NIPPON PAPER RO SYSTEM + 2 Others

March 2014

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District Account Manager

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District Account Manager

NALCO
An Ecolab Company

Purpose: Review the design, function, layout, and operation of the RO system.

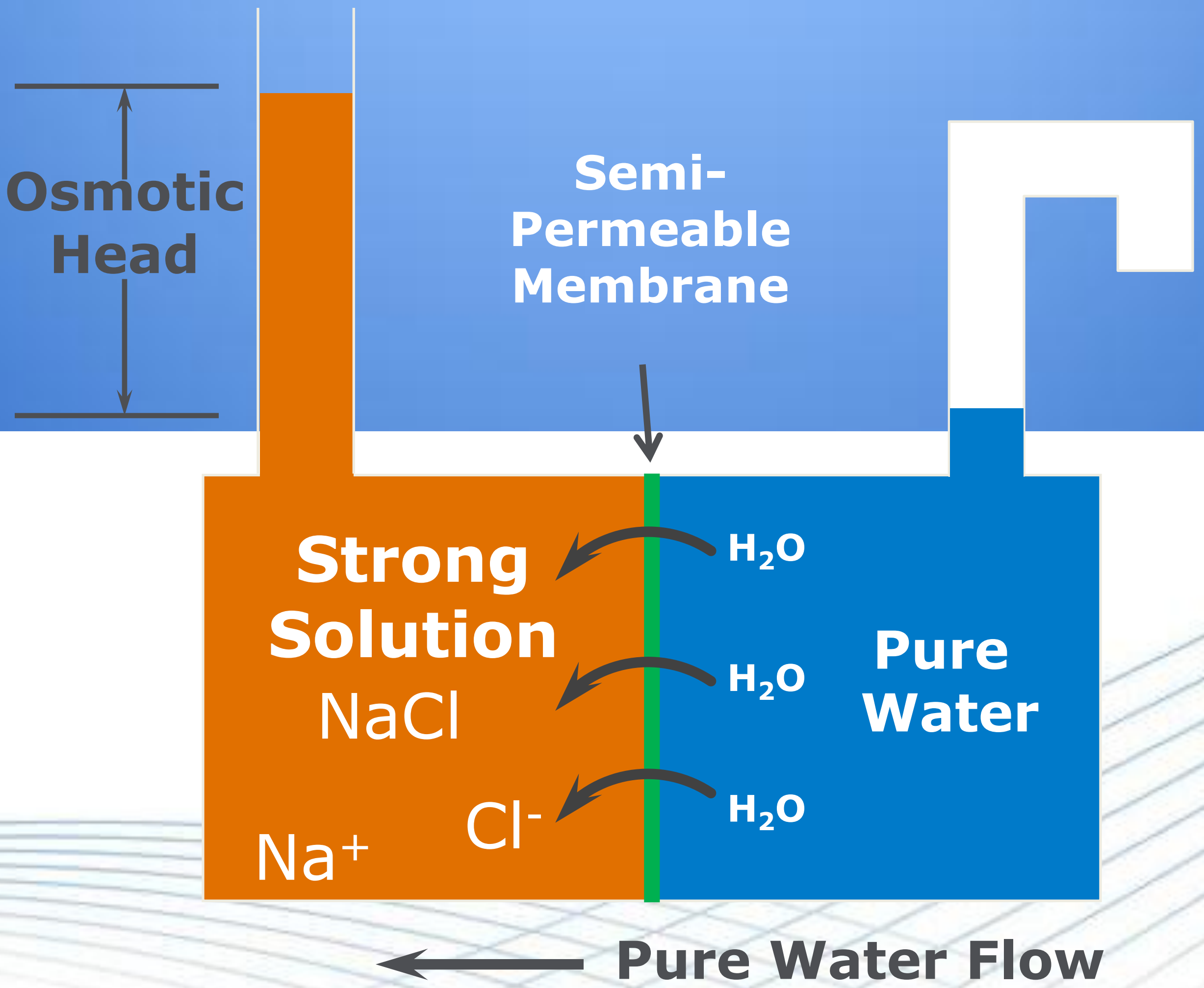
Process: 30-40 minute presentation.

Payoff: Gain a better understanding of the RO system

But First, What is RO?

RO: Reverse Osmosis

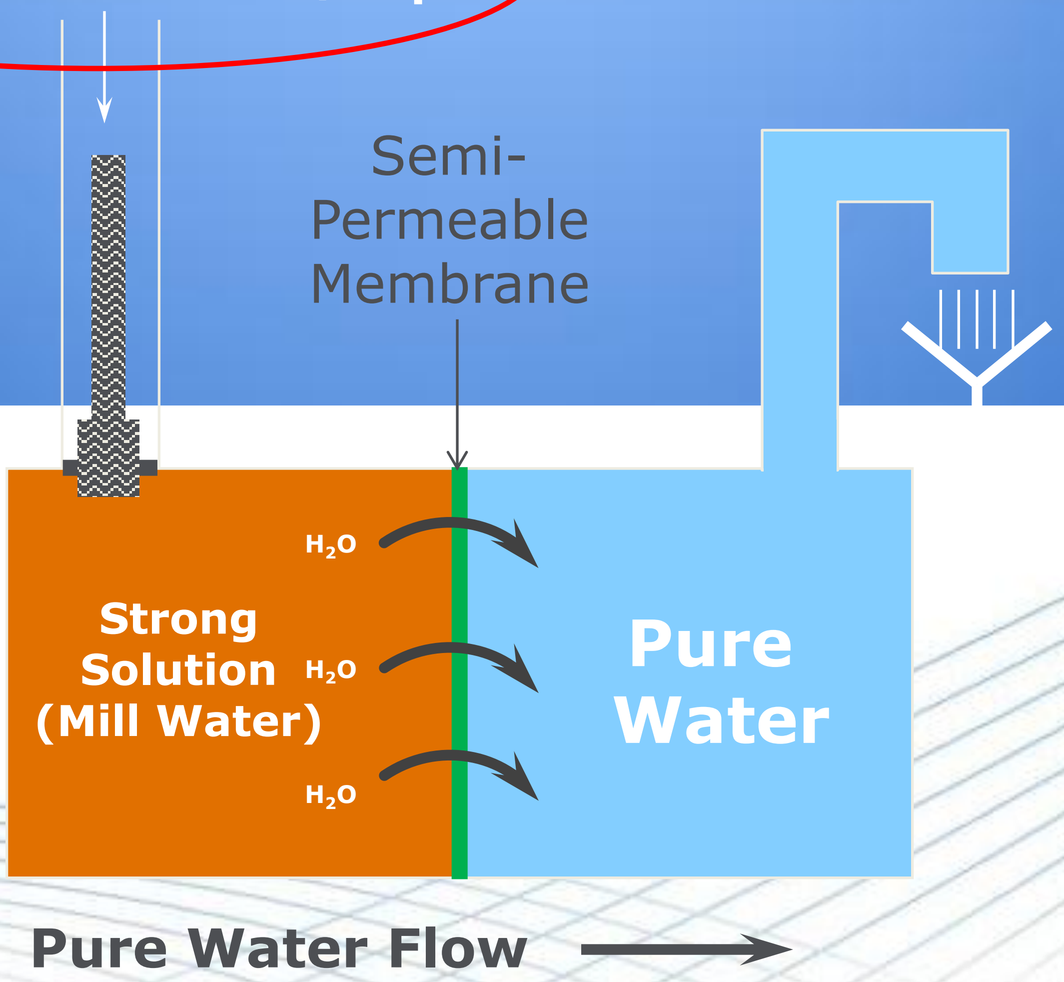
Osmosis


Osmotic Head
Semi-Permeable Membrane
Strong Solution
NaCl
Na^+
Cl^-
H_2O
H_2O
H_2O
Pure Water
Pure Water Flow

REVERSE OSMOSIS

Applied Pressure, P_F > Osmotic Pressure, P_O

What is our applied pressure?



WHY RO at Nippon?

Old Boiler: 225 PSIG
Zeolite Softened Water
No Turbine
Paper Mill Steam Use

Cogen Boiler: 900 PSIG
20 MW Turbine
Steam Extraction + Condensing

ASME TABLE: SUGGESTED WATER CHEMISTRY LIMITS

Boiler type: Industrial watertube, high duty, primary fuel fired, drum type
Makeup water percentage: Up to 100% of feedwater
Conditions: Includes superheater, turbine drives, or process restriction on steam purity
Saturated steam purity target: See tabulated values below

Drum Operating Pressure (1) (11) psig (MPa)	0-300 (0-2.07)	301-450 (2.08-3.10)	541-600 (3.11-4.14)	601-750 (4.15-5.17)	751-900 (5.18-6.21)	901-1000 (6.22-6.89)	1001-1500 (6.90-10.34)	1501-2000 (10.35-13.79)
Feedwater (7)								
Dissolved oxygen ppm (mg/l) O_2— measured before chemical oxygen scavenger addition (8)	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Total iron ppm (mg/l) Fe	≤0.1	≤0.05	≤0.03	≤0.025	≤0.02	≤0.02	≤0.01	≤0.01
Total copper ppm (mg/l) Cu	≤0.05	≤0.025	≤0.02	≤0.02	≤0.015	≤0.01	≤0.01	≤0.01
Total hardness ppm (mg/l) $CaCO_3$	≤0.3	≤0.3	≤0.2	≤0.2	≤0.1	≤0.05	ND	ND
pH range @ 25°C	8.3-10	8.3-10	8.3-10	8.3-10	8.3-10	8.8-9.6	8.8-9.6	8.8-9.6
Chemicals for preboiler system protection	NS	NS	NS	NS	NS	VAM	VAM	VAM
Nonvolatile TOC ppm (mg/l) C (6)	<1	<1	<0.5	<0.5	<0.5	<0.2	<0.2	<0.2
Oily matter ppm (mg/l)	<1	<1	<0.5	<0.5	<0.5	<0.2	<0.2	<0.2
Boiler Water								
Silica ppm (mg/l) SiO_2	≤150	≤90	≤40	≤30	≤20	≤8	≤2	≤1
Total alkalinity ppm (mg/l) $CaCO_3$	<700 (3)	<600 (3)	<500 (3)	<200 (3)	<150 (3)	<100 (3)	NS (4)	NS (4)
Free hydroxide ppm (mg/l) $CaCO_3$ (2)	NS	NS	NS	NS	NS	NS	ND (4)	ND (4)
Unneutralized conductivity µmhos/cm (µS/cm) 25°C (12)	5400-1100(5)	4600-900(5)	3800-800(5)	1500-300(5)	1200-200(5)	1000-200(5)	≤150	≤80
Total Dissolved Solids in Steam (9)								
TDS (maximum) ppm (mg/l)	1.0-0.2	1.0-0.2	1.0-0.2	0.5-0.1	0.5-0.1	0.5-0.1	0.1	0.1

NS = Not specified
ND = Not detectable
VAM = Use only volatile alkaline materials upstream of attemperation water source (10)

Why An RO and Not a DEMIN

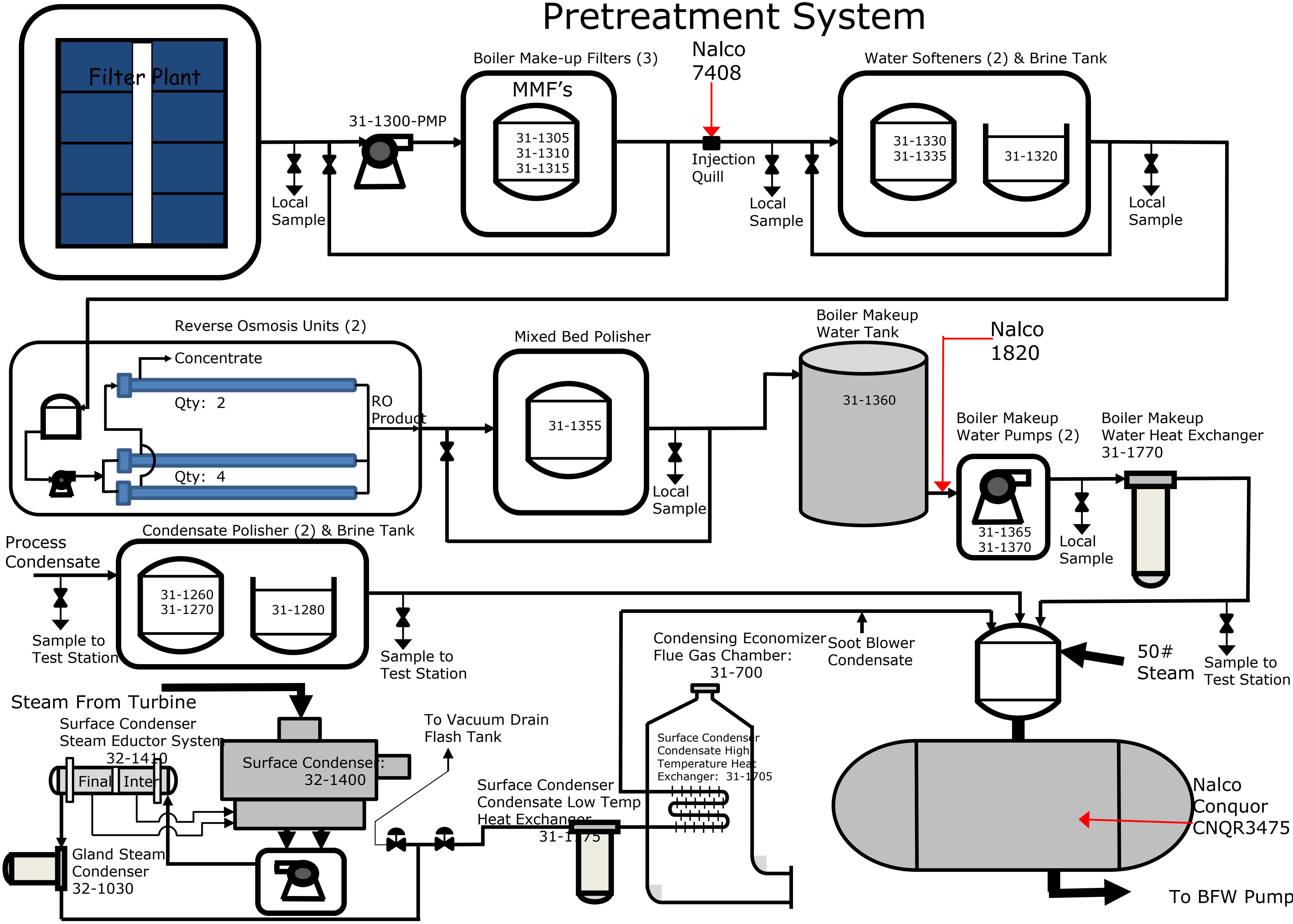
DEMINS:

- ACID and CAUSTIC Regen. Safety Concern
- Potential for silica, hardness breakthrough
- Potential for acid excursions
- Wide Range of flow rates

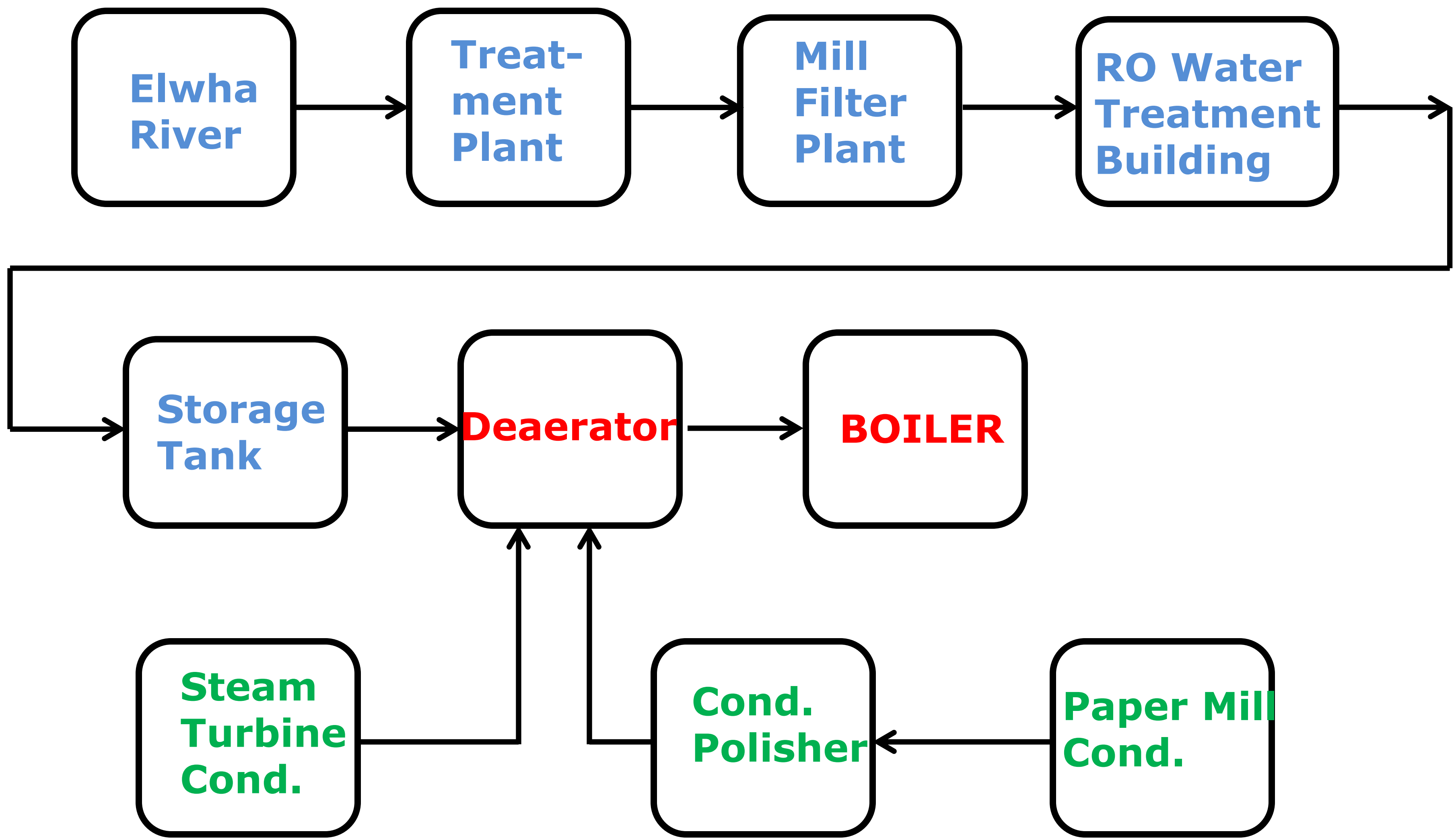
RO’s:

- Consistent Permeate Quality
- No acid or caustic regen system

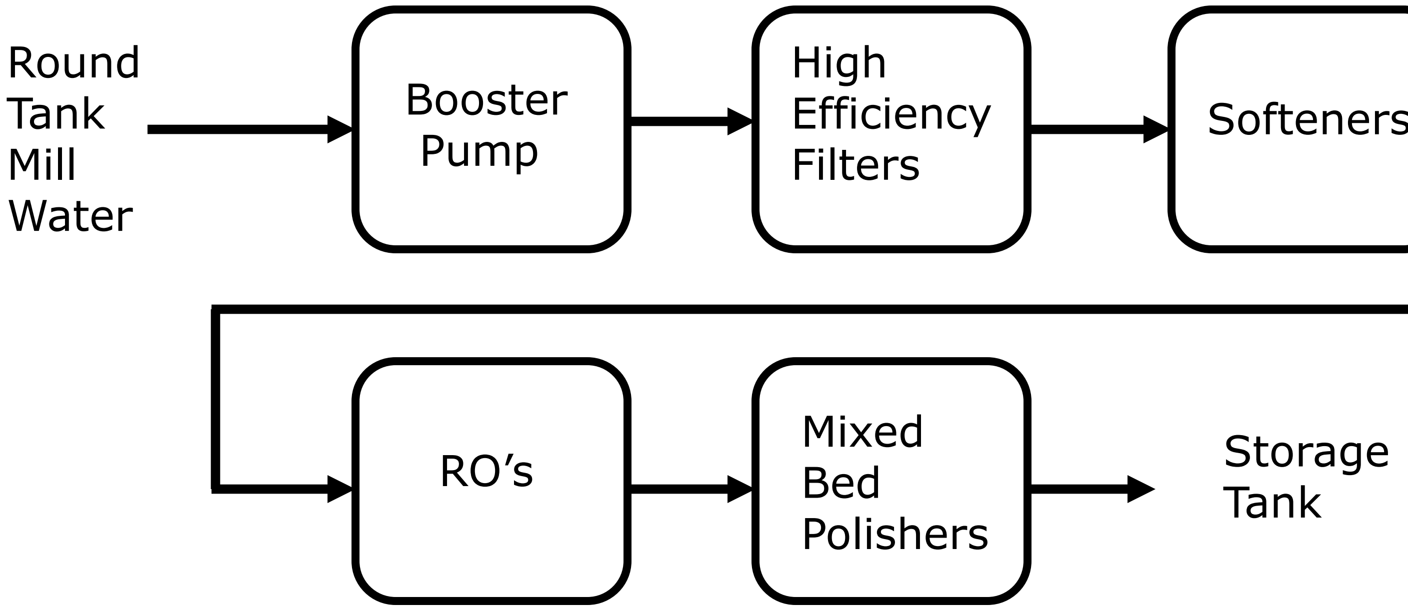
Nippon Paper Cogen Boiler Pretreatment System



Basic Block Diagram of Water Flow



Basic Block Diagram of RO TREATMENT BUILDING



Booster Pump

- Mill water pressure variations
- Too low, RO kick out.
- Protect high pressure pump.

High Efficiency Filters

High Efficiency Filters

Purpose:

- Remove un-dissolved solids
- Particles larger than 0.5 microns

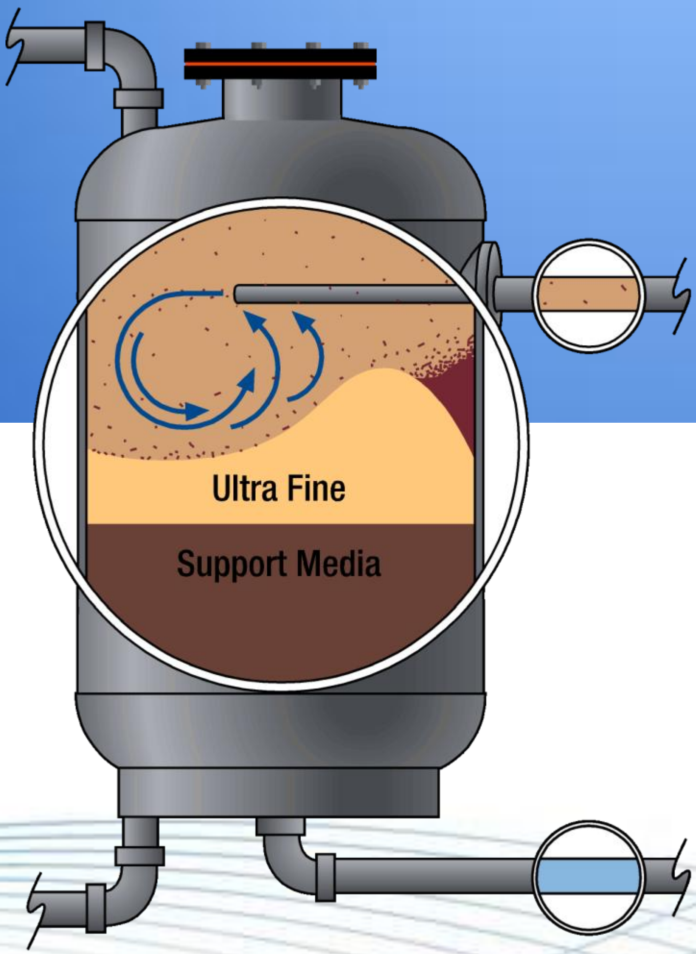
Process:

Pass water through a high efficiency filter

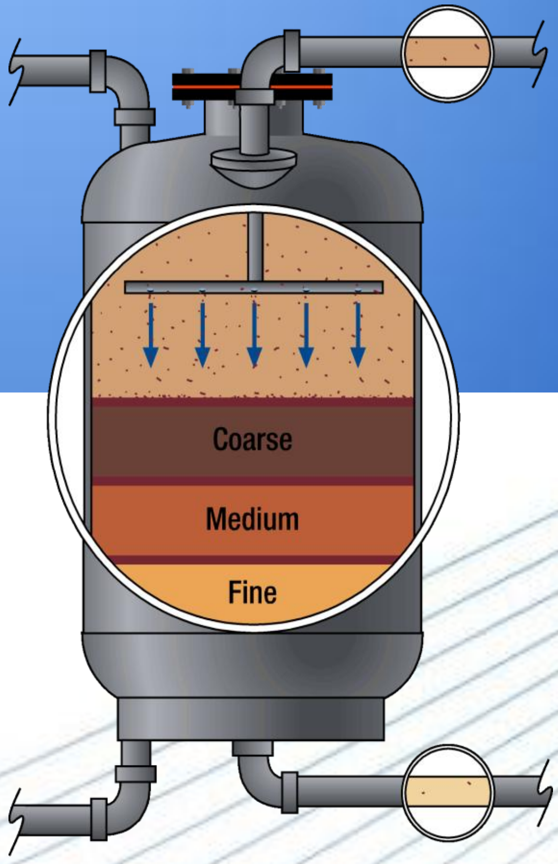
Payoff:

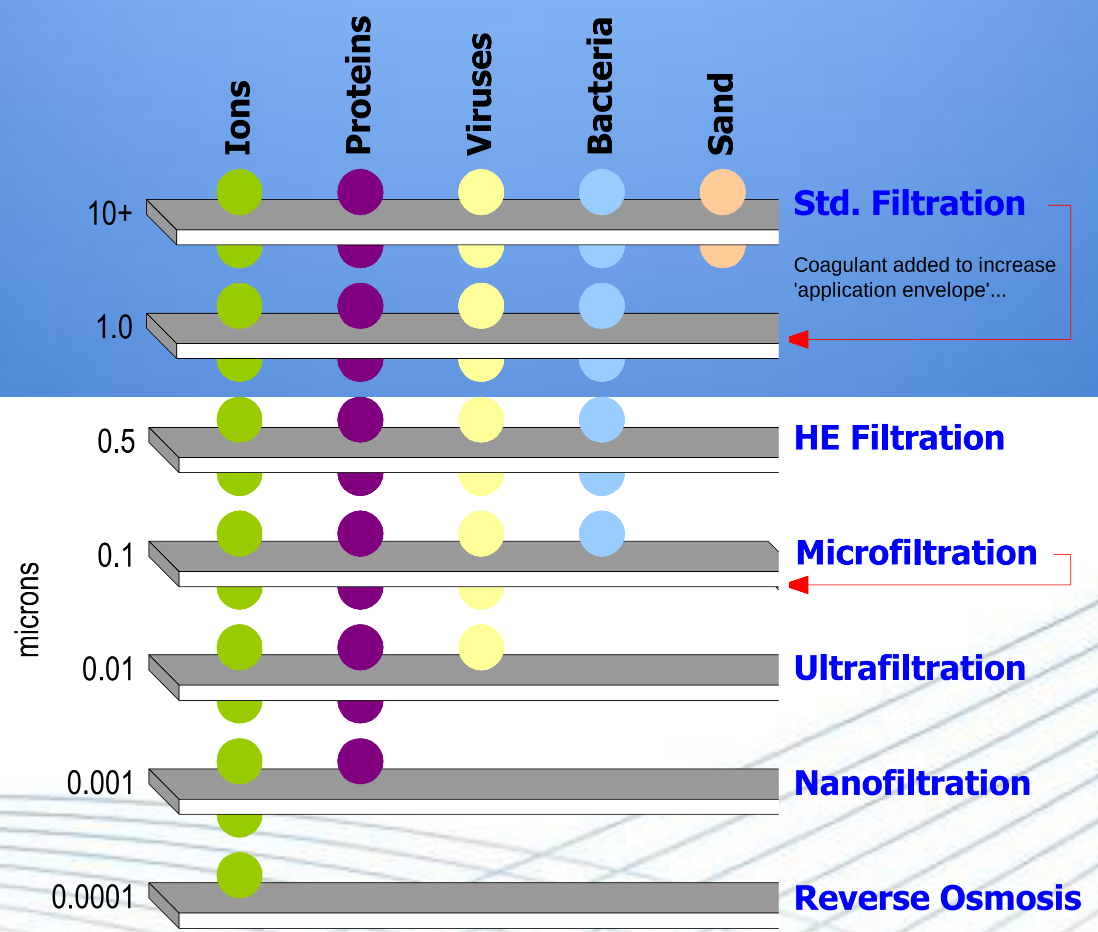
- Produce water of SDI less than 5
- Minimize RO Fouling

UltraSand Plus High Efficiency Filter



Standard Multi-Media Filter

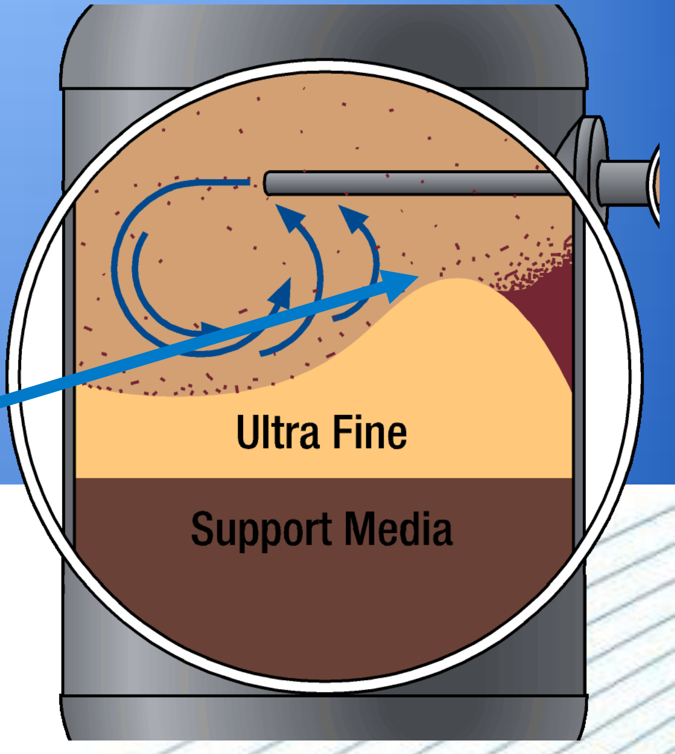




Ions
Proteins
Viruses
Bacteria
Sand
10+
1.0
0.5
0.1
0.01
0.001
0.0001
microns
Std. Filtration
Coagulant added to increase 'application envelope'...
HE Filtration
Microfiltration
Ultrafiltration
Nanofiltration
Reverse Osmosis

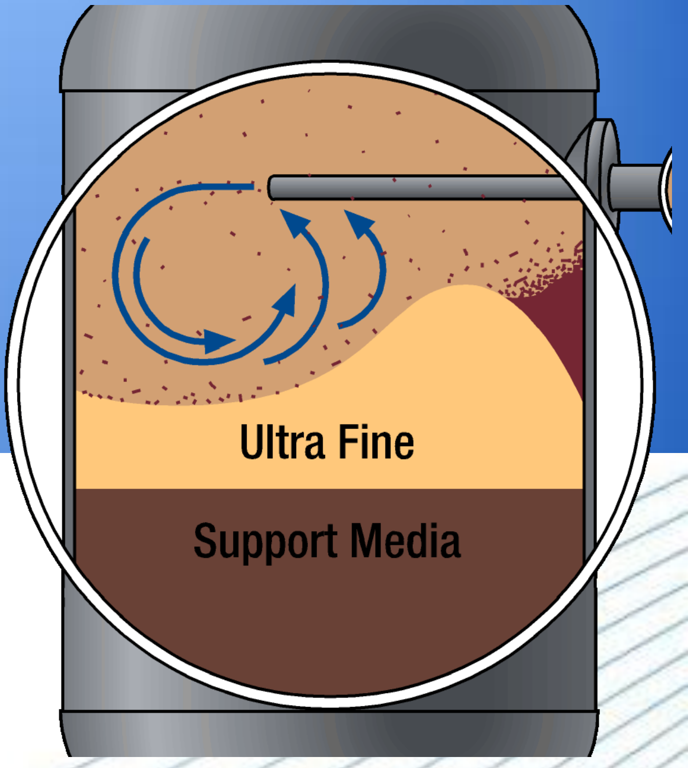
Top Over Bottom (TOB):

- Feed water enters and creates an area of turbulence over the bed and a tangential force that scrubs particles off the bed surface.
- The tangential force carries particles back toward the filter inlet. At the same time, this tangential force also pushes sand towards the filter inlet, creating a "camel hump."
- Behind this "hump" is an area of low turbulence that allows for deposition of particles that have been scrubbed off of the sand.
- This low-turbulence area keeps filling with particles until spilling over the "hump" into the high-turbulence area of the filter.



Top Over Bottom (TOB):

- As particles begin to collect on the turbulent-side of the "hump" adds to the particle loading of the influent water.
- When the loading of solids in the feed water exceeds the capacity of the water to hold them, the particles begin to drop out on the filter bed,
- This increases the differential pressure through the bed, signaling time to backwash the filter.
- Filters are backwashed when the differential pressure reaches 15 psig.



This is all great,
but the mill has a filter plant
Why does it need a High Efficiency Filter

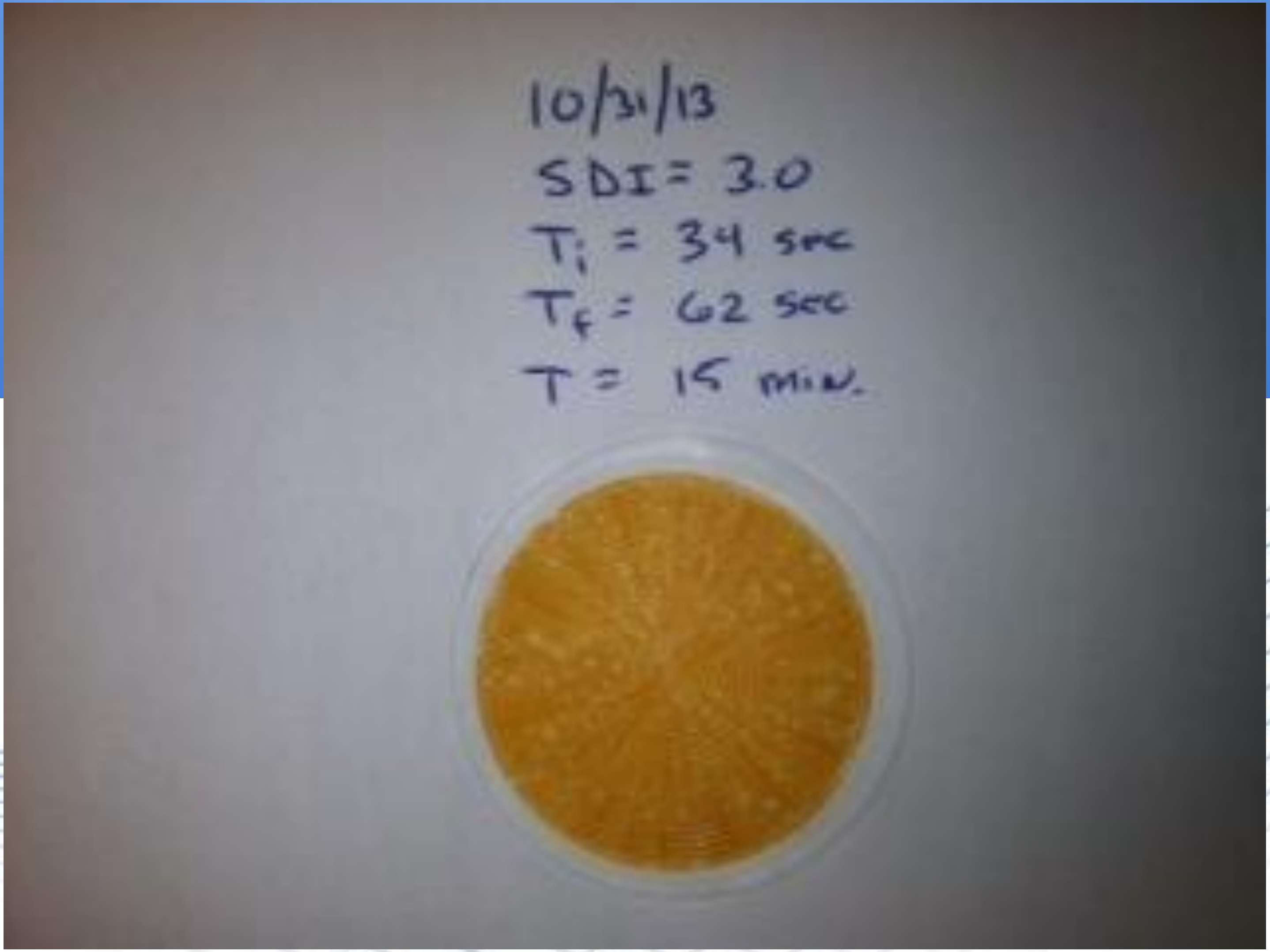
SDI

SILT DENSITY INDEX

SDI Tester

Pressure Gauge

Filter Holder,
0.45 micron, 47 mm


10/31/13
SDI = 3.0
Ti = 34 sec
Tf = 62 sec
T = 15 min.

Silt Density Index

- Measures Fouling potential of RO membranes with suspended solids.
- Higher the number, the greater the potential.
- Most membrane manufactures require an SDI below 5 for warranty.

$$SDI = \frac{1 - (t_i/t_f) \times 100}{T}$$

Where: t_i = initial time to fill to 500 ml
t_f = time after T to fill to 500 ml
T = Time, usually 15 minutes.

BASELINE DATA COLLECTION

From October 2010 to September 2012

SDI were ran 14 times.

Values ranged from 18 - 90

Far too high for an RO
Need to a high efficiency filter

PARTICLE SIZE DISTRIBUTION

Sample sent to a lab, analyze for particle counts and volumes with proscribed micron ranges.

From October 2010 to October 2012, 20 samples sent in to establish baseline.

Analytical Resources
1601 West Diehl Road Naperville IL 60563-1198
Phone: 630-305-1000 Fax Email: globallimssupport@nalco.com

NALCO
Essential Expertise for Water, Energy and Air™

Final - Report Number: 310696
NIPPON PAPER NA
PORT ANGELES WA USA
Sold To: 0001016201 **Ship To:**
Representative: Gregory W Wyrick

Sample Number	NW020897
Date Sampled	19-Jan-2011 14:00
Date Received	26-Jan-2011
Date Completed	28-Jan-2011
Date Authorized	28-Jan-2011

Water Analysis

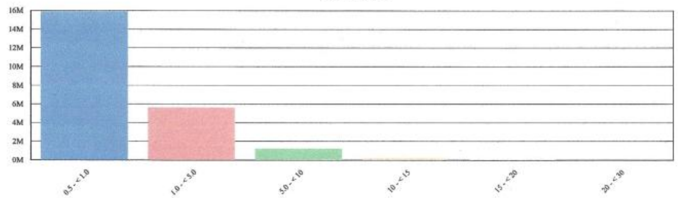
This sample was analyzed as received, the results being as follows:

Sampling point: Filtered Mill Water

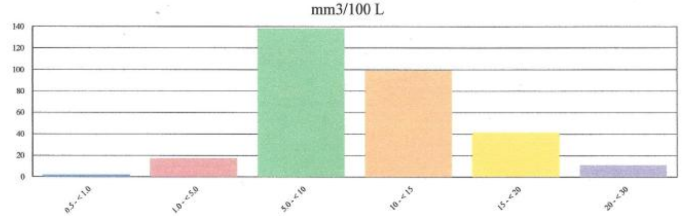
Particle Size Analysis

	Particle Count			Particle Volume		
Micron Range	per 100 ml	Range %	Cum %	mm3/100 L	Range %	Cum %
0.5 - < 1.0	**15,925,398**	**69.5**	**69.5**	**2**	**0.6**	**0.6**
1.0 - < 5.0	**5,611,820**	**24.5**	**94.0**	**17**	**5.5**	**6.1**
5.0 - < 10	**1,223,849**	**5.3**	**99.3**	**138**	**44.7**	**50.8**
10 - < 15	**142,945**	**0.6**	**99.9**	**100**	**32.2**	**83.0**
15 - < 20	**19,399**	**0.1**	**100.0**	**42**	**13.4**	**96.4**
20 - < 30	**1,982**	**0.0**	**100.0**	**11**	**3.6**	**100.0**
Total	**22,925,393**			**309**		

Particle Count
per 100 ml



Particle Volume
mm3/100 L



DNV
An ISO 9001:2008 Certified Laboratory
Cert. # :05424-2003-AQ-HOU-ANAB

Authorized by Acile Said

How Well Does the Filter Work

February 10, 2014

Effluent: SDI = 3.1 Influent: SDI = 18

October 2, 2013

Effluent SDI = 1.06

Influent SDI = 36

PSD Data

Range, micron	Particle % removal	Volume % removal
0.5 - 1	70%	71%
1 – 5	98%	99%
5 – 10	99.7%	99.7
10 - 15	99%	99%
15 – 20	99%	99%
20 – 30	98%	99%
Total	n/a	99%

Operations

- All 3 run at a time.
- Booster pump starts when there is a call for water, ie level is make-up water tank.
- Backwash based on differential pressure.
- Automatically backwash in sequence once differential pressure is reached.
- Takes 8 minutes per unit.

Softeners

Purpose: Remove hardness.

Process: Pass water over cation resin.

Payoff: Protect RO from hardness based scale & no need to add an anti-scalant.

Operations

- 2 units: one in service; one standby
- Scavenge Chlorine out
- Run to a gallons throughput
- Auto switch
- Auto regenerate.
- Operators keep brine tank full of salt

RO

3 Basic Components

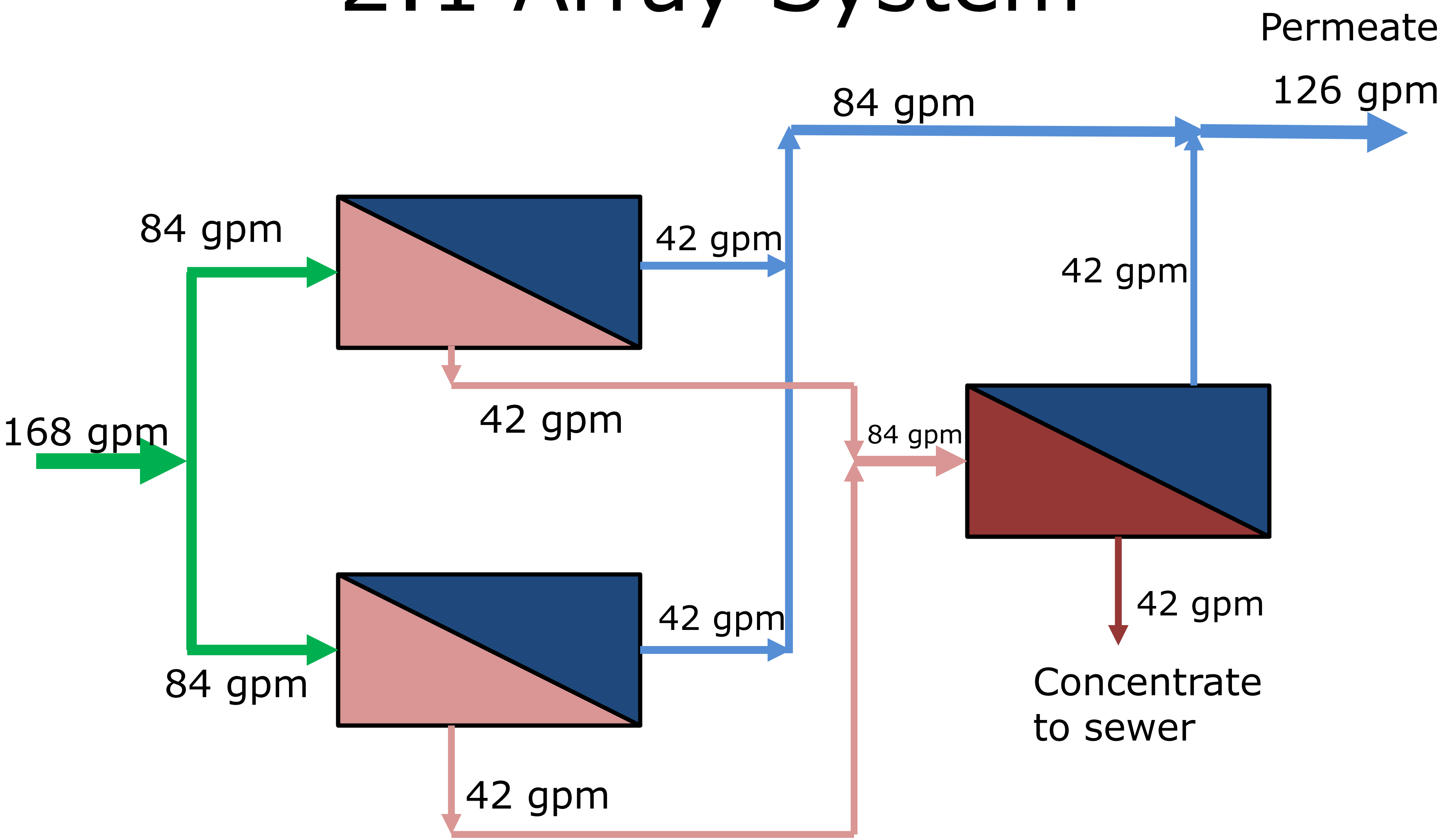
1. Prefilter - Red
2. Pump - Yellow
3. RO Membranes - Blue

Purpose: Remove dissolved ions and colloidal silica from water to condition water for use as boiler feed water.

Process: Water is passed through a semi-permeable membrane.

Payoff: Water is almost good enough for economical use as BFW. Last step is to pass through a mixed bed polisher.

2:1 Array System



75% Recovery
25% Rejection

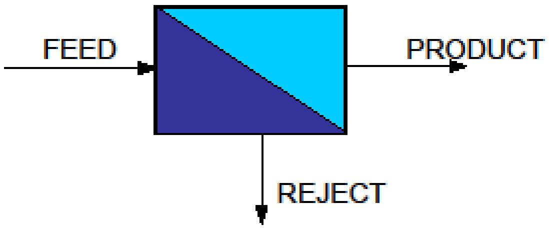
REVERSE OSMOSIS

75% RECOVERY

98% REJECTION = 2% PASSAGE

100 gpm

100 ppm



75 gpm

2 ppm

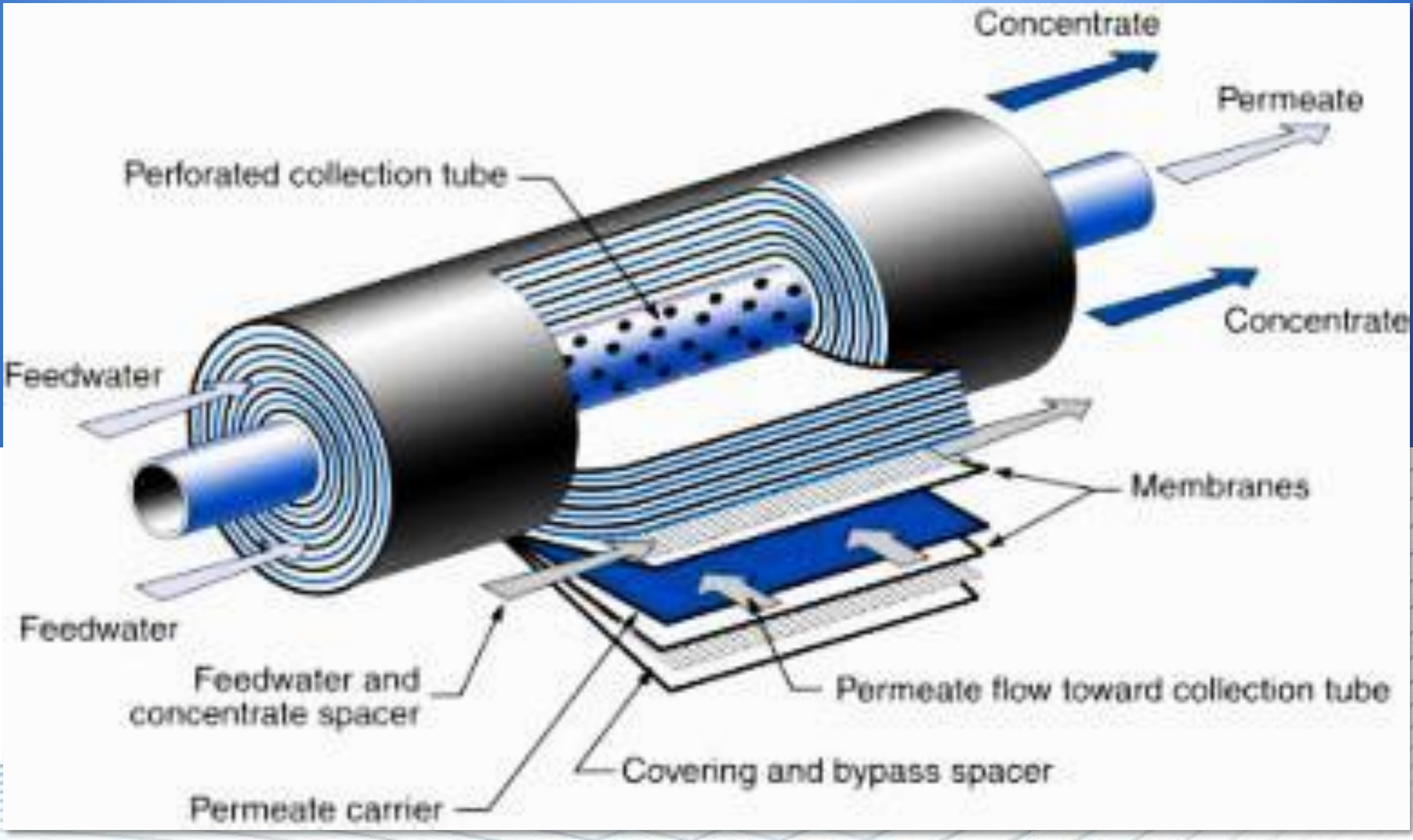
25 gpm

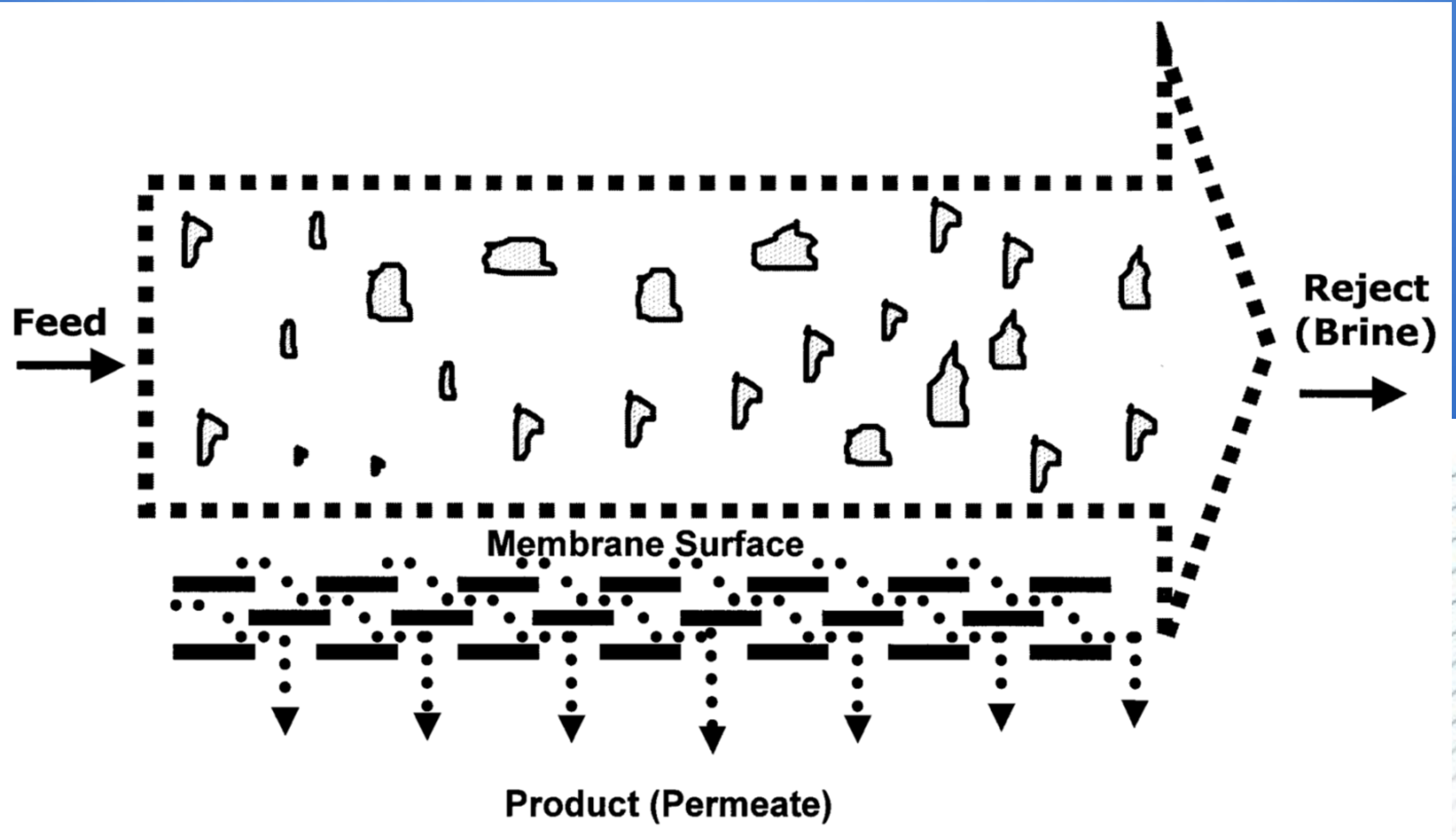
= 4 x 100 ppm = 400 ppm

CONCENTRATION FACTOR: FEED gpm/ REJECT gpm

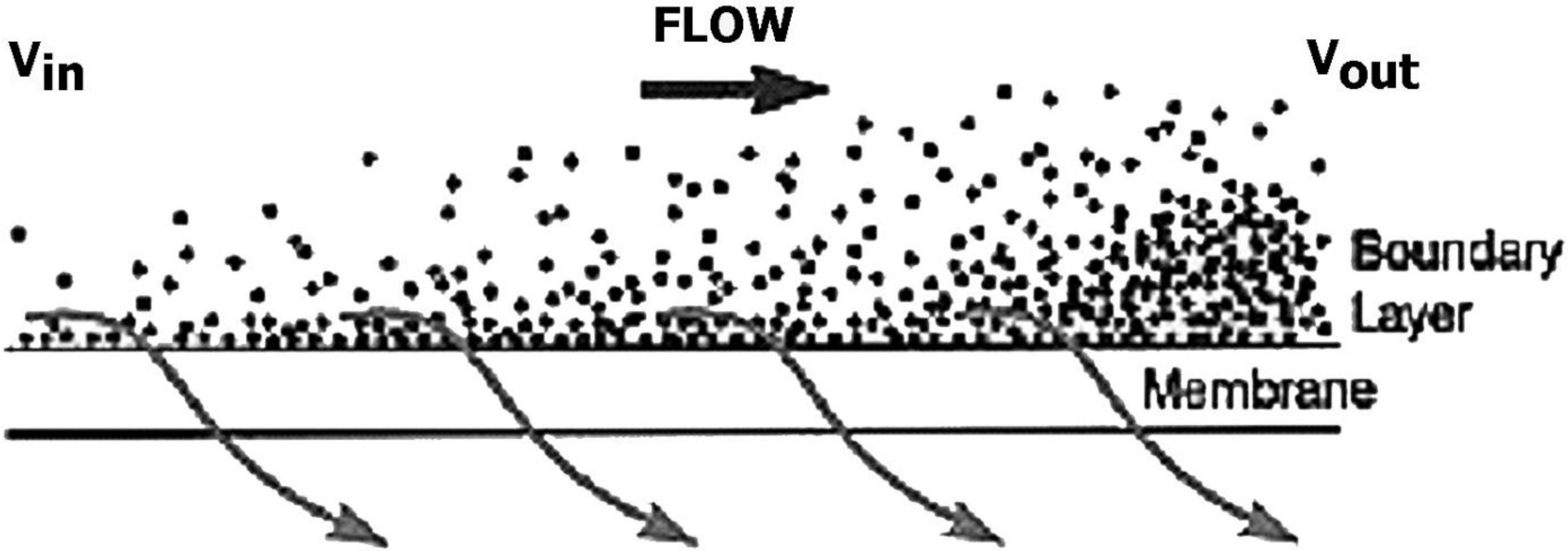
= 100 / 25 = 4

DELIVERING ESSENTIAL EXPERTISE


Concentrate
Permeate
Perforated collection tube
Concentrate
Feedwater
Membranes
Feedwater
Feedwater and
concentrate spacer
Permeate flow toward collection tube
Covering and bypass spacer
Permeate carrier

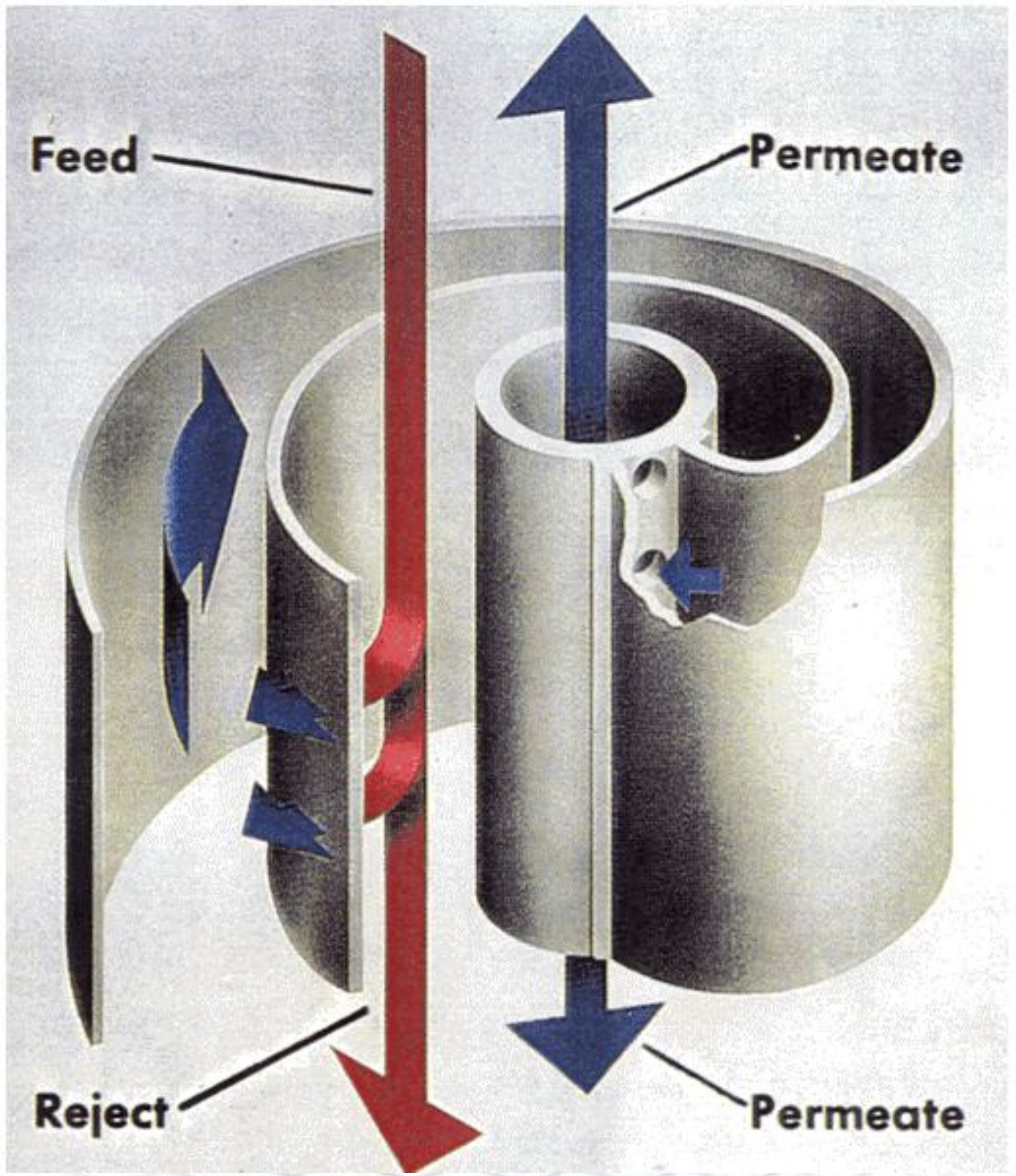

Feed
Reject
(Brine)
Membrane Surface
Product (Permeate)

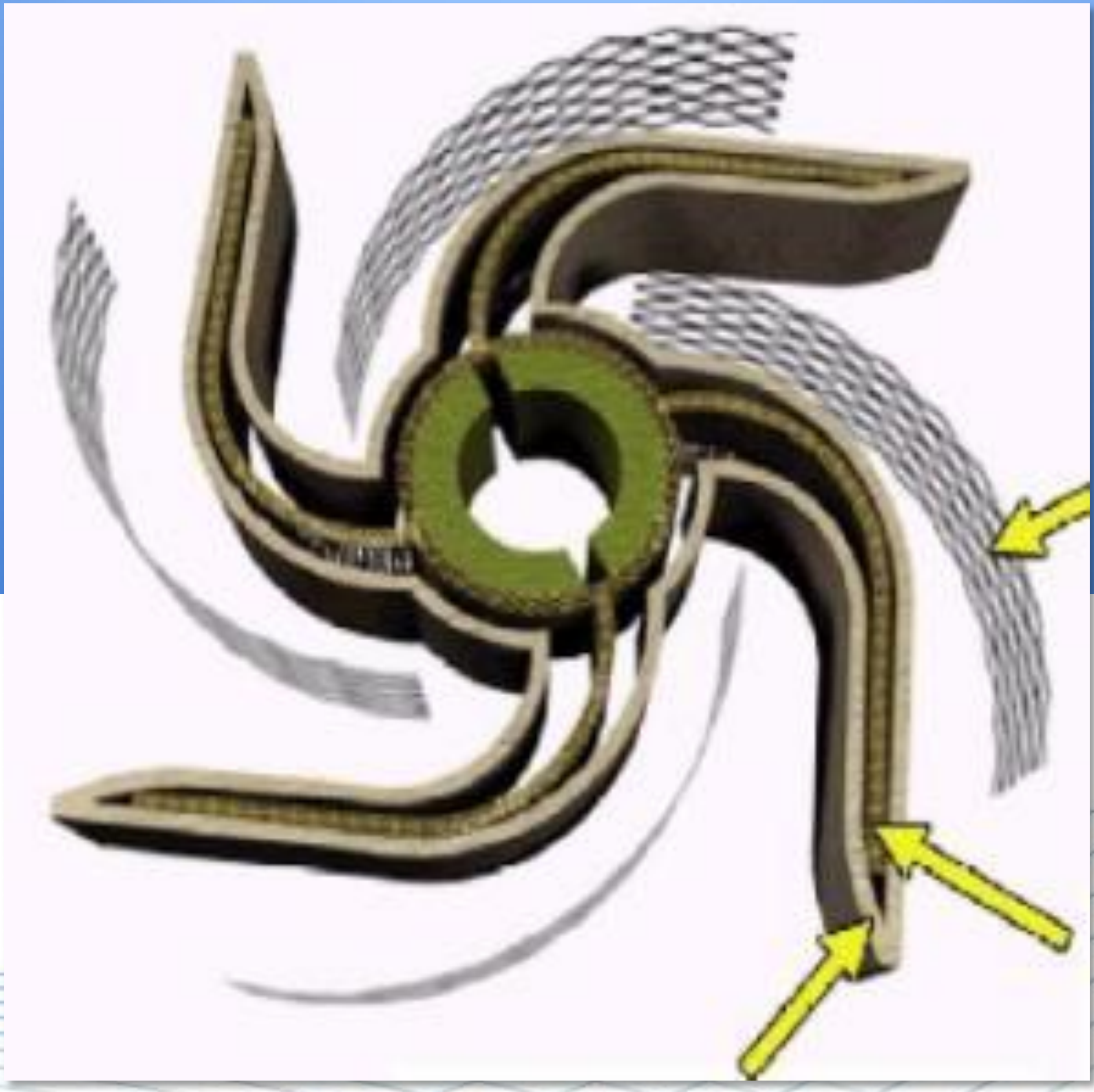
Salt Concentration in the Boundary Layer



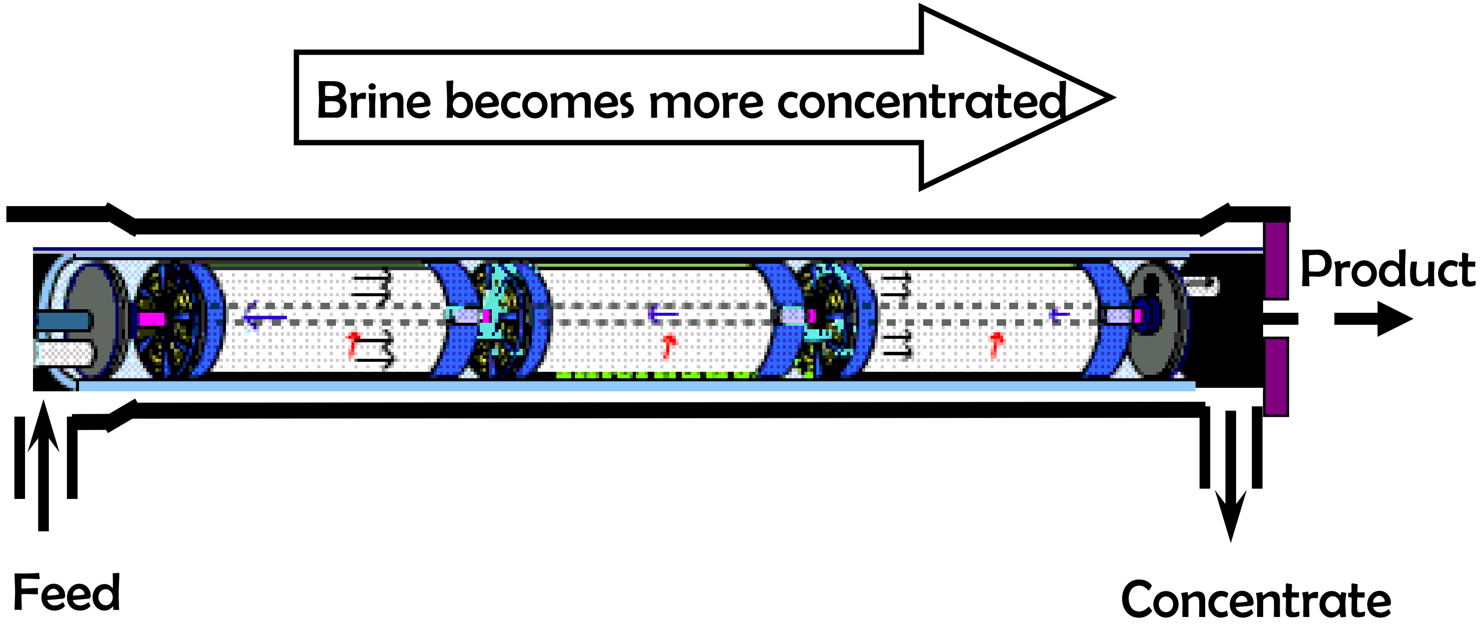
Velocity : $V_{in} > V_{out}$

Salt Conc. : $TDS_{in} < TDS_{out}$

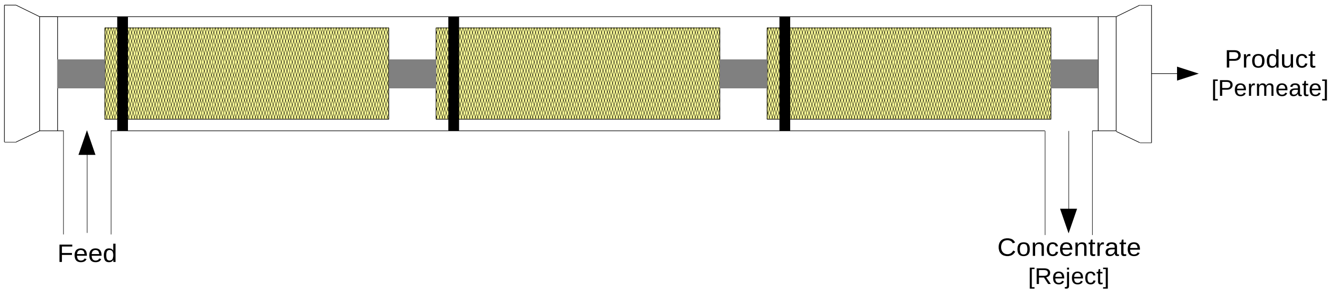

Feed
Permeate
Reject
Permeate


Feed spacer
Permeate spacer
Membrane leaf

- As the feed water travels down the membrane(s), it becomes more concentrated:

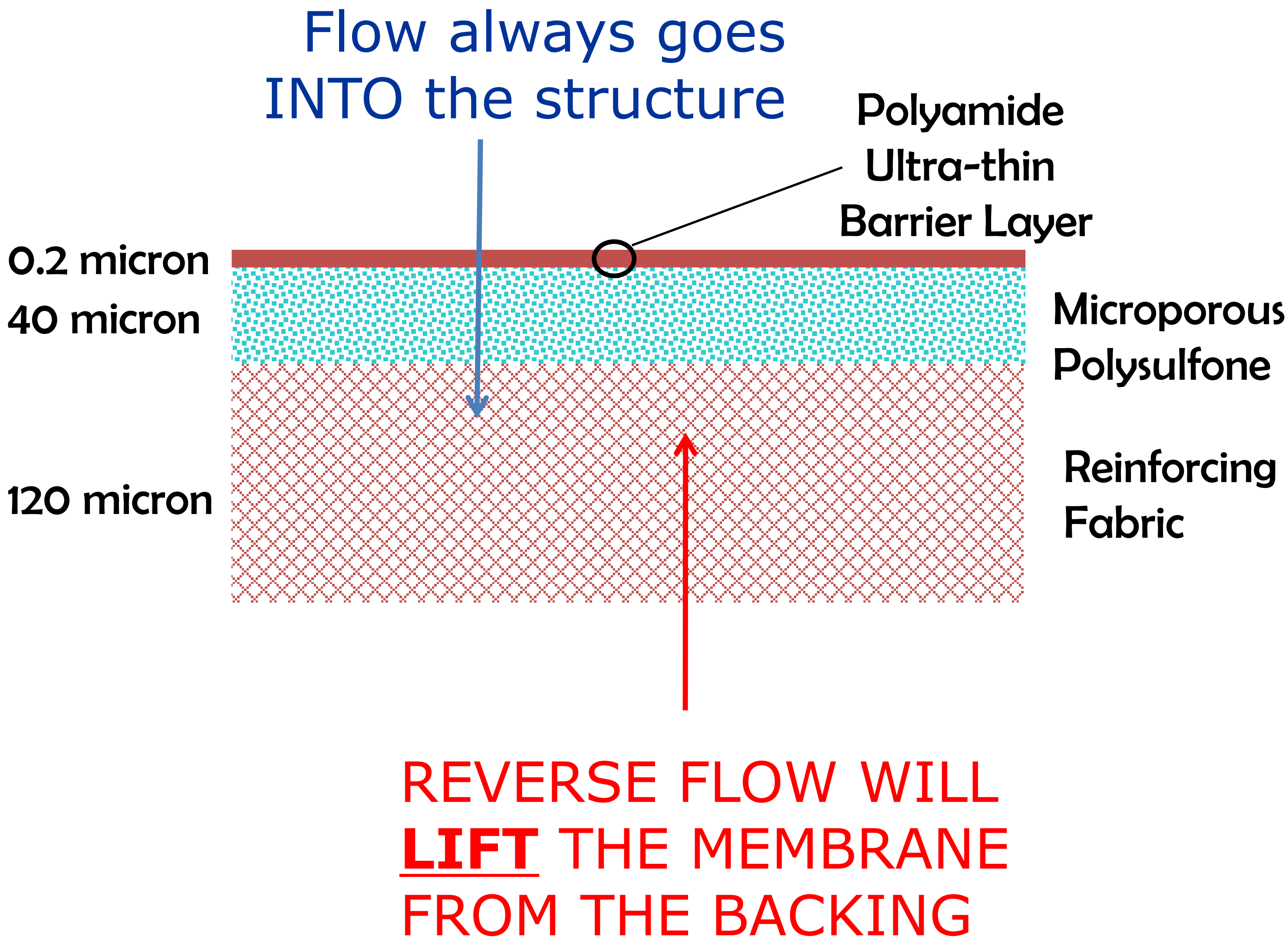


- Pressure Vessel:
  - Multi-Module Pressure Vessel-



Contains 1, 3, 4, 6, or 7 modules in series

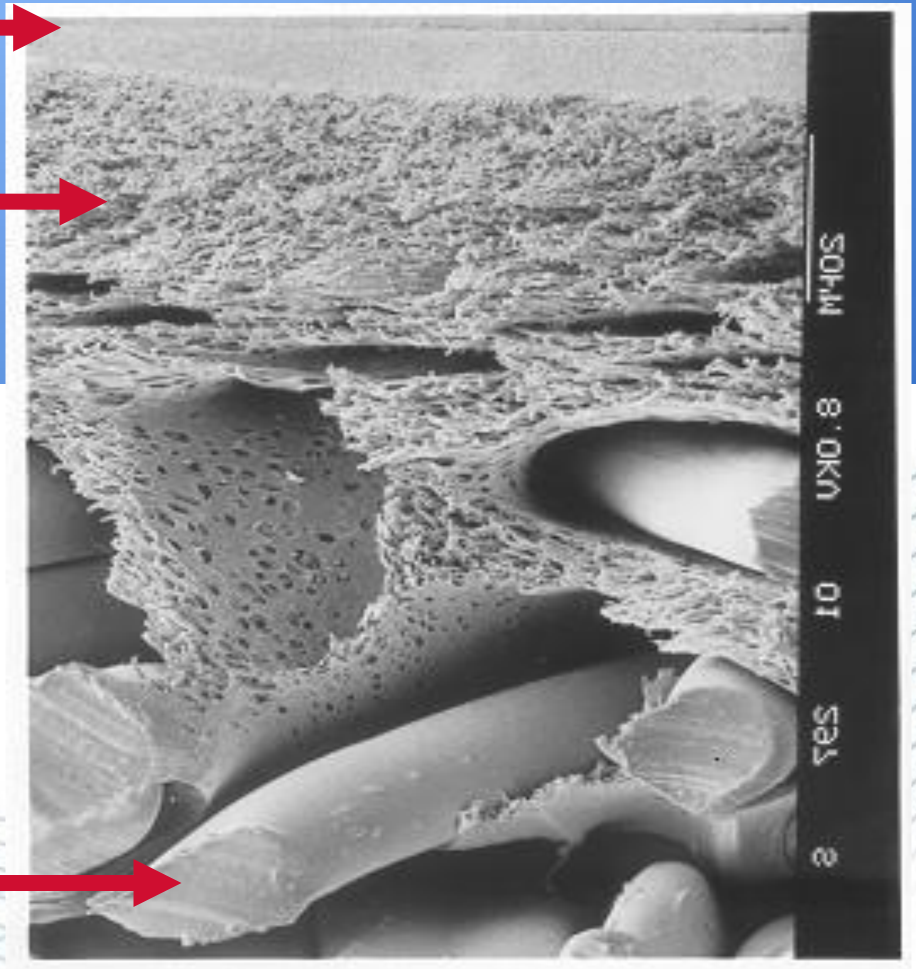
- TFC Membrane:



TFC Membrane

Polyamide Barrier Layer

Polysulfone Backing



Support Layer

Mixed Bed Polisher

- After RO
- Remove any ions (hardness, silica) that gets past the RO.

Mill Water:

Silica: Ave. 6.8 ppm; low: 5.5, high 9.0
98% rejection from RO
Silica in permeate = 0.136 ppm Ave.
0.11 ppm Low
0.18 ppm High

At 50 cycles:
6.8 ppm Ave.
5.5 ppm Low
9 ppm High
Upper boiler limit for silica is 8 ppm

Silica: Ave. 6.8 ppm; low: 5.5, high 9.0
95% rejection from RO
Silica in permeate = 0.34 ppm Ave.
0.275 ppm Low
0.45 ppm High

At 50 cycles:
17 ppm Ave.
13.8 ppm Low
22.5 ppm High
Upper boiler limit for silica is 8 ppm

Can not run at 50 cycles. Have to increase blowdown and run at 23 cycles.

Control and Monitoring


RO Concentrate
INSTRUMENT AIR
RO Concentrate

- Inhibitor Control
- pH
- ORP
- Temperature
- NTU
- Pressures
- Flow


EXIT
NALCO
P-410A
P-410B
SN 913024
PORTA-FEED
NALCO

Automated Tank Level and Usage Reporting

Dashboard Customer - Last 30 Days

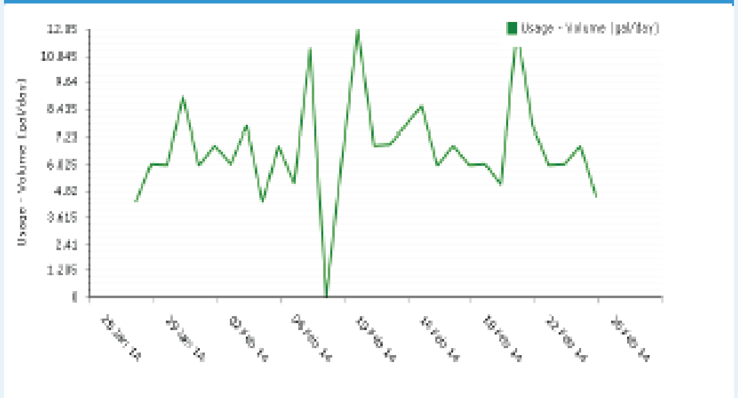
DARIGOLD INC - PORTLAND, OR - DAF Chemical Inventories

Inventory	Product Usage	Tank Name	Tank Serial	Last Update	Current Inventory (Gals)	Usage Ave.30 (GPD)	Usage Ave.7 (GPD)	Usage Ave.2 (GPD)	Days To Reorder Point	Days To Empty
		8187	120076	2/24/2014 8:12:00 AM	145.5	6.9	7.2	6.7	6.3	20.2

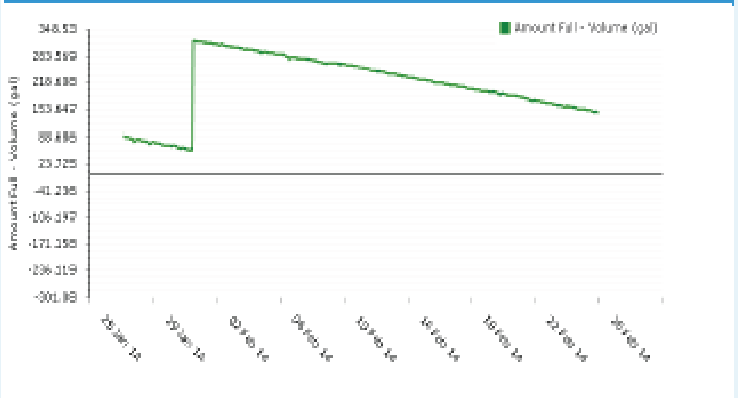
Product Roll Up Inventory Volume - Last 30 Days

Product Name	Base Tank	Last Reading	Oldest Value (Gals)	Deliveries (Gals)	Latest Value (Gals)	Usage (Gals)	Average Usage (GPD)
8187	8187	2/24/2014 8:12:00 AM	88.7	264.2	145.5	207.4	6.9

Usage - Volume (gal/day)- Last 30 Days



Amount Full - Volume (gal)- Last 30 Days



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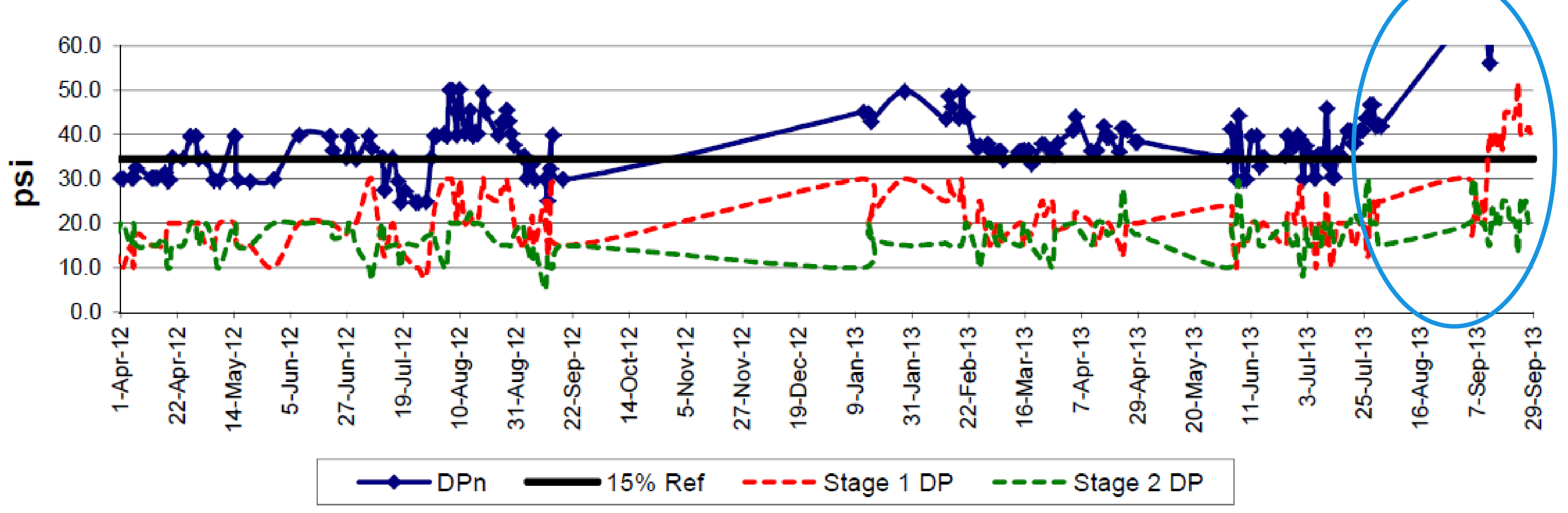
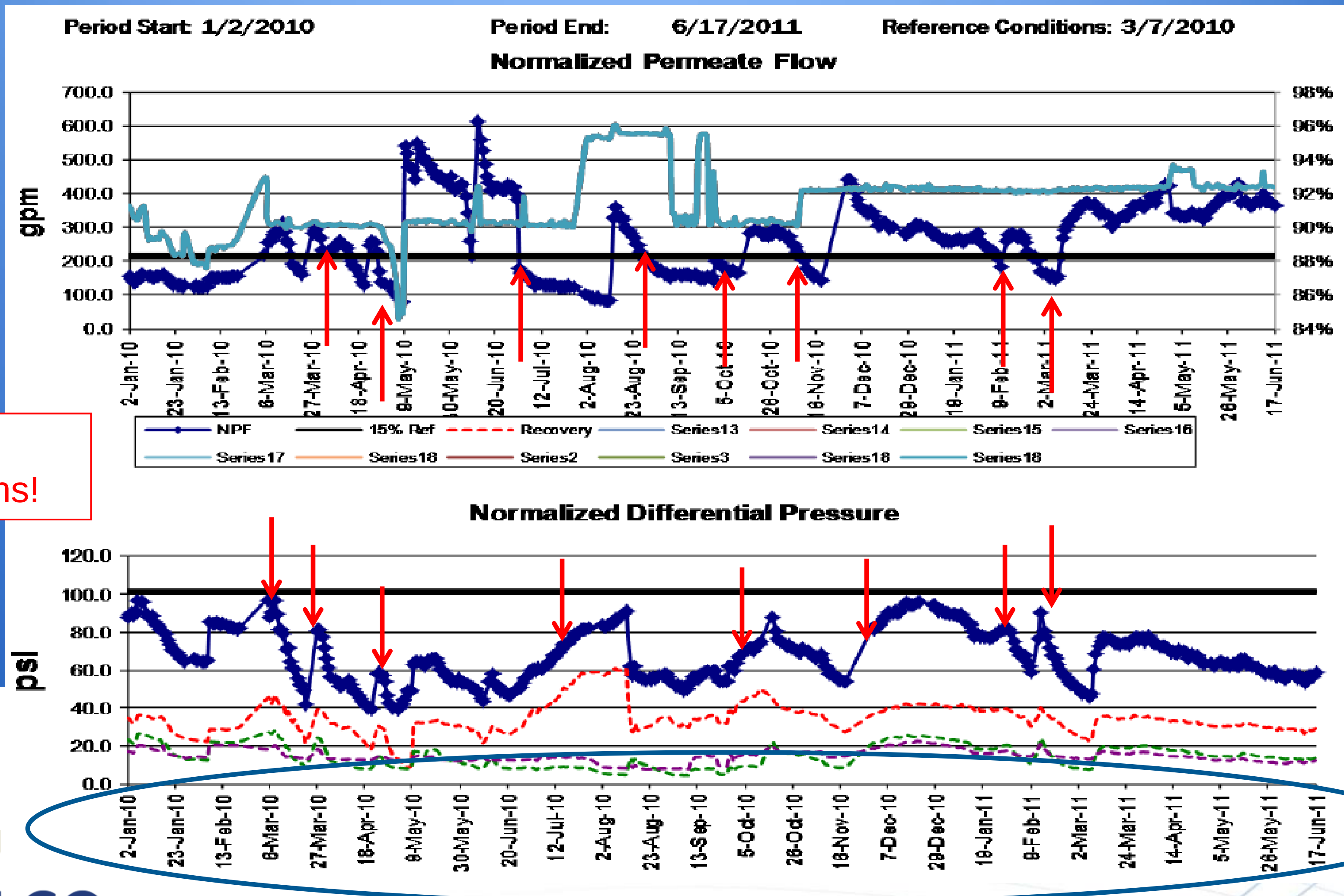
RO Permeate (Polished)
NALCO

Normalized Differential Pressure



3DT for Membranes

Immediate Feedback of Problems



Customer Notifications!

3DTTfM Monitoring

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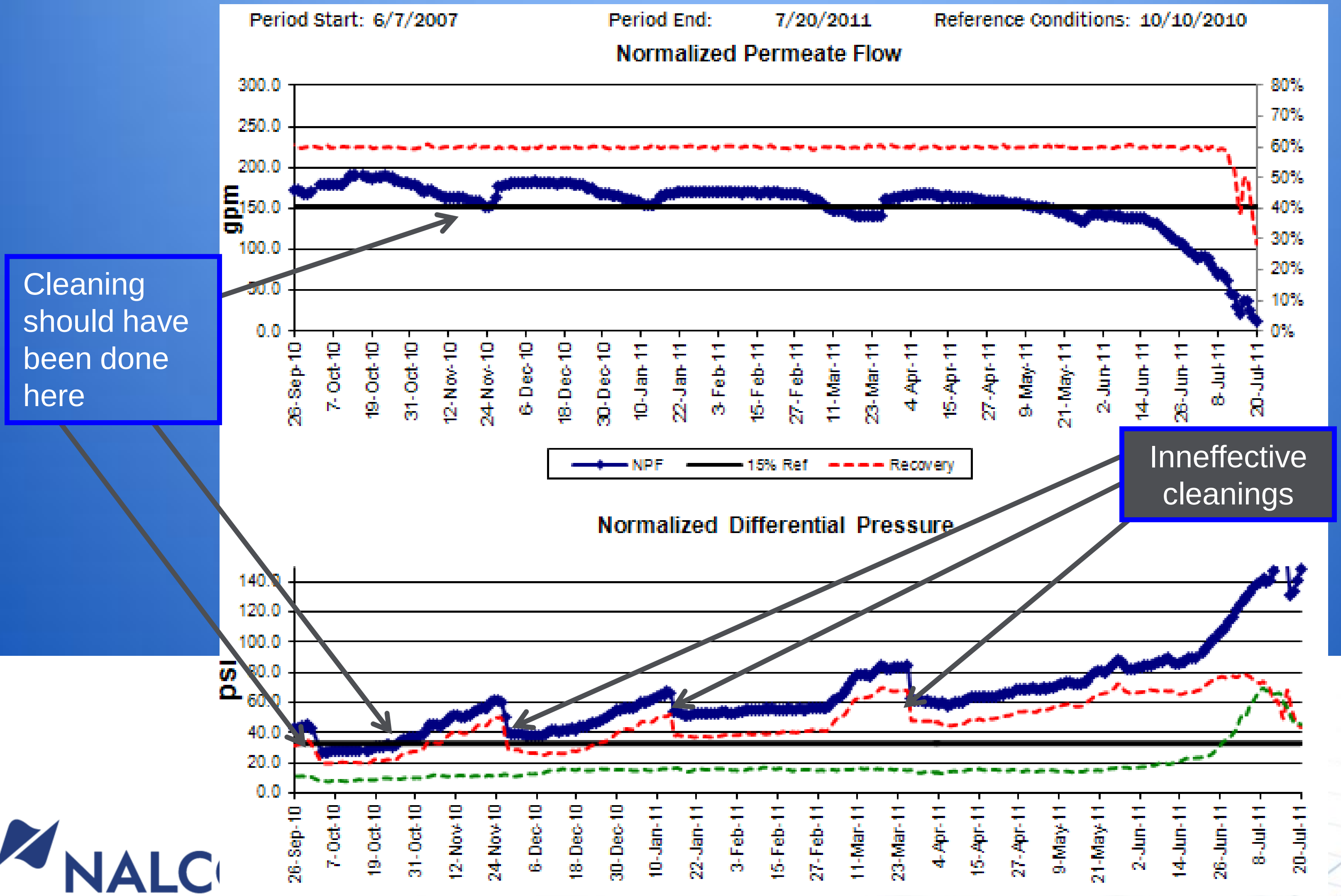
Cleaning at the right time



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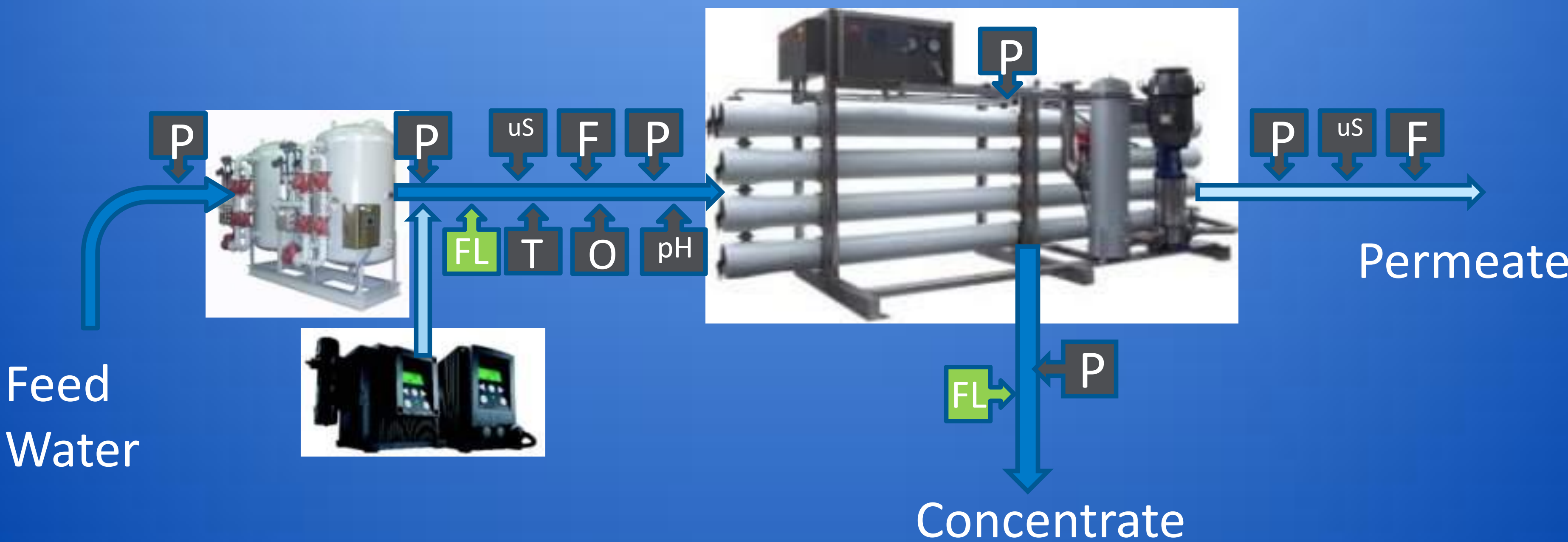
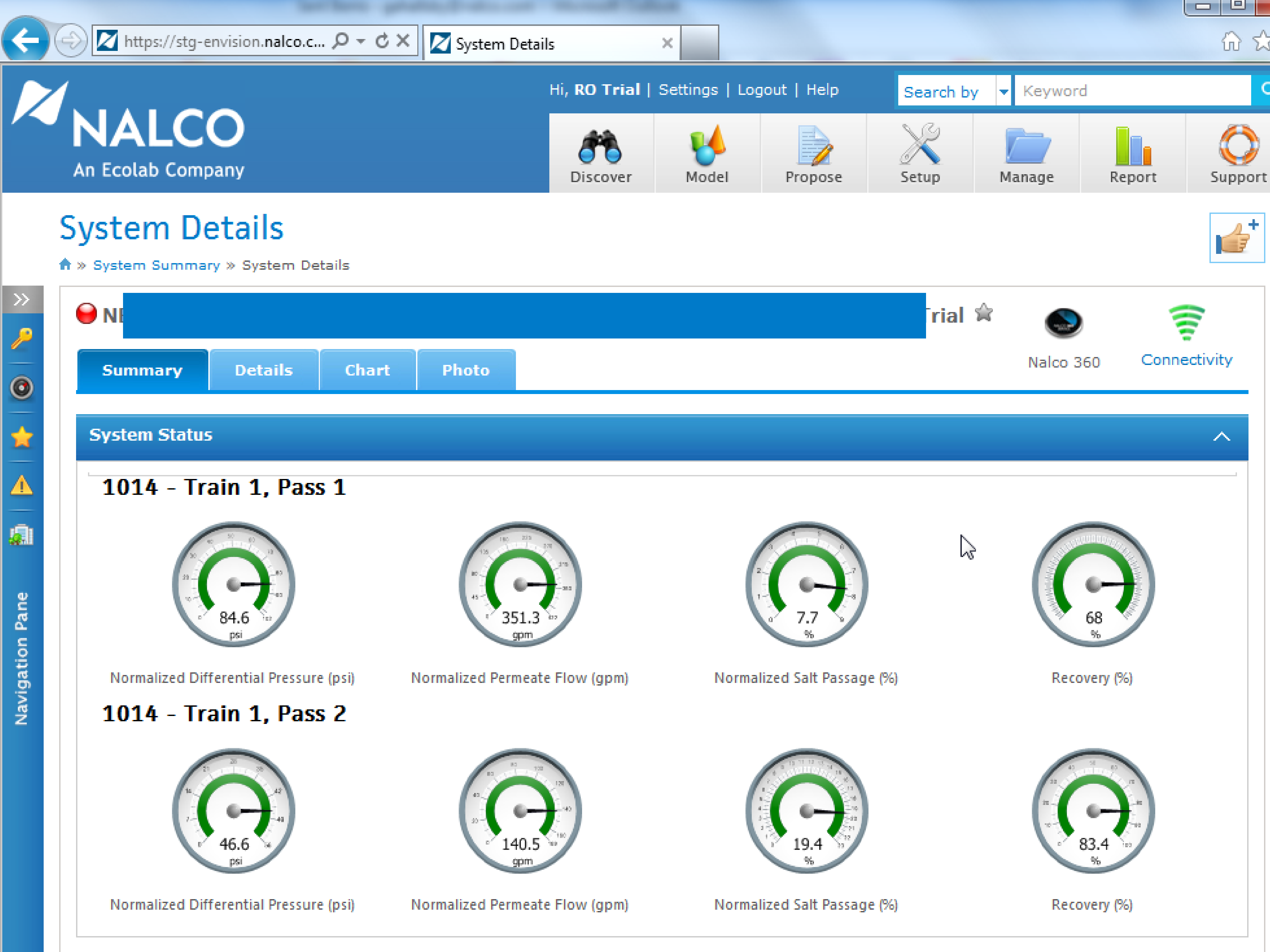
Multiple data streams come into a central unit





https://stg-envision.nalco.c...
System Details
Hi, RO Trial | Settings | Logout | Help
Search by
Keyword
NALCO
An Ecolab Company
Discover
Model
Propose
Setup
Manage
Report
Support
System Details
System Summary » System Details
[redacted]
Nalco 360
Connectivity
Summary
Details
Chart
Photo
Navigation Pane
System Status
1014 - Train 1, Pass 1
84.6
psi
Normalized Differential Pressure (psi)
351.3
gpm
Normalized Permeate Flow (gpm)
7.7
%
Normalized Salt Passage (%)
68
%
Recovery (%)
1014 - Train 1, Pass 2
46.6
psi
Normalized Differential Pressure (psi)
140.5
gpm
Normalized Permeate Flow (gpm)
19.4
%
Normalized Salt Passage (%)
83.4
%
Recovery (%)

https://stg-envision.nalco.c... System Details

System Details

System Summary » System Details

Navigation Pane

[redacted]

Nalco 360 Connectivity

Summary | Details | Chart | Photo

7 Days

1014 - Train 1, Pass 1 | 1014 - Train 1, Pass 2

Parameter Name	Status	Date / Time	Latest Value	Avg.	Min.	Max.	St. Dev.	Low Critical Limit	Low Limit	High Limit	High Critical Limit
	All										
Permeate Flow		03-13-2012 01:50 AM	254.1	329.4	239.8	334.4	6.7				
Normalized Differential Pressure (psi)		03-13-2012 01:50 AM	84.6	65.8	43.9	85.5	2.3				
Normalized Permeate Flow (gpm)		03-13-2012 01:50 AM	351.3	349.7	333	364.9	6.4				
Normalized Salt Passage (%)		03-13-2012 01:50 AM	7.7	2.4	2	7.8	0.5				
Recovery (%)		03-13-2012 01:50 AM	68	75.6	67	82.6	0.9				
Feed Flow		11-10-2011 11:45 PM	379.3	379.3	379.3	379.3	0				
Concentrate Flow		03-13-2012 01:50 AM	119.8	106.3	69.3	119.8	4				
Permeate Conductivity		03-13-2012 01:50 AM	35.6	8.7	7	35.6	2.3				
Feed Conductivity		03-13-2012 01:50 AM	265	252.3	244	265	3.3				
Feed pH		03-13-2012 01:50 AM	7.6	7.6	7	7.8	0.2				

Weekly Operations Report

Customer Name : [redacted]

Address : [redacted]

City : [redacted]

State Province : [redacted]

Nalco Representative: Tripp Morris

Postal Code :

Date Report Issued : 01/06/2012

System Name : 3DTfM Trial RO

Train : Train A

email : whmorris@nalco.com

Range of Report: 11/15/2011--11/22/2011

Attention:

Copy To:

Nalco Copy To:

Data Dashboard

Parameters	Current Status	Reference Value	Current Value	% Change
Normalized Permeate Flow (gpm)		215.840	229.440	6.30%
Normalized Differential Pressure (psi)		53.520	60.949	13.88%
Normalized Salt Passage (%)		0.015	0.030	100.00%
Antiscalant Dosage (ppm)			11.547	

Corrective Action Analysis

Normalized Permeate Flow

The Normalized Permeate Flow (NPF) parameter defines the ability of the RO system to meet water flow requirements. The normalization aspect of this value is very important because it accounts for changes in various system conditions that would prevent an accurate comparison of permeate delivery at different times. During the report period, the calculated NPF did not significantly vary from the baseline condition established for this unit. As such no changes or corrective measures in unit operation to achieve water flow are recommended.

Normalized Differential Pressure

The Normalized Differential Pressure (NDP) parameter defines the resistances to flow through the RO system, specifically fouling and scale formation. The normalization aspect of this value is very important because it accounts for changes in various system conditions that would prevent an accurate comparison of permeate delivery at different times. During the report period the calculated NDP was in the range of 10 - 15% higher than what was observed during the baseline operating condition for this unit. This is an indication that a general troubleshooting process should be implemented on the unit to detect possible causes for the increased pressure drop, such as suspended solids fouling in the front membranes or scale development where the ionic concentrations are higher. Should the condition not be resolved, a system cleaning may be required. Operation of an RO system with more than a 15% increase in pressure drop may indicate a condition that cleaning may not fully resolve.

Normalized Salt Passage

The Normalized Salt Passage (NSP) parameter defines the ability of the RO system to meet permeate chemistry specifications. The normalization aspect of this value is very important because it accounts for changes in various system conditions that would prevent an accurate comparison of permeate quality at different times. During the report period the calculated NSP was more than 15% higher than what was observed during the baseline operating condition for this unit. This is an indication that a general troubleshooting process should be implemented on the unit to detect possible causes for the deterioration in permeate quality and that a system cleaning may be required. Continued operation of an RO system with more than a 15% increase in salt passage could result in a condition that cleaning may not fully resolve.

Comments

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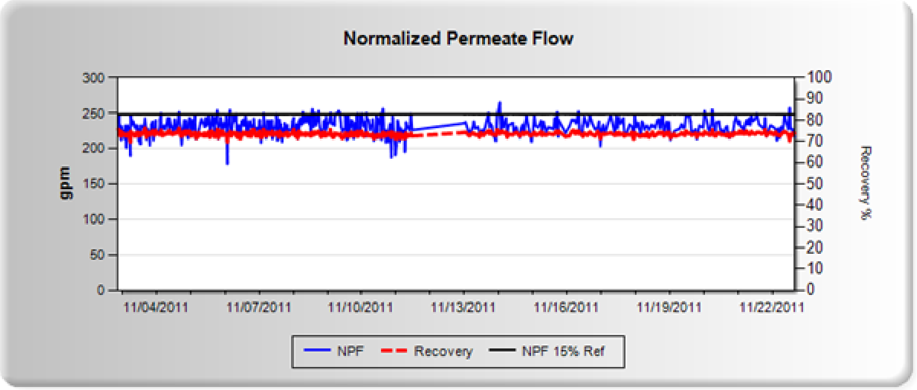
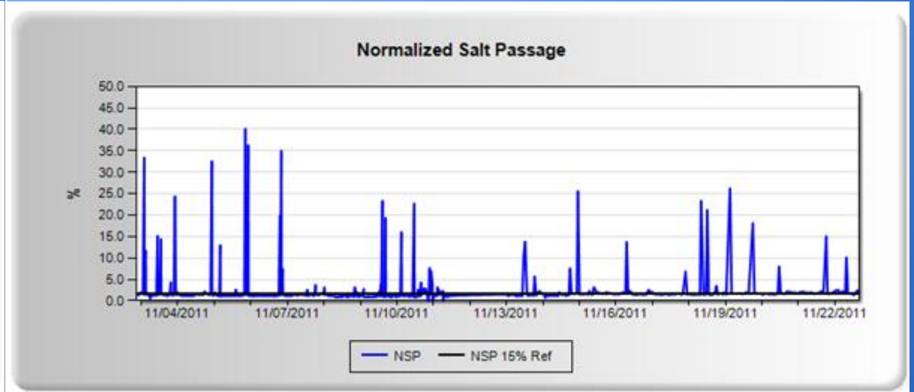
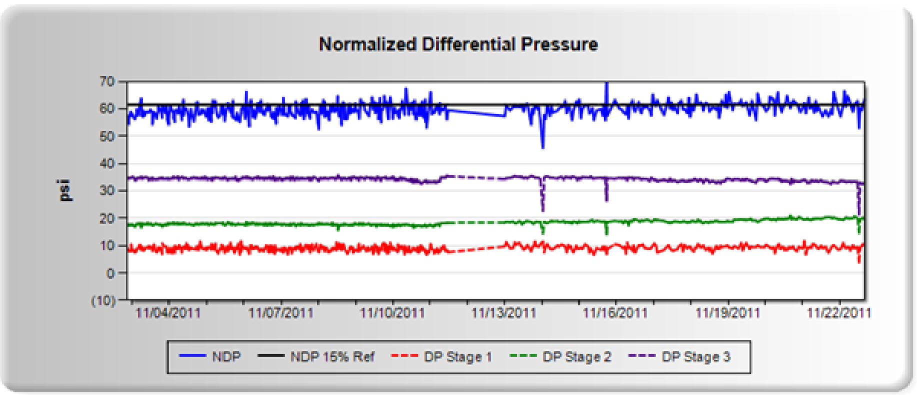
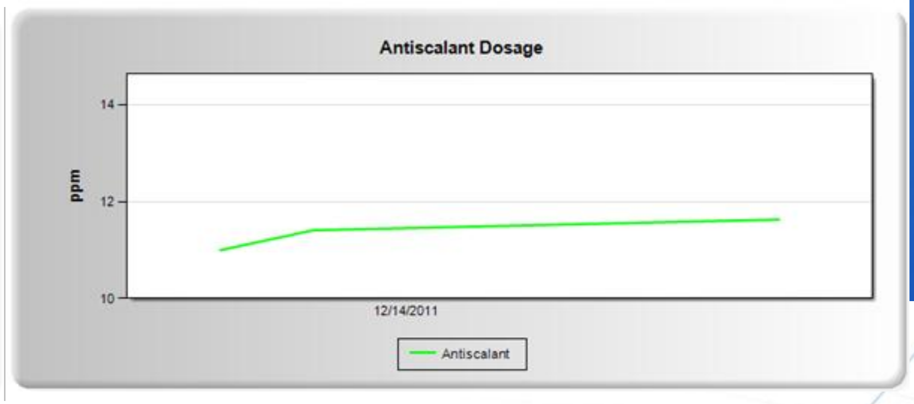
Weekly Operations Report

Normalized Trends-[redacted]









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THANK YOU!