDS: ~8000 mg/L  
COD: 150-200 mg/L  
Hardness: 10-100 mg/L

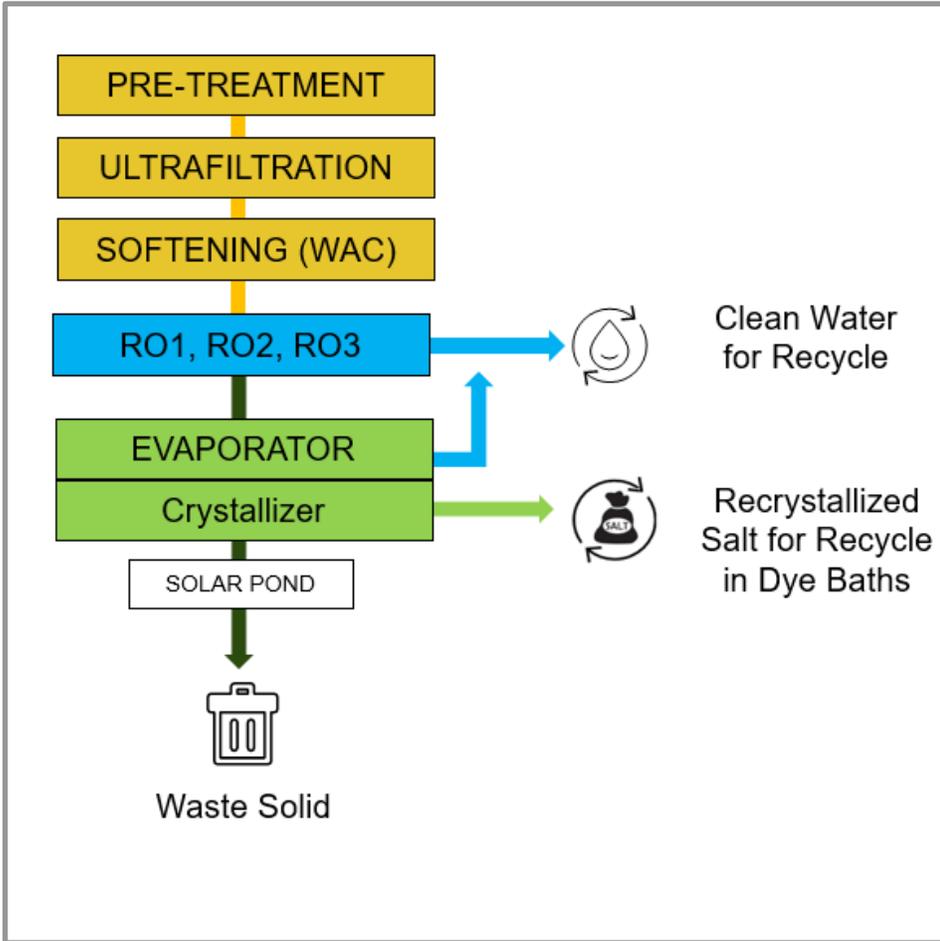
**RO system recovery:**  
85-90%



# Textile MLD-ZLD Wastewater Reuse

Tamil Nadu, India

General wastewater treatment scheme:



Approximate cost of treatment<sup>1</sup>:

Pretreatment	RO System	Evaporator/ Crystallizer	Total Treatment Cost
\$0.60/m <sup>3</sup> 100% WW treated	\$0.61/m <sup>3</sup> 100% WW treated	\$3.48/m <sup>3</sup> 8-17% WW treated	\$1.76/m <sup>3</sup>

51% less than evaporation

Circular value:

Value of fresh water: \$0.56/m<sup>3</sup>

Value of salt<sup>2</sup>: \$0.50/m<sup>3</sup>

**Total circular value: \$1.06/m<sup>3</sup>**

**Net cost: \$0.70/m<sup>3</sup>**

(Similar to the cost of pretreatment)

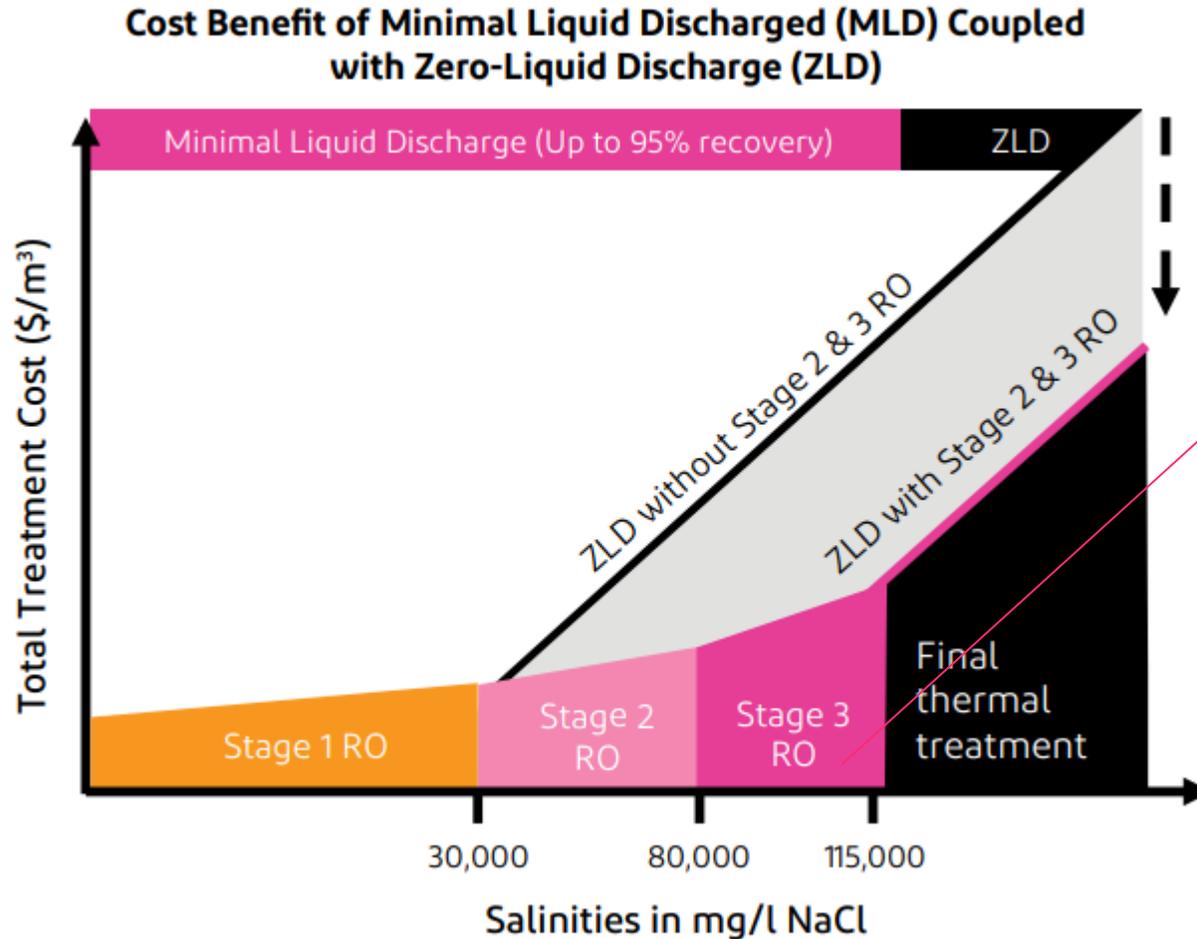
<sup>1</sup>Averaged costs provided from 4 different sites and validated to be in range by additional sites.

<sup>2</sup>Assumed a 8000 mg/L TDS WW contains 8 Kg/m<sup>3</sup> of NaCl salt (industrial grade salt: \$0.063/kg)



# 3. Stage 3 MLD Innovations to go beyond

# Designing for the challenge to reduce total cost



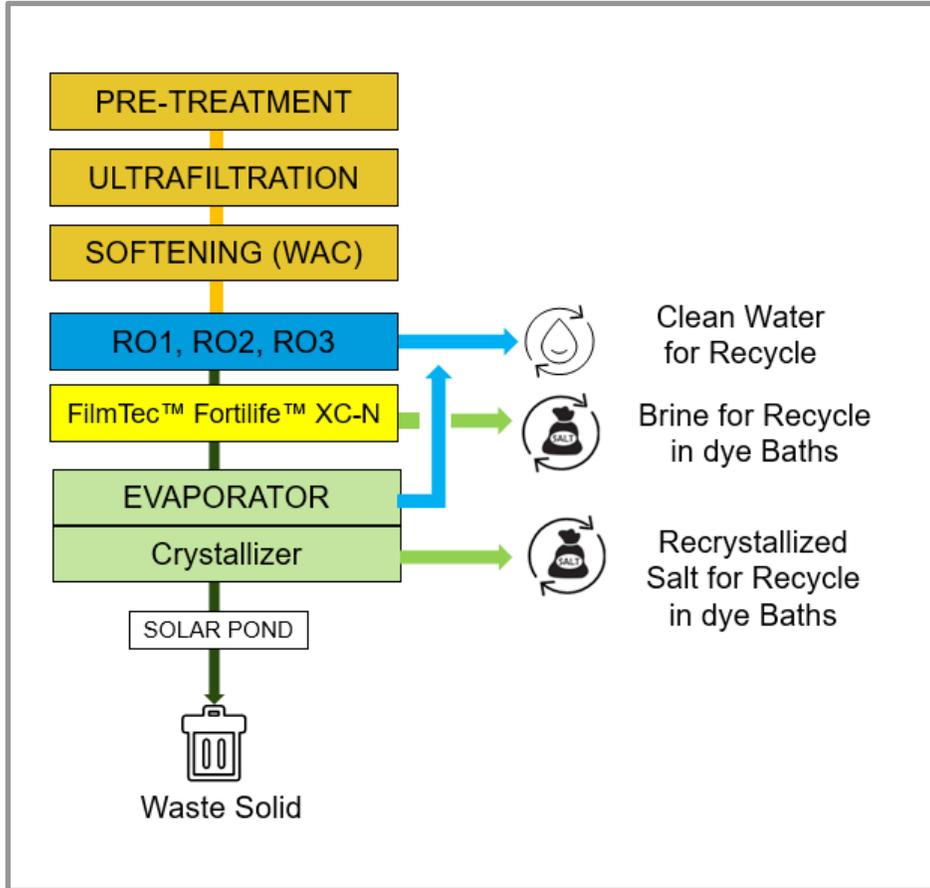
## Stage 3 RO Innovations:

1. Salt Separation Membranes
2. Ultra-high Pressure RO Membranes
3. Moderate Rejecting RO Membranes

# Option 1: Salt Separation Membranes to Save More

Separate mono-valent ions from di-valent ions and COD with FilmTec™ Fortilife™ XC-N

Wastewater treatment scheme:



Approximate cost of treatment<sup>1</sup>:

	Pretreatment	RO System	Evaporator/ Crystallizer	Total Treatment Cost
SOP:	\$0.60/m <sup>3</sup> 100% WW treated	\$0.61/m <sup>3</sup> 100% WW treated	\$3.48/m <sup>3</sup> 10% WW treated	\$1.56/m <sup>3</sup>
w/ NF:	100% WW treated	100% WW treated	4.2% WW treated	\$1.35/m <sup>3</sup>

Circular value:

Value of fresh water: \$0.56/m<sup>3</sup>  
 Value of salt<sup>2</sup>: \$0.50/m<sup>3</sup>  
**Total circular value: \$1.06/m<sup>3</sup>**

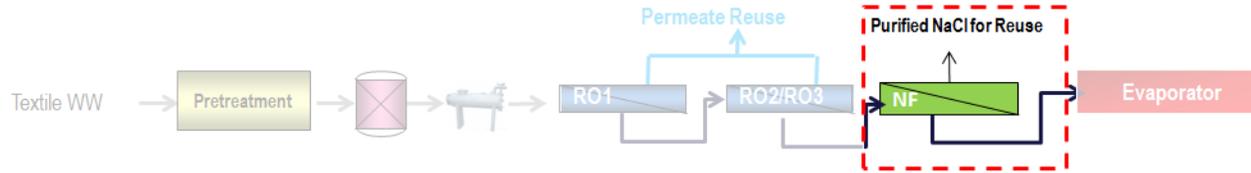
$$\$1.35 - 1.06 = \mathbf{\$0.29}$$

<sup>1</sup>Averaged costs provided from 4 different sites and validated to be in range by additional sites.

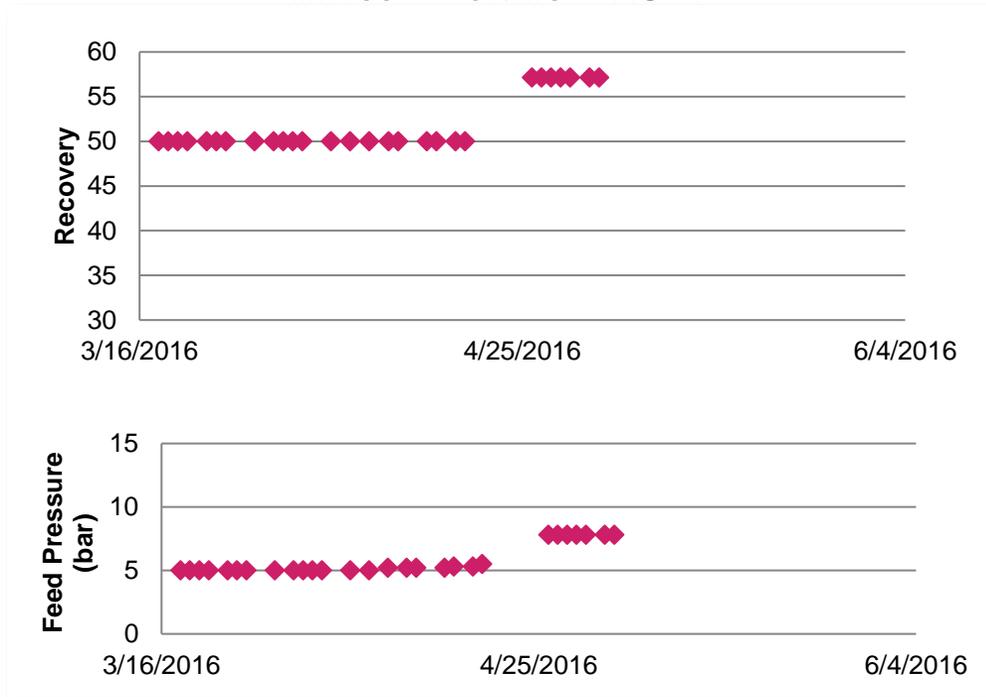
<sup>2</sup>Assumed 8000 mg/L TDS WW contains 8 Kg/m<sup>3</sup> of NaCl salt (industrial grade salt: \$0.063/kg)



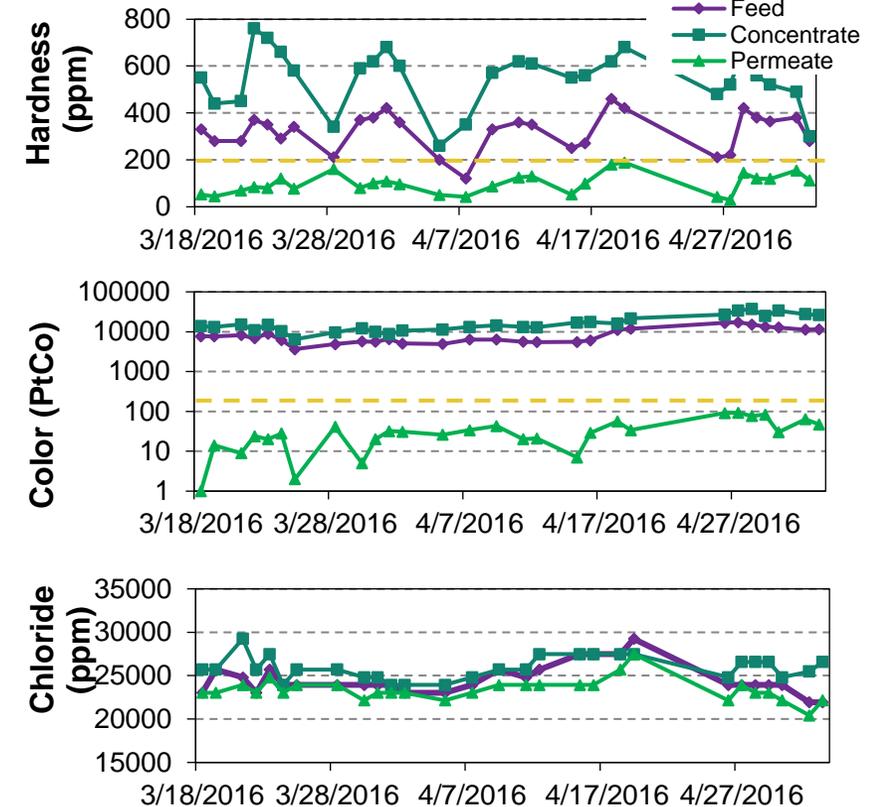
# Option 1. Produce Purified Brine Solution for Reuse in Dye bath



FilmTec™ Fortilife™ XC-N



2<sup>nd</sup> Stage XC-N Separation Performance



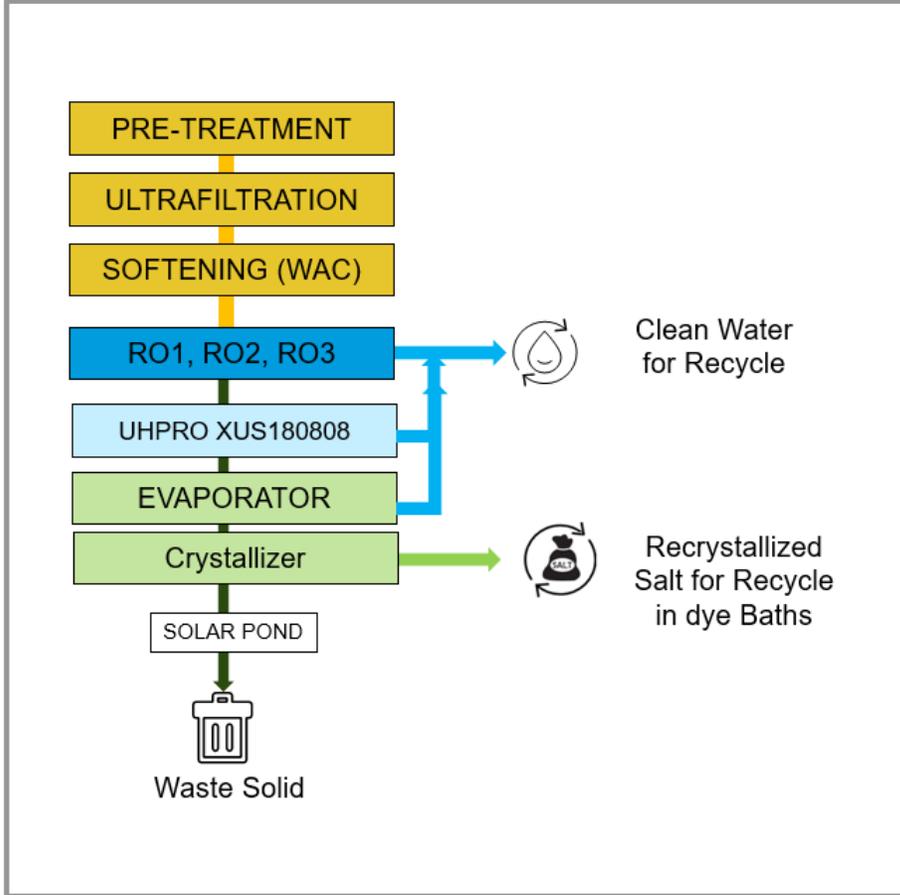
- ✓ Operated up to 58% recovery with feed pressure <10 bar
- ✓ Brine with <200 ppm hardness, <100 PtCo Color, and high chloride concentration



# Option 2: UHPRO Membranes to Save More

Achieve higher RO recovery with DuPont Specialty Membrane XUS180808

General Wastewater Treatment scheme:



Approximate cost of treatment<sup>1</sup>:

	Pretreatment	RO System	Evaporator/ Crystallizer	Total Treatment Cost
benchmark:	\$0.60/m <sup>3</sup> 100% WW treated	\$0.61/m <sup>3</sup> 100% WW treated	\$3.48/m <sup>3</sup> 10% WW treated	\$1.56/m <sup>3</sup>
w/ UHPRO:	100% WW treated	100% WW treated*	7% WW treated	\$1.48/m <sup>3</sup>

\*Assumes: RO System cost increases by 5% to 0.64/m<sup>3</sup>

Circular value:

Value of fresh water: \$0.56/m<sup>3</sup>  
Value of salt<sup>2</sup>: \$0.50/m<sup>3</sup>

**Total circular value: \$1.06/m<sup>3</sup>**

$$\$1.48 - 1.06 = \text{\textcircled{\$0.42}}$$

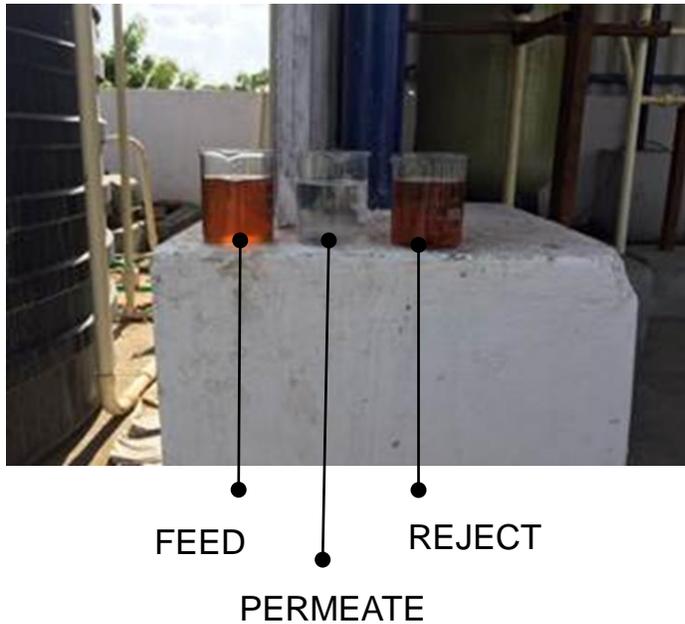
<sup>1</sup>Averaged costs provided from 4 different sites and validated to be in range by additional sites.  
<sup>2</sup>Assumed 8000 mg/L TDS WW contains 8 Kg/m<sup>3</sup> of NaCl salt (industrial grade salt: \$0.063/kg)



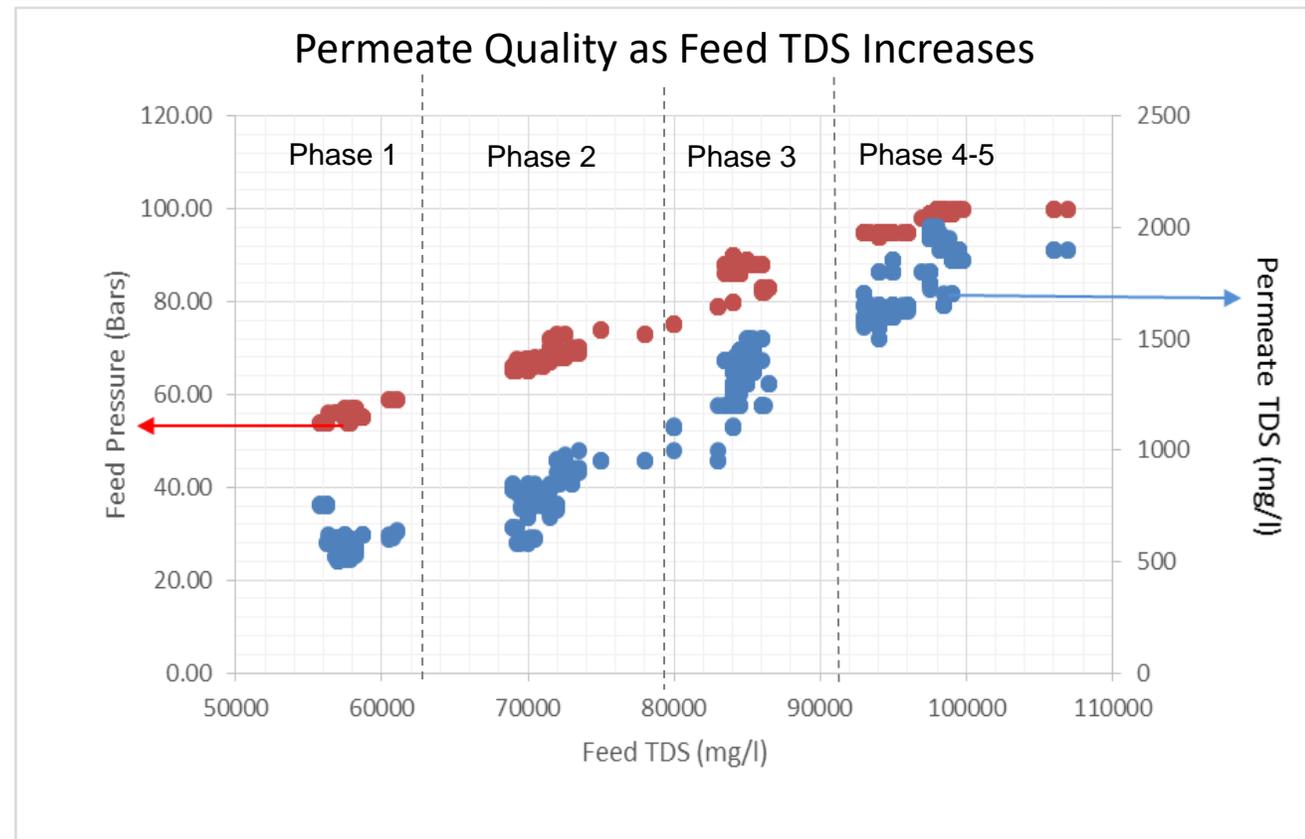
# Option 2. Achieved High TDS Concentrations

Single-element pilot skid treating Textile wastewater RO reject operated at 10-lmh flux, feed composition ~0.68:1 NaCl:Na<sub>2</sub>SO<sub>4</sub>

20% recovery, 30% recovery, 38% recovery, 41% recovery



	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5
Feed TDS (mg/L)	~58,600	~72,900	~83,500	~94,400	~100,000
P <sub>feed</sub> (bar)	58	70	88	95	100
Rejection (%)	> 99	99	> 98	> 98	> 98



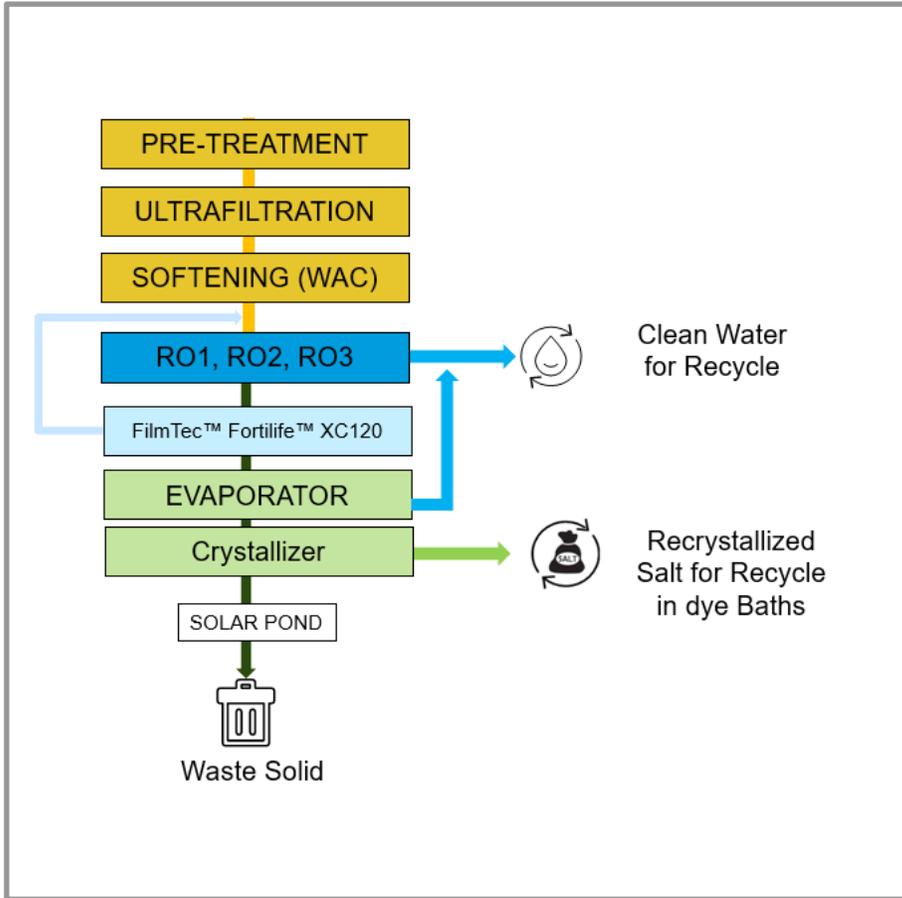
## Valuable benefits:

- ➔ up to 41% reduced downstream thermal plant cost
- ➔ Achieve High Reject TDS

# Option 3: Moderate rejecting RO Membranes to Save More

Achieve higher RO recovery at std. operating pressures with FilmTec™ Fortilife™ XC120

Wastewater Treatment scheme:



Approximate cost of treatment<sup>1</sup>:

	Pretreatment	RO System	Evaporator/ Crystallizer	Total Treatment Cost
benchmark:	\$0.60/m <sup>3</sup> 100% WW treated	\$0.61/m <sup>3</sup> 100% WW treated	\$3.48/m <sup>3</sup> 10% WW treated	\$1.56/m <sup>3</sup>
w/ XC120:	100% WW treated	<b>105% WW treated</b>	7% WW treated	<b>\$1.48/m<sup>3</sup></b>

Circular value:

Value of fresh water: \$0.56/m<sup>3</sup>  
 Value of salt<sup>2</sup>: \$0.50/m<sup>3</sup>  
**Total circular value: \$1.06/m<sup>3</sup>**

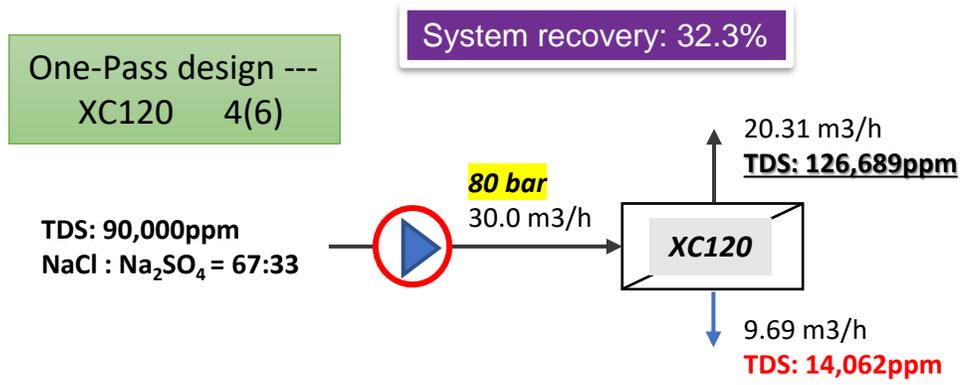
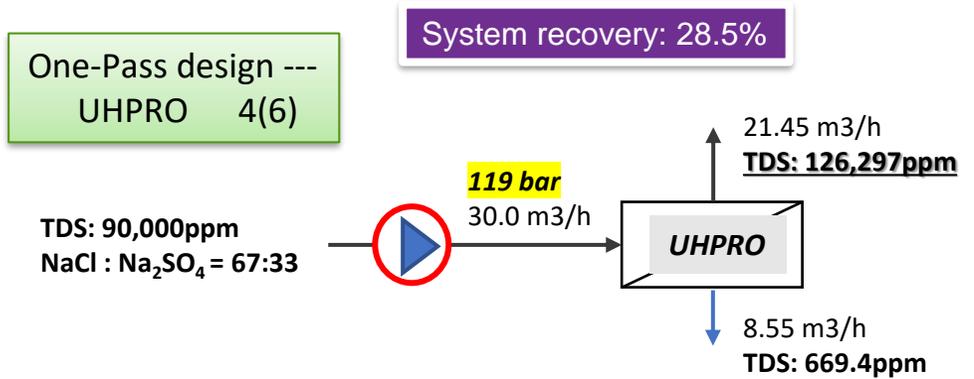
\$1.48 – 1.06 = **\$0.42**

<sup>1</sup>Averaged costs provided from 4 different sites and validated to be in range by additional sites.  
<sup>2</sup>Assumed 8000 mg/L TDS WW contains 8 Kg/m<sup>3</sup> of NaCl salt (industrial grade salt: \$0.063/kg)



# Option 3. Comparison of UHPRO vs. FilmTec™ Fortilife™ XC120

Achieve the same reject TDS concentration at a lower pressure



**Field demonstration in progress:**  
1 6-element pressure vessel of XC120 is treating RO brine from a textile wastewater MLD system.



# MLD with Advanced Stage 3 Technologies

*Lower net OPEX costs and provide potential for ROI*

		Portion of water treated in each process step			Total OPEX (\$/m <sup>3</sup> )	Net (\$/m <sup>3</sup> ) (assume circular value = \$1.06/m <sup>3</sup> )
		Pretreatment (\$0.60/m <sup>3</sup> )	RO System (\$0.61/m <sup>3</sup> )	Evap. Crystallizer (\$3.48/m <sup>3</sup> )		
<b>Current</b>		100%	100%	15%	\$ 1.73	\$ 0.67
<b>1</b>	<b>FilmTec™ Fortilife™ XC-N</b>	100%	100%	4.2%	\$ 1.35	\$ 0.29
<b>2</b>	<b>Ultra-high Pressure RO</b>	100%	100%*	7%	\$ 1.48	\$ 0.42
<b>3</b>	<b>FilmTec™ Fortilife™ XC120</b>	100%	105%	7%	\$ 1.48	\$ 0.42

\*RO System cost charged at an average rate of \$0.64/m<sup>3</sup> to account for ultra-high pressure operation





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