WORLD SALT SYMPOSIUM
June 19-21, 2018 Park City UT, USA

Case Study on the Recovery of Salt from Produced Water Coming from Shale Gas Applications

Kerstin Hirsch; MChemEng., SEP Salt & Evaporation Plants Ltd.

Overview

- Hydrolic Fraturing
- Waste Water Handling
- Case Study of Waste Water Crystallization

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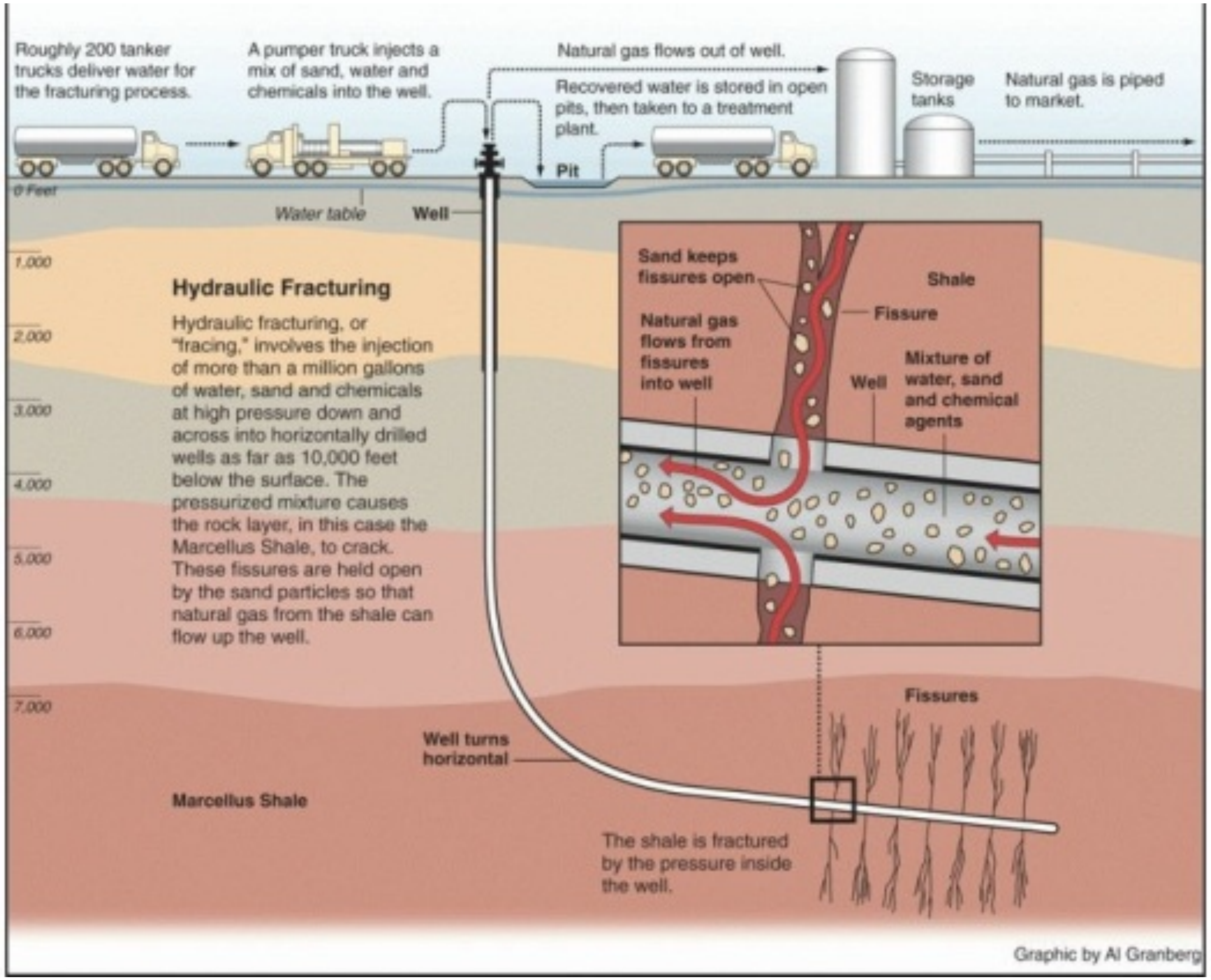
Hydraulic Fracturing and Produced Water



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Water Coming out of the Wells

Chemical constituent or surrogate parameter	Unit of measure	Range reported in produced water from wells drilled in Marcellus Shale 5 days post hydraulic fracturing	Range reported in produced water from wells drilled in Marcellus Shale 14 days post hydraulic fracturing
Total Suspend		10.8-3'2	
Turbidity		2.3-1'5	
Total Dissolv		38'500	
Specific Con		79'500	
Total Organic		3.7-38	
Dissolved Or		30.7-5	
Chemical Oxy		195-17	
Biochemical		37.1-1	
BOD/COD Ra			
Alkalinity		48.8-3	
Acidity		<5-447	
Hardness (as CaCO3)	mg/L	5'100-55'000	630-95'000
Total Kjeldahl Nitrogen (TKN)	mg/L as N	38-204	5.6-261
Ammonia Nitrogen	mg/L as N	29.4-199	3.7-359
Nitrate – N	mg/L as N	<0.1-1.2	0.1-0.92
Chloride		26'400-	
Bromide		185-1'	
Sodium		10'700	
Sulfate		2.4-10	
Oil and Greas		4.6-65	
BTEX (benze			
VOC (volatile			
Naturally occ (NORM)		Non-d	
Barium		21.4-13	
Strontium	mg/L	345-4'830	
Lead	mg/L	Non-detect-0.606	Non-detect-0.349
Iron	mg/L	21.4-180	13.8-242
Manganese	mg/L	0.881-7.04	1.76-18.6

High Salinity

Industrial Chemicals

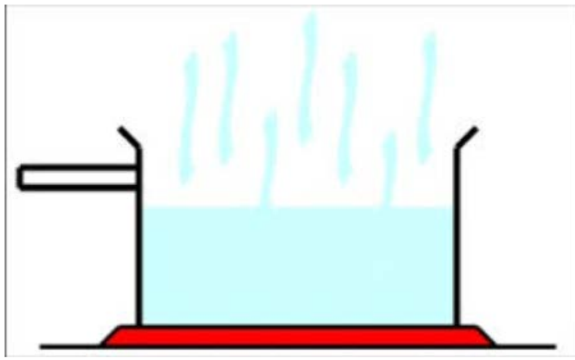
Hydrocarbons

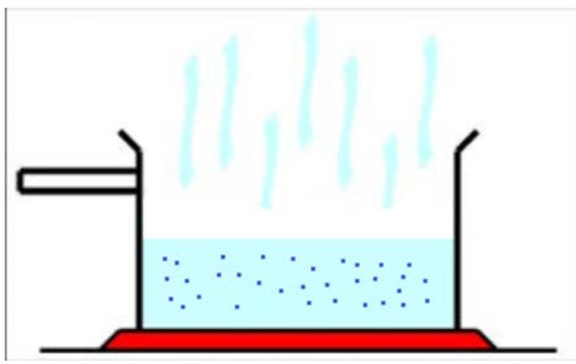
NORM (naturally occuring radioactive materials)

Water Waste Water Management Possibilities

- Reduction of Waste Water Being Generated
- Recycling of Waste Water in the Fracking Process
- Disposal of the Waste Water
- Beneficial Reuse of the Waste Water
- Treatment of Waste Water for Further Processing or Disposal

Thermal Treatment of Waste Water

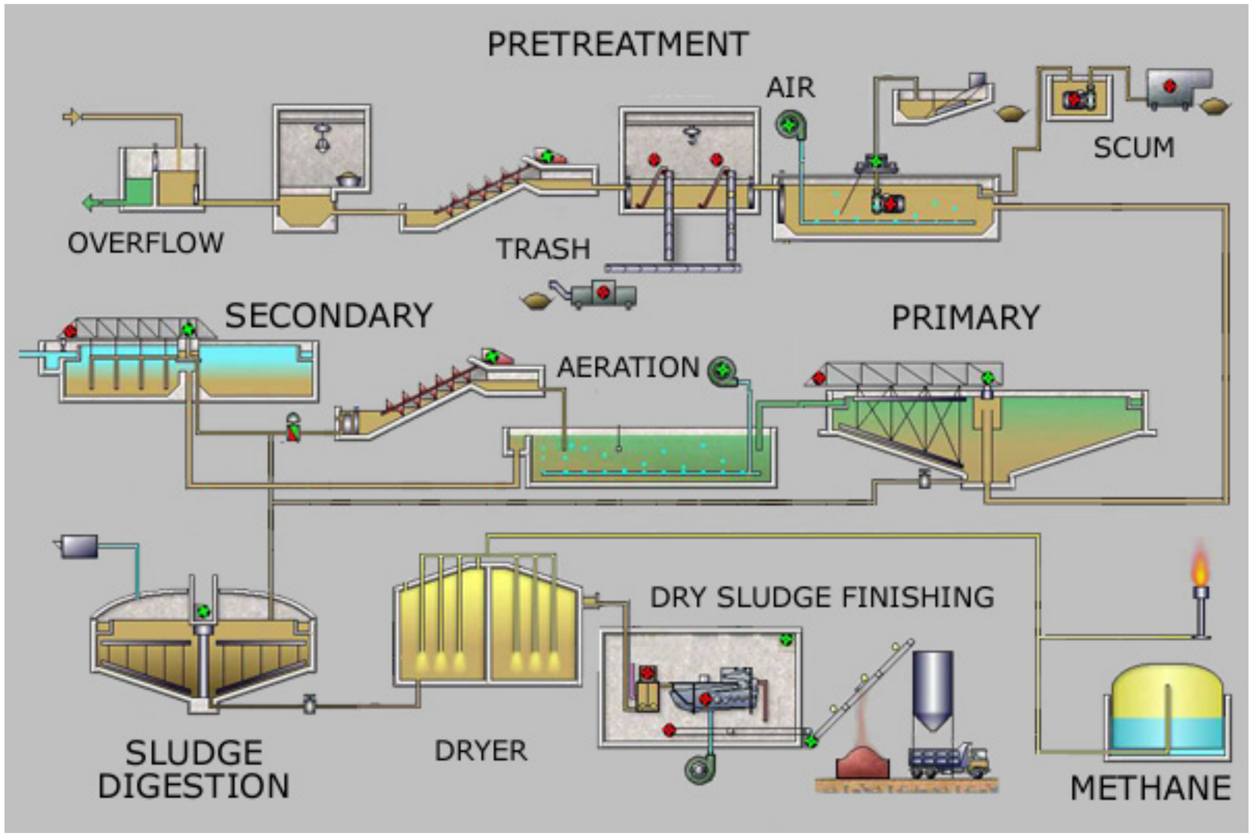




- Evaporation of Water Vapour
- Vapour Condensate is Clean
- Energy Intensive Process
- Stopped before Crystallization occures
- Liquid Distillate left as Waste Material

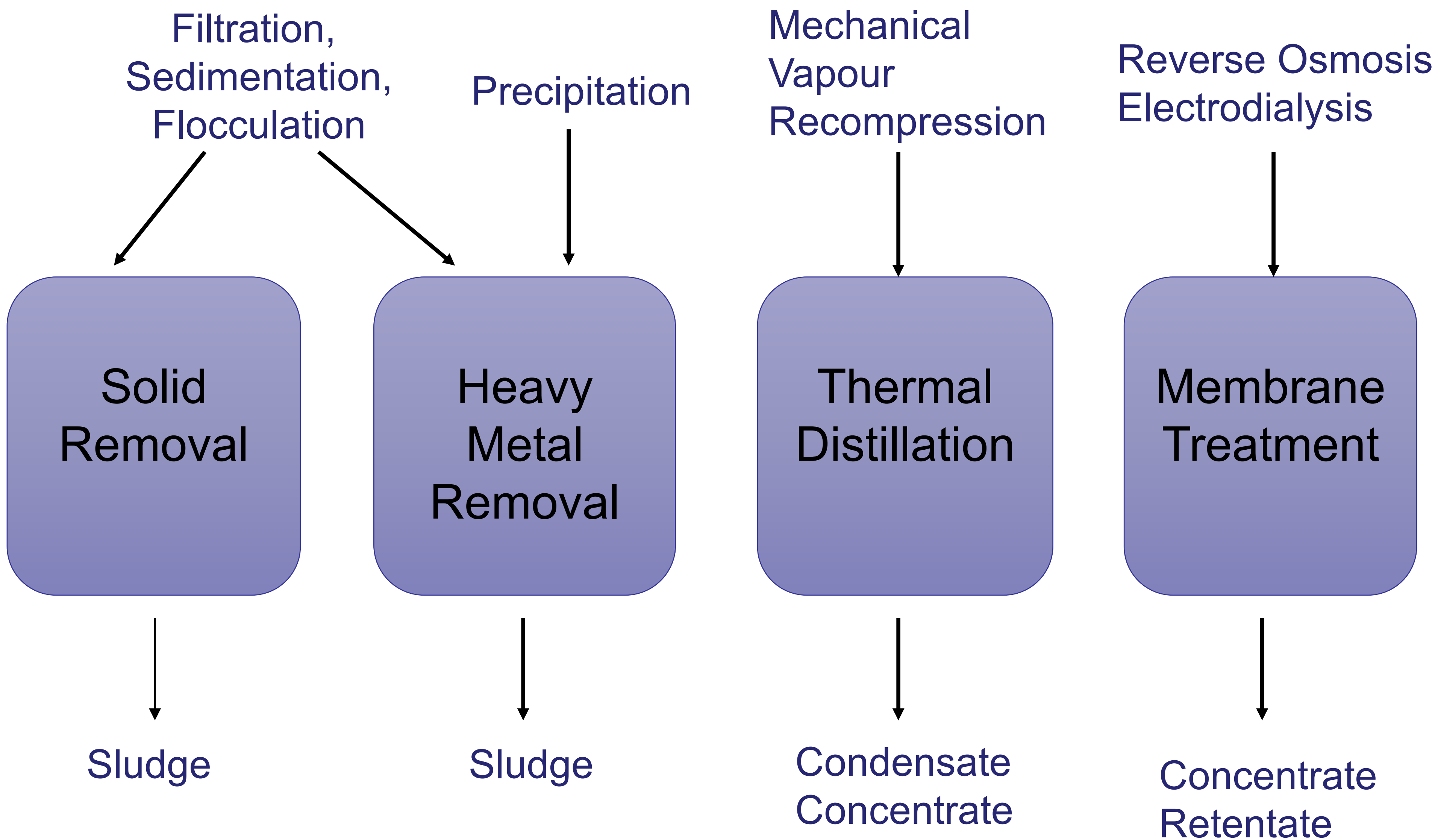
Pretreatment in POTW's

Publicly Owned Treatment Works for Municipal Waste Water:

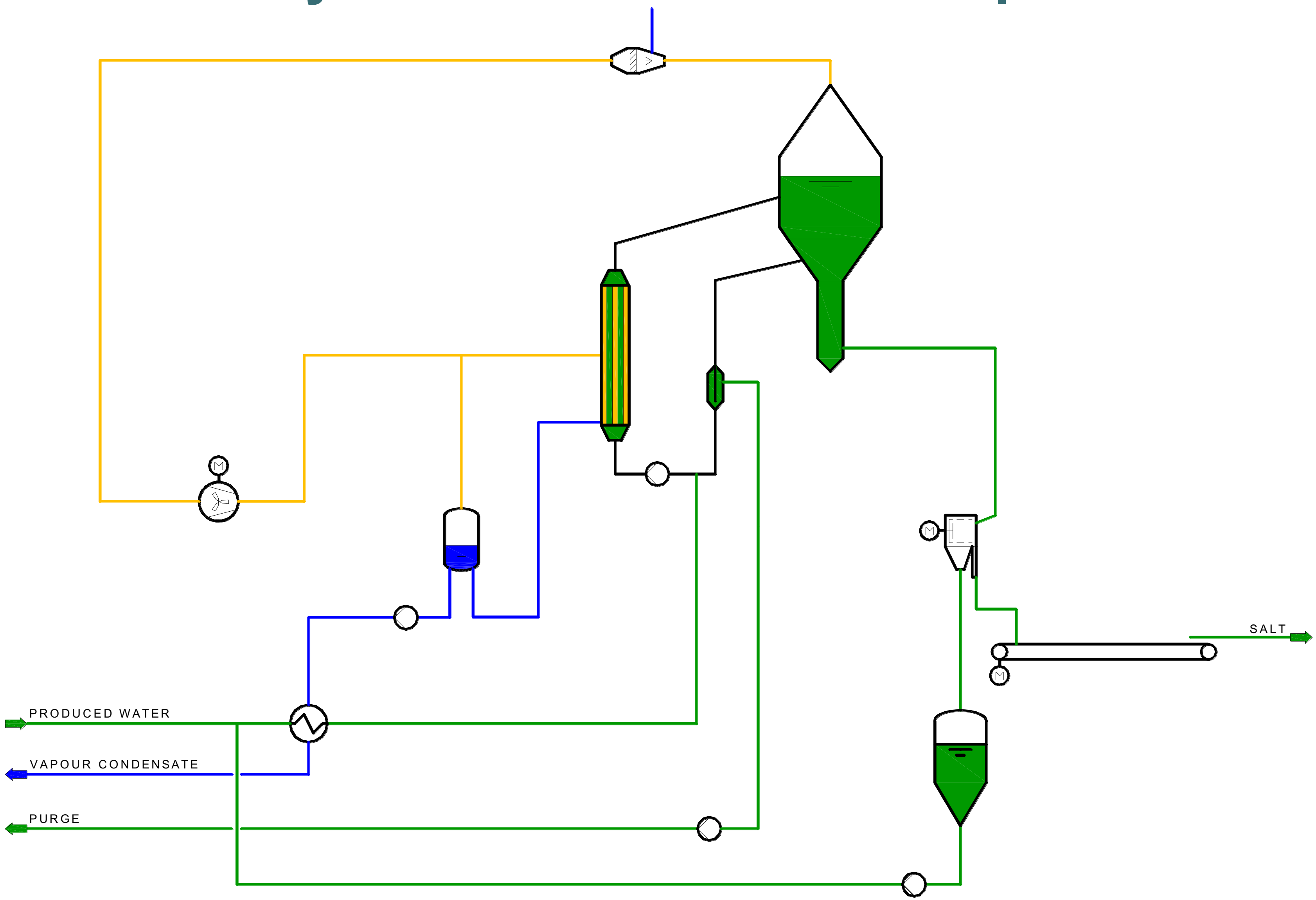


- Salt
- Formaldehyd
- Capacity Limits

Pretreatment in CTW's



Crystallization Plant Concept



Chemical and Physical Challenges

- Solids are Hard to Remove in the Pretreatment Plant Upstream of the Crystallizer
- Reactions can take Place in the Crystallizer and lead to Precipitation or Incrustation
- Chemical Agents can Cause Foaming
- Volatile Chemicals at high Temperatures can Cause Corrosion
- Changing Feed Compositions can lead to Crystallisation of Impurities

Chemical and Physical Requirements

Chemical:

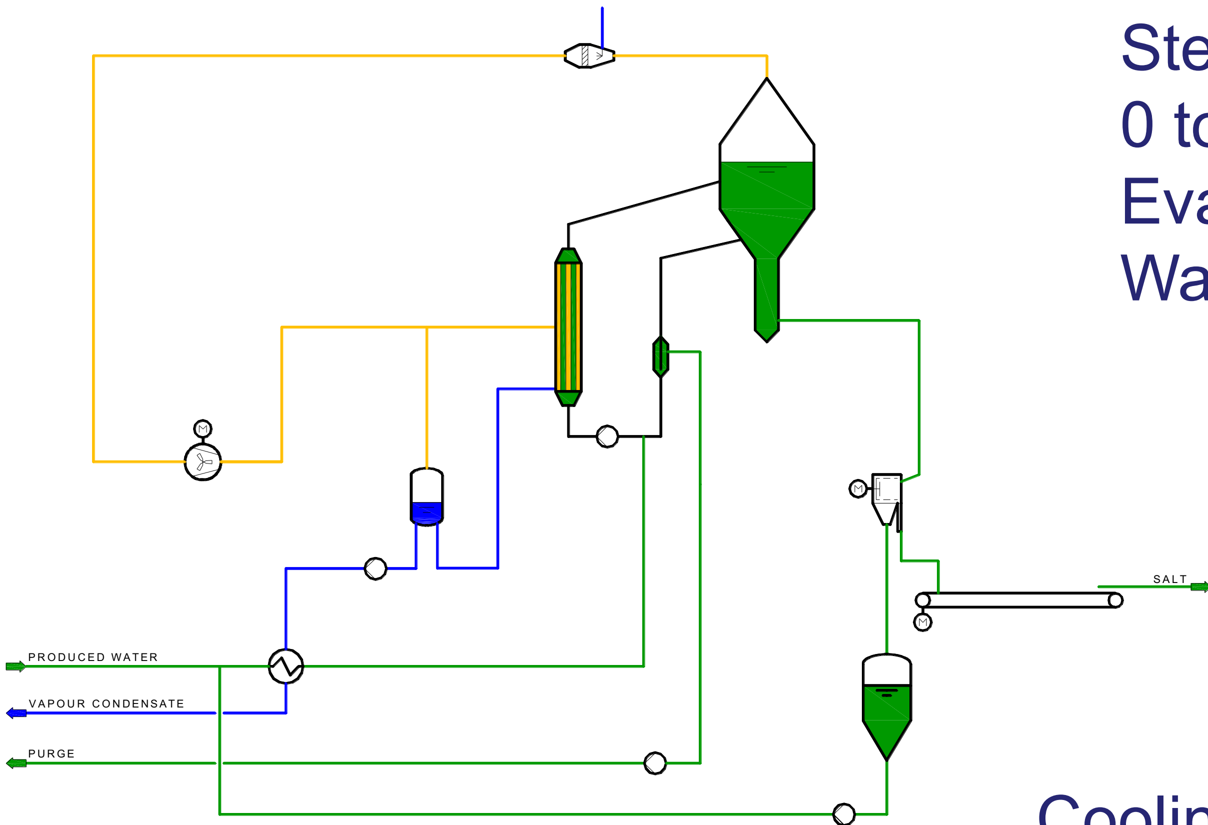
- Pretreated Produced Water as Feed
- pH Higher than 6 - 7
- No Corrosive Volatiles in the Feed Solution
- No Solids in the Feed Solution

Physical:

- Stable Conditions of Utilities
- Steam of 2-3 bar
- Electrical Power @ 480 V
- Compressed Air
- Make-up Water

Frame Data – Consumption Figures

Electrical Consumption: 70 kWh/ t Evaporated Water



Steam: 0 tons / ton Evaporated Water

Concentrate: Depending on Feed Composition

Cooling Water: < 1m^3/h

Feed Capacity: 5000bbl/d

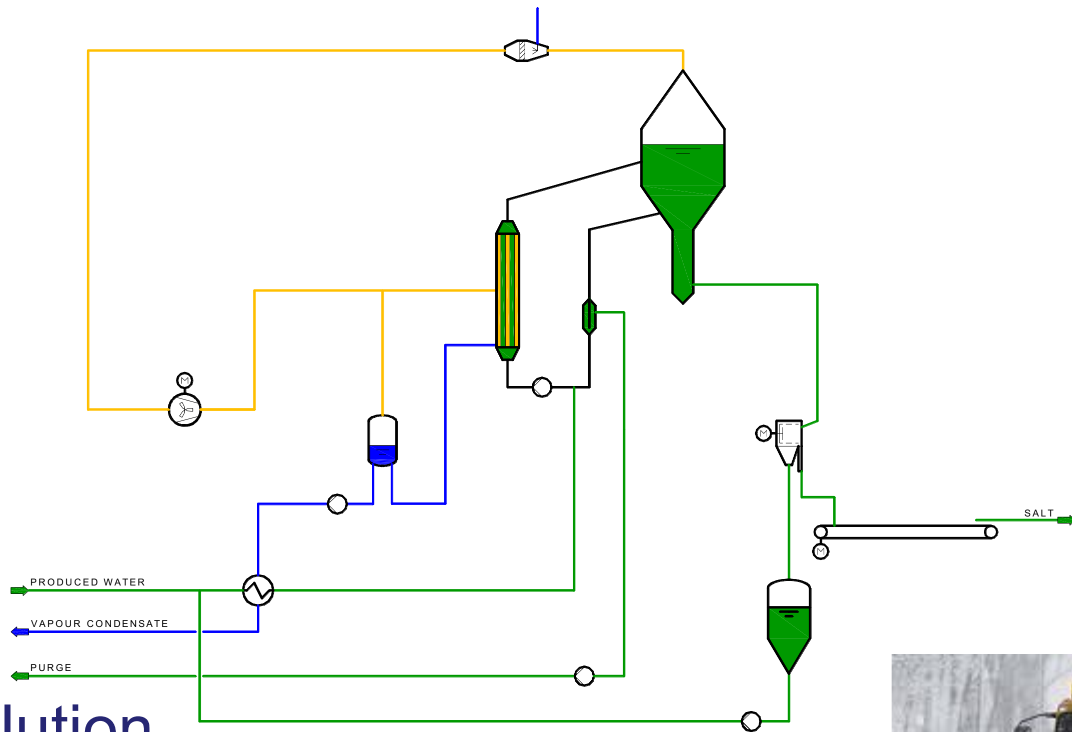
Standing Stone Plant

Salt Production

Salt Production

Products

Clean Water



Salt:
NaCl 99.6%
Guaranteed

Concentrated Solution
Rich in $CaCl_2$

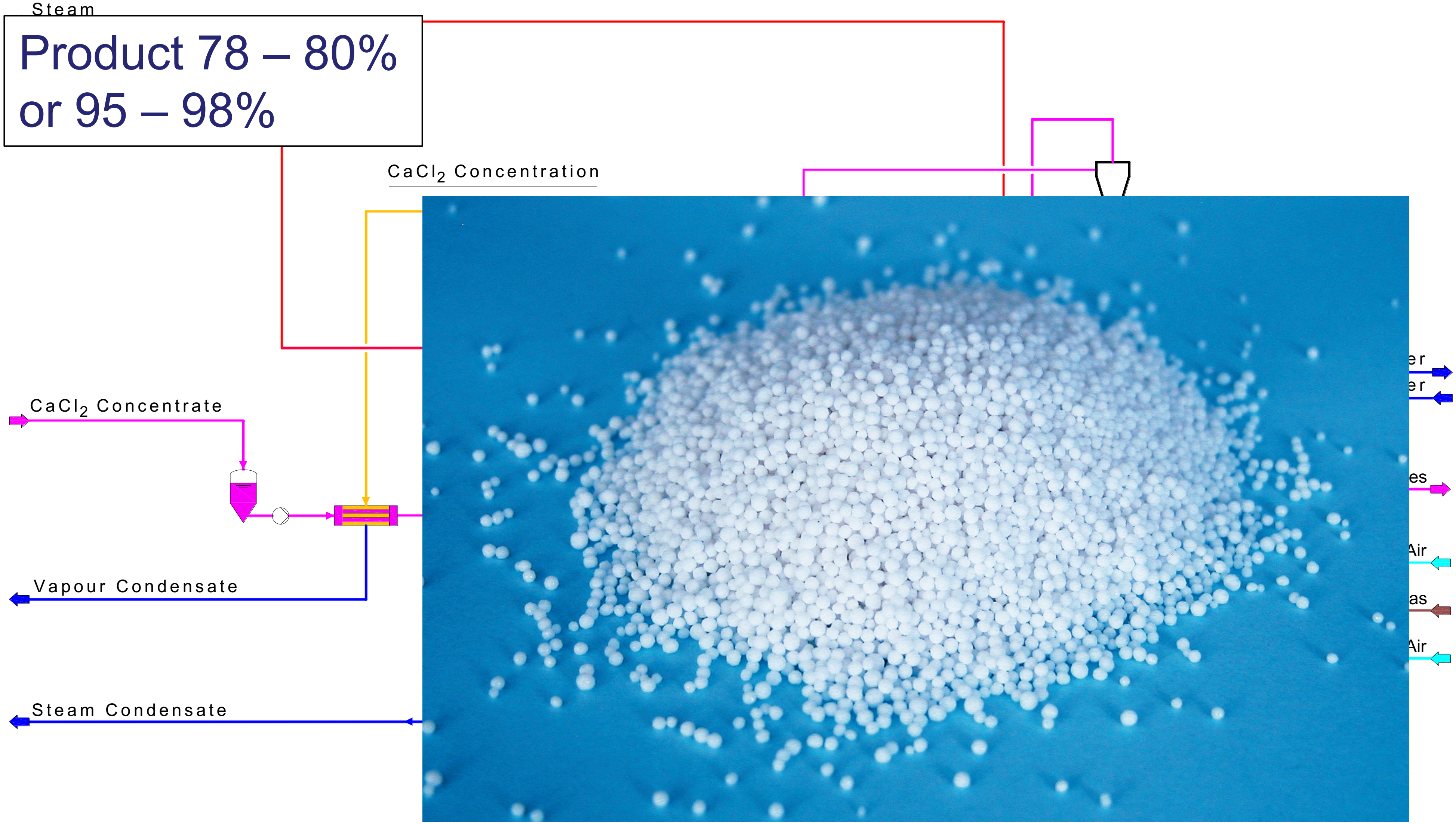
What Else? Future Expansions!

- Recovery of Clean Calcium Chloride out of the Purge
- Recovery of Strontium Chloride out of the Purge Solution
- Recovery of Barium Chloride

A new Definition of Zero Liquid Discharge!

$CaCl_2$ Production

Product 78 – 80%
or 95 – 98%



Summary

- Frac Water Treatment is a Challenging Task
- Changing Compositions and Unknown Constituents Request Flexibility and Good Know-how for the Treatment Methods
- It is Possible and Economic to Crystallize Valuable Salt in Road Salt Quality From Produced Water
- It is Possible to have no Liquid Waste Material at the end of the Treatment Chain
- More Valuable Products Make the Treatment Process an Environmental and Economical win-win Process for all Parties

Thank you!

Kerstin Hirsch
SEP Salt & Evaporation Plants Ltd.
Neuwiesenstrasse 69
8400 Winterthur
Tel.: +41 52 260 50 79
www.sepwin.ch