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Treatment Technologies for Produced Water Evaporators In SAGD Processes

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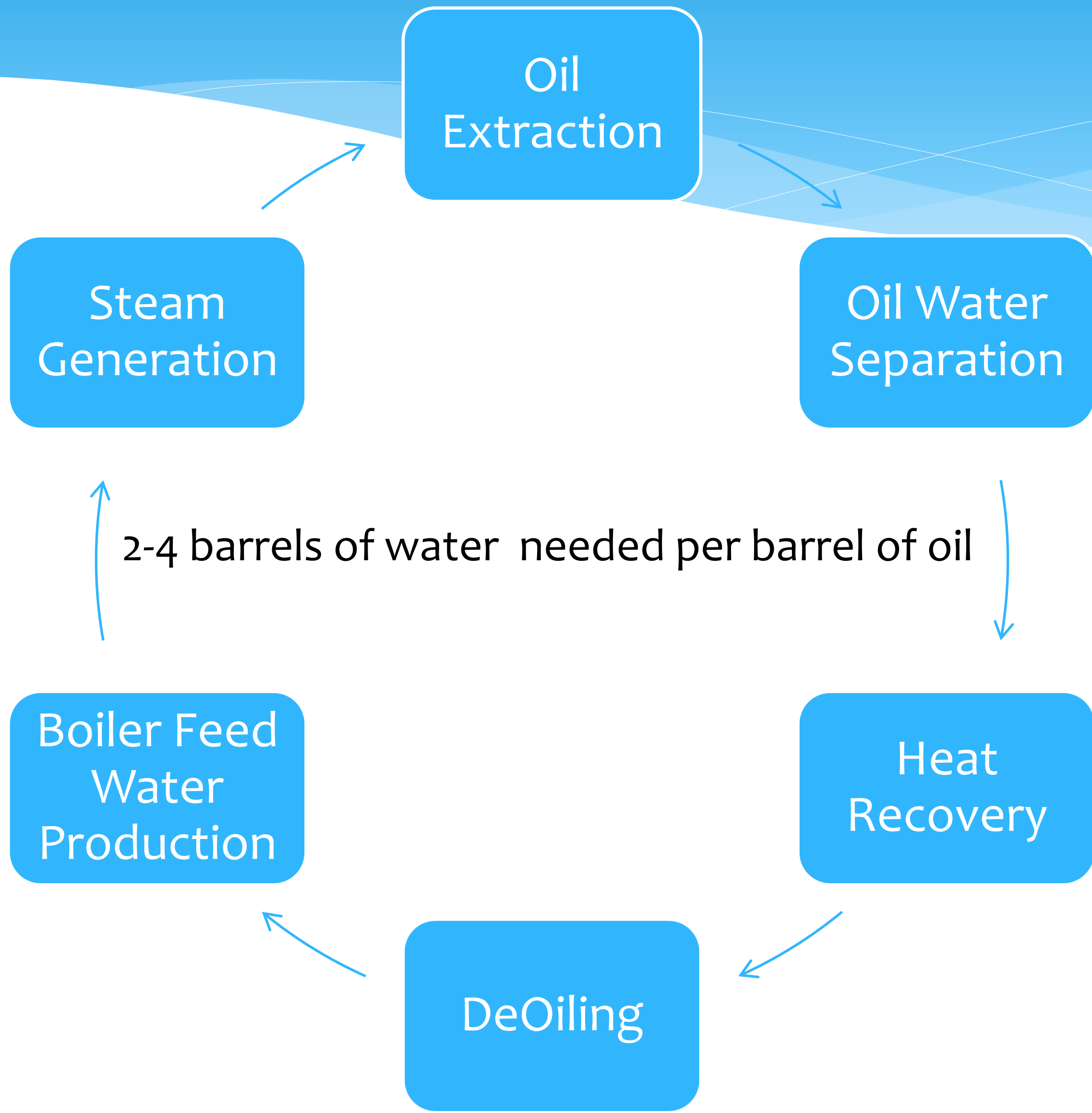
SAGD Produced Water Circuit



2-4 barrels of water needed per barrel of oil

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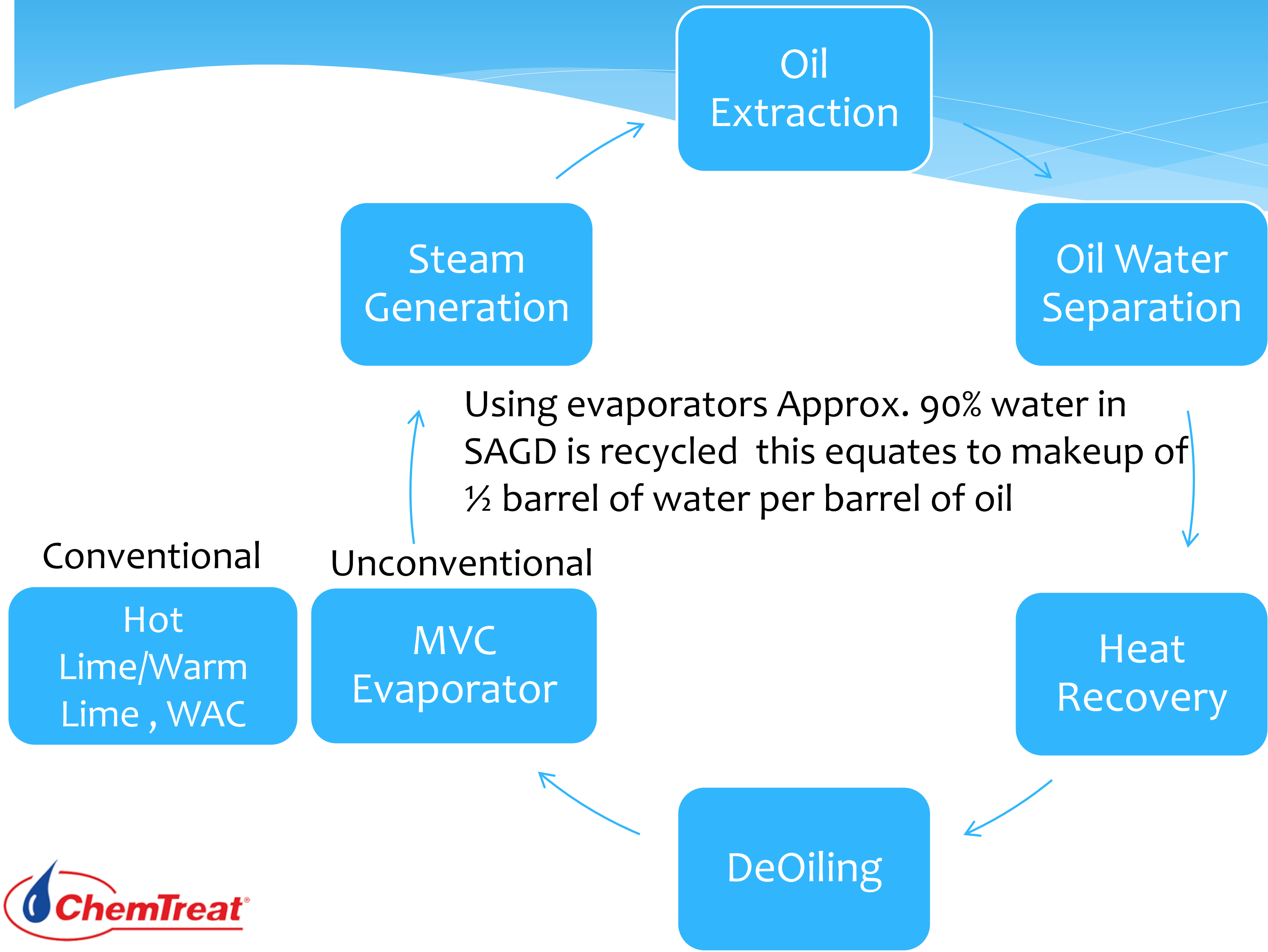
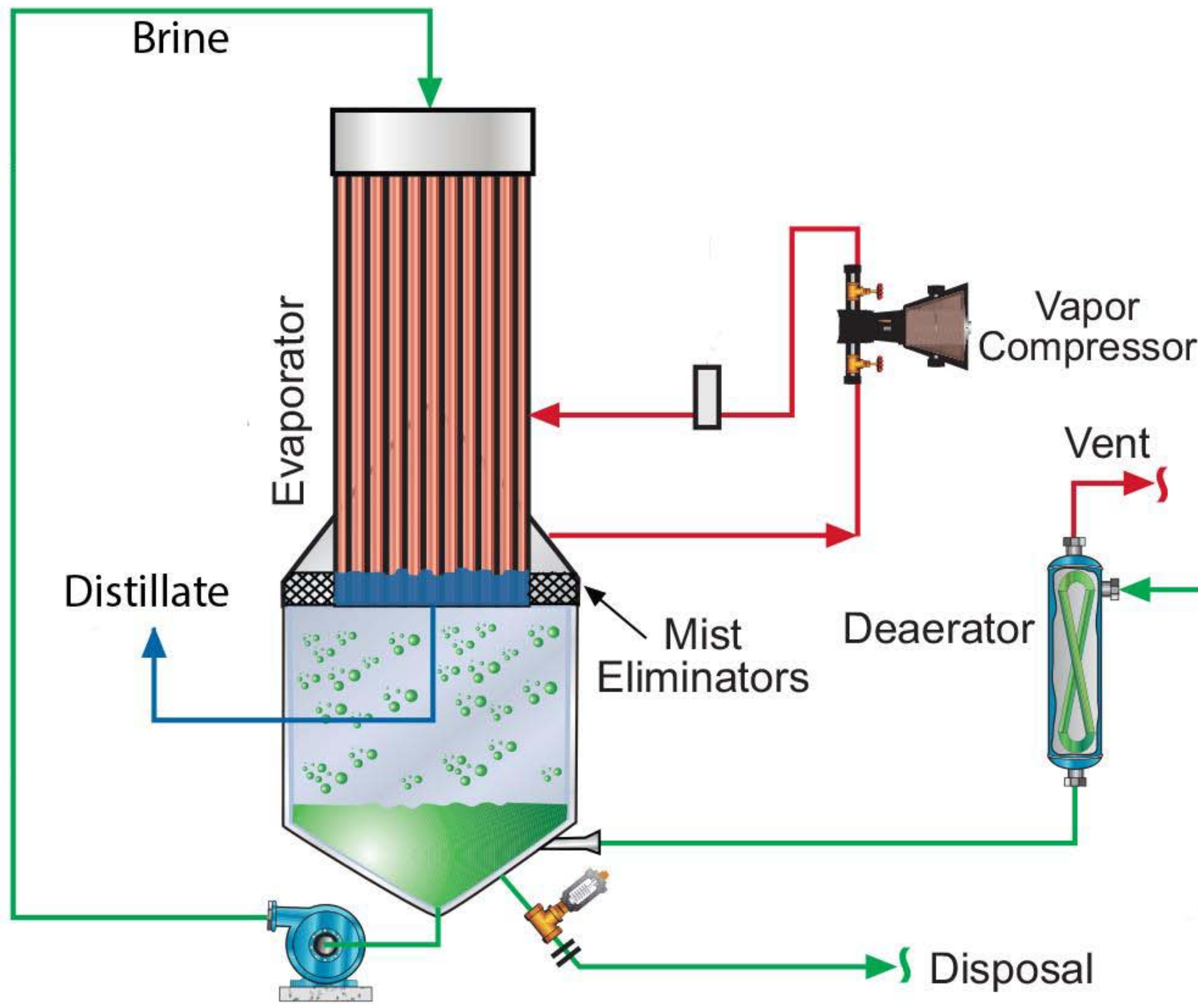


Falling Film Evaporator

* Used in clean , non precipitating liquids
* High Heat Transfer Coefficients
* High Surface Area
* Short Residence Time on Heated Tube
* Multi Stage Systems
* Uses – Caustic soda, Coconut Milk, Concentrated orange juice
* Can Use Steam or Mechanical Vapor Compression as Heat Source

SAGD MVC Falling Film Evaporator



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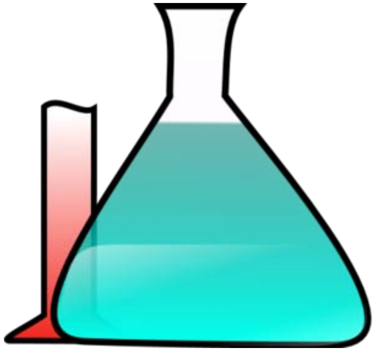
SAGD Evaporator Chemical Treatment Program Objectives

* Minimize, mitigate, prevent and disperse inorganic scale formation and adherence to Steam Evaporator metal surfaces
* Emulsify soluble and residual organics/hydrocarbon and disperse through the Steam Evaporator to minimize/prevent organic fouling



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SAGD Evaporator Key Performance Indicators

- The evaporator chemical treatment program performance is monitored through the measurement of several key performance indicators including
- Steam evaporator U-value coefficient
- Unit pressures
- Temperatures
- Distillate production
- Evaporator materials transport

SAGD Evaporator Feed Water Composition

Parameter	Evaporator Feed Water
pH	8.24
Conductivity µmho	1334
Total Calcium as $CaCO_3$, mg/l	1.4
Total Magnesium as $CaCO_3$ mg/l	<0.5
Sodium as Na, mg/l	241
Chloride, as Cl , mg/L	302
Silica as SiO_2, mg/l	260

Materials Transport

- $Ca\% = 100 \times (Ca\ (BD) \div (Ca(FW) * Cycles))$

Significant challenge to measure sub ppm levels Ca and Mg in oily produced water

Materials Transport

ICP – Spectrometer
Ca Limit Detection
0.005 ppm Std Nebulizer
0.0002 ppm Ultrasonic nebulizer

Graphite Furnace AA
Ca Limit Detection
0.01 ppm Flame
0.03 ppm Furnace

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SAGD Evaporator Materials Of Construction

Location	Alloy
Evaporator vessel	2205 Duplex SS
Shell side of the evaporator vessel:	316L SS
Distillate Tank:	316L SS
Preheaters:	316L SS
De-aerator Vessel:	2205 Duplex SS
Vapor Separator:	2205 Duplex SS
Evaporator feed water piping:	Carbon Steel (ASTM A-106B)

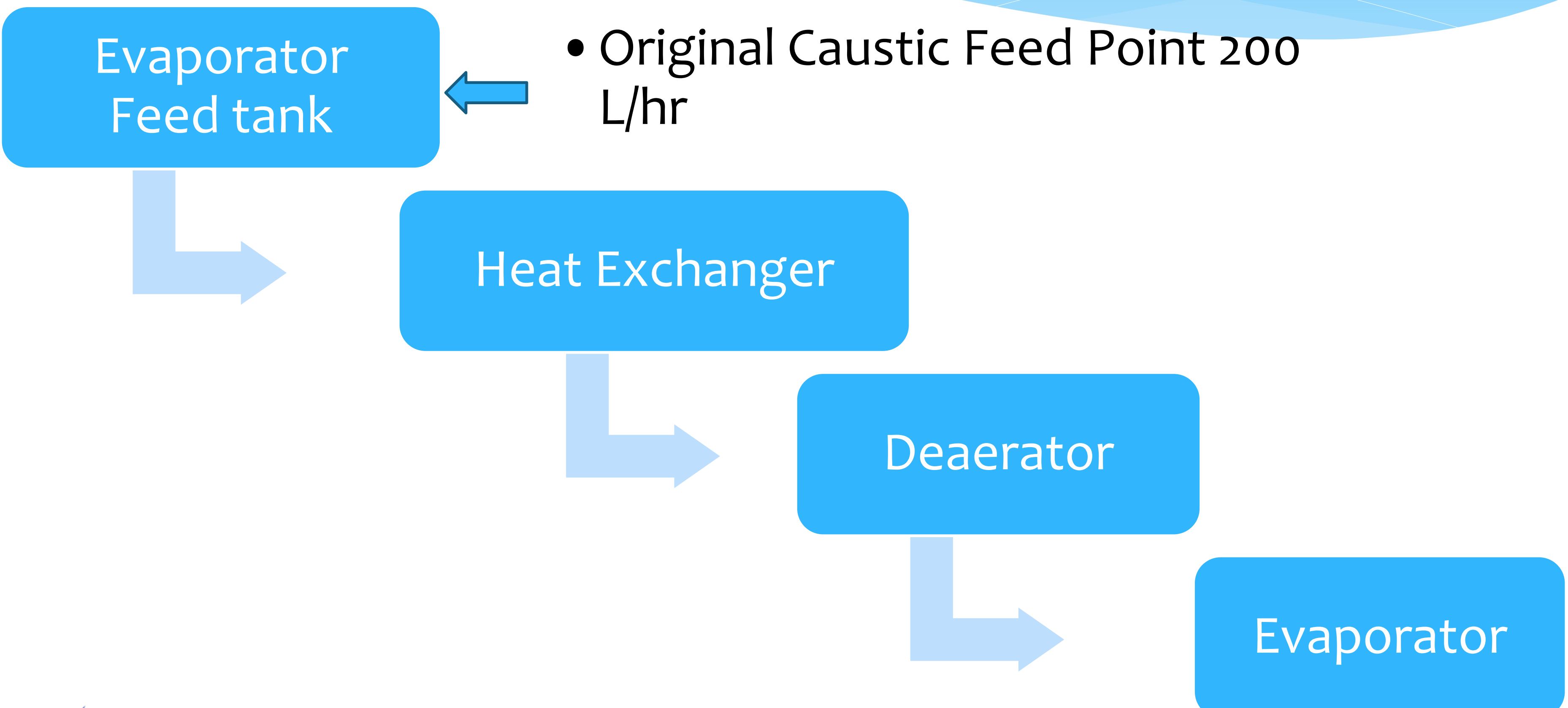
SAGD Evaporator Conventional Treatment

RAISE PH > 12.5 to maintain Silicate Solubility
Precipitate and Disperse Hardness Salts

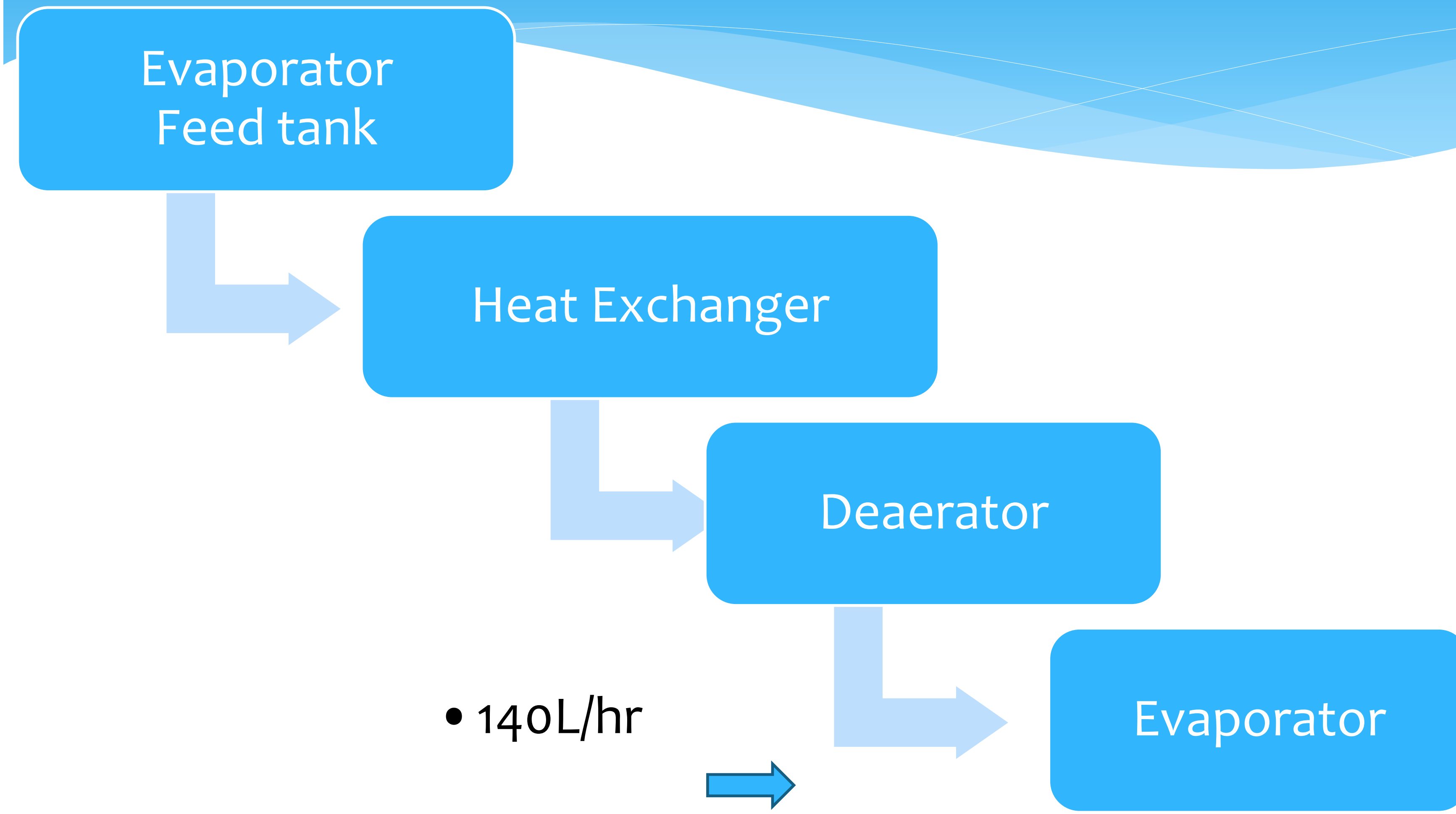
"Operating instructions in this manual shall be strictly adhered to. This includes but is not limited to the following requirements:
DO NOT OPERATE WITH LOW (<12.3) EVAPORATOR SUMP PH"

Conventional Treatment Caustic Addition Pre Deaerator

- Original Caustic Feed Point 200 L/hr



Recommendation Change Caustic Addition Point to After Deaerator



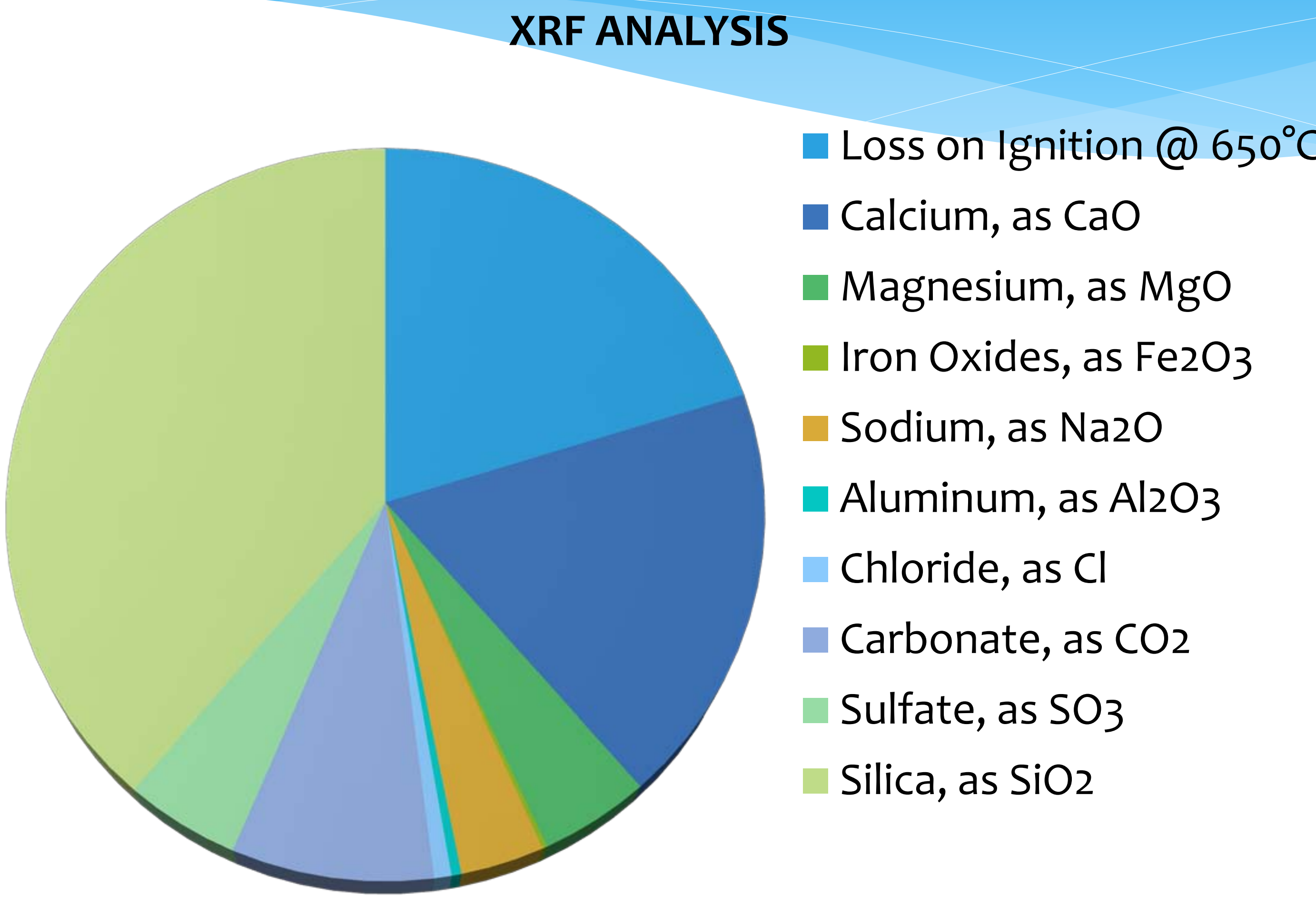
- 140L/hr

Caustic Feed Point Change

* Reduced Scaling Potential on Heat Exchanger
* 200 L/hr to 140 L/hr at 200m3/hr produced water flow
* >$400,000 savings in caustic

Evaporator Deposit Control

Evaporator Deposit Control



Evaporator Chemical Cleaning

Chemical Cleaning
Highly Effective Non Destructive
Estimated 800 Kg of scale removed.
Plugged Tubes were opened up

Silica Thermodyamics

pH 0-10	pH10-12	pH> 12
SiO2	HSiO3-	SiO_3^{2-}

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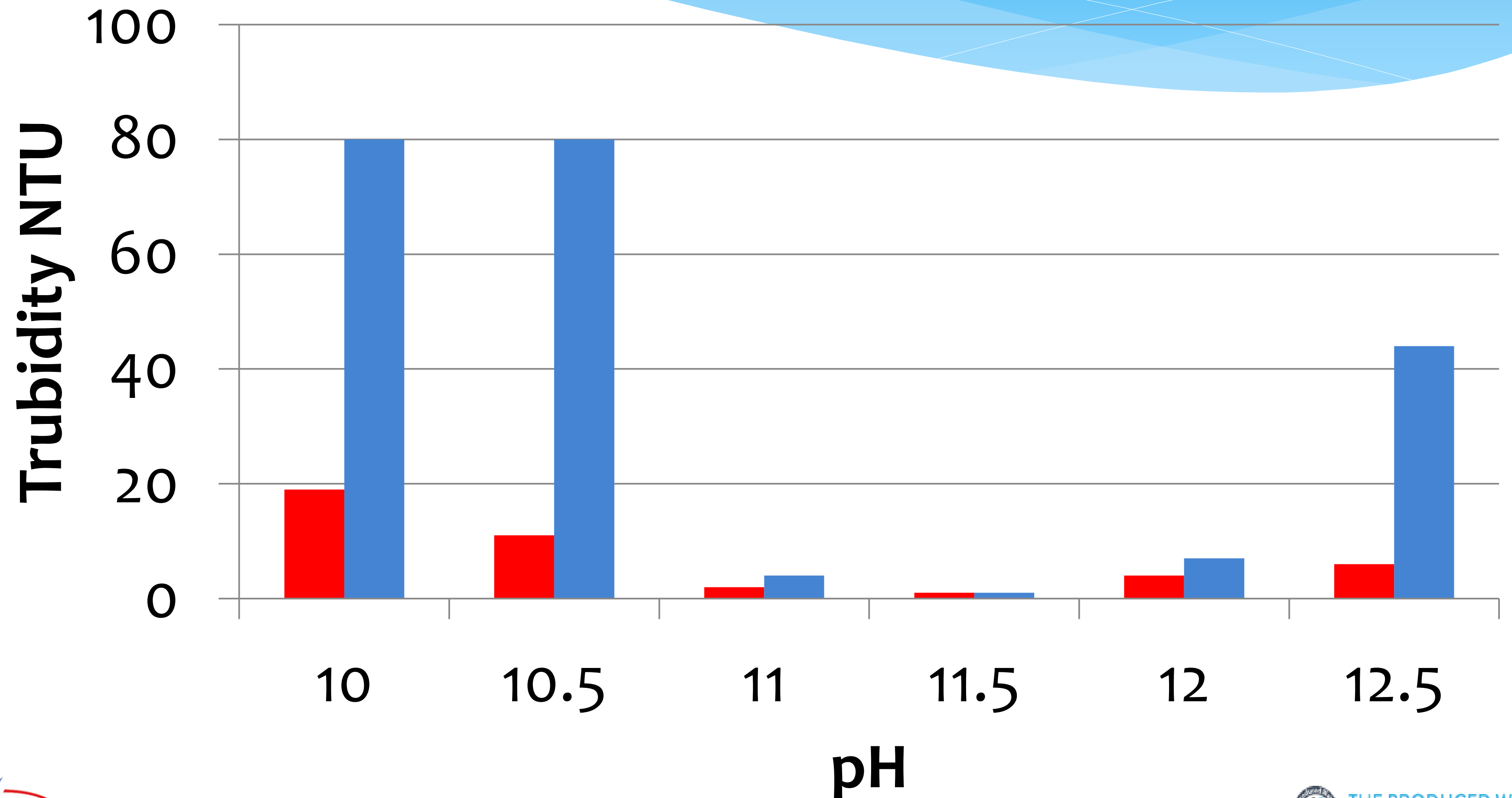
Silica Thermodynamics

pH 0-10

pH10-12

pH> 12

Magnesium Solubility as a function of pH Mg 50 /500, Si 5000



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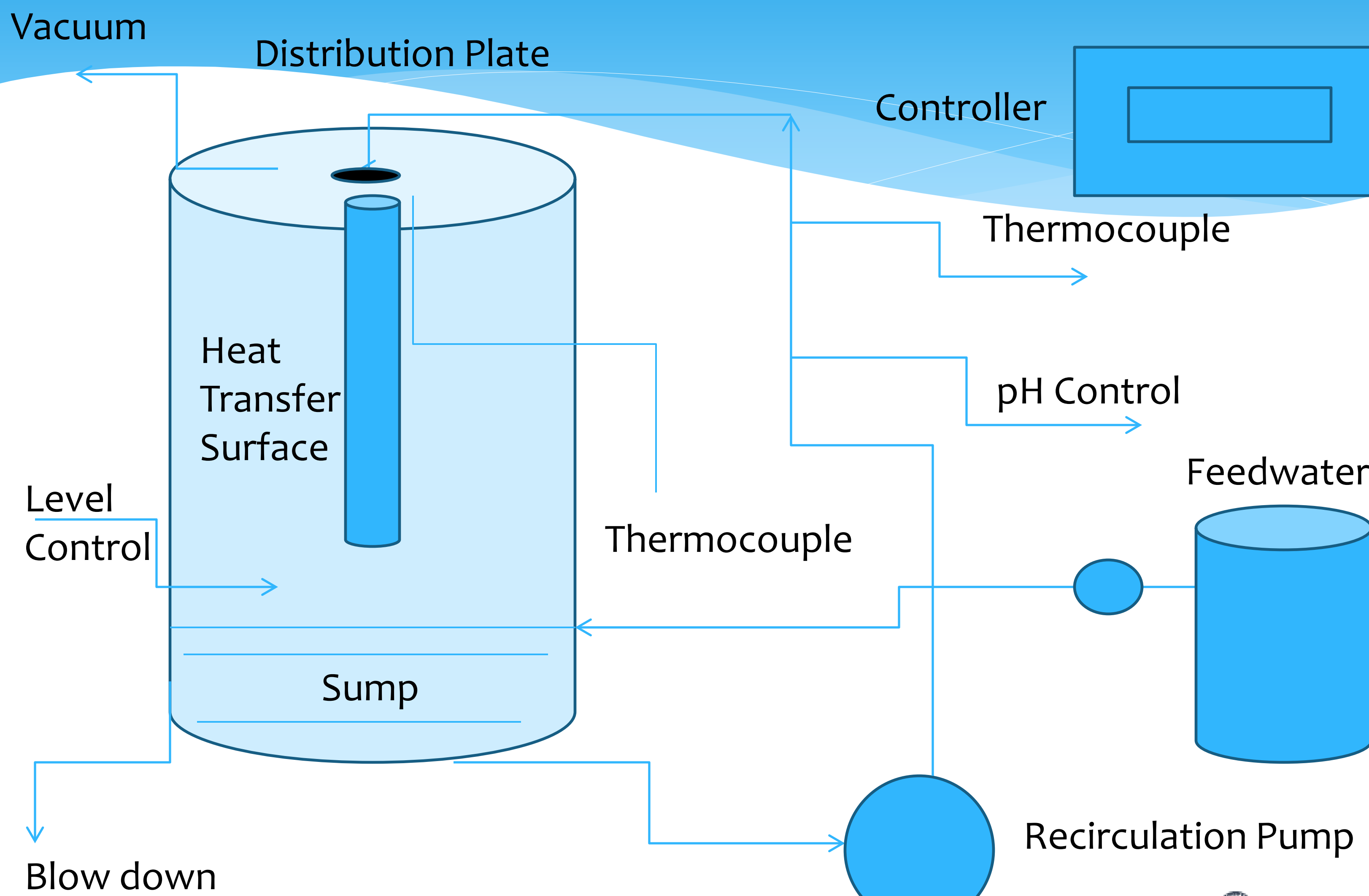
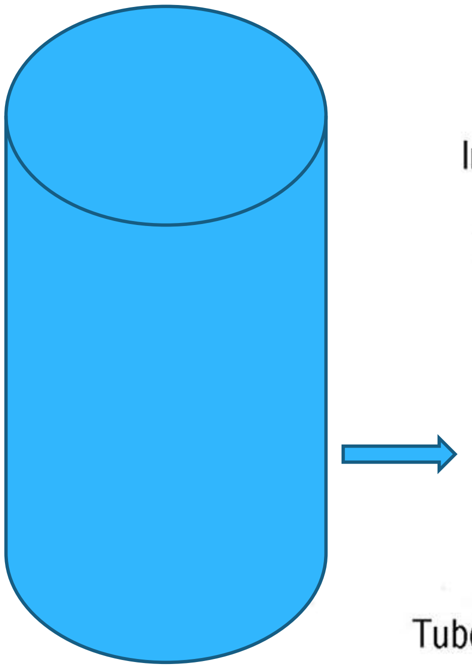
Development of New Treatment Approach to SAGD Falling Film Evaporators

* Substantial Calcium Deposition
* Substantial Silicate Deposition
* Hydrocarbon Deposits
* Caustic Feed Point Sensitivity
* Antifoam Requirement

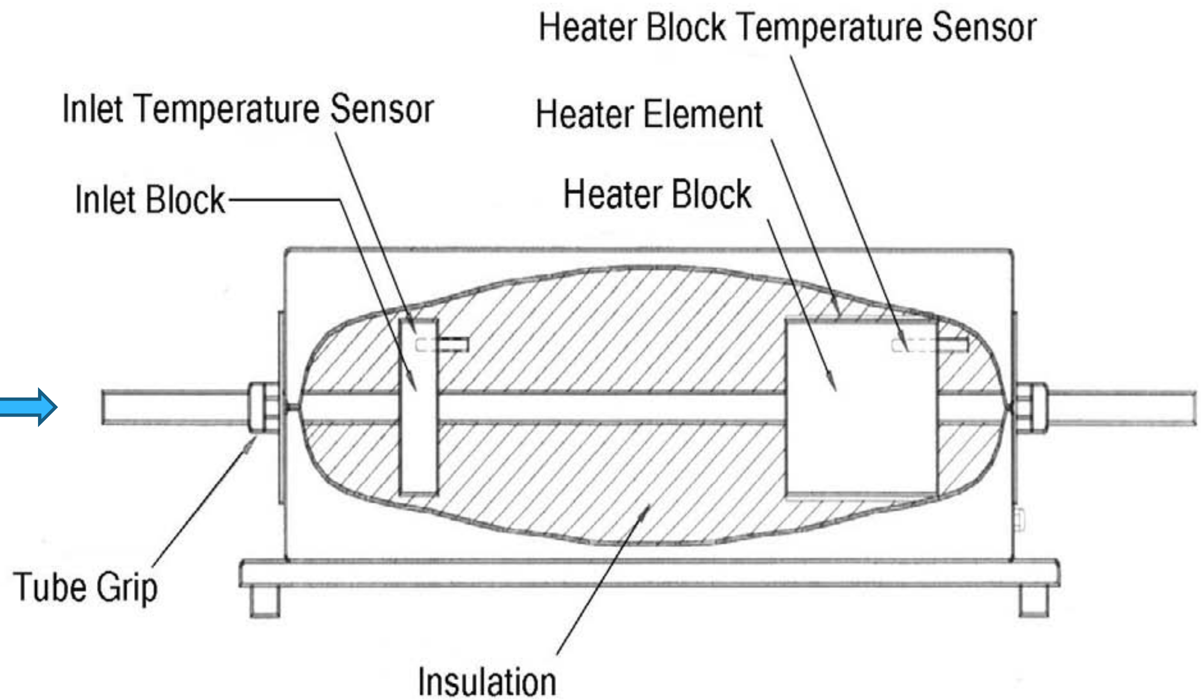
Pilot Falling Film Evaporator



DATs – Pilot Falling Film Evaporator



Concentrated Brine



Measures HEAT TRANSFER RESISTANCE

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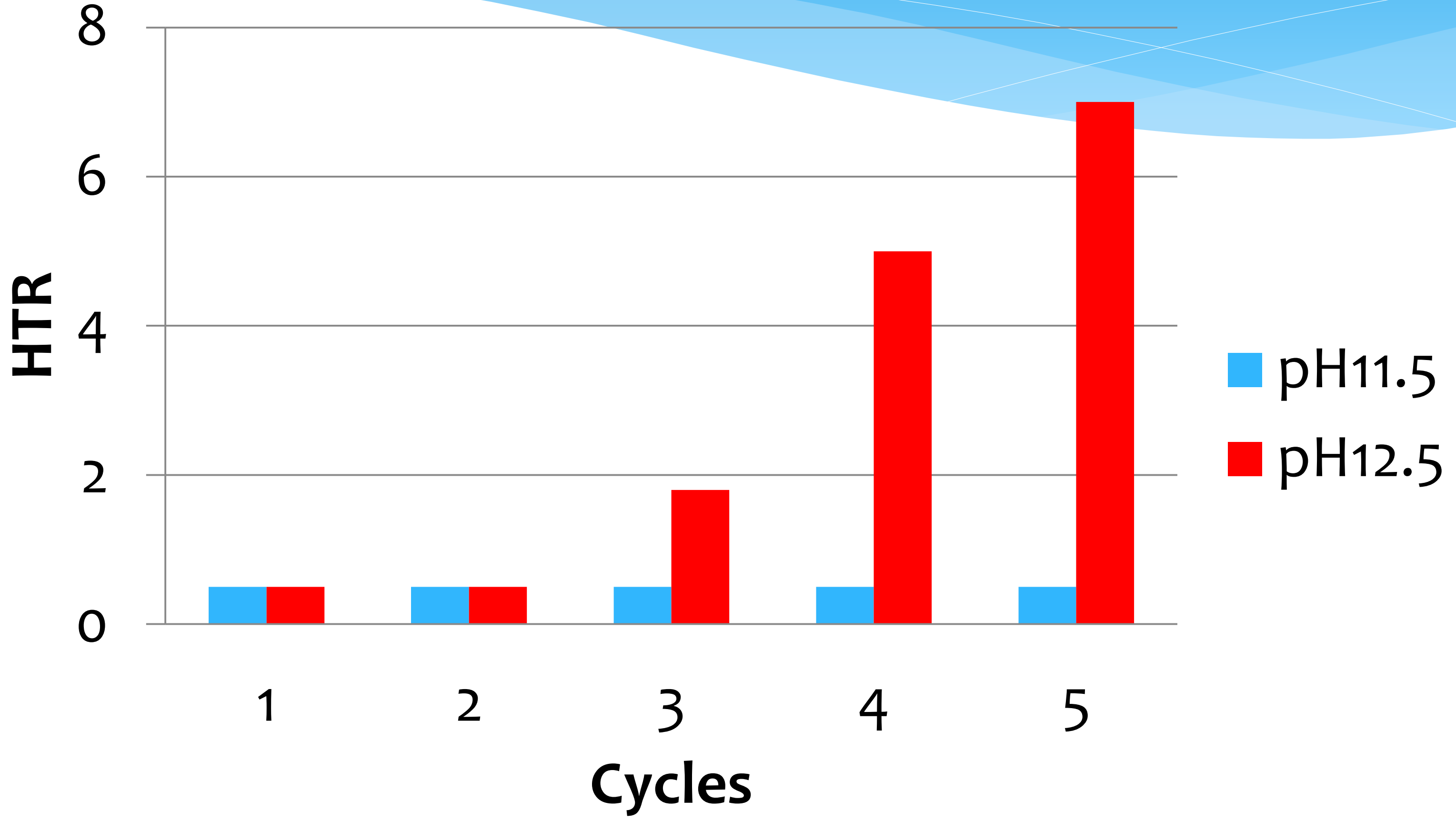
Impact of pH Control pH 12.5 vs 11.5

Parameter	%Transport pH 11.5	%Transport pH 12.5
Calcium as CaCO3 mg/l	>100%	61%
Magnesium as CaCO3 mg/l	92%	54%
Silica as SiO2	95%	78%

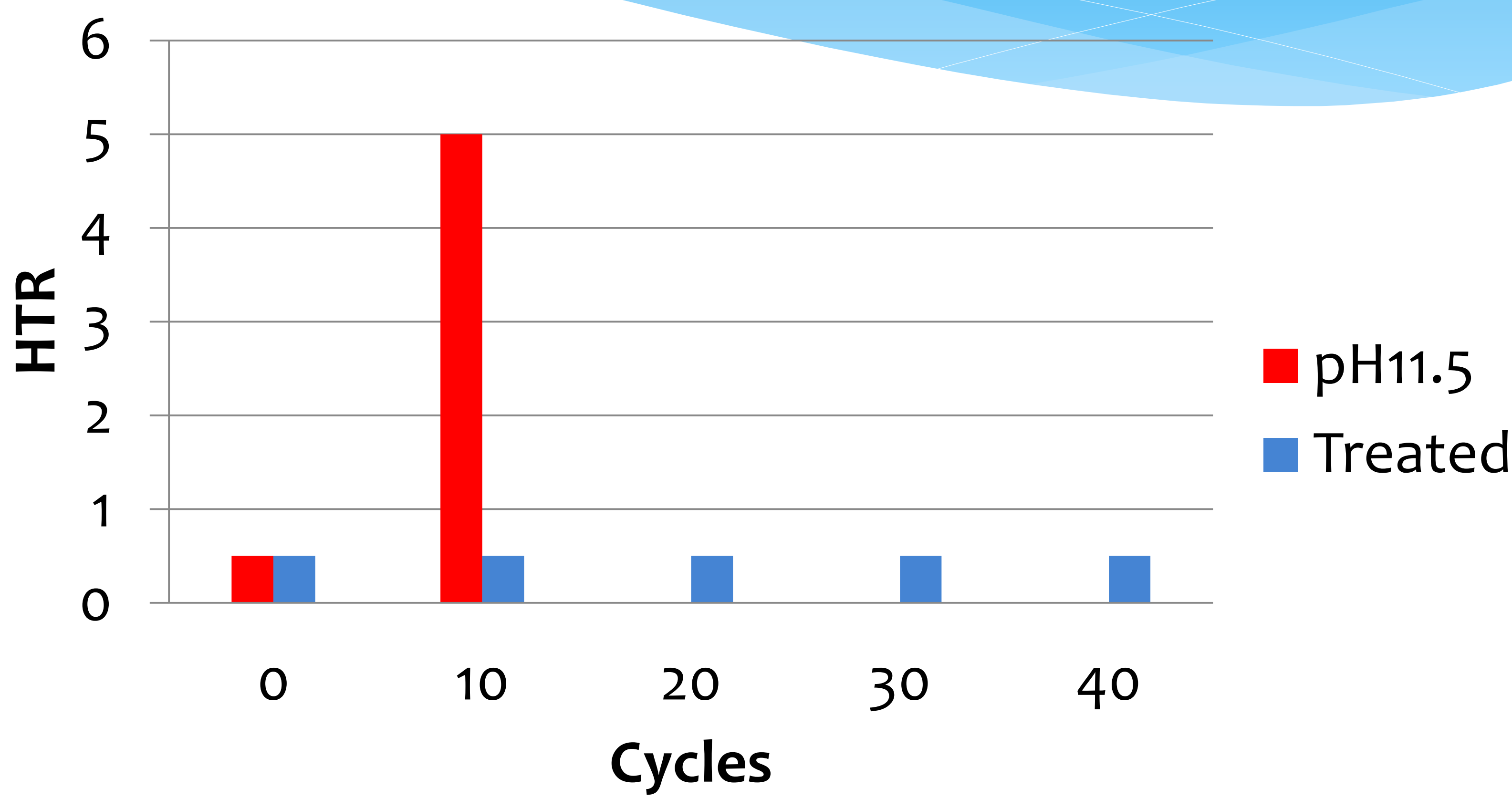
HTR vs. Cycles vs. pH



QuadPolymer Technology

* Calcium Carbonate Inhibitor
* Magnesium Silicate Inhibition
* High Thermal Stability
* Surface Active – surfactant character
* Iron Dispersant

HTR at Extended Cycles Treated vs Untreated



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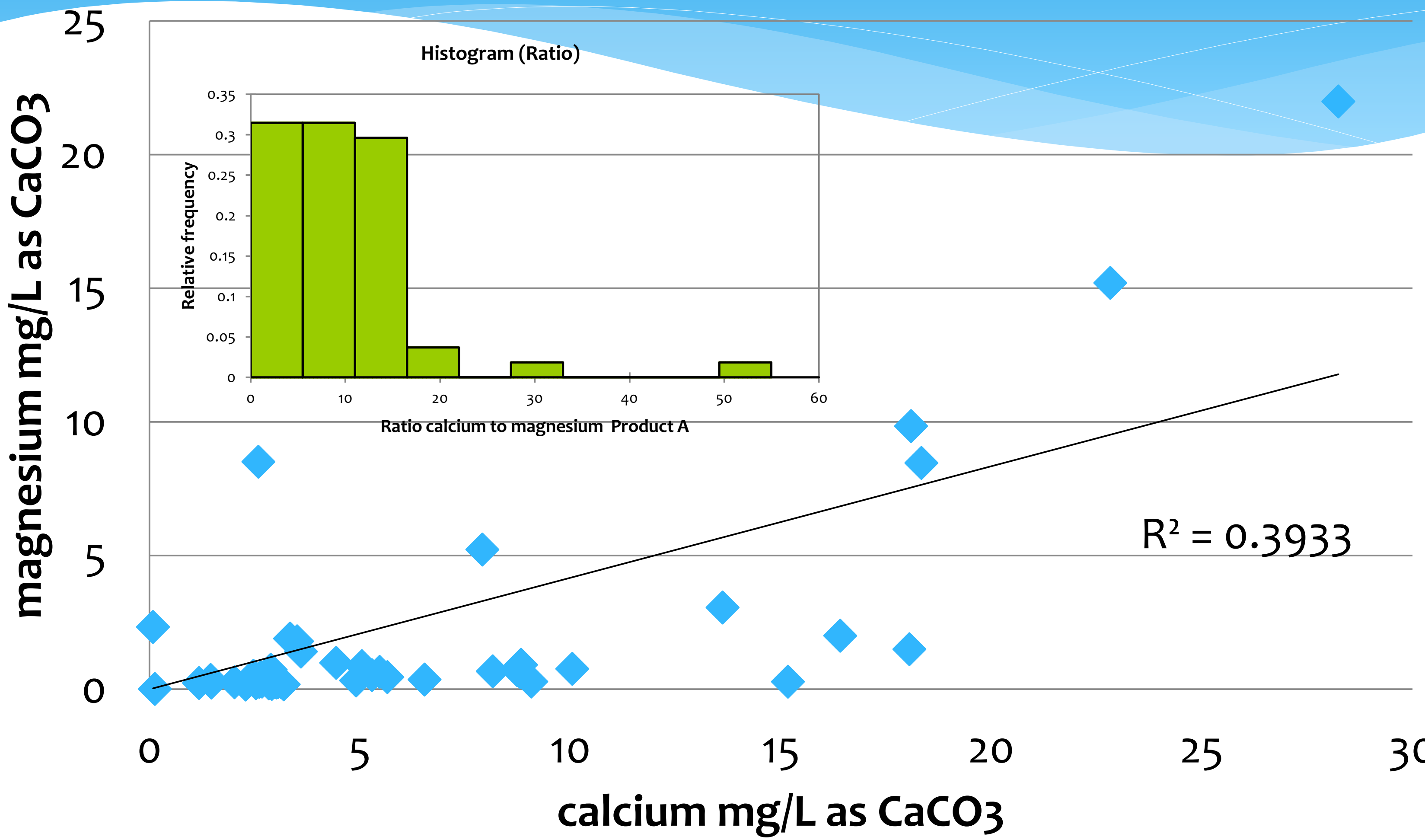
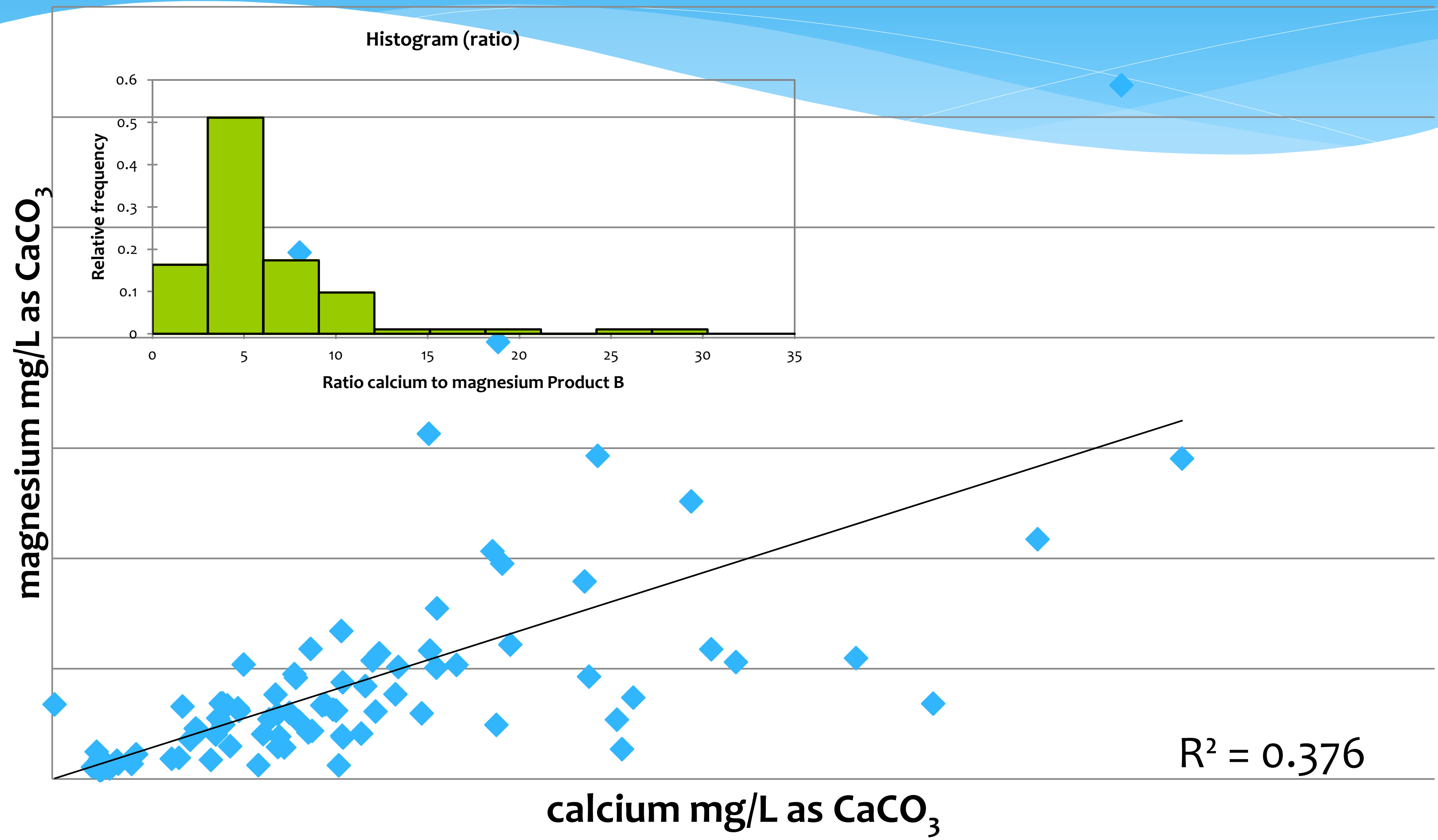
Product A Calcium/Magnesium Ratio Blowdown



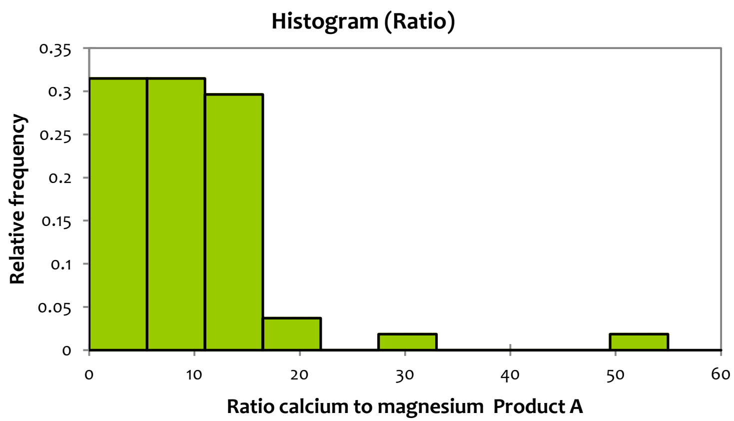
Product B Calcium/Magnesium Ratio Blowdown

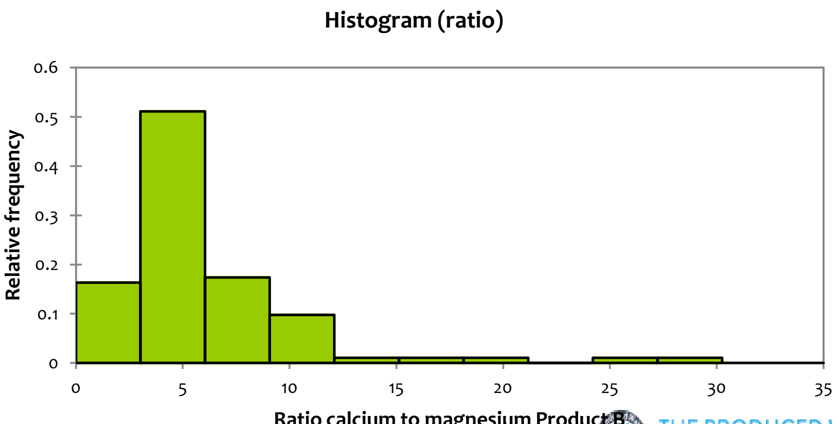


Evaporator Transport Performance Comparison

Statistic	Ratio
Variance (n-1)	71.064
Standard deviation (n-1)	8.43

Variance (n-1)	21.738
Standard deviation (n-1)	4.662





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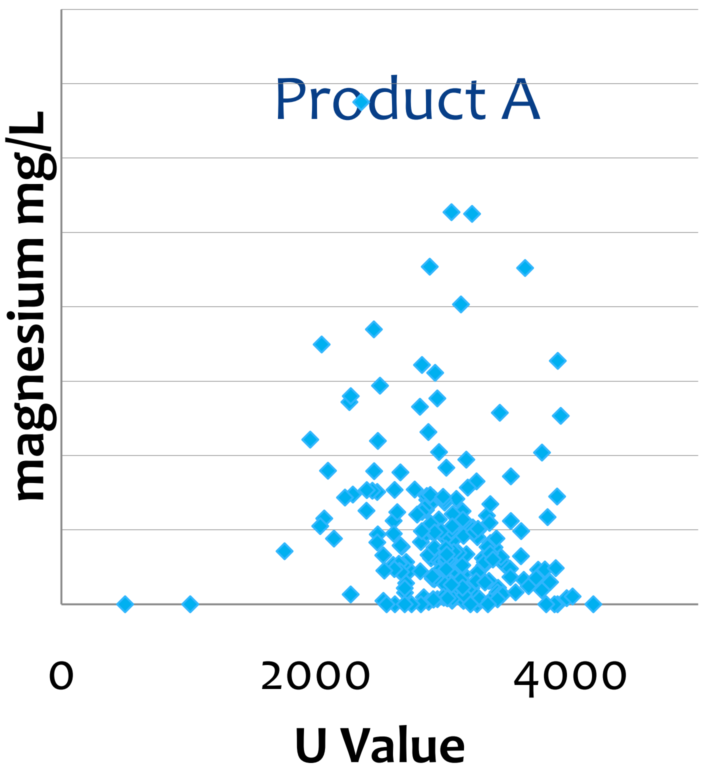
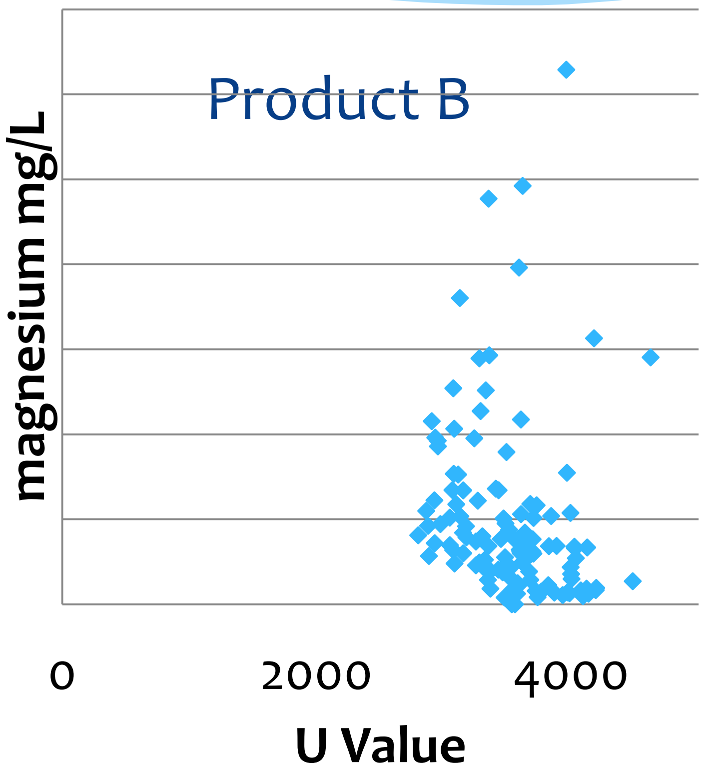
Impact on U value Product A vs. B

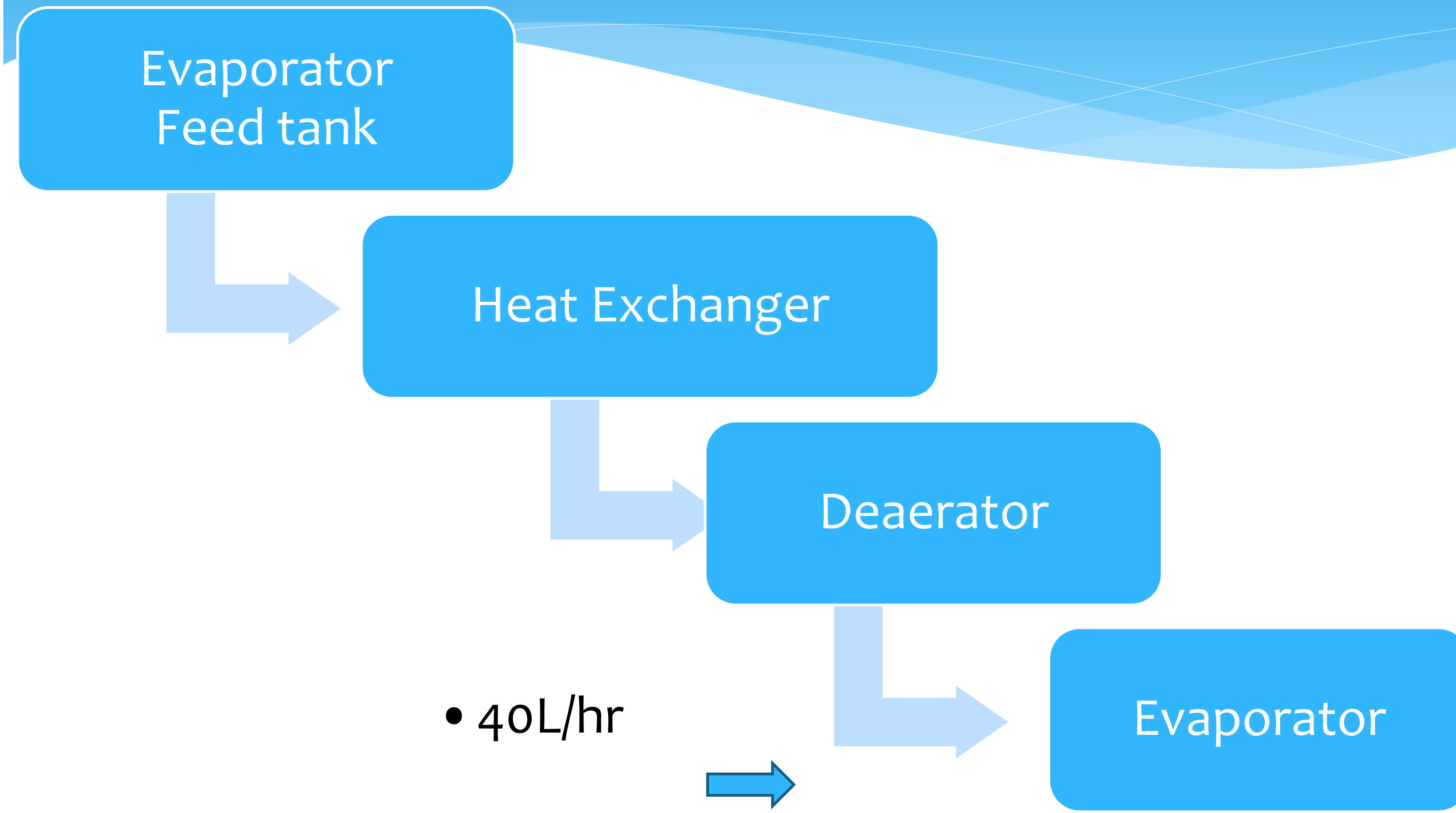




Field Application of New Technology

* Reduced sump pH 11.5 target
* Quad polymer based scale inhibitor program
* Hydrocarbon Dispersant
* Antifoam , low silicon technology
* Enhanced Hardness Transport

Lower Sump pH Net result Caustic reduced to 40L/hr



- 40L/hr

Conclusions

* Significant reduction in Evaporator and Heat Exchanger Fouling
* Minimal periodic chemical cleaning to maintain efficiency
* Improved Distillate production due to improved HTR
* Increased TDS capability – reduced waste disposal costs