APPENDIX A

Part 1: Data-Recorded Measurements and Laboratory Sampling

Summary of Inorganic Analyses – Dow NF270.

Analyte	Units	Feed	Permeate	Concentrate
pH, field	standard units	7.35	7.16	7.59
Conductivity, field	micromho/cm	2083	1452	3063
Total Dissolved Solids	mg/l	1216	752	2162
Metals, Cations				
Aluminum	mg/l	ND	ND	ND
Ammonia	mg/l	2.24	2.03	3.30
Barium	mg/l	0.07	0.03	0.14
Beryllium	mg/l	ND	ND	ND
Cadmium	mg/l	ND	ND	ND
Calcium	mg/l	79.95	34.30	153.50
Chromium	mg/l	ND	ND	ND
Copper	mg/l	0.01	0.16	0.02
Iron	mg/l	0.05	ND	0.13
Lead	mg/l	ND	0.06	ND
Magnesium	mg/l	29.75	11.05	59.25
Manganese	mg/l	0.03	0.01	0.06
Molybdenum	mg/l	ND	ND	0.02
Nickel	Mg/l	ND	ND	0.023
Potassium	mg/l	25.50	18.21	36.50
Sodium	mg/l	211.50	161.02	257.50
Strontium	mg/l	1.15	0.47	2.28
Vanadium	mg/l	ND	ND	ND
Zinc	mg/l	0.06	0.14	0.07
Anions				
Alkalinity, bicarbonate	mg/l as $CaCO_3$	164	107	266
Alkalinity, total	mg/l as $CaCO_3$	168	108	262
Arsenic	mg/l	ND	ND	ND
Chloride	mg/l	402	378.50	442.50
Nitrate	mg/l as N	4.5	5	ND*
Nitrite	mg/l as N	ND	ND	ND
Orthophosphate	mg/l as P	0.86	ND	2.43
Silica	mg/l	8.10	7.23	8.90
Sulfate	mg/l	266.50	ND	752

micromho/cm = micromho per centimeter
mg/l = milligrams per liter
$CaCO_3$ = milligrams as calcium carbonate
N = nitrate
P = phosphorus
ND = not detected
*MDL of 4 mg/l on concentrate samples

Handheld Analytical Measurements/Readings

Part 1 (June 2017)

Date	6/1/2017	6/2/2017	6/2/2017	6/2/2017	6/3/2017	6/3/2017	6/4/2017	6/4/2017	6/5/2017	6/5/2017	6/6/2017	6/6/2017	6/6/2017
Membrane	**Dow NF270**												
Feed Temp, degF	85	85	85	85	85	86	85	86	85	85	86	85	86
Pressure, psi													
Pumped Feed	35	35	35	30	37		30		30	36	35	30	35
Recycle/Concentrate	30	30	30	30	33		25		30	32	35	30	33
Flow, gpm													
Permeate	1.65	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.57	1.5	1.6	1.55
Concentrate	0.6	0.6	0.6	0.5	0.6	0.5	0.6	0.4	0.6	0.6	0.6	0.6	0.6
Recycle	0.6	0.6	0.6	0.65	0.6	0.6	0.65	0.65	0.6	0.62	0.6	0.6	0.6
Conductivity, uhmo/cm													
Feed			2138		2067		30	1600		2060		2058	2083
Permeate			1469		1422					1488		1445	1452
Concentrate			3225		3131					3094		3082	3063
pH													
Feed			7.41		7.41					7.33		7.36	7.35
Permeate			7.16		7.28					7.15		7.05	7.16
Concentrate			7.56		7.58					7.48		7.52	7.59
Metering Pump													
Stroke Speed %	55	55	55	55	25	26	26	26	30	30	35	30	25
Stroke Length %	50	49	49	48	25	26	26	26	30	30	32	30	70
Tank Level	20	20	20	20	20	20	20	20	20	20	20	20	20
Run Hours	**2214**	**2229**	**2229**	**2250**	**2254**	**2263**	**2279**	**2288**	**2300**	**2308**	**2325**	**2300**	**2332**
Calculations													
Membrane area	82	82	82	82	82	82	82	82	82	82	82	82	82
Calculate system recovery	73%	73%	73%	76%	73%	76%	73%	80%	73%	72%	71%	73%	72%
Calculate arraye recovery	58%	57%	57%	58%	57%	59%	56%	60%	57%	56%	56%	57%	56%
Calculate Flux, gfd	14.5	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	13.8	13.2	14.0	13.6

Summary of Inorganic Analyses – CSM NE.

Analyte	Units	Feed	Permeate	Concentrate
pH, field	standard units	7.48	7.35	7.85
Conductivity, field	micromho/cm	2059	1402	3113
Total Dissolved Solids	mg/l	1254	724	2054
Metals, Cations				
Aluminum	mg/l	ND	ND	ND
Ammonia	mg/l as N	2.35	2.08	3.01
Barium	mg/l	0.09	0.02	0.20
Beryllium	mg/l	ND	ND	ND
Cadmium	mg/l	ND	ND	ND
Calcium	mg/l	81.4	28	174.50
Chromium	mg/l	ND	ND	ND
Copper	mg/l	0.02	0.06	0.04
Iron	mg/l	0.05	ND	0.12
Lead	mg/l	ND	ND	ND
Magnesium	mg/l	31.75	5.20	76.75
Manganese	mg/l	0.02	ND	0.06
Molybdenum	mg/l	ND	ND	ND
Nickel	mg/l	ND	0.06	ND
Potassium	mg/l	25	19.50	34
Sodium	mg/l	257.50	209.50	340.50
Strontium	mg/l	1.20	0.31	2.73
Vanadium	mg/l	ND	ND	ND
Zinc	mg/l	0.09	0.07	0.10
Anions				
Alkalinity, bicarbonate	mg/l as $CaCO_3$	167	93	297
Alkalinity, total	mg/l as $CaCO_3$	164	92	294
Arsenic	mg/l	ND	ND	ND
Chloride	mg/l	374.5	351	408
Nitrate	mg/l as N	4.20	4.50	ND*
Nitrite	mg/l as N	ND	ND	ND
Orthophosphate	mg/l as P	2.22	ND	5.92
Silica	mg/l	9.50	9.10	10.50
Sulfate	mg/l	251.5	ND	685.5

micromho/cm = micromho per centimeter
mg/l = milligrams per liter
$CaCO_3$ = milligrams as calcium carbonate
N = nitrate
P = phosphorus
ND = not detected
*MDL of 4 mg/l on concentrate samples

Handheld Analytical Measurements/Readings

Part 1 (June 2017)

Date	6/6/2017	6/7/2017	6/7/2017	6/8/2017	6/8/2017	6/9/2017	6/9/2017	6/10/2017	6/11/2017
Membrane	**CSM NE**								
Feed Temp, degF	86	86	86	86	86	86	86	86	86
Pressure, psi									
Pumped Feed	35	37		40		40	40	40	40+
Recycle/Concentrate	33	33		35		36	35	35	39
Flow, gpm									
Permeate	1.65	1.65	1.7	1.6	1.6	1.6	1.6	1.5	1.5
Concentrate	0.63	0.67	0.8	0.63	0.6	0.63	0.6	0.6	0.65
Recycle	0.63	0.63	0.6	0.6	0.62	0.63	0.6	0.7	0.65
Conductivity, uhmo/cm									
Feed		2114	1610	2094			2059		
Permeate		1430		1403			1402		
Concentrate		3226		3183			3113		
pH									
Feed		7.75		7.22			7.48		
Permeate		7.8		7.03			7.35		
Concentrate		7.9		7.43			7.85		
Metering Pump									
Stroke Speed %	25	25	30	25	30	25	30	30	30
Stroke Length %	70	70	70	70	70	70	70	70	70
Tank Level	20	20	20	20	20	20	20	19	19
Run Hours	**2333**	**2352**	**2359**	**2375**	**2388**	**2396**			
Calculations									
Membrane area	85	85	85	85	85	85	85	85	85
Calculate system recovery	72%	71%	68%	72%	73%	72%	73%	71%	70%
Calculate arraye recovery	57%	56%	55%	57%	57%	56%	57%	54%	54%
Calculate Flux, gfd	14.0	14.0	14.4	13.6	13.6	13.6	13.6	12.7	12.7

Summary of Inorganic Analyses – Hydranautics Nano BW.

Analyte	Units	Feed	Permeate	Concentrate
pH, field	Standard units	7.54	7.18	7.61
Conductivity, field	micromho/cm	2085	1361	3030
Total Dissolved Solids	mg/l	1194	700	1956
Metals, Cations				
Aluminum	mg/l	ND	ND	ND
Ammonia	mg/l as N	1.85	1.33	2.10
Barium	mg/l	0.09	0.03	0.17
Beryllium	mg/l	ND	ND	ND
Cadmium	mg/l	ND	ND	ND
Calcium	mg/l	77.90	30.35	151
Chromium	mg/l	ND	ND	ND
Copper	mg/l	0.02	0.05	0.02
Iron	mg/l	0.05	ND	0.12
Lead	mg/l	ND	ND	ND
Magnesium	mg/l	30.65	10.85	60.60
Manganese	mg/l	0.023	ND	0.05
Molybdenum	mg/l	ND	ND	0.02
Nickel	mg/l	ND	ND	ND
Potassium	mg/l	24	17	35.5
Sodium	mg/l	251.50	185	348
Strontium	mg/l	1.15	0.43	2.24
Vanadium	mg/l	ND	ND	ND
Zinc	mg/l	0.04	0.06	0.07
Anions				
Alkalinity, bicarbonate	mg/l as $CaCO_3$	170	94	278
Alkalinity, total	mg/l as $CaCO_3$	172	96	286
Arsenic	mg/l	ND	ND	ND
Chloride	mg/l	371.5	330.5	453
Nitrate	mg/l as N	3.3	3.7	ND*
Nitrite	mg/l as N	ND	ND	ND
Orthophosphate	mg/l as P	1.19	ND	2.97
Silica	mg/l	10.85	9.85	12.55
Sulfate	mg/l	238.5	ND	620.5

micromho/cm = micromho per centimeter
mg/l = milligrams per liter
$CaCO_3$ = milligrams as calcium carbonate
N = nitrate
P = phosphorus
ND = not detected
*MDL of 4 mg/l on concentrate samples

Handheld Analytical Measurements/Readings

Part 1 (June 2017)

Date	6/11/2017	6/12/2017	6/13/2017	6/14/2017	6/14/2017
Membrane	**Hydranautics Nano BW**				
Feed Temp, degF	86	85	85	85	86
Pressure, psi					
Pumped Feed	58	55	57	55	58
Recycle/Concentrate	53±	51±	55	51	55
Flow, gpm					
Permeate	1.45±	1.4±	1.35	1.35	1.3
Concentrate	0.65	0.8±	0.6	0.5	0.6
Recycle	0.63±	0.75±	0.7	0.75	0.67
Conductivity, uhmo/cm					
Feed		2030	1999	2075	2085
Permeate		1300	1290	1363	1361
Concentrate		3015	3003	3044	3030
pH					
Feed		7.51	7.31	7.28	7.54
Permeate		7.42	7.12	6.91	7.18
Concentrate		7.31	7.51	7.29	7.61
Metering Pump					
Stroke Speed %	70	80	75	75	75
Stroke Length %	30	30	30	30	30
Tank Level	19	20	20	20	20
Run Hours		**2468**	2488	**2514**	**2521**
Calculations					
Membrane area	75	75	75	75	75
Calculate system recovery	69%	64%	69%	73%	68%
Calculate arraye recovery	53%	47%	51%	52%	51%
Calculate Flux, gfd	13.9	13.9	13.0	13.0	12.5

Summary of Inorganic Analyses – Koch Membrane Systems SR200.

Analyte	Units	Feed	Permeate	Concentrate
pH, field	standard units	7.59	7.14	7.88
Conductivity, field	micromho/cm	2108	1129	3721
Total Dissolved Solids	mg/l	1204	516	2408
Metals, Cations				
Aluminum	mg/l	ND	ND	ND
Ammonia	mg/l as N	2.00	1.57	2.4
Barium	mg/l	0.09	ND	0.23
Beryllium	mg/l	ND	ND	ND
Cadmium	mg/l	ND	ND	ND
Calcium	mg/l	75	10.40	193.33
Chromium	mg/l	ND	ND	ND
Copper	mg/l	0.02	0.04	0.02
Iron	mg/l	0.05	ND	0.12
Lead	mg/l	ND	ND	ND
Magnesium	mg/l	30.87	1.67	82.67
Manganese	mg/l	0.02	ND	0.06
Molybdenum	mg/l	ND	ND	0.02
Nickel	mg/l	ND	ND	ND
Potassium	mg/l	23	14.50	40.33
Sodium	mg/l	255.67	166.67	390
Strontium	mg/l	1.15	0.10	3.07
Vanadium	mg/l	ND	ND	ND
Zinc	mg/l	0.04	0.03	0.07
Anions				
Alkalinity, bicarbonate	mg/l as $CaCO_3$	172.7	48	362
Alkalinity, total	mg/l as $CaCO_3$	174	48	394
Arsenic	mg/l	ND	ND	ND
Chloride	mg/l	390.33	272.33	614
Nitrate	mg/l as N	3.60	3.80	3.30
Nitrite	mg/l as N	ND	ND	ND
Orthophosphate	mg/l as P	1.57	ND	4.05
Silica	mg/l	11.53	9.67	14.70
Sulfate	mg/l	242	ND	687.67

micromho/cm = micromho per centimeter
mg/l = milligrams per liter
$CaCO_3$ = milligrams as calcium carbonate
N = nitrate
P = phosphorus
ND = not detected
*MDL of 4 mg/l on concentrate samples

Handheld Analytical Measurements/Readings

Part 1 (June 2017)

Date	6/14/2017	6/15/2017	6/15/2017	6/16/2017	6/17/2017	6/17/2017	6/18/2017	6/18/2017	6/30/2017
Membrane	**Koch Membrane Systems SR200**								
Feed Temp, degF	86	86	86	86	86	86	86	86	88
Pressure, psi									
Pumped Feed	35	70	76		85	88	93	98	73
Recycle/Concentrate	30	68	73		80	85	90	95	70
Flow, gpm									
Permeate	1.65	1.65	1.65	1.6	1.6	1.6	1.65	1.65	1.65
Concentrate	0.62	0.65	0.62	0.62	0.6	0.6	0.6	0.62	0.6
Recycle	0.62	0.62	0.62	0.62	0.62	0.6	0.65	0.6	0.6
Conductivity, uhmo/cm									
Feed		2091	2075		2033	2032	2028	2034	2108
Permeate		1107	1047		1000	1000	971	995	1129
Concentrate		3627	2560		3640	3748	3830	3779	3721
pH									
Feed		7.33	7.53		5.92	7.34	5.96	7.11	7.59
Permeate		6.7	6.76		5.92	6.59	5.96	7	7.14
Concentrate		7.5	7.41		5.92	7.53	5.96	7.59	7.88
Metering Pump									
Stroke Speed %	75	75	75	80	80	80	50	50	0
Stroke Length %	30	30	30	30	30	30	30	30	0
Tank Level	20	18	16	14	13.8	13.8	28	28	
Run Hours		**2534**	**2560**	**2571**	**2584**	**2586**	**2612**	**2629**	
Calculations									
Membrane area	85	85	85	85	85	85	85	85	85
Calculate system recovery	73%	72%	73%	72%	73%	73%	73%	73%	73%
Calculate arraye recovery	57%	57%	57%	56%	57%	57%	57%	57%	58%
Calculate Flux, gfd	14.0	14.0	14.0	13.6	13.6	13.6	14.0	14.0	14.0

APPENDIX B

Part 1: Reverse Osmosis Projections

Projections with DOW FILMTEC NF270-4040 for 80% Recovery

Projection by:	**Robert McCandless**	AWC Proton | 3.031.03
Client name:	BC	(release date: June 25, 2017)
Project:	DWPR / Pass2RO DowNF270 80pct	
Location:	United States / Arizona / Scottsdale	

	Unit	Overall
Source:		Well Water (Brackish)
System Recovery:	%	80.000
Internal Recovery:	%	80.000
Temperature:	°F	86.000
Total permeate:	gal/min	14.400
Average Flux:	gfd	14.050

	Unit	Overall
Recycling flow:	gal/min	0.000
Fouling Factor:		1.000
Feed Pressure:	psi	79.582
Total Δ P Elements:	psi	10.046
Brine Pressure:	psi	69.533

Cations	Raw water (mg/L)	Balanced Feed (mg/L)	Recycling + Feed (mg/L)	Reject (mg/L)	Permeate (mg/L)
Ca^{2+}	36.88	36.88	36.88	182.99	0.35
Mg^{2+}	11.82	11.82	11.82	58.65	0.11
Ba^{2+}	0.03	0.03	0.03	0.15	0.00
Sr^{2+}	0.51	0.51	0.51	2.53	0.00
Na^{+}	221.51	221.51	221.51	1057.57	12.50
K^{+}	19.18	19.18	19.18	91.57	1.08
Fe^{2+}	0.00	0.00	0.00	0.00	0.00
Fe^{3+}	0.00	0.00	0.00	0.00	0.00
Al^{3+}	0.00	0.00	0.00	0.00	0.00
Mn^{2+}	0.01	0.01	0.01	0.05	0.00
NH3/NH4(as N)	2.03	2.03	2.03	9.61	0.13

Anions	Raw water (mg/L)	Balanced Feed (mg/L)	Recycling + Feed (mg/L)	Reject (mg/L)	Permeate (mg/L)
HCO_3^- Alk($CaCO_3$)	108.00	107.90	107.90	516.55	5.08
CO_3^{2-} Alk($CaCO_3$)	0.00	0.23	0.23	6.53	0.00
Total Alk ($CaCO_3$)	108.00	108.13	108.13	523.08	5.08
Ortho-$PO4^3$	0.10	0.10	0.10	0.49	0.00
SO_4^{2-}	5.00	5.00	5.00	24.81	0.05
F^-	0.00	0.00	0.00	0.00	0.00
Cl^-	381.00	381.00	381.00	1833.25	17.94
Br^-	0.00	0.00	0.00	0.00	0.00
SiO_2	7.80	7.80	7.80	37.59	0.35
NO_3^--N	1.13	1.13	1.13	5.43	0.05
NO_2^--N	0.00	0.00	0.00	0.00	0.00
Sulfides (as S^2)	0.00	0.00	0.00	0.00	0.00
B	0.35	0.35	0.35	0.68	0.27
AS (III)	0.00	0.00	0.00	0.00	0.00
AS (V)	0.00	0.00	0.00	0.00	0.00
TDS:	821.300	821.300	821.300	3949.640	39.230
Conductivity (µs/cm):	1452.000	1309.468	1309.467	6302.278	61.234
pH:	7.160	7.160	7.160	7.780	5.880
Flow:	gal/min	18.000	0.000	3.600	14.400

Summary	Product:	Dosage:
pH adjusted using:	HCL	0.000 mg/L
Selected product:	AWC A-102 Ultra	0.600 mg/L

American Water Chemicals Inc does not assume any obligation or liability for results obtained or damages incurred from the application of this information.

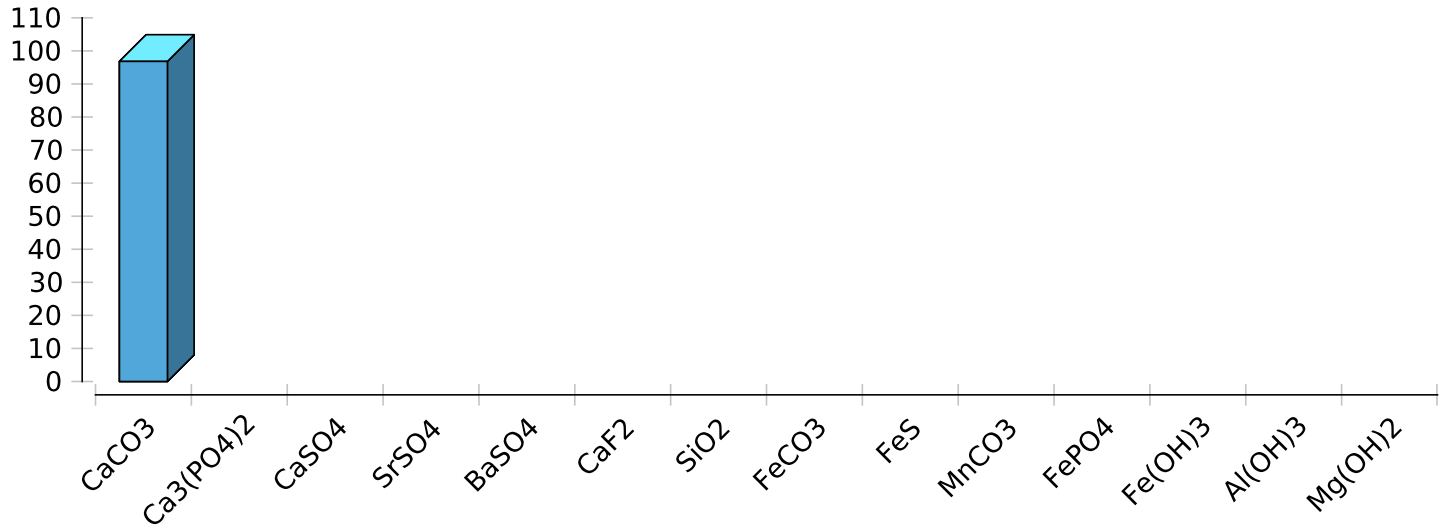
	Unit	Stage 1	Stage 2
Total Elements:		12	6
Total Vessels:		2	1
Elements / Vessels:		6	6
Net Osmotic Pressure:	psi	21.485	39.430
Net Driving Pressure:	psi	57.650	49.002
Req'd P/Stage:	psi	76.289	73.839
Feed P:	psi	79.582	73.839
Permeate Throttle/P:	psi	3.292	0.000
Boost P:	psi	0.000	0.000
Concentrate P:	psi	73.839	69.533

Stages output

	Membrane Model:	Permeate Flow: gal/min	Average Flux: gfd	System Recovery: %	β	Feed Flow / PV: gal/min	Concentrate Flow / PV: gal/min	Δ P: psi	Osmotic P: psi	Net Driving P: psi
Stage1		10.667	15.610	59.259	1.101	9.000	3.667	5.743	21.483	57.650
1	BW30LE-4040	1.003	17.620	11.149	1.102	9.000	7.997	1.602	10.414	65.075
2	BW30LE-4040	0.961	16.869	12.013	1.102	7.997	7.036	1.292	11.741	62.301
3	BW30LE-4040	0.917	16.112	13.040	1.101	7.036	6.119	1.023	13.381	59.503
4	BW30LE-4040	0.872	15.308	14.246	1.101	6.119	5.247	0.792	15.444	56.533
5	BW30LE-4040	0.820	14.406	15.635	1.100	5.247	4.427	0.597	18.078	53.204
6	BW30LE-4040	0.760	13.344	17.166	1.097	4.427	3.667	0.437	21.483	49.282
Stage2		3.733	10.927	50.909	1.113	7.333	3.600	4.306	39.414	49.002
1	BW30LE-4040	0.768	13.488	10.474	1.081	7.333	6.565	1.126	23.460	49.815
2	BW30LE-4040	0.713	12.525	10.863	1.078	6.565	5.852	0.925	25.995	46.255
3	BW30LE-4040	0.656	11.520	11.209	1.074	5.852	5.196	0.754	28.867	42.544
4	BW30LE-4040	0.596	10.464	11.467	1.069	5.196	4.600	0.611	32.085	38.644
5	BW30LE-4040	0.533	9.356	11.581	1.063	4.600	4.067	0.493	35.625	34.552
6	BW30LE-4040	0.467	8.209	11.493	1.057	4.067	3.600	0.398	39.414	30.318

American Water Chemicals Inc does not assume any obligation or liability for results obtained or damages incurred from the application of this information.

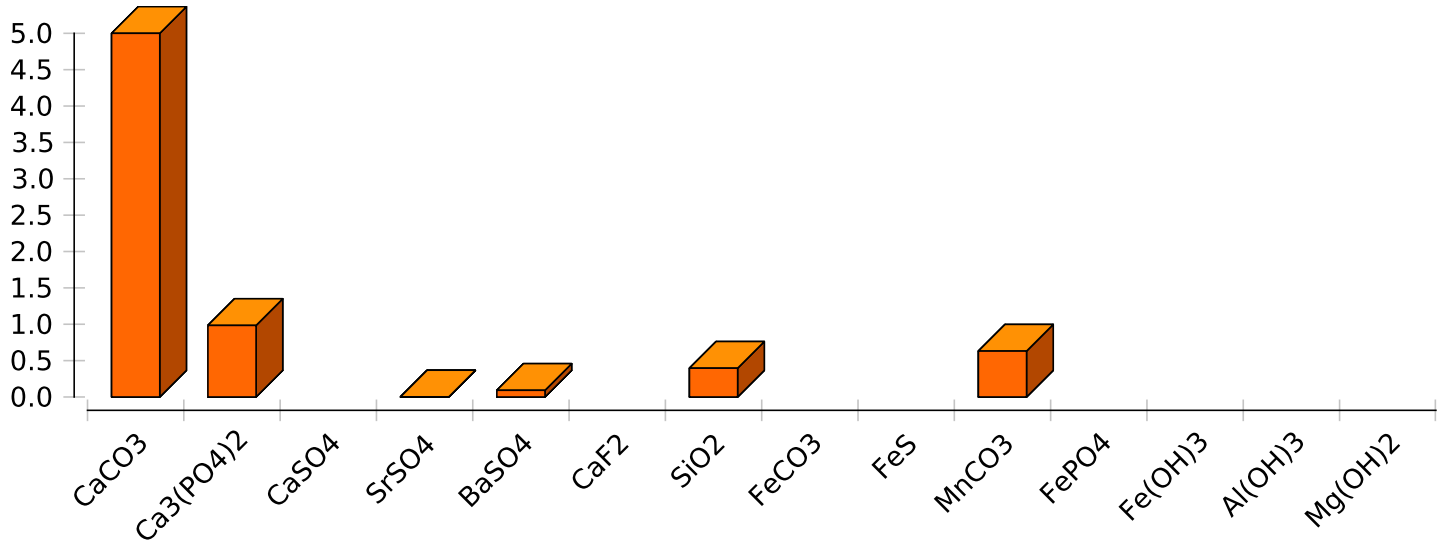
Summary Scale - Precipitation Potentials (mg/L)



Summary Scale - Precipitation Potentials (mg/L)

$CaCO_3$	$Ca_3(PO_4)_2$	$CaSO_4$	$SrSO_4$	$BaSO_4$	CaF_2	SiO_2	$FeCO_3$	FeS	$MnCO_3$	$FePO_4$	$Fe(OH)_3$	$Al(OH)_3$	$Mg(OH)_2$
96.821	0	0	0	0	0	0	0	0	0	0	0	0	0

Summary Scale - X Saturation



Summary Scale - X Saturation

$CaCO_3$	$Ca_3(PO_4)_2$	$CaSO_4$	$SrSO_4$	$BaSO_4$	CaF_2	SiO_2	$FeCO_3$	FeS	$MnCO_3$	$FePO_4$	$Fe(OH)_3$	$Al(OH)_3$	$Mg(OH)_2$
9.705	0.984	0	0.001	0.092	0	0.396	0	0	0.631	0	0	0	0

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Carbonate Scales	Precipitation Potential	X Saturation	Saturation Index
$CaCO_3$	96.821	9.705	0.987
$MgCO_3$	0.000	3.167	0.501
$SrCO_3$	0.000	0.527	-0.278
$BaCO_3$	0.000	0.004	-2.423
$FeCO_3$	0.000	0.000	0.000
$MnCO_3$	0.000	0.631	-0.200

Phosphate Scales	Precipitation Potential	X Saturation	Saturation Index
$Ca_3(PO4)_2$	0.000	0.984	-0.007
$Mg_3(PO4)_2$	0.000	0.000	-5.620
$Sr_3(PO4)_2$	0.000	0.000	-8.618
$Ba_3(PO4)_2$	0.000	0.000	-17.520
$FeHPO_4$	0.000	0.000	0.000
$Fe_3(PO_4)_2$	0.000	0.000	0.000
$Mn_3(PO_4)_2$	0.000	0.000	-17.413
$FePO_4$	0.000	0.000	0.000
$AlPO_4$	0.000	0.000	0.000
$MgNH_4PO_4.6H_2O$	0.000	0.000	-3.485

Sulfate Scales	Precipitation Potential	X Saturation	Saturation Index
$CaSO_4$	0.000	0.000	-3.532
$SrSO_4$	0.000	0.001	-3.143
$BaSO_4$	0.000	0.092	-1.034

Fluoride Scales	Precipitation Potential	X Saturation	Saturation Index
CaF_2	0.000	0.000	0.000
MgF_2	0.000	0.000	0.000
SrF_2	0.000	0.000	0.000
BaF_2	0.000	0.000	0.000
FeF_2	0.000	0.000	0.000

Metal Hydroxide and Oxide Scales	Precipitation Potential	X Saturation	Saturation Index
$Mg(OH)_2$	0.000	0.000	-4.290
$Fe(OH)_2$	0.000	0.000	0.000
$Mn(OH)_2$	0.000	0.000	-6.088
$Fe(OH)_3$	0.000	0.000	0.000
MnO_2	0.000	0.000	0.000
$Al(OH)_3$	0.000	0.000	0.000
$Ca(OH)_2$	0.000	0.000	-9.628

Sulfide Scales	Precipitation Potential	X Saturation	Saturation Index
FeS	0.000	0.000	0.000
MnS	0.000	0.000	0.000

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Projection by:	**Robert McCandless**	AWC Proton | 3.031.03
Client name:	BC	(release date: June 25, 2017)
Project:	DWPR / Pass2RO DowNF270 80pct	
Location:	United States / Arizona / Scottsdale	

Silicate Scales	Precipitation Potential	X Saturation	Saturation Index
$CaSiO_3.H_2O$	0.000	0.000	0.000
$MgSiO_3.H_2O$	0.000	0.037	-1.428
$Mg_3Si_2O_5(OH)_4$	0.000	0.001	-2.871
$Al_2Si_2O_5(OH)_4$	0.000	0.000	0.000
Na_2F_6Si	0.000	0.000	0.000
SiO_2	0.000	0.396	-0.402

Scales above 100% saturation	
$CaCO_3$	Saturation is 9.71 X; [Saturation Index is 0.99]
$MgCO_3$	Saturation is 3.17 X; [Saturation Index is 0.50]

Critical Indices		Guideline	Status
CaCO3 SI (CCNI)	0.987	< 2.300	OK
Mg(OH)2 SI	-4.290	< 9.200	OK
SiO2 (MSI)	0.000	< 10.000	OK
Antiscalant Precipitation Index (API)	8.161	< 9.900	OK
Ca3(PO4)2 SI (MPI)	-0.007	< 4.200	OK
CaSO4 SI	-3.532	< 0.500	OK
BaSO4 SI	-1.034	< 3.000	OK
SrSO4 SI	-3.143	< 1.000	OK
LSI	1.387		OK
Stiff&Davis Index	1.581		OK

Chemical dosing:	AWC A-102 Ultra	HCL
Calculated Dosage:	0.600 mg/L	0.000 mg/L
Total Dosage (modified by user):	0.600 mg/L	N/A
% Concentration:	N/A	37.000%
Density:	1.120 g/cm3	1.184 g/cm3
Dosing Pump:	0.037 ml/min	0.000 ml/min
Hours of Operation/Day:	24 hour(s)	24 hour(s)
Consumption per:		
Day	0.130 lbs	0.000 lbs
Week	0.909 lbs	0.000 lbs
4 Weeks	3.634 lbs	0.000 lbs
Year	47.372 lbs	0.000 lbs
5 Years	236.862 lbs	0.000 lbs

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Comments...

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Projections with DOW FILMTEC NF270-4040 for Maximum Recovery

Projection by:	**Robert McCandless**	AWC Proton | 3.031.03
Client name:	BC	(release date: June 25, 2017)
Project:	DWPR / Pass2RO DowNF270 92.7pct	
Location:	United States / Arizona / Scottsdale	

	Unit	Overall
Source:		Well Water (Brackish)
System Recovery:	%	92.657
Internal Recovery:	%	92.657
Temperature:	°F	86.000
Total permeate:	gal/min	16.678
Average Flux:	gfd	16.270

	Unit	Overall
Recycling flow:	gal/min	0.000
Fouling Factor:		1.000
Feed Pressure:	psi	121.679
Total Δ P Elements:	psi	6.737
Brine Pressure:	psi	114.903

Cations	Raw water (mg/L)	Balanced Feed (mg/L)	Recycling + Feed (mg/L)	Reject (mg/L)	Permeate (mg/L)
Ca^{2+}	36.88	36.88	36.88	520.02	0.00
Mg^{2+}	11.82	11.82	11.82	166.67	0.00
Ba^{2+}	0.03	0.03	0.03	0.42	0.00
Sr^{2+}	0.51	0.51	0.51	7.19	0.00
Na^{+}	221.51	221.51	221.51	2937.45	6.29
K^{+}	19.18	19.18	19.18	254.35	0.54
Fe^{2+}	0.00	0.00	0.00	0.00	0.00
Fe^{3+}	0.00	0.00	0.00	0.00	0.00
Al^{3+}	0.00	0.00	0.00	0.00	0.00
Mn^{2+}	0.01	0.01	0.01	0.14	0.00
NH3/NH4(as N)	2.03	2.03	2.03	26.67	0.08

Anions	Raw water (mg/L)	Balanced Feed (mg/L)	Recycling + Feed (mg/L)	Reject (mg/L)	Permeate (mg/L)
HCO_3^- Alk($CaCO_3$)	108.00	107.90	107.90	1419.65	1.67
CO_3^{2-} Alk($CaCO_3$)	0.00	0.23	0.23	61.38	0.00
Total Alk ($CaCO_3$)	108.00	108.13	108.13	1481.03	1.67
Ortho-$PO4^3$	0.10	0.10	0.10	1.39	0.00
SO_4^{2-}	5.00	5.00	5.00	70.50	0.00
F^-	0.00	0.00	0.00	0.00	0.00
Cl^-	381.00	381.00	381.00	5114.56	5.89
Br^-	0.00	0.00	0.00	0.00	0.00
SiO_2	7.80	7.80	7.80	104.97	0.10
NO_3^--N	1.13	1.13	1.13	15.16	0.02
NO_2^--N	0.00	0.00	0.00	0.00	0.00
Sulfides (as S^2)	0.00	0.00	0.00	0.00	0.00
B	0.35	0.35	0.35	1.10	0.29
AS (III)	0.00	0.00	0.00	0.00	0.00
AS (V)	0.00	0.00	0.00	0.00	0.00
TDS:	821.300	821.300	821.300	11016.710	15.480
Conductivity (µs/cm):	1452.000	1309.468	1309.467	17585.449	20.089
pH:	7.160	7.160	7.160	8.150	5.400
Flow:	gal/min	18.000	0.000	1.320	16.680

Summary	Product:	Dosage:
pH adjusted using:	HCL	0.000 mg/L
Selected product:	AWC A-102 Ultra	1.545 mg/L

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	Unit	Stage 1	Stage 2
Total Elements:		12	6
Total Vessels:		2	1
Elements / Vessels:		6	6
Net Osmotic Pressure:	psi	28.278	97.795
Net Driving Pressure:	psi	66.771	56.755
Req'd P/Stage:	psi	87.854	116.568
Feed P:	psi	121.679	116.568
Permeate Throttle/P:	psi	33.826	0.000
Boost P:	psi	0.000	0.000
Concentrate P:	psi	116.568	114.903

Stages output

	Membrane Model:	Permeate Flow: gal/min	Average Flux: gfd	System Recovery: %	β	Feed Flow / PV: gal/min	Concentrate Flow / PV: gal/min	Δ P: psi	Osmotic P: psi	Net Driving P: psi
Stage1		12.354	18.080	68.635	1.123	9.000	2.823	5.111	28.269	66.771
1	BW30LE-4040	1.175	20.641	13.060	1.123	9.000	7.825	1.573	10.838	76.229
2	BW30LE-4040	1.127	19.793	14.405	1.123	7.825	6.698	1.216	12.572	73.100
3	BW30LE-4040	1.076	18.887	16.059	1.124	6.698	5.622	0.912	14.854	69.754
4	BW30LE-4040	1.016	17.839	18.069	1.124	5.622	4.606	0.659	17.941	65.882
5	BW30LE-4040	0.941	16.527	20.432	1.123	4.606	3.665	0.454	22.229	61.038
6	BW30LE-4040	0.842	14.790	22.979	1.118	3.665	2.823	0.297	28.269	54.622
Stage2		4.324	12.656	76.590	1.254	5.646	1.322	1.665	101.758	56.755
1	BW30LE-4040	1.197	21.023	21.205	1.150	5.646	4.449	0.644	36.524	77.643
2	BW30LE-4040	1.026	18.017	23.237	1.139	4.449	3.423	0.416	46.455	66.541
3	BW30LE-4040	0.806	14.160	24.074	1.117	3.423	2.616	0.262	58.937	52.294
4	BW30LE-4040	0.566	9.945	22.756	1.086	2.616	2.050	0.167	72.432	36.728
5	BW30LE-4040	0.508	8.928	27.178	1.082	2.050	1.542	0.105	95.924	32.971
6	BW30LE-4040	0.220	3.861	13.534	1.030	1.542	1.322	0.071	101.758	14.261

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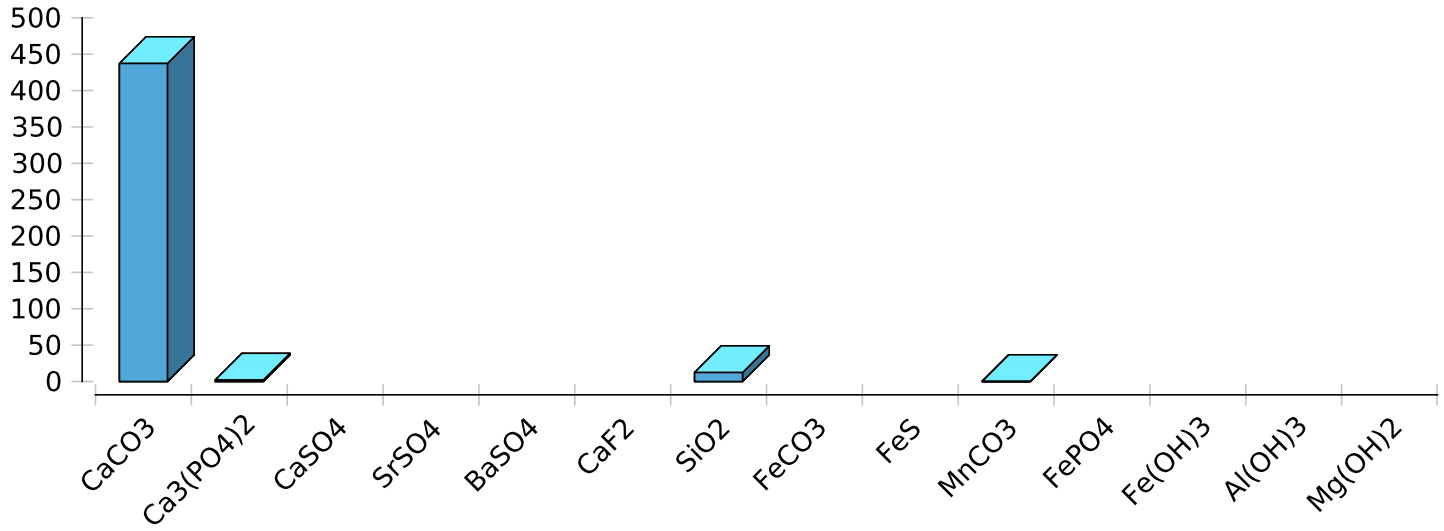
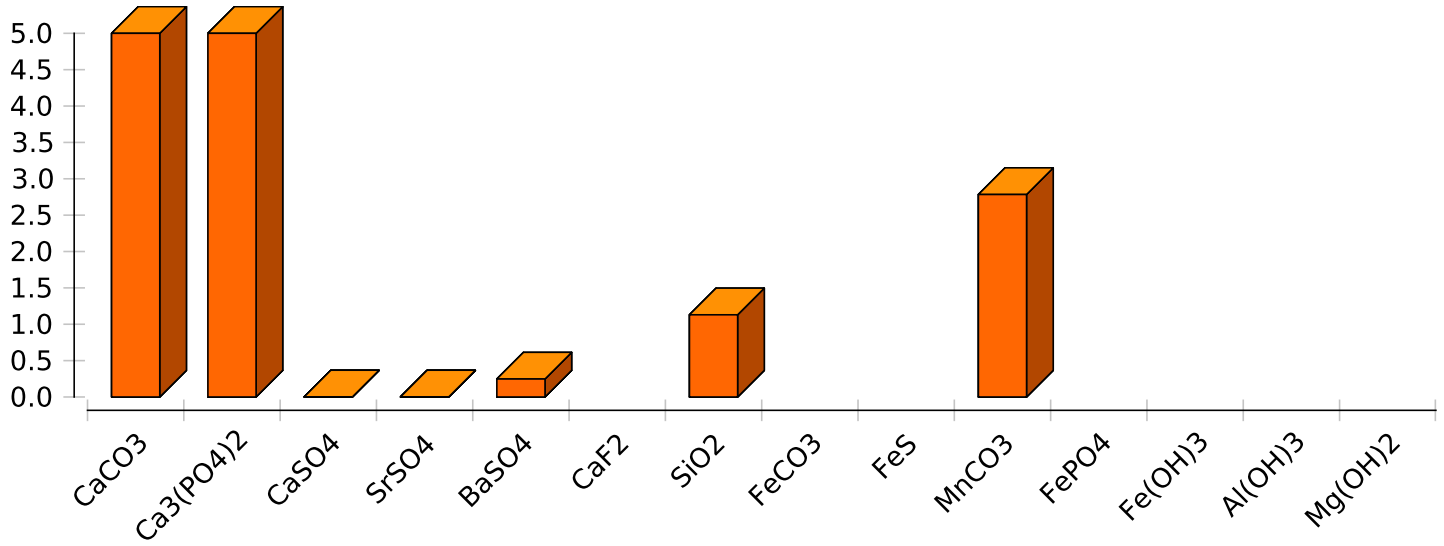
Summary Scale - Precipitation Potentials (mg/L)



Summary Scale - Precipitation Potentials (mg/L)

$CaCO_3$	$Ca_3(PO_4)_2$	$CaSO_4$	$SrSO_4$	$BaSO_4$	CaF_2	SiO_2	$FeCO_3$	FeS	$MnCO_3$	$FePO_4$	$Fe(OH)_3$	$Al(OH)_3$	$Mg(OH)_2$
437.23	2.079	0	0	0	0	12.327	0	0	0.031	0	0	0	0

Summary Scale - X Saturation



Summary Scale - X Saturation

$CaCO_3$	$Ca_3(PO_4)_2$	$CaSO_4$	$SrSO_4$	$BaSO_4$	CaF_2	SiO_2	$FeCO_3$	FeS	$MnCO_3$	$FePO_4$	$Fe(OH)_3$	$Al(OH)_3$	$Mg(OH)_2$
87.458	78.452	0.001	0.001	0.247	0	1.13	0	0	2.784	0	0	0	0

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Carbonate Scales	Precipitation Potential	X Saturation	Saturation Index
$CaCO_3$	437.230	87.458	1.942
$MgCO_3$	7.862	30.498	1.484
$SrCO_3$	7.218	4.702	0.672
$BaCO_3$	0.000	0.034	-1.471
$FeCO_3$	0.000	0.000	0.000
$MnCO_3$	0.031	2.784	0.445

Phosphate Scales	Precipitation Potential	X Saturation	Saturation Index
$Ca_3(PO4)_2$	2.079	78.452	1.895
$Mg_3(PO4)_2$	0.000	0.000	-5.644
$Sr_3(PO4)_2$	0.000	0.000	-8.628
$Ba_3(PO4)_2$	0.000	0.000	-17.522
$FeHPO_4$	0.000	0.000	0.000
$Fe_3(PO_4)_2$	0.000	0.000	0.000
$Mn_3(PO_4)_2$	0.000	0.000	-19.671
$FePO_4$	0.000	0.000	0.000
$AlPO_4$	0.000	0.000	0.000
$MgNH_4PO_4.6H_2O$	0.000	0.001	-3.252

Sulfate Scales	Precipitation Potential	X Saturation	Saturation Index
$CaSO_4$	0.000	0.001	-3.251
$SrSO_4$	0.000	0.001	-3.062
$BaSO_4$	0.000	0.247	-0.607

Fluoride Scales	Precipitation Potential	X Saturation	Saturation Index
CaF_2	0.000	0.000	0.000
MgF_2	0.000	0.000	0.000
SrF_2	0.000	0.000	0.000
BaF_2	0.000	0.000	0.000
FeF_2	0.000	0.000	0.000

Metal Hydroxide and Oxide Scales	Precipitation Potential	X Saturation	Saturation Index
$Mg(OH)_2$	0.000	0.000	-3.302
$Fe(OH)_2$	0.000	0.000	0.000
$Mn(OH)_2$	0.000	0.000	-5.856
$Fe(OH)_3$	0.000	0.000	0.000
MnO_2	0.000	0.000	0.000
$Al(OH)_3$	0.000	0.000	0.000
$Ca(OH)_2$	0.000	0.000	-8.670

Sulfide Scales	Precipitation Potential	X Saturation	Saturation Index
FeS	0.000	0.000	0.000
MnS	0.000	0.000	0.000

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Projection by:	**Robert McCandless**	AWC Proton | 3.031.03
Client name:	BC	(release date: June 25, 2017)
Project:	DWPR / Pass2RO DowNF270 92.7pct	
Location:	United States / Arizona / Scottsdale	

Silicate Scales	Precipitation Potential	X Saturation	Saturation Index
$CaSiO_3.H_2O$	0.000	0.000	0.000
$MgSiO_3.H_2O$	0.000	0.305	-0.516
$Mg_3Si_2O_5(OH)_4$	0.000	0.866	-0.062
$Al_2Si_2O_5(OH)_4$	0.000	0.000	0.000
Na_2F_6Si	0.000	0.000	0.000
SiO_2	12.327	1.130	0.053

Scales above 100% saturation	
$CaCO_3$	Saturation is 87.46 X; [Saturation Index is 1.94]
$MgCO_3$	Saturation is 30.50 X; [Saturation Index is 1.48]
$SrCO_3$	Saturation is 4.70 X; [Saturation Index is 0.67]
$MnCO_3$	Saturation is 2.78 X; [Saturation Index is 0.44]
$Ca_3(PO4)_2$	Saturation is 78.45 X; [Saturation Index is 1.89]
SiO_2	Saturation is 1.13 X; [Saturation Index is 0.05]

Critical Indices		Guideline	Status
CaCO3 SI (CCNI)	1.942	< 2.300	OK
Mg(OH)2 SI	-3.302	< 9.200	OK
SiO2 (MSI)	6.934	< 10.000	OK
Antiscalant Precipitation Index (API)	9.688	< 9.900	OK
Ca3(PO4)2 SI (MPI)	1.895	< 4.200	OK
CaSO4 SI	-3.251	< 0.500	OK
BaSO4 SI	-0.607	< 3.000	OK
SrSO4 SI	-3.062	< 1.000	OK
LSI	2.606		OK
Stiff&Davis Index	2.426		OK

Chemical dosing:	AWC A-102 Ultra	HCL
Calculated Dosage:	1.545 mg/L	0.000 mg/L
Total Dosage (modified by user):	1.545 mg/L	N/A
% Concentration:	N/A	37.000%
Density:	1.120 g/cm3	1.184 g/cm3
Dosing Pump:	0.094 ml/min	0.000 ml/min
Hours of Operation/Day:	24 hour(s)	24 hour(s)
Consumption per:		
Day	0.334 lbs	0.000 lbs
Week	2.340 lbs	0.000 lbs
4 Weeks	9.358 lbs	0.000 lbs
Year	121.992 lbs	0.000 lbs
5 Years	609.958 lbs	0.000 lbs

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Comments...

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Projections with CSM NE4040-40 for 80% Recovery

Projection by:	**Robert McCandless**	AWC Proton | 3.031.03
Client name:	BC	(release date: June 25, 2017)
Project:	DWPR / Pass2RO CSMpermeate 80pct	
Location:	United States / Arizona / Scottsdale	

	Unit	Overall
Source:		Well Water (Brackish)
System Recovery:	%	80.000
Internal Recovery:	%	80.000
Temperature:	°F	86.000
Total permeate:	gal/min	14.400
Average Flux:	gfd	14.050

	Unit	Overall
Recycling flow:	gal/min	0.000
Fouling Factor:		1.000
Feed Pressure:	psi	77.161
Total Δ P Elements:	psi	10.073
Brine Pressure:	psi	67.086

Cations	Raw water (mg/L)	Balanced Feed (mg/L)	Recycling + Feed (mg/L)	Reject (mg/L)	Permeate (mg/L)
Ca^{2+}	28.00	28.00	28.00	138.93	0.27
Mg^{2+}	5.10	5.10	5.10	25.31	0.05
Ba^{2+}	0.02	0.02	0.02	0.12	0.00
Sr^{2+}	0.31	0.31	0.31	1.54	0.00
Na^{+}	217.02	217.02	217.02	1039.62	11.37
K^{+}	20.00	20.00	20.00	95.81	1.05
Fe^{2+}	0.00	0.00	0.00	0.00	0.00
Fe^{3+}	0.00	0.00	0.00	0.00	0.00
Al^{3+}	0.00	0.00	0.00	0.00	0.00
Mn^{2+}	0.00	0.00	0.00	0.00	0.00
NH3/NH4(as N)	2.08	2.08	2.08	9.84	0.14

Anions	Raw water (mg/L)	Balanced Feed (mg/L)	Recycling + Feed (mg/L)	Reject (mg/L)	Permeate (mg/L)
HCO_3^- Alk($CaCO_3$)	92.00	91.86	91.86	438.67	4.31
CO_3^{2-} Alk($CaCO_3$)	0.00	0.30	0.30	8.34	0.00
Total Alk ($CaCO_3$)	92.00	92.16	92.16	447.02	4.31
Ortho-$PO4^3$	0.10	0.10	0.10	0.49	0.00
SO_4^{2-}	5.00	5.00	5.00	24.81	0.05
F^-	0.00	0.00	0.00	0.00	0.00
Cl^-	351.00	351.00	351.00	1689.02	16.49
Br^-	0.00	0.00	0.00	0.00	0.00
SiO_2	8.80	8.80	8.80	42.41	0.40
NO_3^--N	1.02	1.02	1.02	4.89	0.05
NO_2^--N	0.00	0.00	0.00	0.00	0.00
Sulfides (as S^2)	0.00	0.00	0.00	0.00	0.00
B	0.33	0.33	0.33	0.65	0.25
AS (III)	0.00	0.00	0.00	0.00	0.00
AS (V)	0.00	0.00	0.00	0.00	0.00
TDS:	753.160	753.160	753.150	3623.330	35.630
Conductivity (µs/cm):	1402.000	1192.203	1192.202	5738.396	55.607
pH:	7.350	7.350	7.350	7.970	6.060
Flow:	gal/min	18.000	0.000	3.600	14.400

Summary	Product:	Dosage:
pH adjusted using:	HCL	0.000 mg/L
Selected product:	AWC A-102 Ultra	0.600 mg/L

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	Unit	Stage 1	Stage 2
Total Elements:		12	6
Total Vessels:		2	1
Elements / Vessels:		6	6
Net Osmotic Pressure:	psi	19.873	36.388
Net Driving Pressure:	psi	57.650	49.002
Req'd P/Stage:	psi	75.148	71.407
Feed P:	psi	77.161	71.407
Permeate Throttle/P:	psi	2.013	0.000
Boost P:	psi	0.000	0.000
Concentrate P:	psi	71.407	67.086

Stages output

	Membrane Model:	Permeate Flow: gal/min	Average Flux: gfd	System Recovery: %	β	Feed Flow / PV: gal/min	Concentrate Flow / PV: gal/min	Δ P: psi	Osmotic P: psi	Net Driving P: psi
Stage1		10.667	15.610	59.259	1.100	9.000	3.667	5.754	19.871	57.650
1	BW30LE-4040	0.998	17.523	11.087	1.102	9.000	8.002	1.603	9.630	64.717
2	BW30LE-4040	0.957	16.801	11.956	1.101	8.002	7.045	1.294	10.849	62.049
3	BW30LE-4040	0.916	16.079	12.996	1.101	7.045	6.130	1.026	12.357	59.382
4	BW30LE-4040	0.872	15.318	14.230	1.101	6.130	5.258	0.795	14.257	56.572
5	BW30LE-4040	0.824	14.469	15.671	1.100	5.258	4.434	0.599	16.695	53.437
6	BW30LE-4040	0.767	13.468	17.299	1.098	4.434	3.667	0.438	19.871	49.742
Stage2		3.733	10.927	50.909	1.113	7.333	3.600	4.321	36.376	49.002
1	BW30LE-4040	0.759	13.328	10.349	1.080	7.333	6.574	1.128	21.622	49.221
2	BW30LE-4040	0.708	12.424	10.762	1.077	6.574	5.867	0.928	23.929	45.886
3	BW30LE-4040	0.654	11.485	11.148	1.073	5.867	5.213	0.757	26.555	42.417
4	BW30LE-4040	0.598	10.498	11.467	1.069	5.213	4.615	0.614	29.517	38.770
5	BW30LE-4040	0.539	9.457	11.668	1.064	4.615	4.077	0.495	32.807	34.925
6	BW30LE-4040	0.477	8.369	11.691	1.058	4.077	3.600	0.399	36.376	30.909

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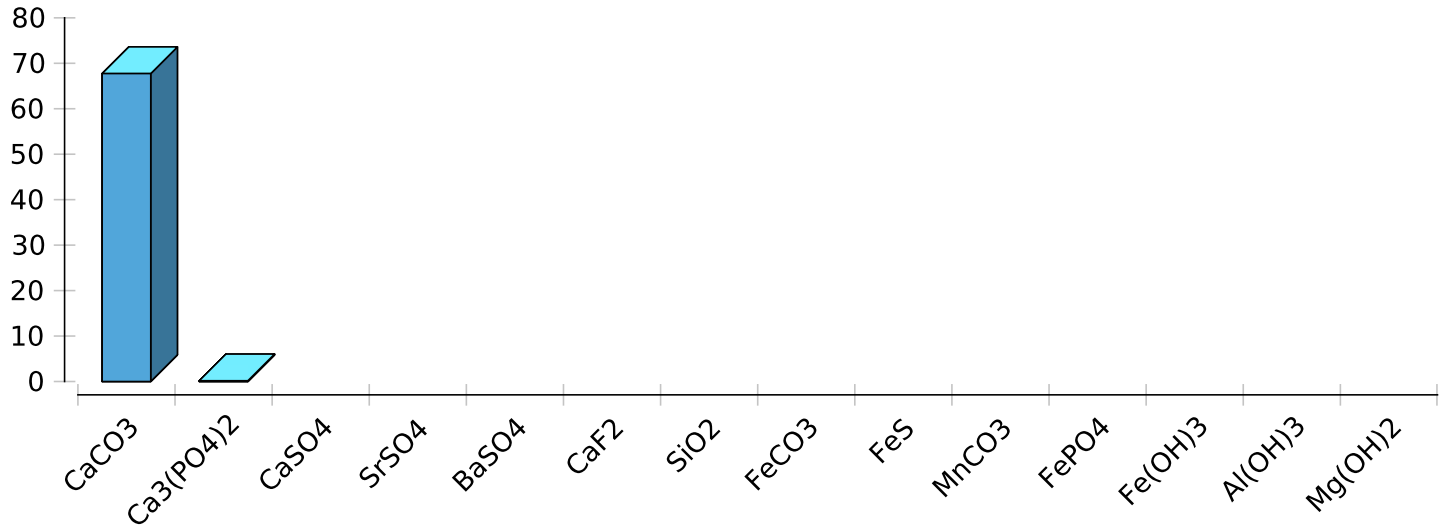
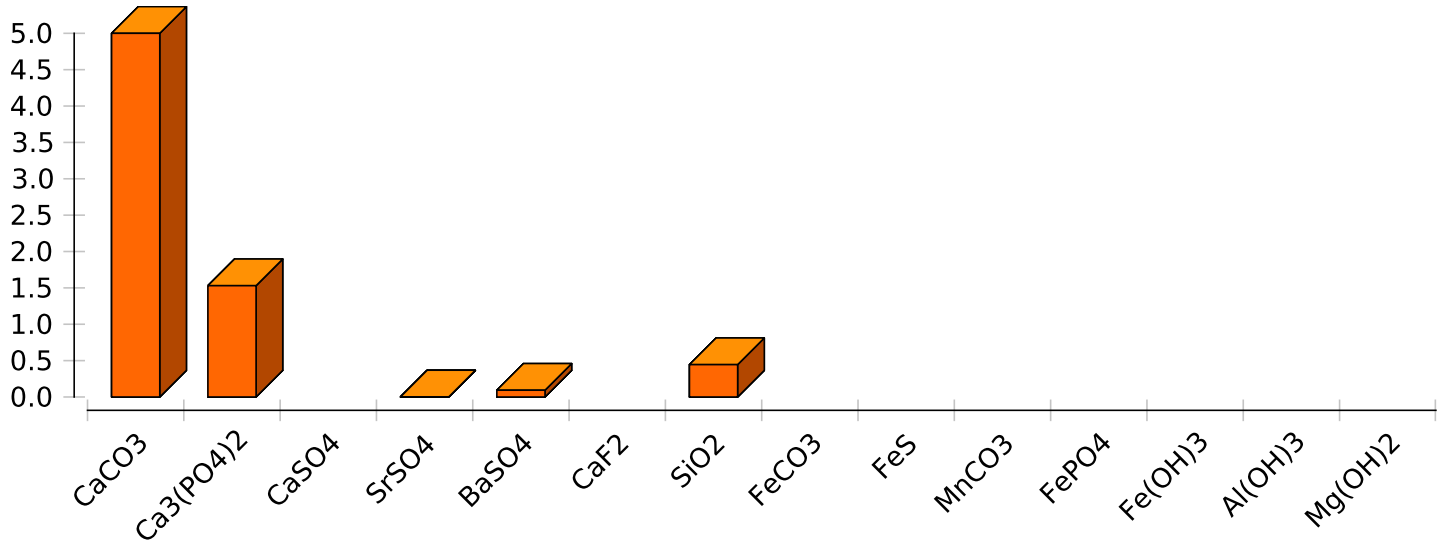
Summary Scale - Precipitation Potentials (mg/L)



Summary Scale - Precipitation Potentials (mg/L)

$CaCO_3$	$Ca_3(PO_4)_2$	$CaSO_4$	$SrSO_4$	$BaSO_4$	CaF_2	SiO_2	$FeCO_3$	FeS	$MnCO_3$	$FePO_4$	$Fe(OH)_3$	$Al(OH)_3$	$Mg(OH)_2$
67.736	0.163	0	0	0	0	0	0	0	0	0	0	0	0

Summary Scale - X Saturation



Summary Scale - X Saturation

$CaCO_3$	$Ca_3(PO_4)_2$	$CaSO_4$	$SrSO_4$	$BaSO_4$	CaF_2	SiO_2	$FeCO_3$	FeS	$MnCO_3$	$FePO_4$	$Fe(OH)_3$	$Al(OH)_3$	$Mg(OH)_2$
9.91	1.53	0	0.001	0.093	0	0.445	0	0	0	0	0	0	0

American Water Chemicals Inc does not assume any obligation or liability for results obtained or damages incurred from the application of this information.

Carbonate Scales	Precipitation Potential	X Saturation	Saturation Index
$CaCO_3$	67.736	9.910	0.996
$MgCO_3$	0.000	1.939	0.288
$SrCO_3$	0.000	0.451	-0.346
$BaCO_3$	0.000	0.004	-2.372
$FeCO_3$	0.000	0.000	0.000
$MnCO_3$	0.000	0.000	0.000

Phosphate Scales	Precipitation Potential	X Saturation	Saturation Index
$Ca_3(PO4)_2$	0.163	1.530	0.185
$Mg_3(PO4)_2$	0.000	0.000	-6.295
$Sr_3(PO4)_2$	0.000	0.000	-8.842
$Ba_3(PO4)_2$	0.000	0.000	-17.387
$FeHPO_4$	0.000	0.000	0.000
$Fe_3(PO_4)_2$	0.000	0.000	0.000
$Mn_3(PO_4)_2$	0.000	0.000	0.000
$FePO_4$	0.000	0.000	0.000
$AlPO_4$	0.000	0.000	0.000
$MgNH_4PO_4.6H_2O$	0.000	0.000	-3.647

Sulfate Scales	Precipitation Potential	X Saturation	Saturation Index
$CaSO_4$	0.000	0.000	-3.501
$SrSO_4$	0.000	0.001	-3.264
$BaSO_4$	0.000	0.093	-1.031

Fluoride Scales	Precipitation Potential	X Saturation	Saturation Index
CaF_2	0.000	0.000	0.000
MgF_2	0.000	0.000	0.000
SrF_2	0.000	0.000	0.000
BaF_2	0.000	0.000	0.000
FeF_2	0.000	0.000	0.000

Metal Hydroxide and Oxide Scales	Precipitation Potential	X Saturation	Saturation Index
$Mg(OH)_2$	0.000	0.000	-4.253
$Fe(OH)_2$	0.000	0.000	0.000
$Mn(OH)_2$	0.000	0.000	0.000
$Fe(OH)_3$	0.000	0.000	0.000
MnO_2	0.000	0.000	0.000
$Al(OH)_3$	0.000	0.000	0.000
$Ca(OH)_2$	0.000	0.000	-9.338

Sulfide Scales	Precipitation Potential	X Saturation	Saturation Index
FeS	0.000	0.000	0.000
MnS	0.000	0.000	0.000

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Projection by:	**Robert McCandless**	AWC Proton | 3.031.03
Client name:	BC	(release date: June 25, 2017)
Project:	DWPR / Pass2RO CSMpermeate 80pct	
Location:	United States / Arizona / Scottsdale	

Silicate Scales	Precipitation Potential	X Saturation	Saturation Index
$CaSiO_3.H_2O$	0.000	0.000	0.000
$MgSiO_3.H_2O$	0.000	0.038	-1.419
$Mg_3Si_2O_5(OH)_4$	0.000	0.002	-2.817
$Al_2Si_2O_5(OH)_4$	0.000	0.000	0.000
Na_2F_6Si	0.000	0.000	0.000
SiO_2	0.000	0.445	-0.352

Scales above 100% saturation	
$CaCO_3$	Saturation is 9.91 X; [Saturation Index is 1.00]
$MgCO_3$	Saturation is 1.94 X; [Saturation Index is 0.29]
$Ca_3(PO_4)_2$	Saturation is 1.53 X; [Saturation Index is 0.18]

Critical Indices		Guideline	Status
CaCO3 SI (CCNI)	0.996	< 2.300	OK
Mg(OH)2 SI	-4.253	< 9.200	OK
SiO2 (MSI)	0.000	< 10.000	OK
Antiscalant Precipitation Index (API)	8.063	< 9.900	OK
Ca3(PO4)2 SI (MPI)	0.185	< 4.200	OK
CaSO4 SI	-3.501	< 0.500	OK
BaSO4 SI	-1.031	< 3.000	OK
SrSO4 SI	-3.264	< 1.000	OK
LSI	1.394		OK
Stiff&Davis Index	1.613		OK

Chemical dosing:	AWC A-102 Ultra	HCL
Calculated Dosage:	0.600 mg/L	0.000 mg/L
Total Dosage (modified by user):	0.600 mg/L	N/A
% Concentration:	N/A	37.000%
Density:	1.120 g/cm3	1.184 g/cm3
Dosing Pump:	0.037 ml/min	0.000 ml/min
Hours of Operation/Day:	24 hour(s)	24 hour(s)
Consumption per:		
Day	0.130 lbs	0.000 lbs
Week	0.909 lbs	0.000 lbs
4 Weeks	3.634 lbs	0.000 lbs
Year	47.372 lbs	0.000 lbs
5 Years	236.862 lbs	0.000 lbs

Insert your additional comments below:

Comments...

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Projections with CSM NE4040-40 for Maximum Recovery

Projection by:	**Robert McCandless**	AWC Proton | 3.031.03
Client name:	BC	(release date: June 25, 2017)
Project:	DWPR / Pass2RO CSMpermeate 93.0pct	
Location:	United States / Arizona / Scottsdale	

	Unit	Overall
Source:		Well Water (Brackish)
System Recovery:	%	93.030
Internal Recovery:	%	93.030
Temperature:	°F	86.000
Total permeate:	gal/min	16.745
Average Flux:	gfd	16.340

	Unit	Overall
Recycling flow:	gal/min	0.000
Fouling Factor:		1.000
Feed Pressure:	psi	118.935
Total Δ P Elements:	psi	6.688
Brine Pressure:	psi	112.216

Cations	Raw water (mg/L)	Balanced Feed (mg/L)	Recycling + Feed (mg/L)	Reject (mg/L)	Permeate (mg/L)
Ca^{2+}	28.00	28.00	28.00	410.66	0.00
Mg^{2+}	5.10	5.10	5.10	74.80	0.00
Ba^{2+}	0.02	0.02	0.02	0.35	0.00
Sr^{2+}	0.31	0.31	0.31	4.55	0.00
Na^{+}	217.02	217.02	217.02	3008.13	7.90
K^{+}	20.00	20.00	20.00	277.22	0.73
Fe^{2+}	0.00	0.00	0.00	0.00	0.00
Fe^{3+}	0.00	0.00	0.00	0.00	0.00
Al^{3+}	0.00	0.00	0.00	0.00	0.00
Mn^{2+}	0.00	0.00	0.00	0.00	0.00
NH3/NH4(as N)	2.08	2.08	2.08	28.41	0.11

Anions	Raw water (mg/L)	Balanced Feed (mg/L)	Recycling + Feed (mg/L)	Reject (mg/L)	Permeate (mg/L)
HCO_3^- Alk($CaCO_3$)	92.00	91.86	91.86	1242.48	2.69
CO_3^{2-} Alk($CaCO_3$)	0.00	0.30	0.30	83.82	0.00
Total Alk ($CaCO_3$)	92.00	92.16	92.16	1326.29	2.69
Ortho-$PO4^3$	0.10	0.10	0.10	1.45	0.00
SO_4^{2-}	5.00	5.00	5.00	73.33	0.00
F^-	0.00	0.00	0.00	0.00	0.00
Cl^-	351.00	351.00	351.00	4898.25	10.30
Br^-	0.00	0.00	0.00	0.00	0.00
SiO_2	8.80	8.80	8.80	123.12	0.24
NO_3^--N	1.02	1.02	1.02	14.19	0.03
NO_2^--N	0.00	0.00	0.00	0.00	0.00
Sulfides (as S^2)	0.00	0.00	0.00	0.00	0.00
B	0.33	0.33	0.33	1.08	0.27
AS (III)	0.00	0.00	0.00	0.00	0.00
AS (V)	0.00	0.00	0.00	0.00	0.00
TDS:	753.160	753.160	753.150	10507.990	23.220
Conductivity (µs/cm):	1402.000	1192.203	1192.202	16644.728	34.655
pH:	7.350	7.350	7.350	8.350	5.860
Flow:	gal/min	18.000	0.000	1.250	16.750

Summary	Product:	Dosage:
pH adjusted using:	HCL	0.000 mg/L
Selected product:	AWC A-108	0.350 mg/L

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	Unit	Stage 1	Stage 2
Total Elements:		12	6
Total Vessels:		2	1
Elements / Vessels:		6	6
Net Osmotic Pressure:	psi	26.408	95.666
Net Driving Pressure:	psi	67.039	56.983
Req'd P/Stage:	psi	86.848	113.826
Feed P:	psi	118.935	113.826
Permeate Throttle/P:	psi	32.087	0.000
Boost P:	psi	0.000	0.000
Concentrate P:	psi	113.826	112.216

Stages output

	Membrane Model:	Permeate Flow: gal/min	Average Flux: gfd	System Recovery: %	β	Feed Flow / PV: gal/min	Concentrate Flow / PV: gal/min	Δ P: psi	Osmotic P: psi	Net Driving P: psi
Stage1		12.404	18.152	68.911	1.123	9.000	2.798	5.109	26.401	67.039
1	BW30LE-4040	1.172	20.587	13.026	1.122	9.000	7.828	1.574	10.028	76.033
2	BW30LE-4040	1.126	19.776	14.387	1.123	7.828	6.702	1.217	11.629	73.036
3	BW30LE-4040	1.077	18.916	16.073	1.124	6.702	5.624	0.913	13.741	69.860
4	BW30LE-4040	1.021	17.925	18.149	1.125	5.624	4.604	0.659	16.613	66.202
5	BW30LE-4040	0.950	16.685	20.638	1.124	4.604	3.654	0.453	20.640	61.620
6	BW30LE-4040	0.856	15.023	23.416	1.120	3.654	2.798	0.294	26.401	55.484
Stage2		4.341	12.707	77.580	1.258	5.596	1.255	1.610	96.159	56.983
1	BW30LE-4040	1.193	20.955	21.323	1.150	5.596	4.403	0.633	34.072	77.389
2	BW30LE-4040	1.031	18.100	23.575	1.140	4.403	3.372	0.408	43.549	66.848
3	BW30LE-4040	0.819	14.388	24.780	1.119	3.372	2.553	0.253	55.789	53.139
4	BW30LE-4040	0.590	10.366	24.155	1.091	2.553	1.962	0.157	69.861	38.285
5	BW30LE-4040	0.537	9.429	29.286	1.088	1.962	1.425	0.095	95.190	34.825
6	BW30LE-4040	0.171	3.000	10.704	1.021	1.425	1.255	0.063	96.159	11.078

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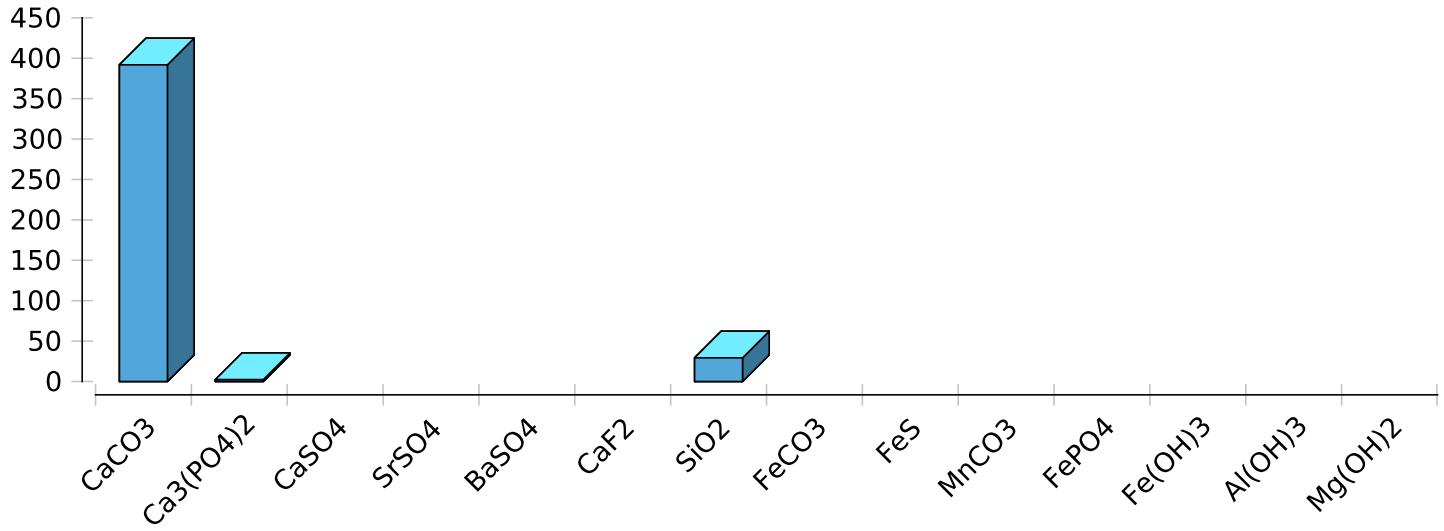
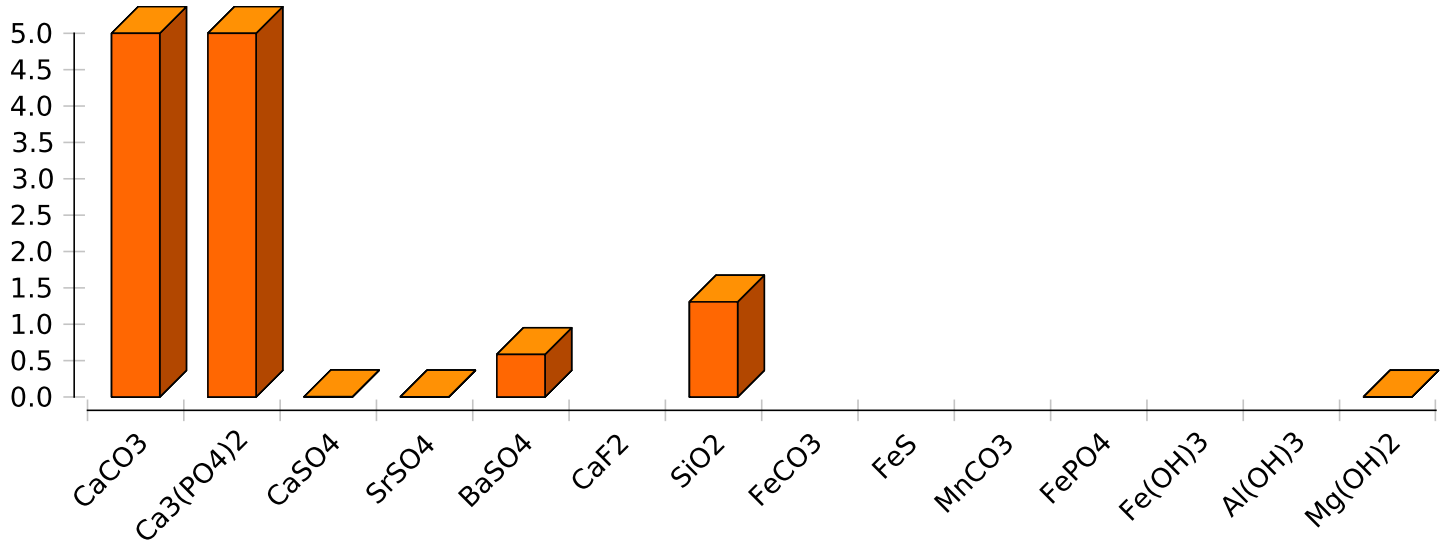
Summary Scale - Precipitation Potentials (mg/L)



Summary Scale - Precipitation Potentials (mg/L)

$CaCO_3$	$Ca_3(PO_4)_2$	$CaSO_4$	$SrSO_4$	$BaSO_4$	CaF_2	SiO_2	$FeCO_3$	FeS	$MnCO_3$	$FePO_4$	$Fe(OH)_3$	$Al(OH)_3$	$Mg(OH)_2$
391.824	2.288	0	0	0	0	29.272	0	0	0	0	0	0	0

Summary Scale - X Saturation



Summary Scale - X Saturation

$CaCO_3$	$Ca_3(PO_4)_2$	$CaSO_4$	$SrSO_4$	$BaSO_4$	CaF_2	SiO_2	$FeCO_3$	FeS	$MnCO_3$	$FePO_4$	$Fe(OH)_3$	$Al(OH)_3$	$Mg(OH)_2$
117.133	331.284	0.004	0.002	0.585	0	1.308	0	0	0	0	0	0	0.001

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Carbonate Scales	Precipitation Potential	X Saturation	Saturation Index
$CaCO_3$	391.824	117.133	2.069
$MgCO_3$	0.000	19.653	1.293
$SrCO_3$	4.453	4.299	0.633
$BaCO_3$	0.000	0.041	-1.391
$FeCO_3$	0.000	0.000	0.000
$MnCO_3$	0.000	0.000	0.000

Phosphate Scales	Precipitation Potential	X Saturation	Saturation Index
$Ca_3(PO4)_2$	2.288	331.284	2.520
$Mg_3(PO4)_2$	0.000	0.000	-6.598
$Sr_3(PO4)_2$	0.000	0.000	-9.126
$Ba_3(PO4)_2$	0.000	0.000	-17.663
$FeHPO_4$	0.000	0.000	0.000
$Fe_3(PO_4)_2$	0.000	0.000	0.000
$Mn_3(PO_4)_2$	0.000	0.000	0.000
$FePO_4$	0.000	0.000	0.000
$AlPO_4$	0.000	0.000	0.000
$MgNH_4PO_4.6H_2O$	0.000	0.000	-3.563

Sulfate Scales	Precipitation Potential	X Saturation	Saturation Index
$CaSO_4$	0.000	0.004	-2.437
$SrSO_4$	0.000	0.002	-2.797
$BaSO_4$	0.000	0.585	-0.232

Fluoride Scales	Precipitation Potential	X Saturation	Saturation Index
CaF_2	0.000	0.000	0.000
MgF_2	0.000	0.000	0.000
SrF_2	0.000	0.000	0.000
BaF_2	0.000	0.000	0.000
FeF_2	0.000	0.000	0.000

Metal Hydroxide and Oxide Scales	Precipitation Potential	X Saturation	Saturation Index
$Mg(OH)_2$	0.000	0.001	-3.227
$Fe(OH)_2$	0.000	0.000	0.000
$Mn(OH)_2$	0.000	0.000	0.000
$Fe(OH)_3$	0.000	0.000	0.000
MnO_2	0.000	0.000	0.000
$Al(OH)_3$	0.000	0.000	0.000
$Ca(OH)_2$	0.000	0.000	-8.384

Sulfide Scales	Precipitation Potential	X Saturation	Saturation Index
FeS	0.000	0.000	0.000
MnS	0.000	0.000	0.000

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Projection by:	**Robert McCandless**	AWC Proton | 3.031.03
Client name:	BC	(release date: June 25, 2017)
Project:	DWPR / Pass2RO CSMpermeate 93.0pct	
Location:	United States / Arizona / Scottsdale	

Silicate Scales	Precipitation Potential	X Saturation	Saturation Index
$CaSiO_3.H_2O$	0.000	0.000	0.000
$MgSiO_3.H_2O$	0.000	0.282	-0.550
$Mg_3Si_2O_5(OH)_4$	0.000	0.868	-0.061
$Al_2Si_2O_5(OH)_4$	0.000	0.000	0.000
Na_2F_6Si	0.000	0.000	0.000
SiO_2	29.272	1.308	0.117

Scales above 100% saturation	
$CaCO_3$	Saturation is 117.13 X; [Saturation Index is 2.07]
$MgCO_3$	Saturation is 19.65 X; [Saturation Index is 1.29]
$SrCO_3$	Saturation is 4.30 X; [Saturation Index is 0.63]
$Ca_3(PO4)_2$	Saturation is 331.28 X; [Saturation Index is 2.52]
SiO_2	Saturation is 1.31 X; [Saturation Index is 0.12]

Critical Indices		Guideline	Status
CaCO3 SI (CCNI)	2.069	< 2.300	OK
Mg(OH)2 SI	-3.227	< 9.200	OK
SiO2 (MSI)	8.618	< 10.000	OK
Antiscalant Precipitation Index (API)	8.725	< 9.900	OK
Ca3(PO4)2 SI (MPI)	2.520	< 4.200	OK
CaSO4 SI	-2.437	< 0.500	OK
BaSO4 SI	-0.232	< 3.000	OK
SrSO4 SI	-2.797	< 1.000	OK
LSI	2.661		OK
Stiff&Davis Index	2.537		OK

Chemical dosing:	AWC A-108	HCL
Calculated Dosage:	0.350 mg/L	0.000 mg/L
Total Dosage (modified by user):	0.350 mg/L	N/A
% Concentration:	N/A	37.000%
Density:	1.280 g/cm3	1.184 g/cm3
Dosing Pump:	0.019 ml/min	0.000 ml/min
Hours of Operation/Day:	24 hour(s)	24 hour(s)
Consumption per:		
Day	0.076 lbs	0.000 lbs
Week	0.530 lbs	0.000 lbs
4 Weeks	2.120 lbs	0.000 lbs
Year	27.634 lbs	0.000 lbs
5 Years	138.170 lbs	0.000 lbs

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Comments...

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Projections with Hydranautics NANO-BW-4040 for 80% Recovery

Projection by:	**Robert McCandless**	AWC Proton | 3.031.03
Client name:	BC	(release date: June 25, 2017)
Project:	DWPR / Pass2 RO NanoBWpermeate 80pct	
Location:	United States / Arizona / Scottsdale	

	Unit	Overall
Source:		Well Water (Brackish)
System Recovery:	%	80.000
Internal Recovery:	%	80.000
Temperature:	°F	86.000
Total permeate:	gal/min	14.400
Average Flux:	gfd	14.050

	Unit	Overall
Recycling flow:	gal/min	0.000
Fouling Factor:		1.000
Feed Pressure:	psi	74.783
Total Δ P Elements:	psi	10.098
Brine Pressure:	psi	64.683

Cations	Raw water (mg/L)	Balanced Feed (mg/L)	Recycling + Feed (mg/L)	Reject (mg/L)	Permeate (mg/L)
Ca^{2+}	29.50	29.50	29.50	146.38	0.28
Mg^{2+}	10.70	10.70	10.70	53.09	0.10
Ba^{2+}	0.03	0.03	0.03	0.15	0.00
Sr^{2+}	0.42	0.42	0.42	2.08	0.00
Na^{+}	187.71	187.71	187.71	896.35	10.55
K^{+}	17.00	17.00	17.00	81.18	0.96
Fe^{2+}	0.00	0.00	0.00	0.00	0.00
Fe^{3+}	0.00	0.00	0.00	0.00	0.00
Al^{3+}	0.00	0.00	0.00	0.00	0.00
Mn^{2+}	0.00	0.00	0.00	0.00	0.00
NH3/NH4(as N)	1.33	1.33	1.33	6.30	0.09

Anions	Raw water (mg/L)	Balanced Feed (mg/L)	Recycling + Feed (mg/L)	Reject (mg/L)	Permeate (mg/L)
HCO_3^- Alk($CaCO_3$)	96.00	95.92	95.92	459.57	4.50
CO_3^{2-} Alk($CaCO_3$)	0.00	0.18	0.18	5.10	0.00
Total Alk ($CaCO_3$)	96.00	96.10	96.10	464.66	4.50
Ortho-PO4^3	0.10	0.10	0.10	0.49	0.00
SO_4^{2-}	5.00	5.00	5.00	24.81	0.05
F^-	0.00	0.00	0.00	0.00	0.00
Cl^-	318.00	318.00	318.00	1530.33	14.92
Br^-	0.00	0.00	0.00	0.00	0.00
SiO_2	9.70	9.70	9.70	46.75	0.44
NO_3^--N	0.84	0.84	0.84	4.02	0.04
NO_2^--N	0.00	0.00	0.00	0.00	0.00
Sulfides (as S^2)	0.00	0.00	0.00	0.00	0.00
B	0.36	0.36	0.36	0.70	0.27
AS (III)	0.00	0.00	0.00	0.00	0.00
AS (V)	0.00	0.00	0.00	0.00	0.00
TDS:	699.050	699.050	699.040	3362.090	33.300
Conductivity (µs/cm):	1290.000	1105.636	1105.635	5322.223	51.461
pH:	7.120	7.120	7.120	7.750	5.830
Flow:	gal/min	18.000	0.000	3.600	14.400

Summary	Product:	Dosage:
pH adjusted using:	HCL	0.000 mg/L
Selected product:	AWC A-102 Ultra	0.600 mg/L

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	Unit	Stage 1	Stage 2
Total Elements:		12	6
Total Vessels:		2	1
Elements / Vessels:		6	6
Net Osmotic Pressure:	psi	18.222	33.451
Net Driving Pressure:	psi	57.650	49.002
Req'd P/Stage:	psi	73.960	69.018
Feed P:	psi	74.783	69.018
Permeate Throttle/P:	psi	0.823	0.000
Boost P:	psi	0.000	0.000
Concentrate P:	psi	69.018	64.683

Stages output

	Membrane Model:	Permeate Flow: gal/min	Average Flux: gfd	System Recovery: %	β	Feed Flow / PV: gal/min	Concentrate Flow / PV: gal/min	Δ P: psi	Osmotic P: psi	Net Driving P: psi
Stage1		10.667	15.610	59.259	1.101	9.000	3.667	5.765	18.221	57.650
1	BW30LE-4040	0.992	17.428	11.027	1.101	9.000	8.008	1.604	8.795	64.363
2	BW30LE-4040	0.953	16.734	11.900	1.101	8.008	7.055	1.296	9.906	61.803
3	BW30LE-4040	0.914	16.047	12.953	1.101	7.055	6.141	1.028	11.283	59.263
4	BW30LE-4040	0.873	15.328	14.214	1.101	6.141	5.268	0.797	13.023	56.610
5	BW30LE-4040	0.827	14.531	15.707	1.100	5.268	4.441	0.601	15.269	53.665
6	BW30LE-4040	0.774	13.591	17.428	1.099	4.441	3.667	0.439	18.221	50.193
Stage2		3.733	10.927	50.909	1.113	7.333	3.600	4.334	33.441	49.002
1	BW30LE-4040	0.751	13.182	10.236	1.079	7.333	6.583	1.129	19.770	48.684
2	BW30LE-4040	0.702	12.334	10.670	1.076	6.583	5.880	0.931	21.871	45.553
3	BW30LE-4040	0.652	11.455	11.093	1.073	5.880	5.228	0.761	24.274	42.304
4	BW30LE-4040	0.600	10.529	11.468	1.069	5.228	4.628	0.617	27.004	38.884
5	BW30LE-4040	0.544	9.548	11.747	1.065	4.628	4.085	0.497	30.069	35.262
6	BW30LE-4040	0.485	8.513	11.868	1.059	4.085	3.600	0.399	33.441	31.442

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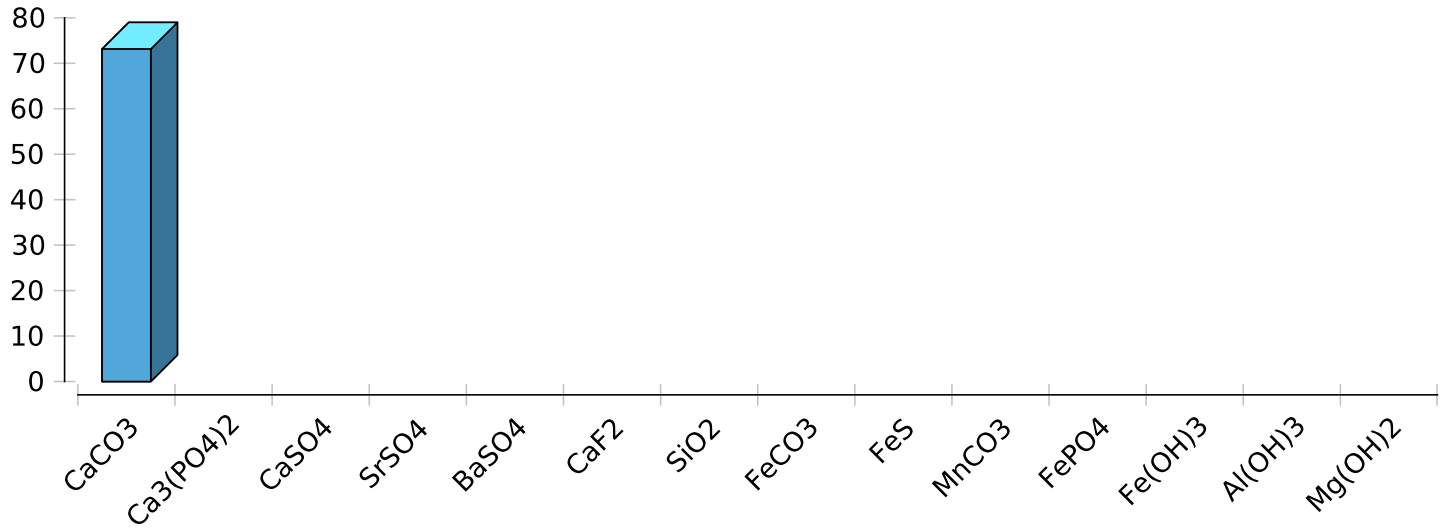
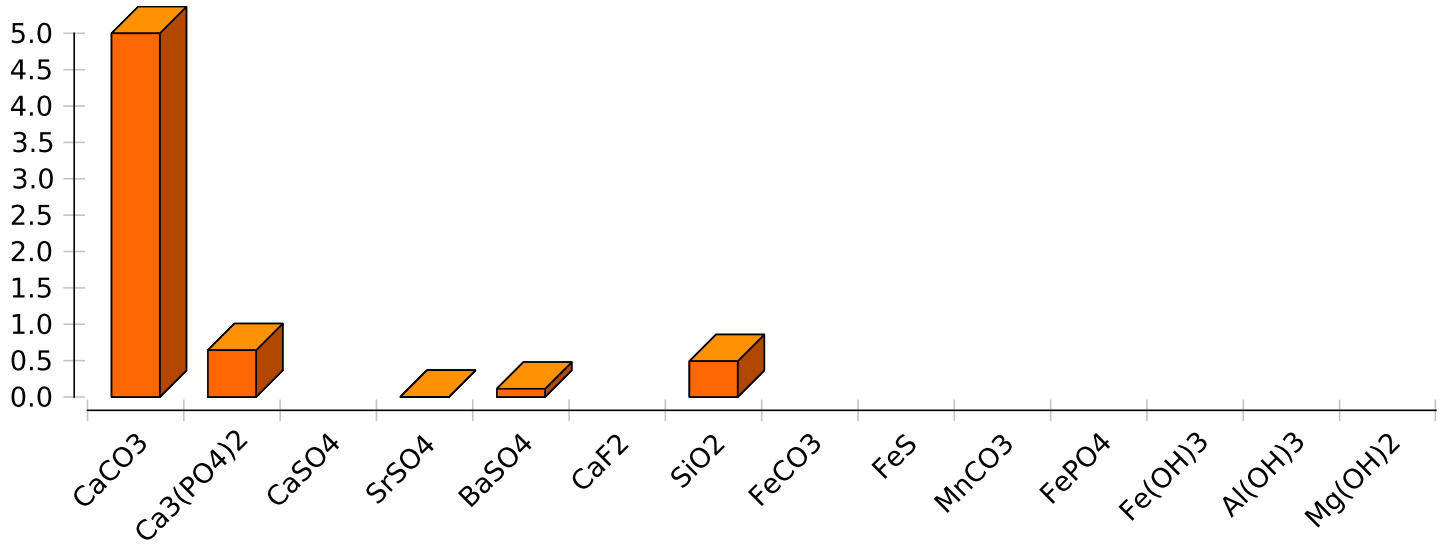
Summary Scale - Precipitation Potentials (mg/L)



Summary Scale - Precipitation Potentials (mg/L)

$CaCO_3$	$Ca_3(PO_4)_2$	$CaSO_4$	$SrSO_4$	$BaSO_4$	CaF_2	SiO_2	$FeCO_3$	FeS	$MnCO_3$	$FePO_4$	$Fe(OH)_3$	$Al(OH)_3$	$Mg(OH)_2$
73.123	0	0	0	0	0	0	0	0	0	0	0	0	0

Summary Scale - X Saturation



Summary Scale - X Saturation

$CaCO_3$	$Ca_3(PO_4)_2$	$CaSO_4$	$SrSO_4$	$BaSO_4$	CaF_2	SiO_2	$FeCO_3$	FeS	$MnCO_3$	$FePO_4$	$Fe(OH)_3$	$Al(OH)_3$	$Mg(OH)_2$
7.086	0.643	0	0.001	0.113	0	0.492	0	0	0	0	0	0	0

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Carbonate Scales	Precipitation Potential	X Saturation	Saturation Index
$CaCO_3$	73.123	7.086	0.850
$MgCO_3$	0.000	2.577	0.411
$SrCO_3$	0.000	0.390	-0.409
$BaCO_3$	0.000	0.003	-2.470
$FeCO_3$	0.000	0.000	0.000
$MnCO_3$	0.000	0.000	0.000

Phosphate Scales	Precipitation Potential	X Saturation	Saturation Index
$Ca_3(PO4)_2$	0.000	0.643	-0.192
$Mg_3(PO4)_2$	0.000	0.000	-5.662
$Sr_3(PO4)_2$	0.000	0.000	-8.786
$Ba_3(PO4)_2$	0.000	0.000	-17.435
$FeHPO_4$	0.000	0.000	0.000
$Fe_3(PO_4)_2$	0.000	0.000	0.000
$Mn_3(PO_4)_2$	0.000	0.000	0.000
$FePO_4$	0.000	0.000	0.000
$AlPO_4$	0.000	0.000	0.000
$MgNH_4PO_4.6H_2O$	0.000	0.000	-3.673

Sulfate Scales	Precipitation Potential	X Saturation	Saturation Index
$CaSO_4$	0.000	0.000	-3.502
$SrSO_4$	0.000	0.001	-3.149
$BaSO_4$	0.000	0.113	-0.948

Fluoride Scales	Precipitation Potential	X Saturation	Saturation Index
CaF_2	0.000	0.000	0.000
MgF_2	0.000	0.000	0.000
SrF_2	0.000	0.000	0.000
BaF_2	0.000	0.000	0.000
FeF_2	0.000	0.000	0.000

Metal Hydroxide and Oxide Scales	Precipitation Potential	X Saturation	Saturation Index
$Mg(OH)_2$	0.000	0.000	-4.376
$Fe(OH)_2$	0.000	0.000	0.000
$Mn(OH)_2$	0.000	0.000	0.000
$Fe(OH)_3$	0.000	0.000	0.000
MnO_2	0.000	0.000	0.000
$Al(OH)_3$	0.000	0.000	0.000
$Ca(OH)_2$	0.000	0.000	-9.767

Sulfide Scales	Precipitation Potential	X Saturation	Saturation Index
FeS	0.000	0.000	0.000
MnS	0.000	0.000	0.000

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Projection by:	**Robert McCandless**	AWC Proton | 3.031.03
Client name:	BC	(release date: June 25, 2017)
Project:	DWPR / Pass2 RO NanoBWpermeate 80pct	
Location:	United States / Arizona / Scottsdale	

Silicate Scales	Precipitation Potential	X Saturation	Saturation Index
$CaSiO_3.H_2O$	0.000	0.000	0.000
$MgSiO_3.H_2O$	0.000	0.039	-1.410
$Mg_3Si_2O_5(OH)_4$	0.000	0.001	-2.922
$Al_2Si_2O_5(OH)_4$	0.000	0.000	0.000
Na_2F_6Si	0.000	0.000	0.000
SiO_2	0.000	0.492	-0.308

Scales above 100% saturation	
$CaCO_3$	Saturation is 7.09 X; [Saturation Index is 0.85]
$MgCO_3$	Saturation is 2.58 X; [Saturation Index is 0.41]

Critical Indices		Guideline	Status
CaCO3 SI (CCNI)	0.850	< 2.300	OK
Mg(OH)2 SI	-4.376	< 9.200	OK
SiO2 (MSI)	0.000	< 10.000	OK
Antiscalant Precipitation Index (API)	8.017	< 9.900	OK
Ca3(PO4)2 SI (MPI)	-0.192	< 4.200	OK
CaSO4 SI	-3.502	< 0.500	OK
BaSO4 SI	-0.948	< 3.000	OK
SrSO4 SI	-3.149	< 1.000	OK
LSI	1.210		OK
Stiff&Davis Index	1.435		OK

Chemical dosing:	AWC A-102 Ultra	HCL
Calculated Dosage:	0.600 mg/L	0.000 mg/L
Total Dosage (modified by user):	0.600 mg/L	N/A
% Concentration:	N/A	37.000%
Density:	1.120 g/cm3	1.184 g/cm3
Dosing Pump:	0.037 ml/min	0.000 ml/min
Hours of Operation/Day:	24 hour(s)	24 hour(s)
Consumption per:		
Day	0.130 lbs	0.000 lbs
Week	0.909 lbs	0.000 lbs
4 Weeks	3.634 lbs	0.000 lbs
Year	47.372 lbs	0.000 lbs
5 Years	236.862 lbs	0.000 lbs

Insert your additional comments below:

Comments...

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Projections with Hydranautics NANO-BW-4040 for Maximum Recovery

Projection by:	**Robert McCandless**	AWC Proton | 3.031.03
Client name:	BC	(release date: June 25, 2017)
Project:	DWPR / Pass2 RO NanoBWpermeate 93.3pct	
Location:	United States / Arizona / Scottsdale	

	Unit	Overall
Source:		Well Water (Brackish)
System Recovery:	%	93.335
Internal Recovery:	%	93.335
Temperature:	°F	86.000
Total permeate:	gal/min	16.800
Average Flux:	gfd	16.390

	Unit	Overall
Recycling flow:	gal/min	0.000
Fouling Factor:		1.000
Feed Pressure:	psi	115.721
Total Δ P Elements:	psi	6.652
Brine Pressure:	psi	109.079

Cations	Raw water (mg/L)	Balanced Feed (mg/L)	Recycling + Feed (mg/L)	Reject (mg/L)	Permeate (mg/L)
Ca^{2+}	29.50	29.50	29.50	424.06	1.32
Mg^{2+}	10.70	10.70	10.70	153.81	0.48
Ba^{2+}	0.03	0.03	0.03	0.43	0.00
Sr^{2+}	0.42	0.42	0.42	6.04	0.02
Na^{+}	187.71	187.71	187.71	2536.09	20.01
K^{+}	17.00	17.00	17.00	229.68	1.81
Fe^{2+}	0.00	0.00	0.00	0.00	0.00
Fe^{3+}	0.00	0.00	0.00	0.00	0.00
Al^{3+}	0.00	0.00	0.00	0.00	0.00
Mn^{2+}	0.00	0.00	0.00	0.00	0.00
NH3/NH4(as N)	1.33	1.33	1.33	17.81	0.15

Anions	Raw water (mg/L)	Balanced Feed (mg/L)	Recycling + Feed (mg/L)	Reject (mg/L)	Permeate (mg/L)
HCO_3^- Alk($CaCO_3$)	96.00	95.92	95.92	1288.99	9.05
CO_3^{2-} Alk($CaCO_3$)	0.00	0.18	0.18	49.39	0.00
Total Alk ($CaCO_3$)	96.00	96.10	96.10	1338.38	9.05
Ortho-$PO4^3$	0.10	0.10	0.10	1.42	0.01
SO_4^{2-}	5.00	5.00	5.00	71.88	0.22
F^-	0.00	0.00	0.00	0.00	0.00
Cl^-	318.00	318.00	318.00	4350.03	30.07
Br^-	0.00	0.00	0.00	0.00	0.00
SiO_2	9.70	9.70	9.70	133.03	0.89
NO_3^--N	0.84	0.84	0.84	11.43	0.08
NO_2^--N	0.00	0.00	0.00	0.00	0.00
Sulfides (as S^2)	0.00	0.00	0.00	0.00	0.00
B	0.36	0.36	0.36	1.15	0.30
AS (III)	0.00	0.00	0.00	0.00	0.00
AS (V)	0.00	0.00	0.00	0.00	0.00
TDS:	699.050	699.050	699.040	9554.730	66.650
Conductivity (µs/cm):	1290.000	1105.636	1105.635	15131.650	104.017
pH:	7.120	7.120	7.120	8.120	6.130
Flow:	gal/min	18.000	0.000	1.200	16.800

Summary	Product:	Dosage:
pH adjusted using:	HCL	0.000 mg/L
Selected product:	AWC A-102 Ultra	1.080 mg/L

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	Unit	Stage 1	Stage 2
Total Elements:		12	6
Total Vessels:		2	1
Elements / Vessels:		6	6
Net Osmotic Pressure:	psi	24.423	94.560
Net Driving Pressure:	psi	67.259	57.170
Req'd P/Stage:	psi	85.718	110.610
Feed P:	psi	115.721	110.610
Permeate Throttle/P:	psi	30.003	0.000
Boost P:	psi	0.000	0.000
Concentrate P:	psi	110.610	109.079

Stages output

	Membrane Model:	Permeate Flow: gal/min	Average Flux: gfd	System Recovery: %	β	Feed Flow / PV: gal/min	Concentrate Flow / PV: gal/min	Δ P: psi	Osmotic P: psi	Net Driving P: psi
Stage1		12.445	18.212	69.137	1.124	9.000	2.778	5.111	24.418	67.259
1	BW30LE-4040	1.168	20.516	12.981	1.122	9.000	7.832	1.575	9.162	75.769
2	BW30LE-4040	1.124	19.741	14.354	1.123	7.832	6.708	1.219	10.625	72.909
3	BW30LE-4040	1.078	18.928	16.069	1.124	6.708	5.630	0.914	12.562	69.906
4	BW30LE-4040	1.025	17.998	18.205	1.125	5.630	4.605	0.659	15.210	66.471
5	BW30LE-4040	0.959	16.832	20.815	1.126	4.605	3.646	0.452	18.960	62.165
6	BW30LE-4040	0.869	15.254	23.822	1.123	3.646	2.778	0.292	24.418	56.335
Stage2		4.356	12.748	78.404	1.256	5.555	1.200	1.531	93.375	57.170
1	BW30LE-4040	1.203	21.131	21.660	1.152	5.555	4.352	0.623	31.639	78.042
2	BW30LE-4040	1.053	18.498	24.206	1.144	4.352	3.299	0.396	40.862	68.317
3	BW30LE-4040	0.858	15.067	26.001	1.126	3.299	2.441	0.240	53.377	55.646
4	BW30LE-4040	0.655	11.507	26.728	1.102	2.441	1.785	0.140	69.570	42.498
5	BW30LE-4040	0.540	9.481	28.794	1.088	1.785	1.246	0.078	93.375	35.015
6	BW30LE-4040	0.046	0.804	2.885	1.000	1.246	1.200	0.054	85.809	2.970

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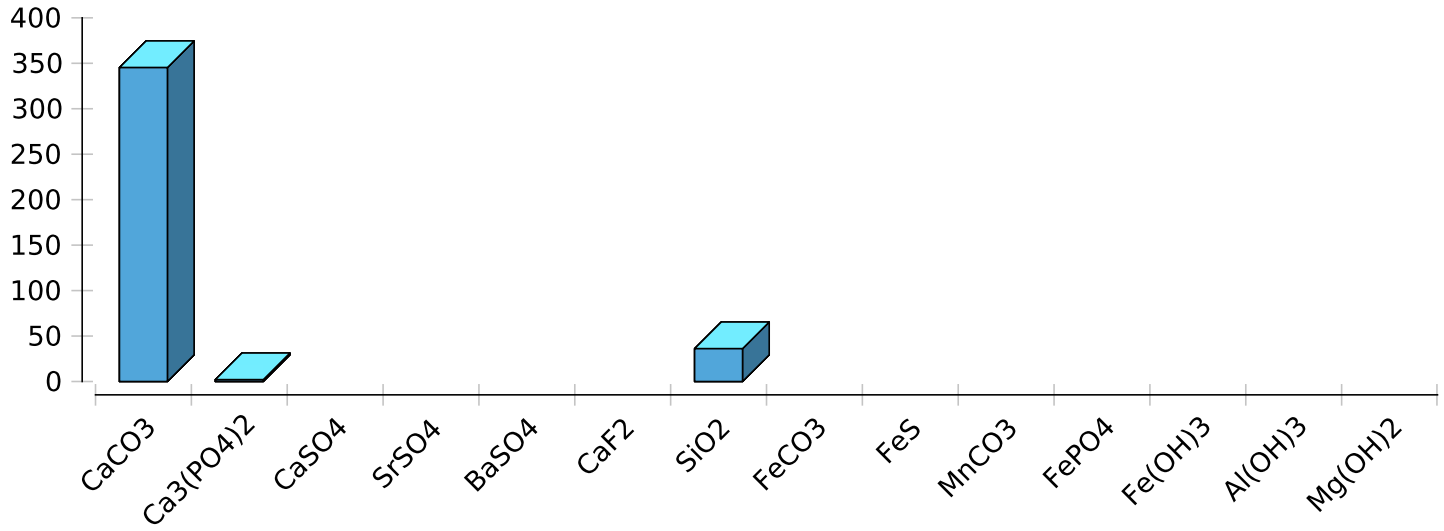
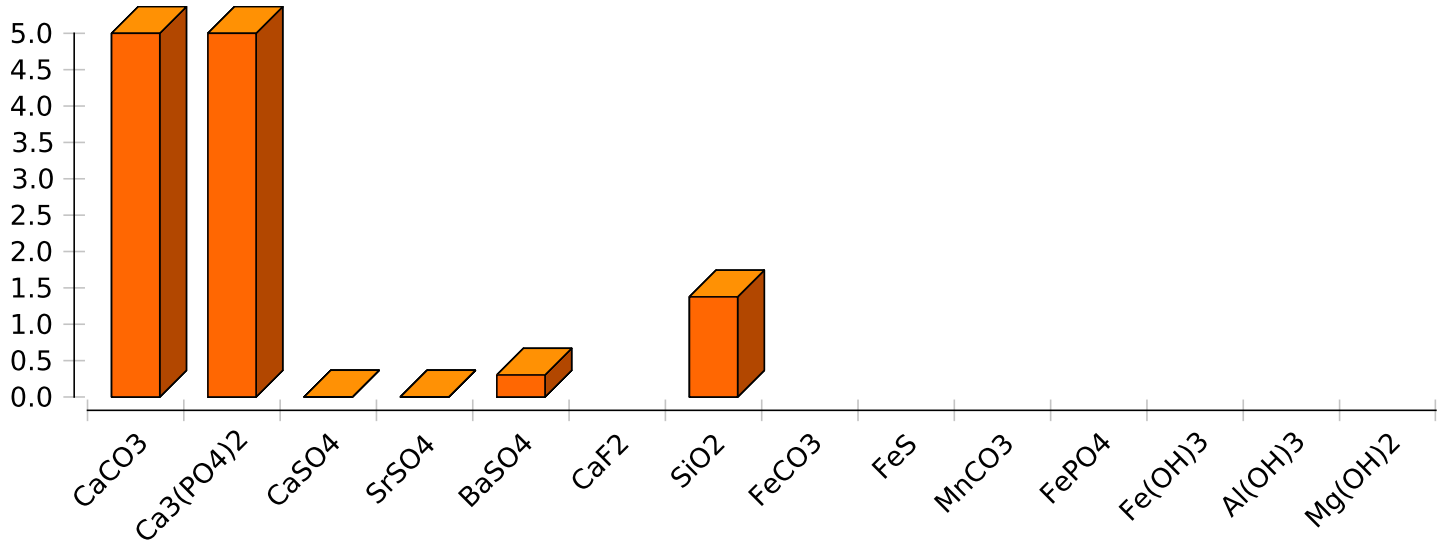
Summary Scale - Precipitation Potentials (mg/L)



Summary Scale - Precipitation Potentials (mg/L)

$CaCO_3$	$Ca_3(PO_4)_2$	$CaSO_4$	$SrSO_4$	$BaSO_4$	CaF_2	SiO_2	$FeCO_3$	FeS	$MnCO_3$	$FePO_4$	$Fe(OH)_3$	$Al(OH)_3$	$Mg(OH)_2$
345.257	1.999	0	0	0	0	36.087	0	0	0	0	0	0	0

Summary Scale - X Saturation



Summary Scale - X Saturation

$CaCO_3$	$Ca_3(PO_4)_2$	$CaSO_4$	$SrSO_4$	$BaSO_4$	CaF_2	SiO_2	$FeCO_3$	FeS	$MnCO_3$	$FePO_4$	$Fe(OH)_3$	$Al(OH)_3$	$Mg(OH)_2$
64.24	53.096	0.001	0.001	0.303	0	1.377	0	0	0	0	0	0	0

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Carbonate Scales	Precipitation Potential	X Saturation	Saturation Index
$CaCO_3$	345.257	64.240	1.808
$MgCO_3$	17.953	25.509	1.407
$SrCO_3$	5.453	3.578	0.554
$BaCO_3$	0.000	0.031	-1.505
$FeCO_3$	0.000	0.000	0.000
$MnCO_3$	0.000	0.000	0.000

Phosphate Scales	Precipitation Potential	X Saturation	Saturation Index
$Ca_3(PO4)_2$	1.999	53.096	1.725
$Mg_3(PO4)_2$	0.000	0.000	-5.470
$Sr_3(PO4)_2$	0.000	0.000	-8.582
$Ba_3(PO4)_2$	0.000	0.000	-17.222
$FeHPO_4$	0.000	0.000	0.000
$Fe_3(PO_4)_2$	0.000	0.000	0.000
$Mn_3(PO_4)_2$	0.000	0.000	0.000
$FePO_4$	0.000	0.000	0.000
$AlPO_4$	0.000	0.000	0.000
$MgNH_4PO_4.6H_2O$	0.000	0.000	-3.336

Sulfate Scales	Precipitation Potential	X Saturation	Saturation Index
$CaSO_4$	0.000	0.001	-3.236
$SrSO_4$	0.000	0.001	-3.019
$BaSO_4$	0.000	0.303	-0.519

Fluoride Scales	Precipitation Potential	X Saturation	Saturation Index
CaF_2	0.000	0.000	0.000
MgF_2	0.000	0.000	0.000
SrF_2	0.000	0.000	0.000
BaF_2	0.000	0.000	0.000
FeF_2	0.000	0.000	0.000

Metal Hydroxide and Oxide Scales	Precipitation Potential	X Saturation	Saturation Index
$Mg(OH)_2$	0.000	0.000	-3.349
$Fe(OH)_2$	0.000	0.000	0.000
$Mn(OH)_2$	0.000	0.000	0.000
$Fe(OH)_3$	0.000	0.000	0.000
MnO_2	0.000	0.000	0.000
$Al(OH)_3$	0.000	0.000	0.000
$Ca(OH)_2$	0.000	0.000	-8.792

Sulfide Scales	Precipitation Potential	X Saturation	Saturation Index
FeS	0.000	0.000	0.000
MnS	0.000	0.000	0.000

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Projection by:	**Robert McCandless**	AWC Proton | 3.031.03
Client name:	BC	(release date: June 25, 2017)
Project:	DWPR / Pass2 RO NanoBWpermeate 93.3pct	
Location:	United States / Arizona / Scottsdale	

Silicate Scales	Precipitation Potential	X Saturation	Saturation Index
$CaSiO_3.H_2O$	0.000	0.000	0.000
$MgSiO_3.H_2O$	0.000	0.333	-0.477
$Mg_3Si_2O_5(OH)_4$	0.000	0.895	-0.048
$Al_2Si_2O_5(OH)_4$	0.000	0.000	0.000
Na_2F_6Si	0.000	0.000	0.000
SiO_2	36.087	1.377	0.139

Scales above 100% saturation	
$CaCO_3$	Saturation is 64.24 X; [Saturation Index is 1.81]
$MgCO_3$	Saturation is 25.51 X; [Saturation Index is 1.41]
$SrCO_3$	Saturation is 3.58 X; [Saturation Index is 0.55]
$Ca_3(PO4)_2$	Saturation is 53.10 X; [Saturation Index is 1.73]
SiO_2	Saturation is 1.38 X; [Saturation Index is 0.14]

Critical Indices		Guideline	Status
CaCO3 SI (CCNI)	1.808	< 2.300	OK
Mg(OH)2 SI	-3.349	< 9.200	OK
SiO2 (MSI)	8.782	< 10.000	OK
Antiscalant Precipitation Index (API)	9.493	< 9.900	OK
Ca3(PO4)2 SI (MPI)	1.725	< 4.200	OK
CaSO4 SI	-3.236	< 0.500	OK
BaSO4 SI	-0.519	< 3.000	OK
SrSO4 SI	-3.019	< 1.000	OK
LSI	2.460		OK
Stiff&Davis Index	2.365		OK

Chemical dosing:	AWC A-102 Ultra	HCL
Calculated Dosage:	1.080 mg/L	0.000 mg/L
Total Dosage (modified by user):	1.080 mg/L	N/A
% Concentration:	N/A	37.000%
Density:	1.120 g/cm3	1.184 g/cm3
Dosing Pump:	0.066 ml/min	0.000 ml/min
Hours of Operation/Day:	24 hour(s)	24 hour(s)
Consumption per:		
Day	0.234 lbs	0.000 lbs
Week	1.635 lbs	0.000 lbs
4 Weeks	6.539 lbs	0.000 lbs
Year	85.246 lbs	0.000 lbs
5 Years	426.231 lbs	0.000 lbs

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Comments...

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location to another and may change with time, customer is responsible for determining whether products are appropriate for customer's use. American Water Chemicals assumes no liability, if, as a result of customer's use of the Proton membrane aqueous chemistry calculator, the customer should be sued for alleged infringement of any patent not owned or controlled by American Water Chemicals Inc.

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Projections with KMS 4040-SR200 for 80% Recovery

Projection by:	**Robert McCandless**	AWC Proton | 3.031.03
Client name:	BC	(release date: June 25, 2017)
Project:	DWPR / Pass2RO KMS SR200 Permeate 80pct	
Location:	United States / Arizona / Scottsdale	

	Unit	Overall
Source:		Well Water (Brackish)
System Recovery:	%	80.000
Internal Recovery:	%	80.000
Temperature:	°F	86.000
Total permeate:	gal/min	14.400
Average Flux:	gfd	14.050

	Unit	Overall
Recycling flow:	gal/min	0.000
Fouling Factor:		1.000
Feed Pressure:	psi	78.066
Total Δ P Elements:	psi	10.752
Brine Pressure:	psi	67.312

Cations	Raw water (mg/L)	Balanced Feed (mg/L)	Recycling + Feed (mg/L)	Reject (mg/L)	Permeate (mg/L)
Ca^{2+}	12.10	12.10	12.10	60.06	0.11
Mg^{2+}	2.10	2.10	2.10	10.42	0.02
Ba^{2+}	0.00	0.00	0.00	0.00	0.00
Sr^{2+}	0.13	0.13	0.13	0.64	0.00
Na^{+}	190.56	190.56	190.56	917.18	8.91
K^{+}	15.00	15.00	15.00	72.19	0.70
Fe^{2+}	0.00	0.00	0.00	0.00	0.00
Fe^{3+}	0.00	0.00	0.00	0.00	0.00
Al^{3+}	0.00	0.00	0.00	0.00	0.00
Mn^{2+}	0.00	0.00	0.00	0.00	0.00
NH3/NH4(as N)	2.08	2.08	2.08	9.88	0.13

Anions	Raw water (mg/L)	Balanced Feed (mg/L)	Recycling + Feed (mg/L)	Reject (mg/L)	Permeate (mg/L)
HCO_3^- Alk($CaCO_3$)	50.00	49.93	49.93	238.88	2.25
CO_3^{2-} Alk($CaCO_3$)	0.00	0.16	0.16	4.33	0.00
Total Alk ($CaCO_3$)	50.00	50.09	50.09	243.21	2.25
Ortho-PO4^3	0.10	0.10	0.10	0.49	0.00
SO_4^{2-}	5.00	5.00	5.00	24.82	0.05
F^-	0.00	0.00	0.00	0.00	0.00
Cl^-	299.00	299.00	299.00	1441.03	13.49
Br^-	0.00	0.00	0.00	0.00	0.00
SiO_2	10.30	10.30	10.30	49.71	0.45
NO_3^--N	0.79	0.79	0.79	3.81	0.04
NO_2^--N	0.00	0.00	0.00	0.00	0.00
Sulfides (as S^2)	0.00	0.00	0.00	0.00	0.00
B	0.30	0.30	0.30	0.59	0.23
AS (III)	0.00	0.00	0.00	0.00	0.00
AS (V)	0.00	0.00	0.00	0.00	0.00
TDS:	600.690	600.690	600.690	2895.010	27.120
Conductivity (µs/cm):	1100.000	959.840	959.839	4627.315	42.924
pH:	7.350	7.350	7.350	7.980	6.040
Flow:	gal/min	18.000	0.000	3.600	14.400

Summary	Product:	Dosage:
pH adjusted using:	HCL	0.000 mg/L
Selected product:	AWC A-102 Ultra	0.600 mg/L

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	Unit	Stage 1	Stage 2
Total Elements:		12	6
Total Vessels:		2	1
Elements / Vessels:		6	6
Net Osmotic Pressure:	psi	15.085	30.281
Net Driving Pressure:	psi	54.615	50.519
Req'd P/Stage:	psi	69.165	72.077
Feed P:	psi	78.066	72.077
Permeate Throttle/P:	psi	8.901	0.000
Boost P:	psi	0.000	0.000
Concentrate P:	psi	72.077	67.312

Stages output

	Membrane Model:	Permeate Flow: gal/min	Average Flux: gfd	System Recovery: %	β	Feed Flow / PV: gal/min	Concentrate Flow / PV: gal/min	Δ P: psi	Osmotic P: psi	Net Driving P: psi
Stage1		10.105	14.788	56.140	1.093	9.000	3.947	5.990	15.085	54.615
1	BW30LE-4040	0.934	16.398	10.375	1.094	9.000	8.066	1.613	7.797	60.562
2	BW30LE-4040	0.897	15.757	11.124	1.093	8.066	7.169	1.323	8.698	58.192
3	BW30LE-4040	0.862	15.136	12.023	1.093	7.169	6.307	1.067	9.796	55.900
4	BW30LE-4040	0.826	14.509	13.100	1.093	6.307	5.481	0.844	11.156	53.584
5	BW30LE-4040	0.788	13.841	14.381	1.093	5.481	4.693	0.652	12.874	51.118
6	BW30LE-4040	0.745	13.088	15.882	1.092	4.693	3.947	0.490	15.085	48.336
Stage2		4.295	12.570	54.400	1.127	7.895	3.600	4.764	30.274	50.519
1	BW30LE-4040	0.844	14.826	10.694	1.088	7.895	7.051	1.279	16.684	54.753
2	BW30LE-4040	0.797	13.992	11.301	1.086	7.051	6.254	1.043	18.600	51.676
3	BW30LE-4040	0.747	13.126	11.952	1.083	6.254	5.506	0.841	20.858	48.476
4	BW30LE-4040	0.695	12.200	12.617	1.080	5.506	4.812	0.669	23.521	45.058
5	BW30LE-4040	0.637	11.192	13.245	1.076	4.812	4.174	0.525	26.649	41.333
6	BW30LE-4040	0.574	10.084	13.756	1.071	4.174	3.600	0.407	30.274	37.242

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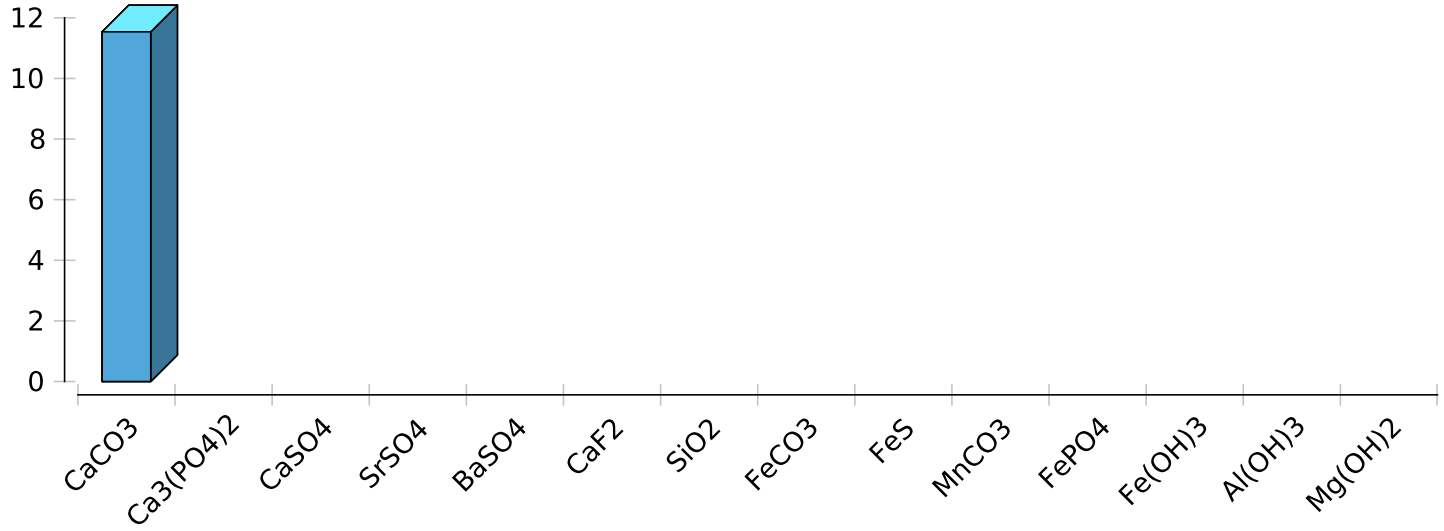
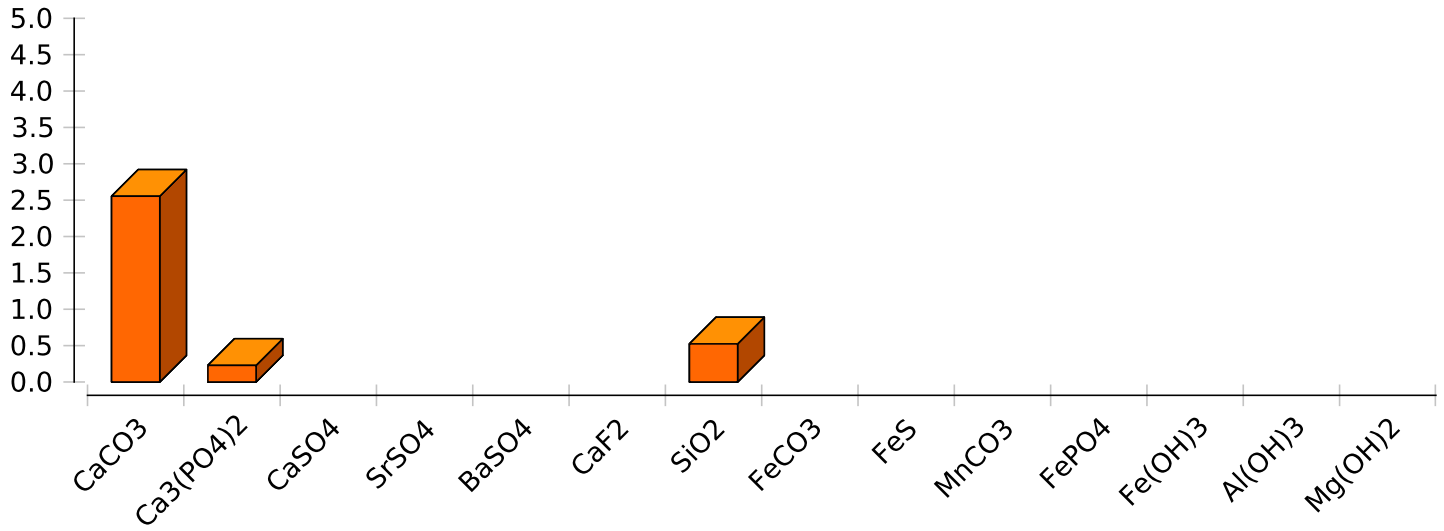
Summary Scale - Precipitation Potentials (mg/L)



Summary Scale - Precipitation Potentials (mg/L)

$CaCO_3$	$Ca_3(PO_4)_2$	$CaSO_4$	$SrSO_4$	$BaSO_4$	CaF_2	SiO_2	$FeCO_3$	FeS	$MnCO_3$	$FePO_4$	$Fe(OH)_3$	$Al(OH)_3$	$Mg(OH)_2$
11.538	0	0	0	0	0	0	0	0	0	0	0	0	0

Summary Scale - X Saturation



Summary Scale - X Saturation

$CaCO_3$	$Ca_3(PO_4)_2$	$CaSO_4$	$SrSO_4$	$BaSO_4$	CaF_2	SiO_2	$FeCO_3$	FeS	$MnCO_3$	$FePO_4$	$Fe(OH)_3$	$Al(OH)_3$	$Mg(OH)_2$
2.554	0.228	0	0	0	0	0.524	0	0	0	0	0	0	0

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Carbonate Scales	Precipitation Potential	X Saturation	Saturation Index
$CaCO_3$	11.538	2.554	0.407
$MgCO_3$	0.000	0.527	-0.278
$SrCO_3$	0.000	0.120	-0.919
$BaCO_3$	0.000	0.000	0.000
$FeCO_3$	0.000	0.000	0.000
$MnCO_3$	0.000	0.000	0.000

Phosphate Scales	Precipitation Potential	X Saturation	Saturation Index
$Ca_3(PO4)_2$	0.000	0.228	-0.643
$Mg_3(PO4)_2$	0.000	0.000	-6.903
$Sr_3(PO4)_2$	0.000	0.000	-9.437
$Ba_3(PO4)_2$	0.000	0.000	0.000
$FeHPO_4$	0.000	0.000	0.000
$Fe_3(PO_4)_2$	0.000	0.000	0.000
$Mn_3(PO_4)_2$	0.000	0.000	0.000
$FePO_4$	0.000	0.000	0.000
$AlPO_4$	0.000	0.000	0.000
$MgNH_4PO_4.6H_2O$	0.000	0.000	-3.767

Sulfate Scales	Precipitation Potential	X Saturation	Saturation Index
$CaSO_4$	0.000	0.000	-3.417
$SrSO_4$	0.000	0.000	-3.401
$BaSO_4$	0.000	0.000	0.000

Fluoride Scales	Precipitation Potential	X Saturation	Saturation Index
CaF_2	0.000	0.000	0.000
MgF_2	0.000	0.000	0.000
SrF_2	0.000	0.000	0.000
BaF_2	0.000	0.000	0.000
FeF_2	0.000	0.000	0.000

Metal Hydroxide and Oxide Scales	Precipitation Potential	X Saturation	Saturation Index
$Mg(OH)_2$	0.000	0.000	-4.587
$Fe(OH)_2$	0.000	0.000	0.000
$Mn(OH)_2$	0.000	0.000	0.000
$Fe(OH)_3$	0.000	0.000	0.000
MnO_2	0.000	0.000	0.000
$Al(OH)_3$	0.000	0.000	0.000
$Ca(OH)_2$	0.000	0.000	-9.600

Sulfide Scales	Precipitation Potential	X Saturation	Saturation Index
FeS	0.000	0.000	0.000
MnS	0.000	0.000	0.000

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Projection by:	**Robert McCandless**	AWC Proton | 3.031.03
Client name:	BC	(release date: June 25, 2017)
Project:	DWPR / Pass2RO KMS SR200 Permeate 80pct	
Location:	United States / Arizona / Scottsdale	

Silicate Scales	Precipitation Potential	X Saturation	Saturation Index
$CaSiO_3.H_2O$	0.000	0.000	0.000
$MgSiO_3.H_2O$	0.000	0.025	-1.606
$Mg_3Si_2O_5(OH)_4$	0.000	0.000	-3.521
$Al_2Si_2O_5(OH)_4$	0.000	0.000	0.000
Na_2F_6Si	0.000	0.000	0.000
SiO_2	0.000	0.524	-0.281

Scales above 100% saturation	
$CaCO_3$	Saturation is 2.55 X; [Saturation Index is 0.41]

Critical Indices		Guideline	Status
CaCO3 SI (CCNI)	0.407	< 2.300	OK
Mg(OH)2 SI	-4.587	< 9.200	OK
SiO2 (MSI)	0.000	< 10.000	OK
Antiscalant Precipitation Index (API)	7.321	< 9.900	OK
Ca3(PO4)2 SI (MPI)	-0.643	< 4.200	OK
CaSO4 SI	-3.417	< 0.500	OK
BaSO4 SI	0.000	< 3.000	OK
SrSO4 SI	-3.401	< 1.000	OK
LSI	0.782		OK
Stiff&Davis Index	1.031		OK

Chemical dosing:	AWC A-102 Ultra	HCL
Calculated Dosage:	0.600 mg/L	0.000 mg/L
Total Dosage (modified by user):	0.600 mg/L	N/A
% Concentration:	N/A	37.000%
Density:	1.120 g/cm3	1.184 g/cm3
Dosing Pump:	0.037 ml/min	0.000 ml/min
Hours of Operation/Day:	24 hour(s)	24 hour(s)
Consumption per:		
Day	0.130 lbs	0.000 lbs
Week	0.909 lbs	0.000 lbs
4 Weeks	3.634 lbs	0.000 lbs
Year	47.372 lbs	0.000 lbs
5 Years	236.862 lbs	0.000 lbs

Insert your additional comments below:

Comments...

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Projections with KMS 4040-SR200 for Maximum Recovery

Projection by:	**Robert McCandless**	AWC Proton | 3.031.03
Client name:	BC	(release date: June 25, 2017)
Project:	DWPR / Pass2RO KMS SR200 Permeate 93.7pct	
Location:	United States / Arizona / Scottsdale	

	Unit	Overall
Source:		Well Water (Brackish)
System Recovery:	%	93.744
Internal Recovery:	%	93.744
Temperature:	°F	86.000
Total permeate:	gal/min	16.874
Average Flux:	gfd	16.460

	Unit	Overall
Recycling flow:	gal/min	0.000
Fouling Factor:		1.000
Feed Pressure:	psi	108.571
Total Δ P Elements:	psi	6.606
Brine Pressure:	psi	101.975

Cations	Raw water (mg/L)	Balanced Feed (mg/L)	Recycling + Feed (mg/L)	Reject (mg/L)	Permeate (mg/L)
Ca^{2+}	12.10	12.10	12.10	172.64	1.39
Mg^{2+}	2.10	2.10	2.10	29.96	0.24
Ba^{2+}	0.00	0.00	0.00	0.00	0.00
Sr^{2+}	0.13	0.13	0.13	1.83	0.01
Na^{+}	190.56	190.56	190.56	2582.15	30.96
K^{+}	15.00	15.00	15.00	203.25	2.44
Fe^{2+}	0.00	0.00	0.00	0.00	0.00
Fe^{3+}	0.00	0.00	0.00	0.00	0.00
Al^{3+}	0.00	0.00	0.00	0.00	0.00
Mn^{2+}	0.00	0.00	0.00	0.00	0.00
NH3/NH4(as N)	2.08	2.08	2.08	27.77	0.37

Anions	Raw water (mg/L)	Balanced Feed (mg/L)	Recycling + Feed (mg/L)	Reject (mg/L)	Permeate (mg/L)
HCO_3^- Alk($CaCO_3$)	50.00	49.93	49.93	658.83	7.98
CO_3^{2-} Alk($CaCO_3$)	0.00	0.16	0.16	40.15	0.00
Total Alk ($CaCO_3$)	50.00	50.09	50.09	698.98	7.98
Ortho-$PO4^3$	0.10	0.10	0.10	1.41	0.01
SO_4^{2-}	5.00	5.00	5.00	71.34	0.57
F^-	0.00	0.00	0.00	0.00	0.00
Cl^-	299.00	299.00	299.00	4058.30	48.12
Br^-	0.00	0.00	0.00	0.00	0.00
SiO_2	10.30	10.30	10.30	140.16	1.63
NO_3^--N	0.79	0.79	0.79	10.73	0.13
NO_2^--N	0.00	0.00	0.00	0.00	0.00
Sulfides (as S^2)	0.00	0.00	0.00	0.00	0.00
B	0.30	0.30	0.30	0.97	0.26
AS (III)	0.00	0.00	0.00	0.00	0.00
AS (V)	0.00	0.00	0.00	0.00	0.00
TDS:	600.690	600.690	600.690	8154.840	96.500
Conductivity (µs/cm):	1100.000	959.840	959.839	13034.855	153.965
pH:	7.350	7.350	7.350	8.360	6.580
Flow:	gal/min	18.000	0.000	1.130	16.870

Summary	Product:	Dosage:
pH adjusted using:	HCL	0.000 mg/L
Selected product:	AWC A-102 Ultra	0.600 mg/L

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	Unit	Stage 1	Stage 2
Total Elements:		12	6
Total Vessels:		2	1
Elements / Vessels:		6	6
Net Osmotic Pressure:	psi	22.114	93.175
Net Driving Pressure:	psi	67.554	57.421
Req'd P/Stage:	psi	84.496	103.460
Feed P:	psi	108.571	103.460
Permeate Throttle/P:	psi	24.075	0.000
Boost P:	psi	0.000	0.000
Concentrate P:	psi	103.460	101.975

Stages output

	Membrane Model:	Permeate Flow: gal/min	Average Flux: gfd	System Recovery: %	β	Feed Flow / PV: gal/min	Concentrate Flow / PV: gal/min	Δ P: psi	Osmotic P: psi	Net Driving P: psi
Stage1		12.499	18.291	69.440	1.124	9.000	2.750	5.111	22.110	67.554
1	BW30LE-4040	1.164	20.439	12.932	1.121	9.000	7.836	1.575	8.223	75.485
2	BW30LE-4040	1.122	19.707	14.321	1.122	7.836	6.714	1.220	9.529	72.781
3	BW30LE-4040	1.079	18.949	16.071	1.124	6.714	5.635	0.916	11.262	69.981
4	BW30LE-4040	1.030	18.090	18.281	1.126	5.635	4.605	0.660	13.644	66.810
5	BW30LE-4040	0.969	17.017	21.044	1.127	4.605	3.636	0.451	17.053	62.846
6	BW30LE-4040	0.885	15.547	24.351	1.125	3.636	2.750	0.289	22.110	57.419
Stage2		4.375	12.804	79.529	1.248	5.501	1.126	1.485	76.654	57.421
1	BW30LE-4040	1.186	20.830	21.563	1.149	5.501	4.315	0.613	28.460	76.929
2	BW30LE-4040	1.058	18.576	24.302	1.143	4.315	3.257	0.389	36.842	68.605
3	BW30LE-4040	0.891	15.641	26.650	1.130	3.257	2.366	0.231	48.672	57.764
4	BW30LE-4040	0.706	12.406	28.048	1.109	2.366	1.660	0.129	64.725	45.816
5	BW30LE-4040	0.420	7.374	21.657	1.065	1.660	1.240	0.073	76.654	27.234
6	BW30LE-4040	0.114	1.998	7.730	1.010	1.240	1.126	0.051	75.296	7.378

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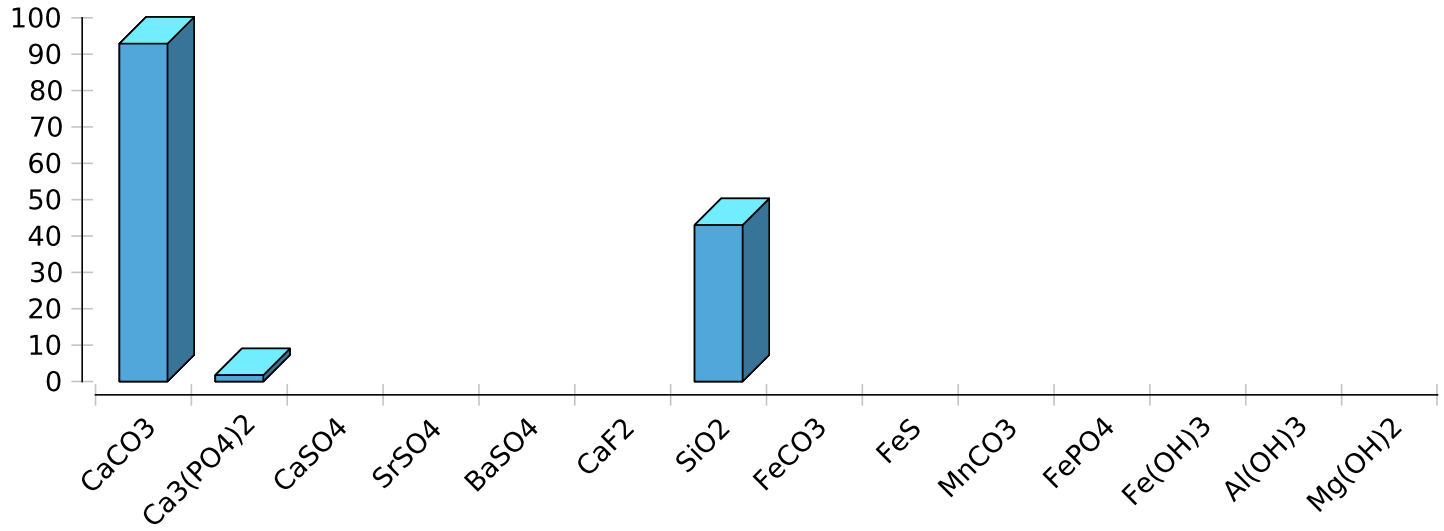
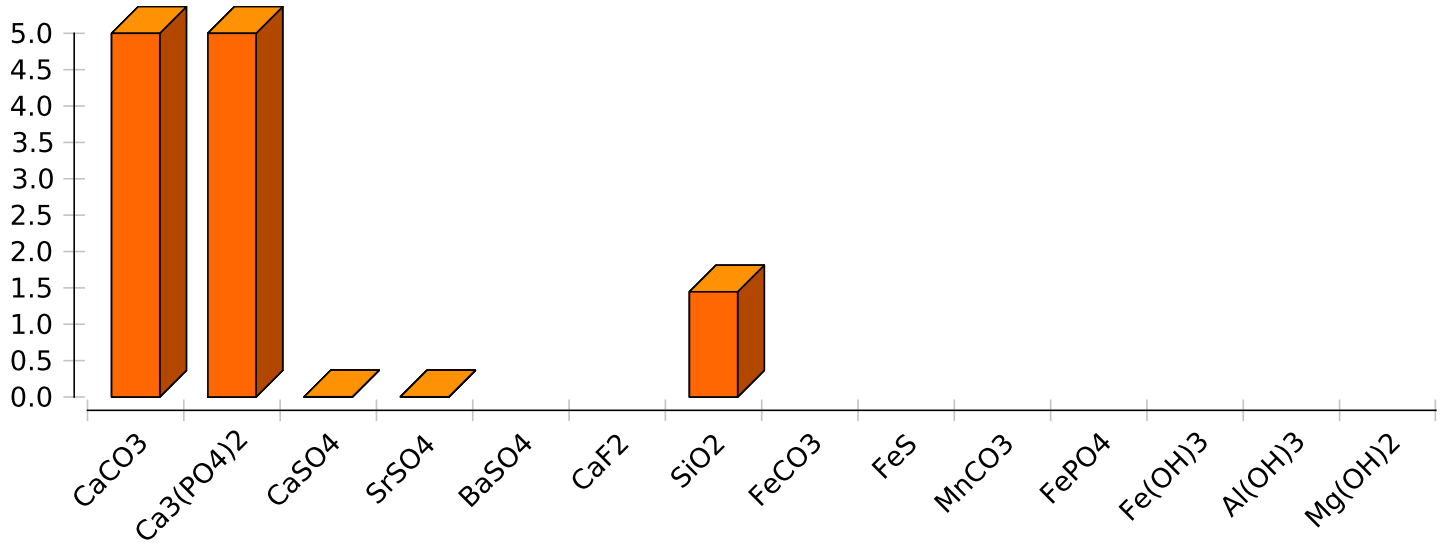
Summary Scale - Precipitation Potentials (mg/L)



Summary Scale - Precipitation Potentials (mg/L)

$CaCO_3$	$Ca_3(PO_4)_2$	$CaSO_4$	$SrSO_4$	$BaSO_4$	CaF_2	SiO_2	$FeCO_3$	FeS	$MnCO_3$	$FePO_4$	$Fe(OH)_3$	$Al(OH)_3$	$Mg(OH)_2$
92.889	1.744	0	0	0	0	43.011	0	0	0	0	0	0	0

Summary Scale - X Saturation



Summary Scale - X Saturation

$CaCO_3$	$Ca_3(PO_4)_2$	$CaSO_4$	$SrSO_4$	$BaSO_4$	CaF_2	SiO_2	$FeCO_3$	FeS	$MnCO_3$	$FePO_4$	$Fe(OH)_3$	$Al(OH)_3$	$Mg(OH)_2$
21.092	15.856	0.003	0.002	0	0	1.446	0	0	0	0	0	0	0

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Carbonate Scales	Precipitation Potential	X Saturation	Saturation Index
$CaCO_3$	92.889	21.092	1.324
$MgCO_3$	0.000	5.309	0.725
$SrCO_3$	0.266	1.125	0.051
$BaCO_3$	0.000	0.000	0.000
$FeCO_3$	0.000	0.000	0.000
$MnCO_3$	0.000	0.000	0.000

Phosphate Scales	Precipitation Potential	X Saturation	Saturation Index
$Ca_3(PO4)_2$	1.744	15.856	1.200
$Mg_3(PO4)_2$	0.000	0.000	-6.130
$Sr_3(PO4)_2$	0.000	0.000	-8.640
$Ba_3(PO4)_2$	0.000	0.000	0.000
$FeHPO_4$	0.000	0.000	0.000
$Fe_3(PO_4)_2$	0.000	0.000	0.000
$Mn_3(PO_4)_2$	0.000	0.000	0.000
$FePO_4$	0.000	0.000	0.000
$AlPO_4$	0.000	0.000	0.000
$MgNH_4PO_4.6H_2O$	0.000	0.001	-3.164

Sulfate Scales	Precipitation Potential	X Saturation	Saturation Index
$CaSO_4$	0.000	0.003	-2.462
$SrSO_4$	0.000	0.002	-2.604
$BaSO_4$	0.000	0.000	0.000

Fluoride Scales	Precipitation Potential	X Saturation	Saturation Index
CaF_2	0.000	0.000	0.000
MgF_2	0.000	0.000	0.000
SrF_2	0.000	0.000	0.000
BaF_2	0.000	0.000	0.000
FeF_2	0.000	0.000	0.000

Metal Hydroxide and Oxide Scales	Precipitation Potential	X Saturation	Saturation Index
$Mg(OH)_2$	0.000	0.000	-3.552
$Fe(OH)_2$	0.000	0.000	0.000
$Mn(OH)_2$	0.000	0.000	0.000
$Fe(OH)_3$	0.000	0.000	0.000
MnO_2	0.000	0.000	0.000
$Al(OH)_3$	0.000	0.000	0.000
$Ca(OH)_2$	0.000	0.000	-8.614

Sulfide Scales	Precipitation Potential	X Saturation	Saturation Index
FeS	0.000	0.000	0.000
MnS	0.000	0.000	0.000

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Silicate Scales	Precipitation Potential	X Saturation	Saturation Index
$CaSiO_3.H_2O$	0.000	0.000	0.000
$MgSiO_3.H_2O$	0.000	0.200	-0.700
$Mg_3Si_2O_5(OH)_4$	0.000	0.203	-0.692
$Al_2Si_2O_5(OH)_4$	0.000	0.000	0.000
Na_2F_6Si	0.000	0.000	0.000
SiO_2	43.011	1.446	0.160

Scales above 100% saturation	
$CaCO_3$	Saturation is 21.09 X; [Saturation Index is 1.32]
$MgCO_3$	Saturation is 5.31 X; [Saturation Index is 0.73]
$SrCO_3$	Saturation is 1.12 X; [Saturation Index is 0.05]
$Ca_3(PO4)_2$	Saturation is 15.86 X; [Saturation Index is 1.20]
SiO_2	Saturation is 1.45 X; [Saturation Index is 0.16]

Critical Indices		Guideline	Status
CaCO3 SI (CCNI)	1.324	< 2.300	OK
Mg(OH)2 SI	-3.552	< 9.200	OK
SiO2 (MSI)	9.293	< 10.000	OK
Antiscalant Precipitation Index (API)	8.515	< 9.900	OK
Ca3(PO4)2 SI (MPI)	1.200	< 4.200	OK
CaSO4 SI	-2.462	< 0.500	OK
BaSO4 SI	0.000	< 3.000	OK
SrSO4 SI	-2.604	< 1.000	OK
LSI	2.027		OK
Stiff&Davis Index	2.032		OK

Chemical dosing:	AWC A-102 Ultra	HCL
Calculated Dosage:	0.600 mg/L	0.000 mg/L
Total Dosage (modified by user):	0.600 mg/L	N/A
% Concentration:	N/A	37.000%
Density:	1.120 g/cm3	1.184 g/cm3
Dosing Pump:	0.037 ml/min	0.000 ml/min
Hours of Operation/Day:	24 hour(s)	24 hour(s)
Consumption per:		
Day	0.130 lbs	0.000 lbs
Week	0.909 lbs	0.000 lbs
4 Weeks	3.634 lbs	0.000 lbs
Year	47.372 lbs	0.000 lbs
5 Years	236.862 lbs	0.000 lbs

Insert your additional comments below:

Comments...

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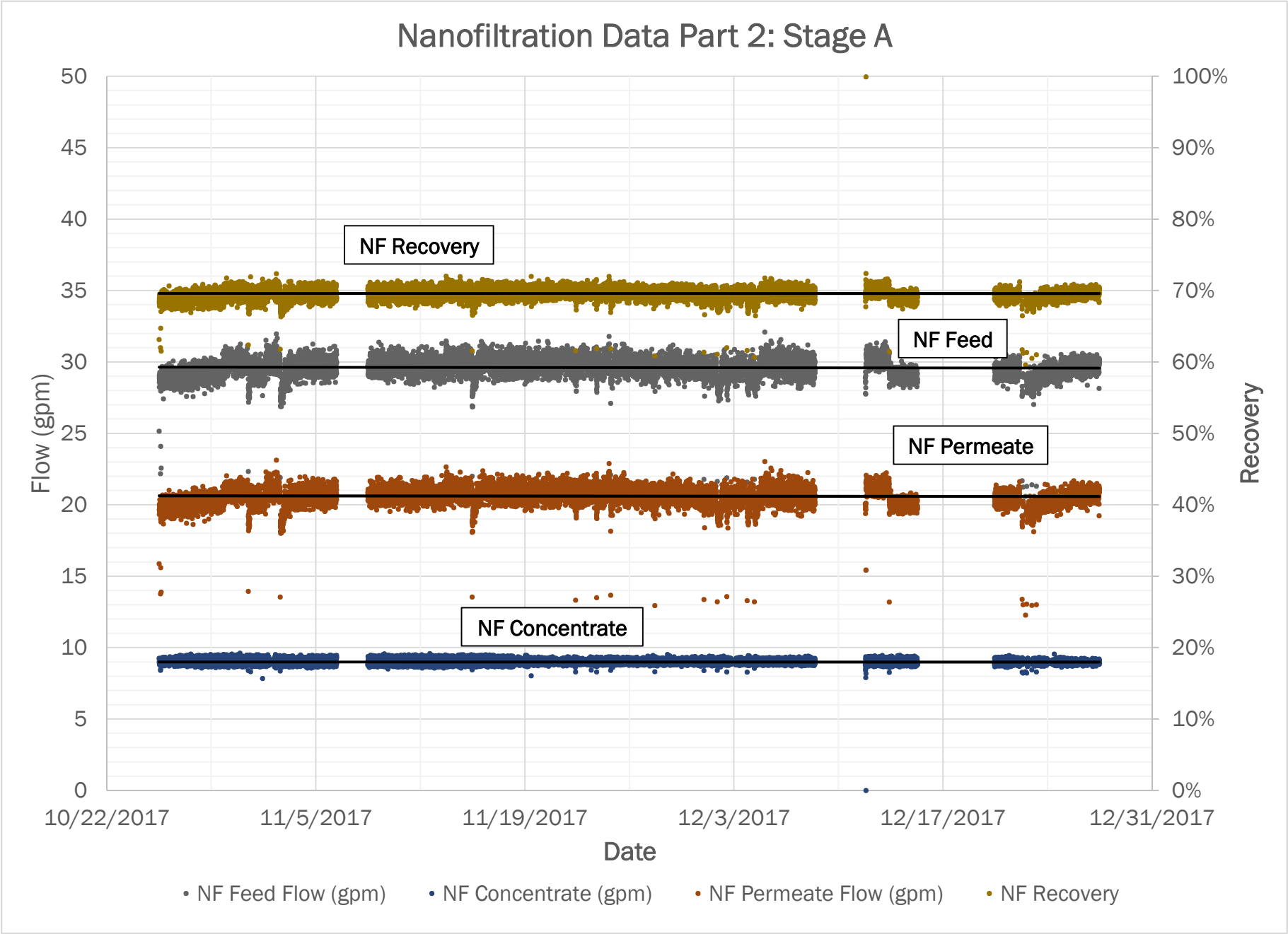
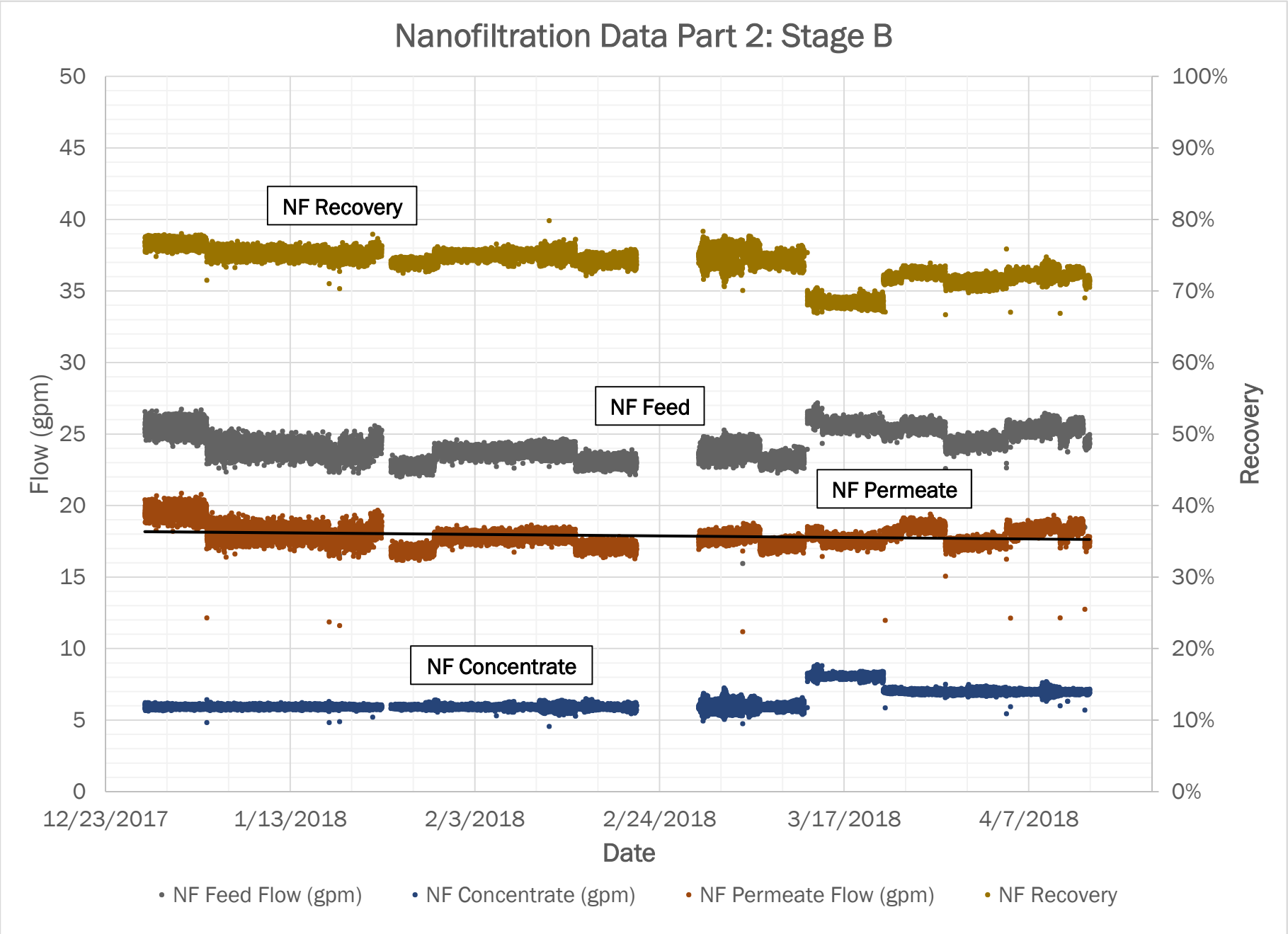
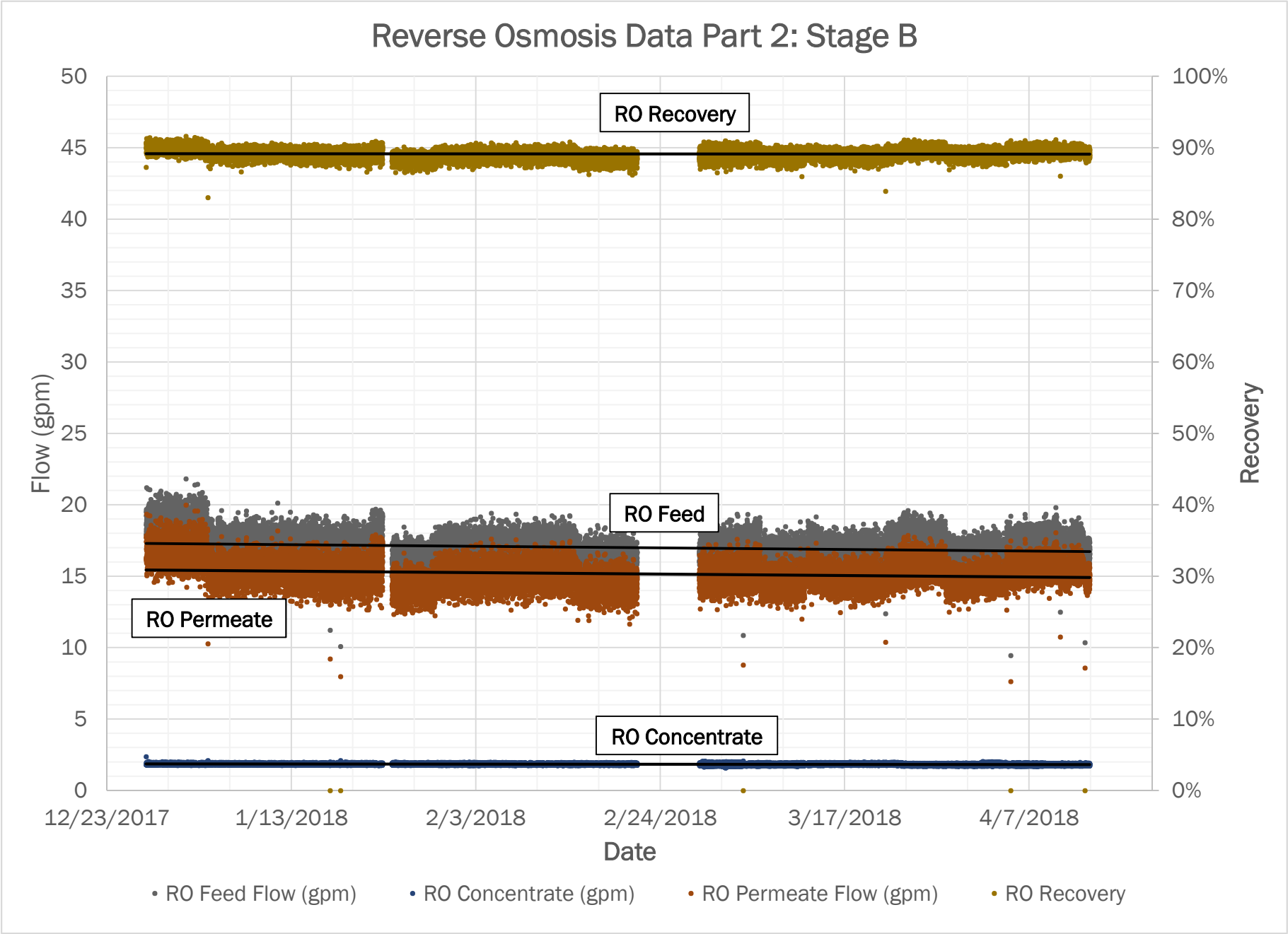
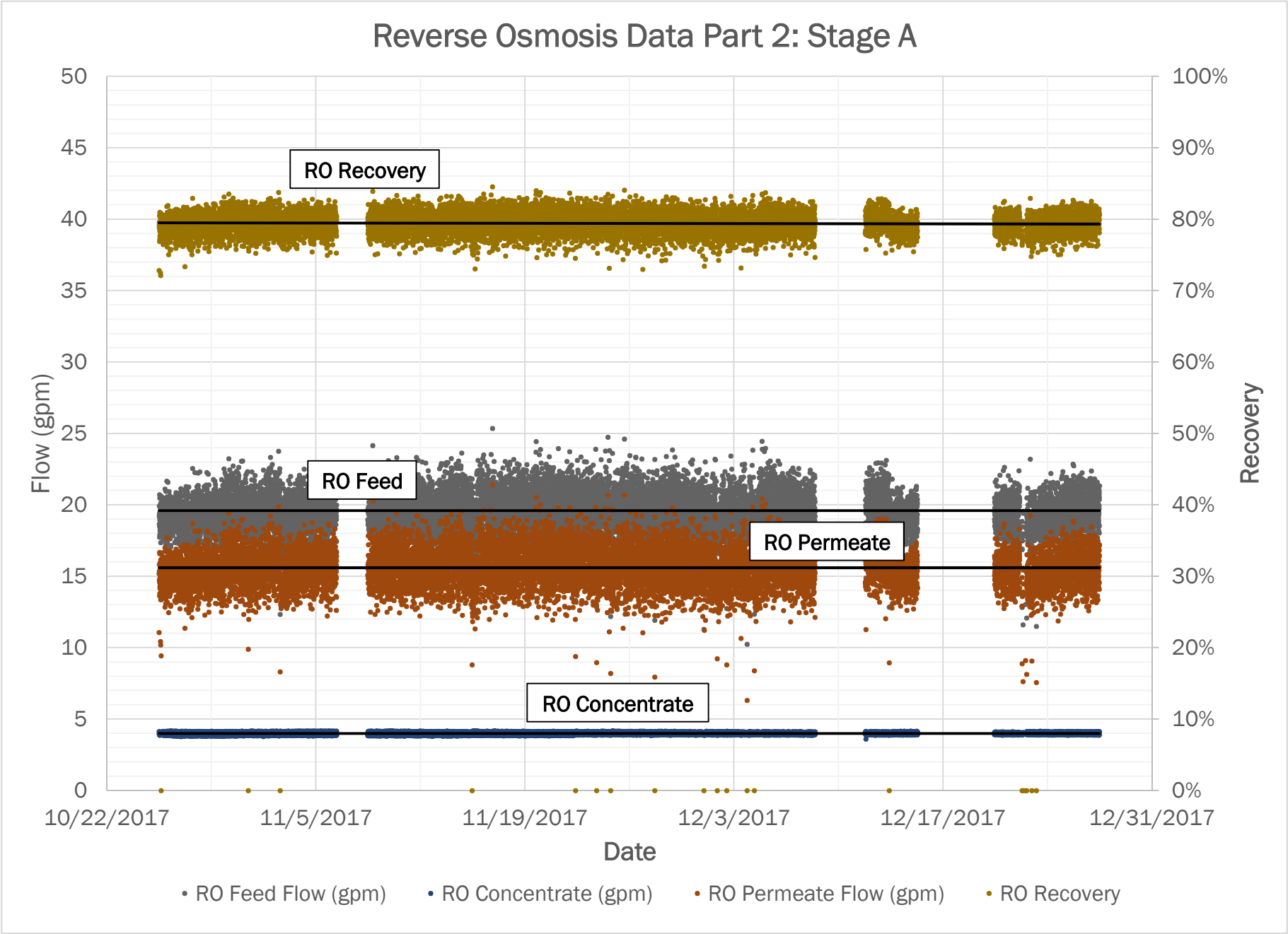
APPENDIX C

Part 2: Phases A and B Pilot Operational Data


Nanofiltration Data Part 2: Stage A
NF Recovery
NF Feed
NF Permeate
NF Concentrate
Flow (gpm)
Recovery
Date
50
45
40
35
30
25
20
15
10
5
0
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
10/22/2017
11/5/2017
11/19/2017
12/3/2017
12/17/2017
12/31/2017
NF Feed Flow (gpm)
NF Concentrate (gpm)
NF Permeate Flow (gpm)
NF Recovery


Nanofiltration Data Part 2: Stage B
NF Recovery
NF Feed
NF Permeate
NF Concentrate
Flow (gpm)
Recovery
Date
50
45
40
35
30
25
20
15
10
5
0
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
12/23/2017
1/13/2018
2/3/2018
2/24/2018
3/17/2018
4/7/2018
NF Feed Flow (gpm)
NF Concentrate (gpm)
NF Permeate Flow (gpm)
NF Recovery


Reverse Osmosis Data Part 2: Stage B
RO Recovery
RO Feed
RO Permeate
RO Concentrate
Flow (gpm)
Recovery
Date
50
45
40
35
30
25
20
15
10
5
0
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
12/23/2017
1/13/2018
2/3/2018
2/24/2018
3/17/2018
4/7/2018
RO Feed Flow (gpm)
RO Concentrate (gpm)
RO Permeate Flow (gpm)
RO Recovery


Reverse Osmosis Data Part 2: Stage A
RO Recovery
RO Feed
RO Permeate
RO Concentrate
Flow (gpm)
Recovery
Date
50
45
40
35
30
25
20
15
10
5
0
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
10/22/2017
11/5/2017
11/19/2017
12/3/2017
12/17/2017
12/31/2017
RO Feed Flow (gpm)
RO Concentrate (gpm)
RO Permeate Flow (gpm)
RO Recovery

APPENDIX D

Part 2: Phases A and B Water Quality Summary

Laboratory Sample Data Summary

Part 2: Stage A (October 18, 2017 to December 20, 2017)

		Sample Count						Average						Maximum						Minimum					
Analyte Name	Units	Total	NF Feed	NF Perm	NF Conc	RO Perm	RO Conc	NF Feed	NF Perm	NF Conc	RO Perm	RO Conc	Blend	NF Feed	NF Perm	NF Conc	RO Perm	RO Conc	Blend	NF Feed	NF Perm	NF Conc	RO Perm	RO Conc	Blend
Acetaminophen	ng/L	6	1	1	1	1	1	1.8	0.0	4.4	0.0	1.4	2.4	1.8	0.0	4.4	0.0	1.4	2.4	1.8	0.0	4.4	0.0	1.4	2.4
Alkalinity, Bicarbonate	mg/L	18	3	3	3	3	3	152.7	44.7	368.7	0.0	204.0	159.3	158.0	46.0	386.0	0.0	210.0	174.0	148.0	44.0	352.0	0.0	196.0	148.0
Alkalinity, Total	mg/L	60	10	10	10	10	10	153.8	44.8	386.6	0.0	202.2	150.8	162.0	48.0	412.0	0.0	212.0	174.0	136.0	42.0	348.0	0.0	182.0	128.0
Atrazine	ng/L	6	1	1	1	1	1	0.0	4.0	1.2	0.0	0.0	0.0	0.0	4.0	1.2	0.0	0.0	0.0	0.0	4.0	1.2	0.0	0.0	0.0
Barium, Ba	mg/L	54	9	9	9	9	9	0.1	0.0	0.3	0.0	0.0	0.1	0.1	0.0	0.3	0.0	0.1	0.1	0.1	0.0	0.3	0.0	0.0	0.1
Boron, B	mg/L	54	9	9	9	9	9	0.3	0.3	0.4	0.2	0.6	0.3	0.4	0.3	0.4	0.3	0.7	0.3	0.3	0.3	0.3	0.2	0.5	0.3
Caffeine	ng/L	6	1	1	1	1	1	7.9	7.1	13.2	6.4	7.6	7.7	7.9	7.1	13.2	6.4	7.6	7.7	7.9	7.1	13.2	6.4	7.6	7.7
Calcium, Ca	mg/L	54	9	9	9	9	9	79.6	12.1	223.0	0.0	59.1	83.7	81.8	13.7	236.0	0.0	67.3	87.6	76.2	10.7	214.0	0.0	53.2	79.6
Carbamazepine	ng/L	6	1	1	1	1	1	2.8	0.0	12.4	10.4	1.5	4.1	2.8	0.0	12.4	10.4	1.5	4.1	2.8	0.0	12.4	10.4	1.5	4.1
Carbon, Total Organic, TOC	mg/L	12	2	2	2	2	2	2.5	0.3	5.5	0.0	0.9	3.4	2.6	0.5	5.8	0.0	1.1	3.6	2.3	0.0	5.1	0.0	0.8	3.2
Chloride, Cl	mg/L	57	10	10	9	9	9	375.1	267.8	475.2	0.0	1238.7	226.9	415.0	297.0	674.0	0.0	1490.0	248.0	344.0	245.0	13.0	0.0	498.0	214.0
Cotinine	ng/L	6	1	1	1	1	1	39.8	4.4	174.0	4.6	19.7	45.4	39.8	4.4	174.0	4.6	19.7	45.4	39.8	4.4	174.0	4.6	19.7	45.4
DEET	ng/L	6	1	1	1	1	1	71.4	19.0	222.0	27.8	59.8	72.1	71.4	19.0	222.0	27.8	59.8	72.1	71.4	19.0	222.0	27.8	59.8	72.1
Diazepam	ng/L	6	1	1	1	1	1	0.0	0.0	2.8	0.0	0.0	0.0	0.0	0.0	2.8	0.0	0.0	0.0	0.0	0.0	2.8	0.0	0.0	0.0
Diclofenac	ng/L	6	1	1	1	1	1	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0
Dilantin	ng/L	6	1	1	1	1	1	21.1	2.3	89.8	6.5	9.2	20.6	21.1	2.3	89.8	6.5	9.2	20.6	21.1	2.3	89.8	6.5	9.2	20.6
Diuron	ng/L	6	1	1	1	1	1	3.8	3.3	7.9	0.0	13.6	3.0	3.8	3.3	7.9	0.0	13.6	3.0	3.8	3.3	7.9	0.0	13.6	3.0
Estradiol	ng/L	6	1	1	1	1	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Estrone	ng/L	6	1	1	1	1	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ethinylestradiol	ng/L	6	1	1	1	1	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fluoxetine	ng/L	6	1	1	1	1	1	18.2	3.0	73.8	8.2	8.1	20.8	18.2	3.0	73.8	8.2	8.1	20.8	18.2	3.0	73.8	8.2	8.1	20.8
Gemfibrozil	ng/L	6	1	1	1	1	1	0.0	0.0	2.2	1.8	0.0	0.0	0.0	0.0	2.2	1.8	0.0	0.0	0.0	0.0	2.2	1.8	0.0	0.0
Hydrocodone	ng/L	6	1	1	1	1	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ibuprofen	ng/L	6	1	1	1	1	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Iron, Fe	mg/L	54	9	9	9	9	9	0.0	0.0	0.1	0.0	0.0	0.1	0.1	0.0	0.2	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.0
Magnesium, Mg	mg/L	54	9	9	9	9	9	28.2	2.0	80.2	0.0	9.8	31.7	29.3	2.5	84.5	0.0	12.8	33.3	27.0	1.7	77.8	0.0	8.5	29.7
Manganese, Mn	mg/L	54	9	9	9	9	9	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0
Meprobamate	ng/L	6	1	1	1	1	1	137.0	14.3	456.0	20.3	68.1	147.0	137.0	14.3	456.0	20.3	68.1	147.0	137.0	14.3	456.0	20.3	68.1	147.0
Naproxen	ng/L	6	1	1	1	1	1	5.4	1.0	6.1	3.4	6.1	5.2	5.4	1.0	6.1	3.4	6.1	5.2	5.4	1.0	6.1	3.4	6.1	5.2
Nitrate, NO3	mg/L	45	8	8	7	7	7	4.9	5.0	3.8	0.3	18.6	2.0	8.2	8.3	8.2	0.5	36.5	3.1	0.0	0.0	0.0	0.0	0.0	0.0
Nitrogen, Ammonia, N	mg/L	12	2	2	2	2	2	1.1	1.0	1.5	0.1	3.2	1.0	1.3	1.2	1.8	0.3	4.0	1.3	1.0	0.8	1.2	0.0	2.4	0.7
Nitrogen, Total Kjeldahl, TKN	mg/L	6	1	1	1	1	1	1.8	1.0	4.0	0.6	3.1	1.5	1.8	1.0	4.0	0.6	3.1	1.5	1.8	1.0	4.0	0.6	3.1	1.5
Orthophosphate as P	mg/L	12	2	2	2	2	2	2.1	0.0	6.9	0.0	1.7	2.5	2.4	0.0	8.2	0.0	2.2	2.6	1.7	0.0	5.7	0.0	1.2	2.3
Oxybenzone	ng/L	6	1	1	1	1	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Potassium, K	mg/L	54	9	9	9	9	9	24.8	15.9	44.0	0.0	76.0	16.4	26.0	16.0	47.0	0.0	78.0	18.0	24.0	15.0	42.0	0.0	74.0	16.0
Primidone	ng/L	6	1	1	1	1	1	111.0	7.5	346.0	21.8	33.0	126.0	111.0	7.5	346.0	21.8	33.0	126.0	111.0	7.5	346.0	21.8	33.0	126.0
Progesterone	ng/L	6	1	1	1	1	1	0.0	0.0	1.2	1.2	0.0	0.0	0.0	0.0	1.2	1.2	0.0	0.0	0.0	0.0	1.2	1.2	0.0	0.0
Residue, Total Dissolved	mg/L	12	2	2	2	2	2	1163.0	543.0	2601.0	0.0	2683.0	932.0	1206.0	598.0	2674.0	0.0	2974.0	992.0	1120.0	488.0	2528.0	0.0	2392.0	872.0
Silica, as SiO2	mg/L	54	9	9	9	9	9	11.7	9.9	15.5	0.0	48.1	5.8	13.1	10.8	17.6	0.0	55.0	6.9	11.0	9.5	14.5	0.0	44.9	5.3
Sodium, Na	mg/L	60	10	10	10	10	10	250.9	158.0	475.5	3.9	813.6	159.5	265.0	168.0	499.0	5.0	850.0	168.0	241.0	150.0	446.0	3.0	768.0	149.0
Strontium, Sr	mg/L	54	9	9	9	9	9	1.1	0.1	3.3	0.0	0.6	1.2	1.2	0.1	3.5	0.0	0.7	1.3	1.1	0.1	3.2	0.0	0.5	1.2
Sucralose	ng/L	6	1	1	1	1	1	20800.0	2370.0	65700.0	4880.0	9670.0	25300.0	20800.0	2370.0	65700.0	4880.0	9670.0	25300.0	20800.0	2370.0	65700.0	4880.0	9670.0	25300.0
Sulfamethoxazole	ng/L	6	1	1	1	1	1	7.3	2.7	30.5	3.0	2.6	8.5	7.3	2.7	30.5	3.0	2.6	8.5	7.3	2.7	30.5	3.0	2.6	8.5
Sulfate, SO4	mg/L	57	10	10	9	9	9	239.2	3.5	576.7	0.0	49.9	274.7	261.0	13.0	814.0	0.0	71.0	295.0	223.0	0.0	17.0	0.0	21.0	249.0
Testosterone	ng/L	6	1	1	1	1	1	0.0	0.0	1.4	0.0	0.0	0.0	0.0	0.0	1.4	0.0	0.0	0.0	0.0	0.0	1.4	0.0	0.0	0.0
Triclosan	ng/L	6	1	1	1	1	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Trimethoprim	ng/L	6	1	1	1	1	1	0.0	0.0	4.2	0.0	0.0	1.3	0.0	0.0	4.2	0.0	0.0	1.3	0.0	0.0	4.2	0.0	0.0	1.3

Laboratory Sample Data Summary

Part 2: Stage B (December 27, 2017 to April 11, 2018)

			Count					Average						Maximum						Minimum					
Analyte Name	Units	Total	NF Feed	NF Perm	NF Conc	RO Perm	RO Conc	NF Feed	NF Perm	NF Conc	RO Perm	RO Conc	Blend	NF Feed	NF Perm	NF Conc	RO Perm	RO Conc	Blend	NF Feed	NF Perm	NF Conc	RO Perm	RO Conc	Blend
Acetaminophen	ng/L	24	4	4	4	4	4	0.3	0.7	4.6	0.0	3.2	1.4	1.2	1.7	15.5	0.0	12.7	4.0	0.0	0.0	0.0	0.0	0.0	0.0
Alkalinity, Bicarbonate	mg/L	36	6	6	6	6	6	161.3	61.0	445.0	0.0	520.0	130.7	182.0	68.0	480.0	0.0	600.0	154.0	148.0	58.0	392.0	0.0	464.0	114.0
Alkalinity, Total	mg/L	90	15	15	15	15	15	159.3	60.4	435.3	0.0	508.8	128.5	196.0	70.0	512.0	0.0	600.0	166.0	144.0	54.0	390.0	0.0	462.0	110.0
Atrazine	ng/L	24	4	4	4	4	4	4.7	0.0	0.0	0.0	0.0	0.0	18.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Barium, Ba	mg/L	81	14	13	13	14	13	0.1	0.0	0.3	0.0	0.1	0.1	0.1	0.0	0.4	0.0	0.2	0.1	0.1	0.0	0.2	0.0	0.1	0.1
Boron, B	mg/L	79	14	13	13	14	13	0.4	0.3	0.4	0.3	0.9	0.3	0.4	0.4	0.4	0.3	1.0	0.3	0.3	0.3	0.3	0.3	0.8	0.3
Caffeine	ng/L	24	4	4	4	4	4	82.6	19.6	230.2	7.5	170.1	79.0	236.0	53.0	663.0	21.4	505.0	223.0	24.7	5.8	58.0	1.4	49.8	22.8
Calcium, Ca	mg/L	81	14	13	13	14	13	81.8	18.4	252.2	0.0	165.5	74.1	87.6	21.0	286.0	0.0	186.0	80.5	72.9	14.8	187.0	0.0	147.0	64.2
Carbamazepine	ng/L	23	4	4	4	4	4	142.9	17.5	436.0	0.0	143.5	141.8	221.0	25.1	615.0	0.0	220.0	205.0	39.5	4.6	119.0	0.0	42.8	33.4
Carbon, Total Organic, TOC	mg/L	23	4	4	4	4	4	3.6	0.3	12.3	0.1	2.4	5.8	6.0	1.1	26.5	0.4	6.8	8.8	2.7	0.0	7.0	0.0	0.9	4.2
Chloride, Cl	mg/L	91	15	15	15	16	15	392.6	316.6	601.8	0.7	2827.3	179.9	464.0	377.0	677.0	6.1	3370.0	226.0	352.0	276.0	539.0	0.0	2500.0	157.0
Cotinine	ng/L	24	4	4	4	4	4	68.4	7.9	269.5	0.0	73.1	66.2	85.7	10.4	379.0	0.0	116.0	74.6	54.4	5.3	199.0	0.0	43.7	55.9
DEET	ng/L	23	4	4	4	4	4	170.5	30.7	488.0	7.7	222.3	178.7	234.0	39.4	686.0	10.0	326.0	279.0	137.0	21.8	382.0	5.6	174.0	118.0
Diazepam	ng/L	24	4	4	4	4	4	3.0	0.0	8.0	0.0	0.8	2.6	5.9	0.0	14.7	0.0	1.8	5.3	0.0	0.0	0.0	0.0	0.0	0.0
Diclofenac	ng/L	23	4	4	4	4	4	1.6	0.9	4.6	0.0	11.1	45.3	4.6	3.6	15.2	0.0	41.3	131.0	0.0	0.0	0.0	0.0	0.0	0.0
Dilantin	ng/L	24	4	4	4	4	4	54.6	5.6	183.8	0.0	49.0	51.1	74.4	6.6	309.0	0.0	64.5	84.1	42.4	5.0	130.0	0.0	32.4	35.9
Diuron	ng/L	23	4	4	4	4	4	24.3	22.9	42.6	1.8	154.8	8.0	26.3	27.6	56.9	2.7	190.0	12.7	22.1	18.8	26.7	1.4	124.0	0.0
Estradiol	ng/L	24	4	4	4	4	4	0.5	0.0	3.0	0.0	0.0	0.5	1.9	0.0	8.2	0.0	0.0	1.8	0.0	0.0	0.0	0.0	0.0	0.0
Estrone	ng/L	24	4	4	4	4	4	0.0	0.0	1.8	0.0	0.0	0.0	0.0	0.0	4.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ethinylestradiol	ng/L	24	4	4	4	4	4	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fluoxetine	ng/L	24	4	4	4	4	4	50.3	3.5	145.4	0.3	29.7	45.2	67.7	6.0	200.0	1.3	47.6	56.7	27.0	2.5	91.5	0.0	20.6	22.3
Gemfibrozil	ng/L	24	4	4	4	4	4	101.1	3.1	320.7	0.0	31.4	82.7	288.0	6.4	879.0	0.0	62.2	216.0	20.2	0.0	74.9	0.0	5.6	21.5
Hydrocodone	ng/L	24	4	4	4	4	4	6.8	0.0	22.8	0.0	0.4	8.0	23.8	0.0	79.2	0.0	1.7	25.6	0.0	0.0	0.0	0.0	0.0	0.0
Ibuprofen	ng/L	24	4	4	4	4	4	9.4	1.0	30.3	0.0	2.3	10.8	17.0	3.9	48.7	0.0	9.1	20.6	3.7	0.0	16.1	0.0	0.0	0.0
Iron, Fe	mg/L	81	14	13	13	14	13	0.1	0.0	0.2	0.0	0.0	0.1	0.1	0.0	0.3	0.0	0.0	0.1	0.0	0.0	0.2	0.0	0.0	0.0
Magnesium, Mg	mg/L	81	14	13	13	14	13	29.0	2.8	93.7	0.0	25.6	29.2	30.5	3.6	102.0	0.0	33.1	31.1	27.0	2.4	77.5	0.0	20.8	27.2
Manganese, Mn	mg/L	81	14	13	13	14	13	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0
Meprobamate	ng/L	24	4	4	4	4	4	190.8	20.3	580.5	0.0	172.5	189.8	199.0	22.4	679.0	0.0	178.0	206.0	170.0	17.7	474.0	0.0	169.0	181.0
Naproxen	ng/L	24	4	4	4	4	4	202.0	8.4	606.2	0.0	65.5	205.3	746.0	26.8	2380.0	0.0	248.0	793.0	1.0	0.0	0.0	0.0	0.0	0.0
Nitrate, NO3	mg/L	30	5	5	5	5	5	5.8	6.0	6.0	0.6	46.5	1.8	9.5	9.7	8.6	0.9	73.4	2.8	2.9	3.1	4.4	0.4	23.6	1.1
Nitrogen, Ammonia, N	mg/L	24	4	4	4	4	4	3.1	2.4	4.2	0.5	19.4	1.4	5.4	4.0	8.5	1.0	38.3	2.6	1.1	0.9	1.4	0.2	6.5	0.6
Nitrogen, Total Kjeldahl, TKN	mg/L	24	4	4	4	4	4	3.6	2.0	6.9	0.0	18.4	2.4	6.5	4.2	12.6	0.0	39.6	4.2	2.1	0.9	4.5	0.0	6.2	1.4
Orthophosphate as P	mg/L	24	4	4	4	4	4	1.5	0.0	6.7	0.0	2.5	1.6	2.4	0.0	10.3	0.0	3.7	2.5	0.2	0.0	0.0	0.0	0.0	0.2
Oxybenzone	ng/L	24	4	4	4	4	4	37.2	27.5	239.6	15.3	205.2	35.9	68.0	72.1	686.0	48.2	416.0	74.2	0.0	0.0	14.3	0.0	18.1	0.0
Potassium, K	mg/L	81	14	13	13	14	13	24.9	17.8	44.8	0.0	160.0	13.1	27.0	19.0	49.0	0.0	169.0	14.0	24.0	16.0	39.0	0.0	140.0	12.0
Primidone	ng/L	24	4	4	4	4	4	266.3	13.1	894.0	0.0	110.0	262.0	307.0	17.7	994.0	0.0	147.0	310.0	236.0	10.5	754.0	0.0	89.9	207.0
Progesterone	ng/L	24	4	4	4	4	4	0.3	0.0	1.3	0.0	0.3	0.3	1.0	0.0	3.3	0.0	1.3	1.1	0.0	0.0	0.0	0.0	0.0	0.0
Residue, Total Dissolved	mg/L	35	6	6	6	6	6	1189.0	628.3	2855.8	18.7	5900.0	806.4	1226.0	662.0	2980.0	32.0	6230.0	844.0	1152.0	572.0	2755.0	0.0	5644.0	750.0
Silica, as SiO2	mg/L	81	14	13	13	14	13	10.3	9.1	13.6	0.0	81.4	4.2	13.8	12.0	17.5	0.0	106.0	6.1	8.0	6.8	10.7	0.0	63.7	3.2
Sodium, Na	mg/L	81	14	13	13	14	13	261.0	189.9	478.4	6.6	1691.5	138.0	291.0	229.0	531.0	9.0	1930.0	163.0	238.0	156.0	406.0	5.0	1320.0	125.0
Strontium, Sr	mg/L	81	14	13	13	14	13	1.1	0.2	3.8	0.0	1.7	1.1	1.3	0.2	4.4	0.0	1.9	1.2	1.0	0.2	2.7	0.0	1.5	0.9
Sucralose	ng/L	24	4	4	4	4	4	35150.0	2105.0	109675.0	22.2	14100.0	40600.0	44400.0	3480.0	137000.0	37.6	17700.0	54500.0	23100.0	1160.0	55700.0	0.0	10200.0	23500.0
Sulfamethoxazole	ng/L	24	4	4	4	4	4	315.4	16.7	1013.0	0.0	150.9	302.7	1030.0	50.0	3260.0	0.0	449.0	983.0	44.0	2.3	113.0	0.0	18.4	45.8
Sulfate, SO4	mg/L	91	15	16	15	15	15	241.3	6.6	880.8	0.0	90.4	252.3	291.0	22.0	1040.0	0.0	223.0	320.0	184.0	0.0	570.0	0.0	16.0	196.0
Testosterone	ng/L	24	4	4	4	4	4	0.0	0.0	0.0	0.0	0.0	2.7	0.0	0.0	0.0	0.0	0.0	10.9	0.0	0.0	0.0	0.0	0.0	0.0
Triclosan	ng/L	24	4	4	4	4	4	3.0	0.0	6.5	0.0	0.0	0.0	12.1	0.0	25.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Trimethoprim	ng/L	24	4	4	4	4	4	128.6	9.1	413.6	0.0	79.7	129.3	438.0	31.2	1410.0	0.0	259.0	445.0	14.2	0.0	39.4	0.0	7.6	12.1

APPENDIX E

Part 2: Membrane Autopsy Report

Membrane Autopsy Report

Completed for:

Brown & Caldwell

Scottsdale Water Campus

Serial Number C7520230

P2-S2-5

06/25/2018 WO#053018-5

CORPORATE OFFICES

Avista Technologies, Inc.
Global Headquarters
+1.760.744.0536
info@avistatech.com

Avista Technologies (UK) Ltd
+44 (0) 131 449 6677
info@avistatech.co.uk

Creative Chemistry. Smart Solutions.

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Executive Summary

Background

Brown & Caldwell provided 6 Koch SR200-4040 nanofiltration (NF) and 12 Hydranautics ESPA4-LD-4040 reverse osmosis (RO) membrane elements from Scottsdale Water Campus to Avista Technologies wet testing. Element Serial Number (SN) KM8048229-7015 (Koch SR200-4040) and SN C7520230 (Hydranautics ESPA4-LD-4040) were selected for dissection and analysis to identify foulant constituents, as well as other causes for loss of performance. SN KM8048229-7015 was noted as position "P1-6" while SN C7520230 came from position "P2-S2-5". The remainder of this report pertains to SN C7520230 (P2-S2-5).

Initial Element Testing

The element produced lower than normal flow (90% of normal), lower than normal rejection (91.0%) and a differential pressure of 4 psi. The element passed integrity testing, indicating the absence of damage to the internal components of the spiral wound element.

External Inspection

The fiberglass casing, brine seal and permeate tube displayed no visible damages. The feed (brine seal end) and concentrate (opposite brine seal) ATDs were in good condition.

Internal Inspection

The feed scroll end had uneven discoloration along the glue line of one leaf and possessed brown-colored, granular particles deposited on the surface. A piece of thin, flaky plastic was blocking part of the feed channels. The concentrate scroll end also possessed brown-colored granular material in the flow channels. The exposed membrane surfaces were virtually free of any visible or removable foulant material. Obvious signs of physical damage (e.g. abrasion, delamination) were not present. The feed spacers were in good condition and clear of foulant material. The glue lines possessed discoloration (as observed on the feed scroll end) but displayed no clear signs of performance-affecting defects or damages. Visible foulant was not observed on the permeate spacers or membrane backings.

Cell Testing Results

Flat sheet samples harvested from the full element produced 96% of normal water passage and normal salt passage upon baseline cell testing.

Foulant Analysis

As there was no removable foulant material on the membrane surface, foulant density determination and loss on ignition testing to determine organic content were non-applicable. Acid testing performed on the membrane surface was negative for the presence of carbonates and no visible color change - which is associated with the presence of metals - occurred. Microscope imaging could not be performed due to the absence of foulant. Fourier-Transform Infrared (FT-IR) spectroscopy performed directly on a sample of the membrane detected only peaks representative of the membrane structure components (e.g. polysulfone).

The Energy Dispersive Spectroscopy (EDS) analysis performed on the membrane surface detected only carbon, oxygen and sulfur. Carbon can be contributed by the presence of foreign organics but is also a component of the membrane materials. The sulfur weight percentage (5.60 wt%) is associated with the membrane support layer (polysulfone) and suggests no masking of the membrane surface as analysis of new membranes usually detects between 5.00 and 7.00 weight percent of sulfur. Foreign inorganic elements were not present. Scanning Electron Microscope (SEM) imaging (500x) revealed that the membrane surface was predominantly free of foulant material. Only traces of particulate materials were observed. Close-up (1000x) imaging displayed topography representative of the membrane surface itself. Chromatic Elemental Imaging℠ (CEI℠) identified only an alternating pattern of carbon and sulfur, which is representative of the membrane surface and backing materials. Foreign elements were not identified. A small patch of material was observed; however, the layer was very thin and only the elements associated with the membrane materials were detected.

Based on the analysis it was determined that the membrane was predominantly clear of foulant.

Cleaning Study

As the membrane possessed no foulant and performed closely to the manufacturer's specification, a cleaning study is not required at this time.

Testing for Flat Sheet Damage

Fujiwara testing was negative for the presence of halogens (e.g. chlorine) in the membrane structure.

Full Element Wet Testing

A discrepancy between the full element and flat sheet performance of SN C7520230 was observed - the full element displayed relatively low rejection (91%) while the flat sheet samples performed with normal salt passage. Internal and external inspection of the element showed no clear signs of damage. Due to this discrepancy, one of the remaining elements which performed most similarly to SN C7520230, SN C7520228 (P2-S1-4), was retested. Element performance was analyzed after the first five minutes of rinse-up, then once more after 20 minutes. The wet test trial revealed that the membrane rejection was fully recovered after the extended rinse-up time. This is an indication that contamination of the permeate side of the membrane occurred.

Initial Element Test Results

Element Weight

All elements are weighed prior to autopsy as weight is often indicative of the degree of fouling. New eight-inch elements weigh approximately 30 to 35 pounds. Additionally, elements in excess of 50 pounds cannot be wet tested.

SN C7520230 weighed 8 pounds.

Wet Test

The element was wet tested using dechlorinated City of San Marcos, CA water. Wet test results were normalized to the manufacturer's published test conditions.

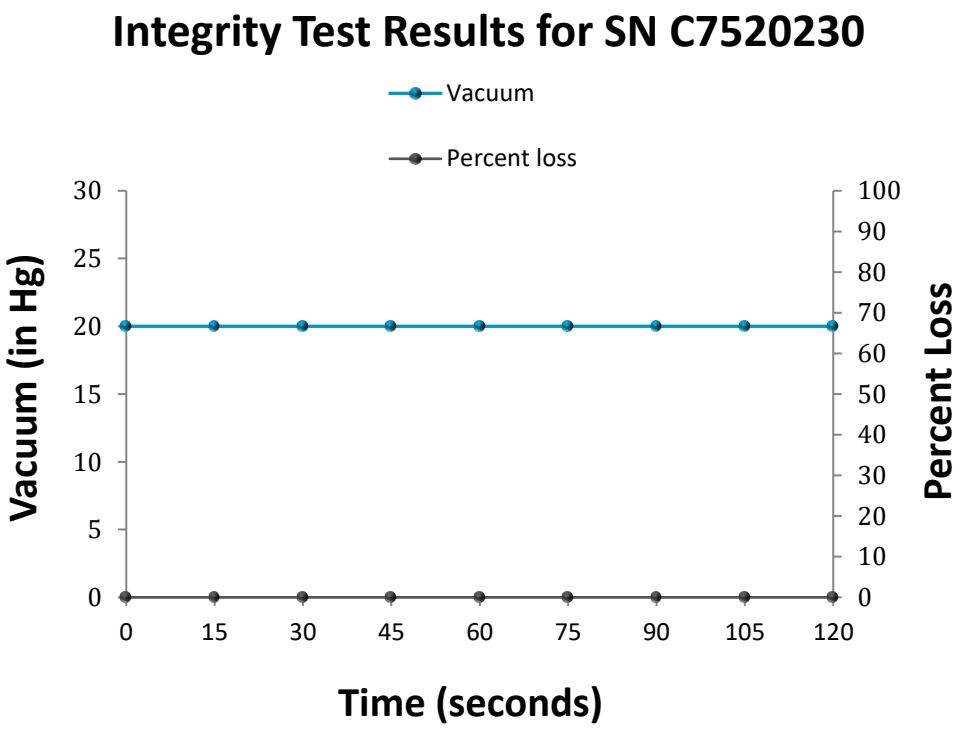
Hydranautics ESPA4-LD-4040	Flow (gpm)	Rejection (%)	Pressure Drop (psi)
SN C7520230	1.24	91.0	4
Manufacturer's Specifications	1.39 to 1.88	99.0 to 99.2	≤15

Element wet testing

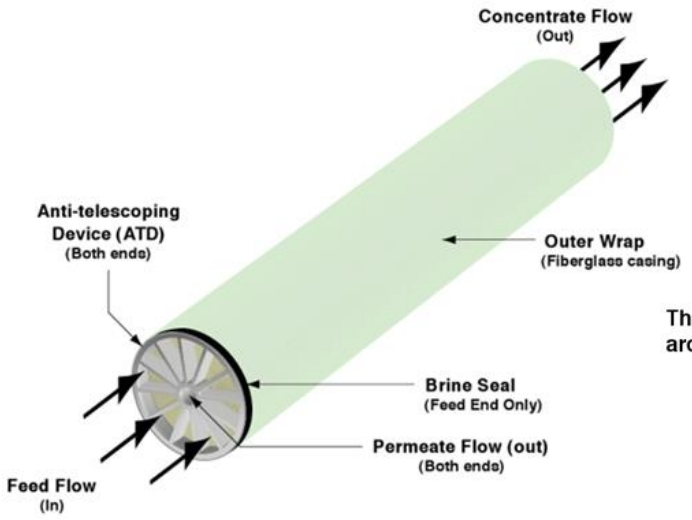
Integrity Test

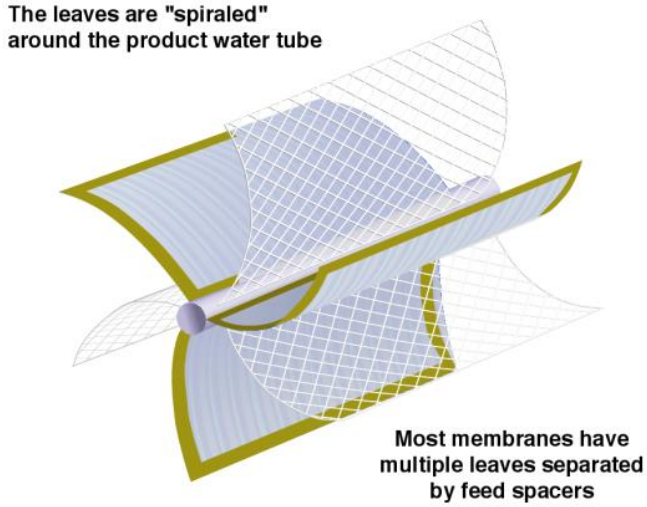
Integrity testing is performed to identify mechanical damage to the internal components of the spiral wound element. In this test, a vacuum of approximately 22 inches Mercury (in. Hg) is applied to the permeate side of the membrane and the membrane is then sealed. The vacuum is monitored for a duration of 120 seconds. Any loss of vacuum indicates the presence of damage; however, membranes that lose over 35% of the vacuum within the 120 second period have severe physical damage.

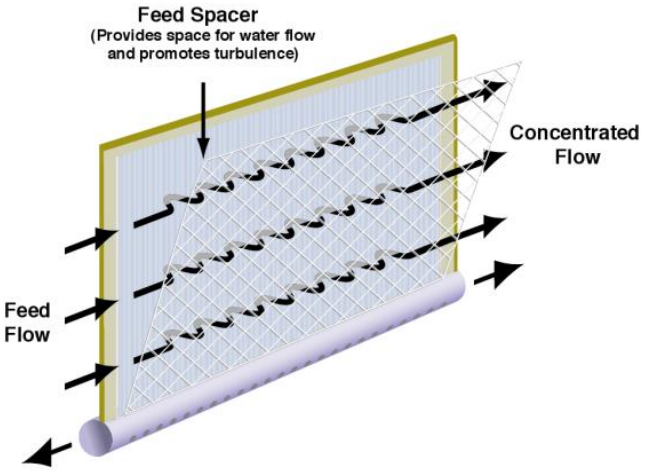
The element maintained stable vacuum pressure, passing the integrity test.

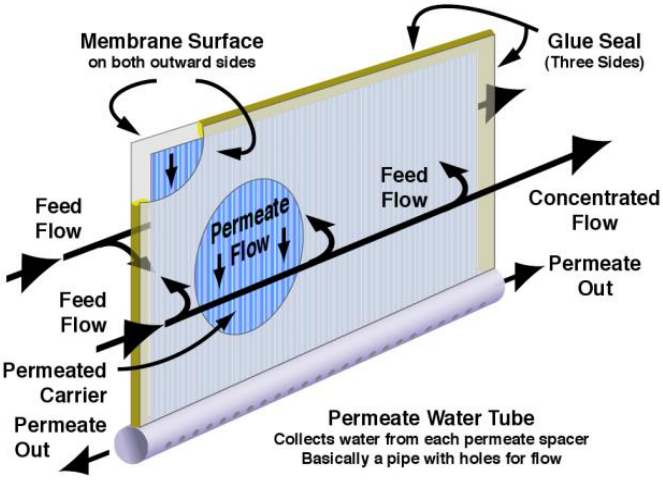


Membrane Construction Diagrams







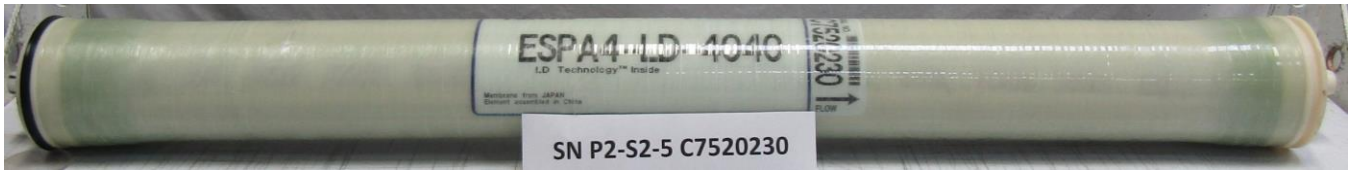


External Inspection

Fiberglass Casing

The purpose of the fiberglass casing is to ensure that the various membrane components are held in their correct position for optimum performance. Damage to the casing can be an indication of rough handling or damage from excessive differential pressure across the element.

The fiberglass casing was free of damage and foulant.



Fiberglass casing of SN C7520230

Brine Seal

The brine seal is used to seal against the inside diameter of the pressure vessels and the outside diameter of the membrane to ensure that all the feed water passes through the element. Feed water passing on the exterior of the element can result in higher pressures, which can cause cracking of the fiberglass casing.

The brine seal was in good condition.

Permeate Tube

The permeate tube is a pipe that is located at the center of the element. It contains lines of holes and is bonded to each membrane leaf allowing permeate water to travel from the leaves into the permeate tube to be collected. Damage to the ends of the permeate tube can lead to o-ring failures, causing bypass of feed or concentrate water into the permeate stream. Cracking of the permeate tube can also result in permeate contamination.

The permeate tube displayed no visible damages.

Anti-Telescoping Devices (ATDs)

The function of the ATDs are to stabilize the components of the element. This helps to prevent shifting of the internal mechanical components under pressure, also known as telescoping. Telescoping may still occur if pressures exceed the manufacturer's specifications.

The feed and concentrate ATDs possessed no damages or foulant.

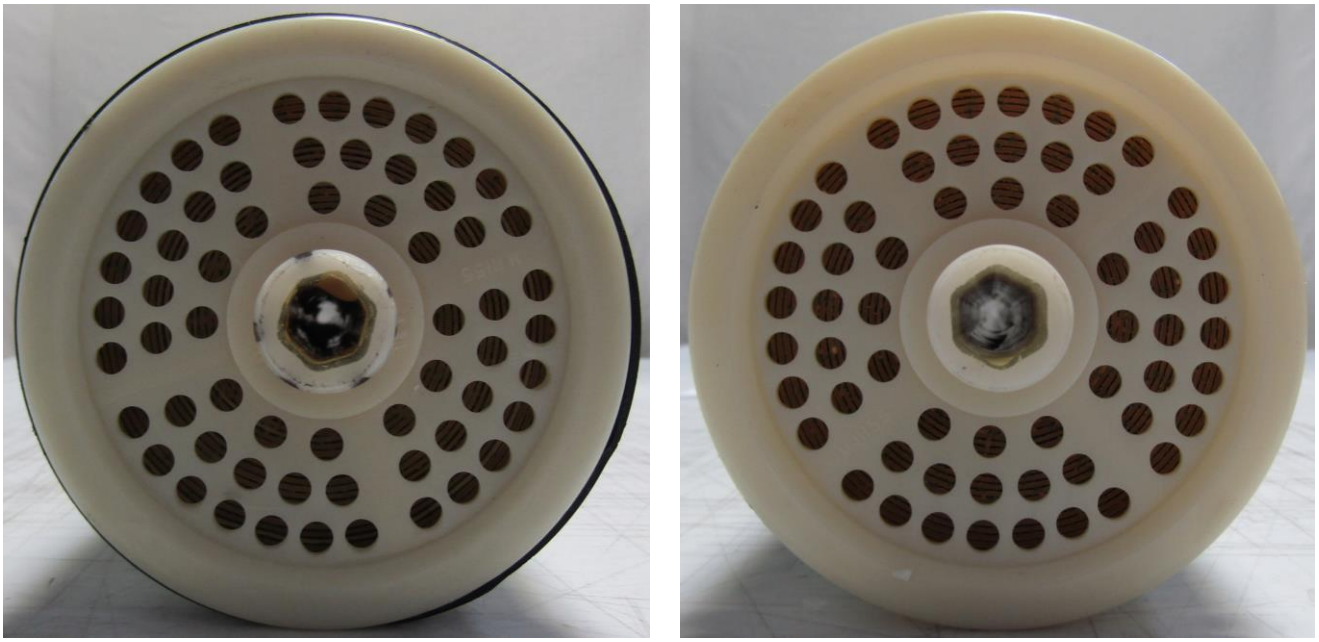


Image of the feed (left) and concentrate (right) ATD of SN C7520230

Internal Inspection

Scroll Ends

The ends of the element are called scroll ends. They are examined for the presence of foulant debris and mechanical damage (e.g. gapping, feed spacer extrusion). The presence of foulant on the scroll ends can cause elevated delta pressures while gapping and feed spacer extrusion indicate uneven hydraulics (high flow/low flow regions). In addition, each scroll end is examined for telescoping, the gradual axial shift of the membrane leaves from the outer diameter of the element towards the permeate tube. Telescoping is often caused by the development of high differential pressure (greater than the manufacturer's specification) across the element or when pressure is applied too quickly, causing a water hammer effect.

The feed scroll end had uneven discoloration along the glue line of one leaf and possessed brown-colored, granular particles deposited on the surface. A piece of thin, flaky plastic was blocking part of the feed channels. The concentrate scroll end also possessed brown-colored granular material in the flow channels.

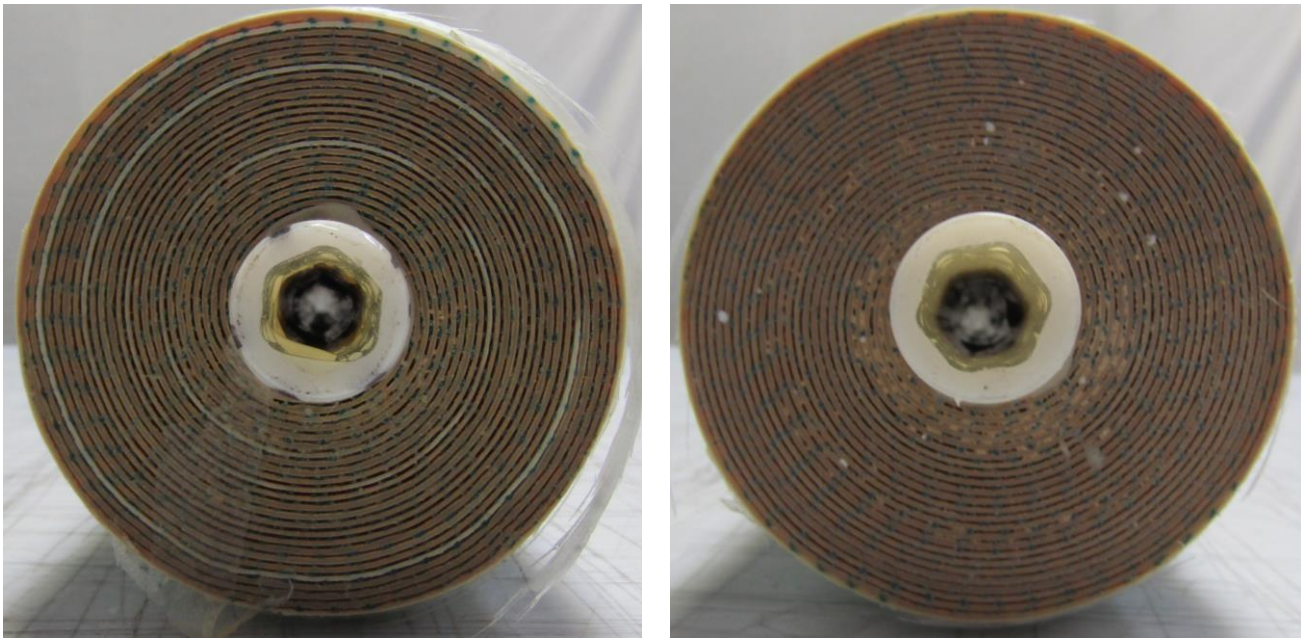
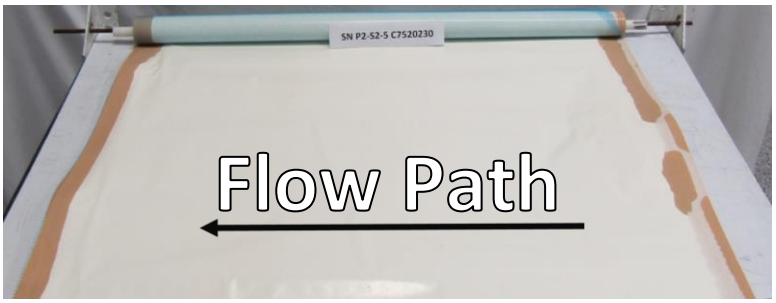


Image of feed scroll end (left) and concentrate scroll end (right) of SN C7520230

Membrane Surface

New membrane surfaces are uniform and shiny. Foulant can often be detected through visual examination; however, membrane appearance can be misleading as some foulants are not visible. The presence of foulant on the membrane surface can cause elevated delta pressure, loss in flow and damage if the foulant is abrasive. Additionally, the membrane surface is inspected for damage such as delamination. Delamination is the lifting of the thin-film membrane from the support layer and often occurs due to a positive pressure on the permeate side of the element.

The exposed membrane surfaces were virtually free of any visible or removable foulant material. Obvious signs of physical damage (e.g. abrasion, delamination) were not present.



Exposed membrane surface of SN C7520230

Exposed membrane surface from feed end of SN C7520230

Feed Spacers

The feed spacer is a plastic net material designed to separate the membrane leaves, forming a flow path, and to promote turbulence within the feed water channels. Foulant blocking the feed channels causes more resistance for the feed water flowing through the element and results in higher than normal delta pressures.

The feed spacers were in good condition and clear of foulant material.

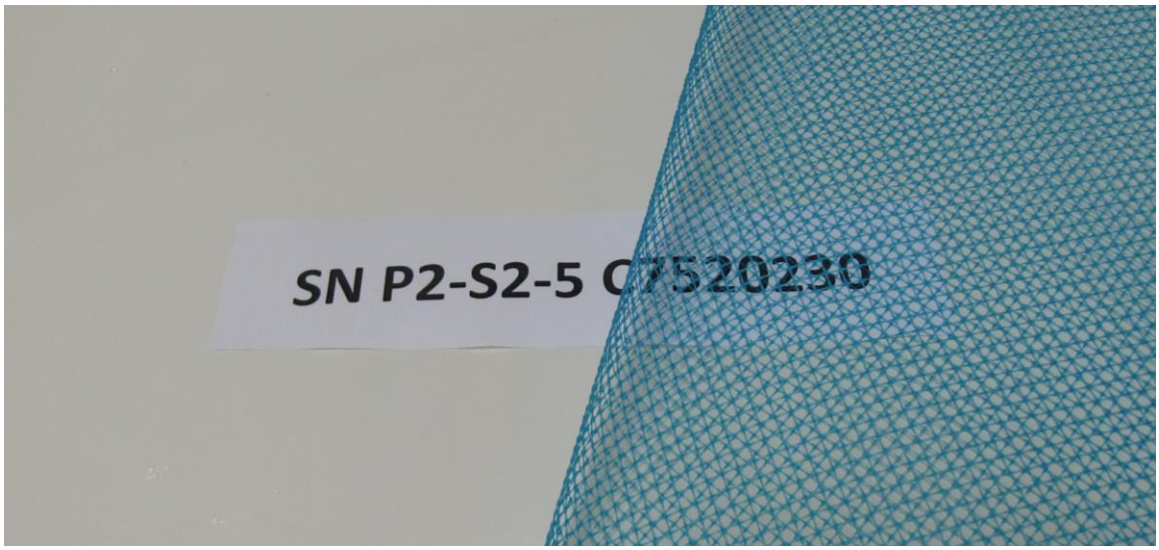


Image of feed spacer

Glue Lines

Membrane leaves are glued on three sides to separate the feed and permeate streams. The glue lines are inspected for specific damage, including glue flaps and pouching. Glue flaps refer to excess inactive membrane material located closest to the ends of the element. Flaps found on the feed end of the element can flair during operation, blocking the feed channels on the scroll end, potentially causing increased differential pressure. Pouching of the glue line, which is often a result of delamination, allows feed water to pass through the inactive membrane at the glue line, contaminating the permeate stream.

The glue lines possessed discoloration (as observed on the feed scroll end) but displayed no clear signs of performance-affecting defects or damages.

Permeate Spacers and Membrane Backing

The permeate spacers provide a path for permeate water to flow towards the permeate tube, which minimizes permeate-side pressure losses. New permeate spacers and membrane backing are uniform in color. Foulant found on the permeate side of the membrane leaves indicates contamination of the permeate stream.

Visible foulant material was not observed on the permeate spacers or membrane backings.

Cell Test for Permeate Water & Salt Passage

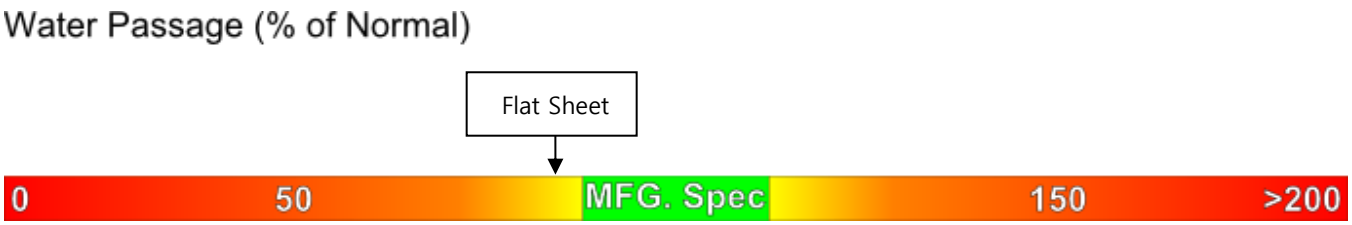
To determine membrane performance characteristics, membrane samples are tested in a cell test apparatus. The water passage constant is expressed as the "A" value, and the salt passage constant is expressed as the "B" value. Both constants are functions of the chemical-physical properties of the membrane and any fouling layer present.

"A" and "B" value constants are also independent of operating parameters such as pressure, temperature and salt content of the feed stream. "A" value units are cm/sec/atm. "B" value units are cm/sec.

The flat sheet performance is normalized to the manufacturer's specifications so the flat sheet performance can be compared to that of the full element. The results are shown in the table below.

SN C7520230	**Water Passage Constant "A" Value**	**Salt Passage Constant "B" Value**
Flat Sheet Membrane	1.96E-04 96% of Normal	1.37E-05 Normal
Manufacturer's Specifications	2.06 to 2.79E-04 Normal Range	1.33 to 1.67E-06 Normal Range

Note: testing conducted using dechlorinated city water from San Marcos, CA



Foulant Analysis

Organic Content Testing

Loss on ignition (LOI) testing gives an approximation of the organic content of the foulant. Values higher than 65% represent notable organic fouling.

Loss on ignition testing was unnecessary due to the absence of foulant on the membrane surface.

Foulant Density Measurement

The foulant density is the weight of dry foulant per area of membrane surface. The foulant densities determined from past autopsies at Avista Technologies range from 0.02 to 5.23 mg/cm^2 with an average of 0.45 mg/cm^2.

Since there was no foulant on the membrane surface, foulant density measurement was non-applicable.

Acid Testing

Acid testing is used to determine the presence of carbonates and metals on the membrane surface. In this test, several drops of dilute hydrochloric acid were placed on the foulant surfaces. Effervescing indicates the presence of carbonates while a color change is associated with the presence of metals.

Acid testing was negative for the presence of carbonates and no visible color change occurred.

Microbiological Analysis

This analysis is performed to identify the biological activity of foulant removed from the membrane surface. Foulant samples are stained and examined with a light microscope at 1000x using an oil immersion lens. Gram positive bacteria are stained purple while Gram negative bacteria are stained pink.

Microscope analysis could not be performed due to the absence of removable foulant.

Zeta Potential Testing

The zeta potential is the charge that resides at the double layer boundary of colloids. Most naturally occurring colloids are negatively charged. A goal of coagulation is to neutralize the colloids to form floc prior to filtration. If an excess of coagulant is present, the charge of the colloids switches from negative to positive.

The zeta potential of the foulant present on the membrane surface is measured to determine if coagulant is being overfed. Two grams of wet foulant is required for this test.

Zeta potential testing could not be performed due to the absence of foulant material.

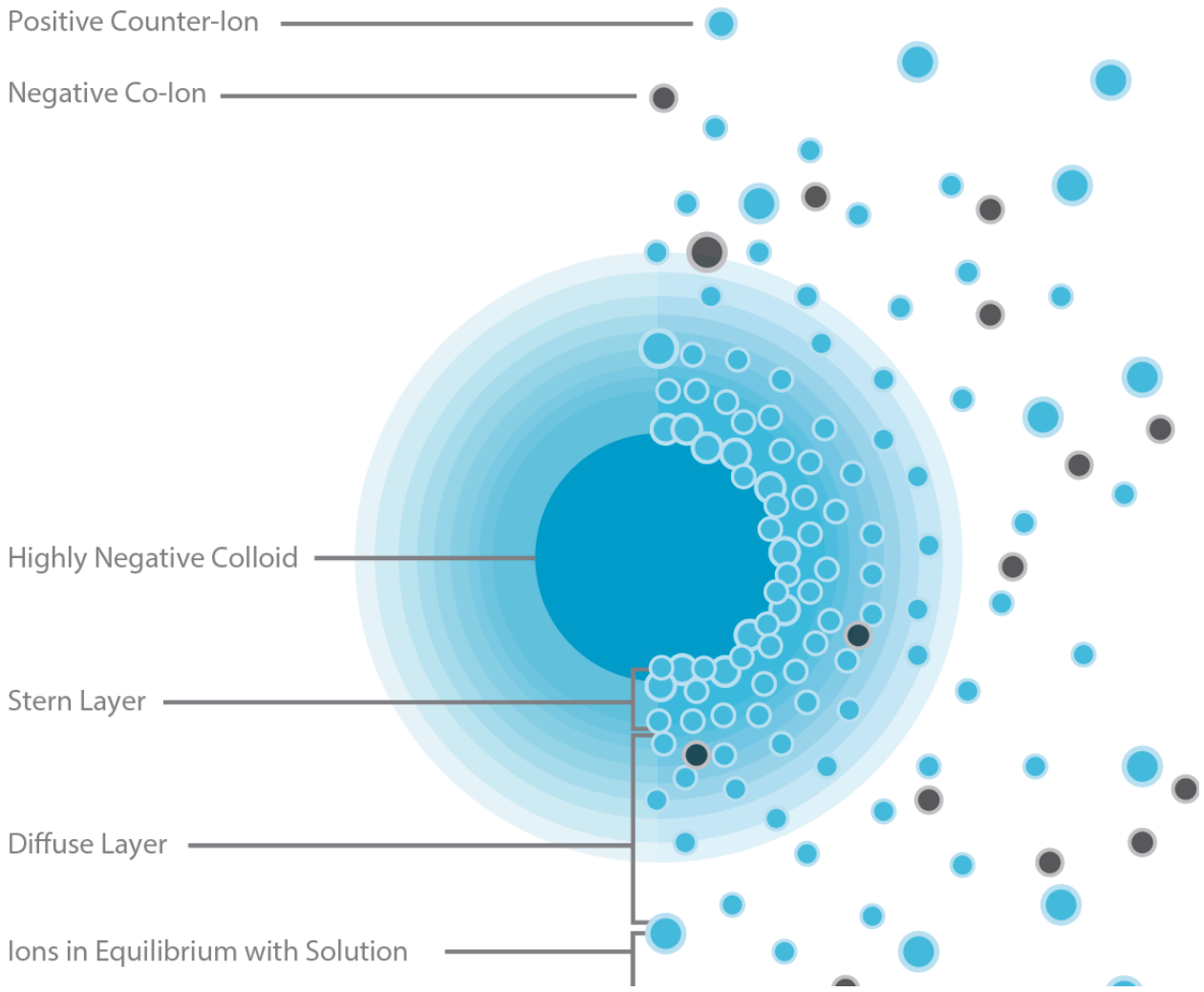
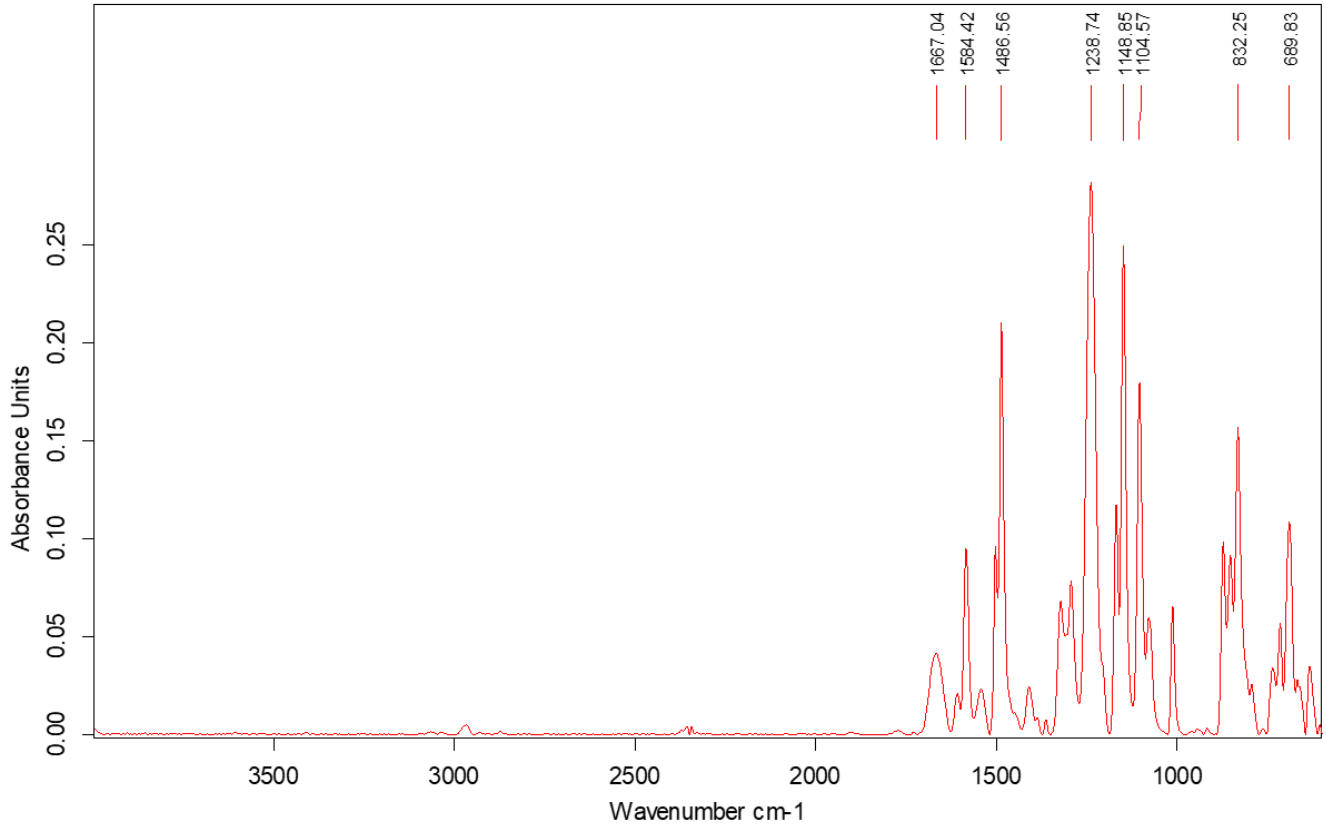


Image based on diagram from Particle Characterization Laboratories, Inc.

Fourier Transform Infrared Spectroscopy Analysis

Fourier Transform Infrared Spectroscopy (FT-IR) is an analytical technique used to identify functional groups (specific groups of atoms or bonds within molecules). Infrared radiation passes through a sample, with some of the radiation absorbed and some transmitted. A measurement and interpretation of this data produces a spectrum which can then be compared and matched to the known spectra for functional groups based on the wavenumber at which bands appear and their respective shapes (e.g. sharp, broad, strong, weak).

FT-IR spectroscopy performed directly on a sample of the membrane detected only peaks representative of the membrane structure components (e.g. polysulfone).



FT-IR spectral image of the membrane surface of SN C7520230

Energy Dispersive Spectroscopy (EDS) Analysis

Energy Dispersive Spectroscopy analysis is used to determine the relative concentration of elements present in a sample. EDS analysis is performed on a dry membrane sample. The element sulfur is at least in part associated with the membrane support material (polysulfone) rather than a foulant layer. Avista's analysis of new membranes typically detects between 5.00 and 7.00 weight percentage. Relative concentrations below 5.00 percent indicate the presence of a foulant layer masking the membrane surface.

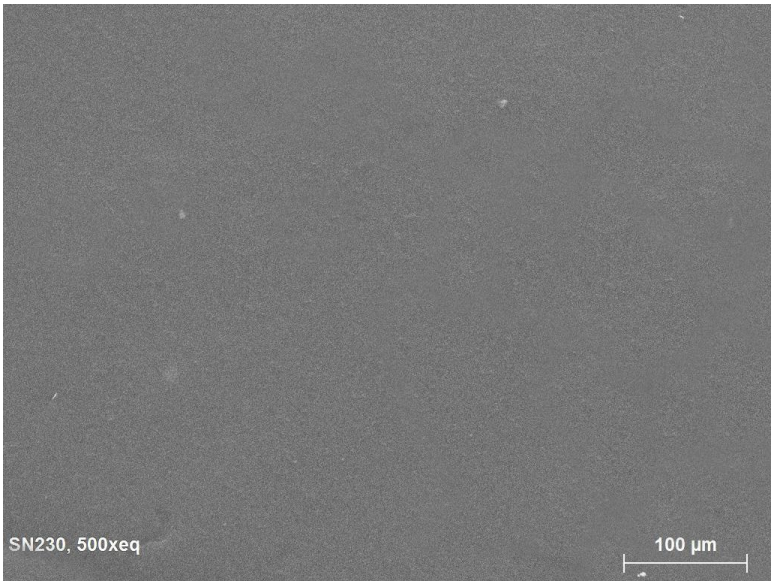
EDS analysis performed on the membrane surface detected only carbon, oxygen and sulfur. Foreign inorganic elements were not present. The element carbon can be contributed by the presence of foreign organics but is also a component of the membrane materials. The sulfur weight percentage (5.60 wt%) suggests no masking of the membrane surface.

Elements	**SN C7520230** **Weight Percent (wt%)**
Carbon	82.37
Oxygen	12.03
Sulfur	5.60

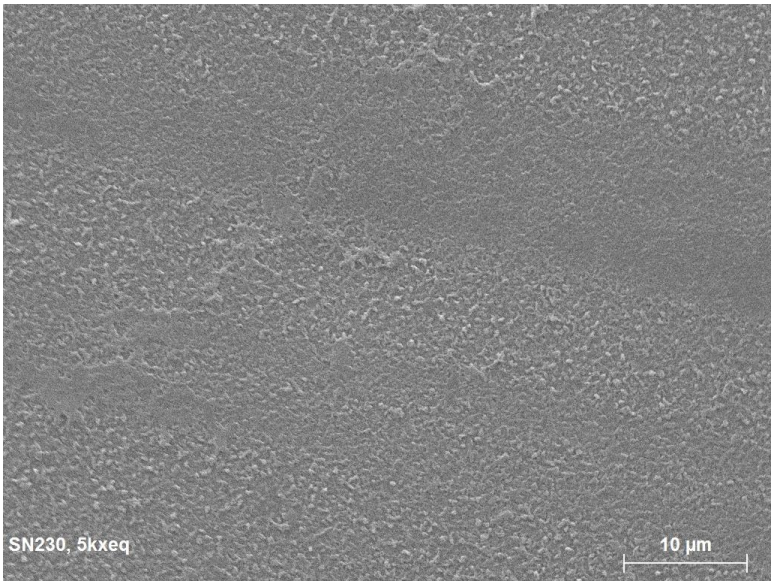
Scanning Electron Microscope (SEM) Imaging

SEM imaging is performed on the membrane surface to observe the topography of the foulant material. Foulant morphology can be an indicator of the type of foulant.

SEM imaging (500x) revealed that the membrane surface was predominantly free of foulant material. Only traces of particulate material were observed. Close-up (1000x) imaging displayed topography representative of the membrane surface itself.



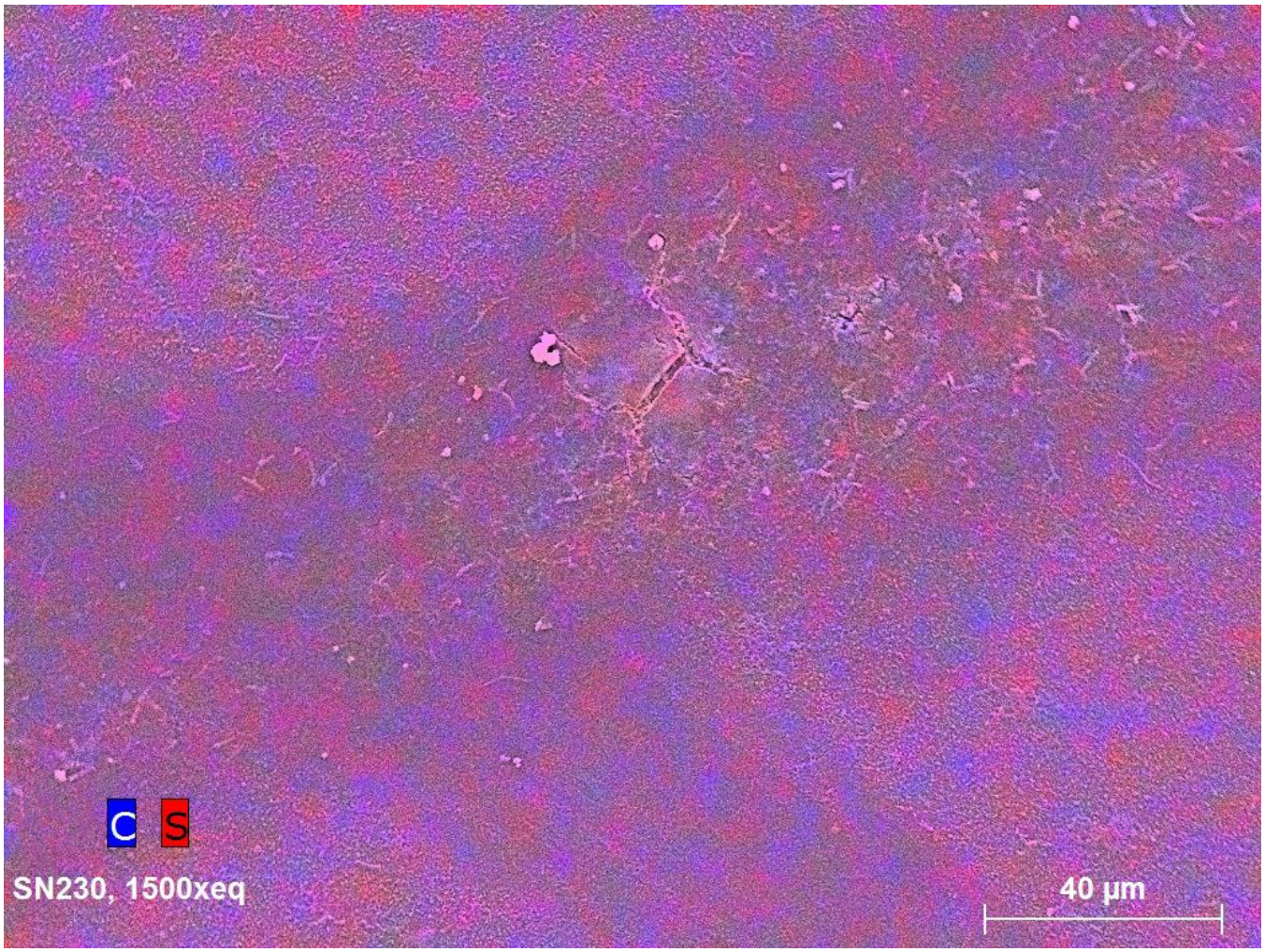
SEM image (500x) of the membrane surface of SN C7520230



Close-up SEM image (5000x) of the membrane surface of SN C7520230

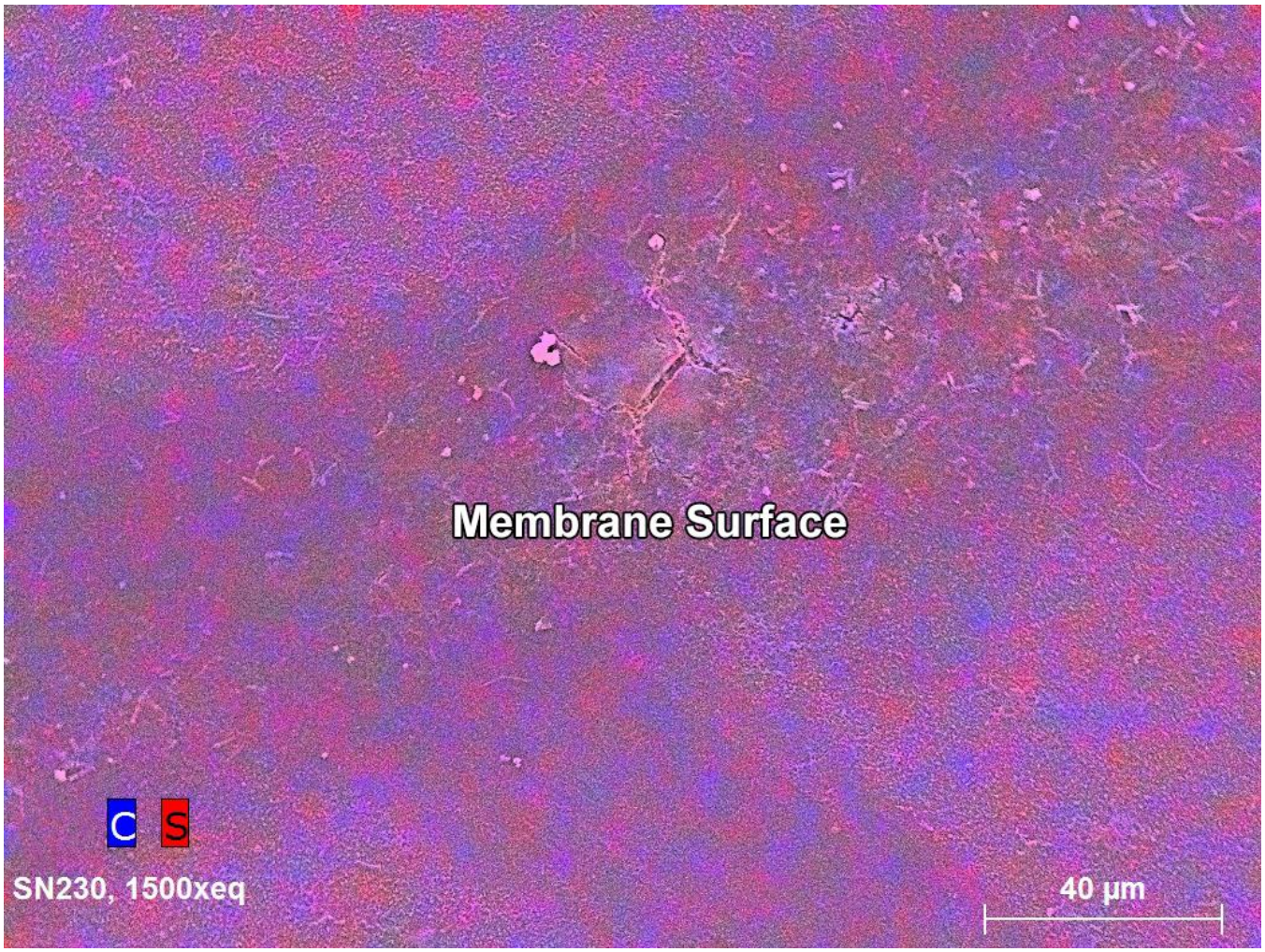
Chromatic Elemental Imaging℠ (CEI℠)

CEI is an analytical technique used to determine the spatial distribution of elements in a foulant sample. In this technique, a beam of focused electrons is accelerated across the surface of a foulant sample and interacts with the sample's inorganic elements by causing the elements to emit electrons. An element's electron emission from its atomic shell generates a characteristic X-ray spectrum that allows for its identification. CEI assigns each element a color (colors for each element are shown in a legend on the bottom left corner of the CEI image) and provides a high-resolution image where the colors correspond to the exact location of the elements in the sample. An element's color intensity in a CEI is largely influenced by its concentration in the foulant sample; i.e. elements present with higher relative concentrations are displayed with greater color intensity in the image. CEI can uniquely identify the distinct elements in a mixed foulant sample.



CEI image (1500x) of the membrane surface

CEI[SM] identified only an alternating pattern of carbon (blue) and sulfur (red), which is representative of the membrane surface and backing materials. Foreign elements were not identified. A small patch of material was observed; however, the layer was very thin and only the elements associated with the membrane materials were detected.



CEI image (1500x) of the membrane surface with labels

Cell Test & Laboratory Clean-in-Place Study

Flat sheet membrane samples harvested from the full element are placed in a cell test apparatus and cleaned with various Avista chemicals to determine the most effective cleaner combinations and contact times. The most effective cleaner is chosen based on overall improvement in water and salt passage and visual foulant removal.

Since the membrane surface was clear of foulant and the flat sheet samples flowed only slightly below normal, a cleaning study was not required at this time.

Testing to Determine Damage to Flat Sheet Samples

Fujiwara Testing

Fujiwara testing is a qualitative analysis which determines if a polyamide (PA) thin-film membrane has been exposed to an oxidizing halogen, such as chlorine, bromine, or iodine. If the solution changes color to pink or red, the element is declared positive for the presence of oxidizing halogens. A color change does not occur if the membranes has not been exposed to halogens. Common symptoms of halogen oxidation include increased flow and loss in permeate quality.

Fujiwara testing was negative for the presence of halogens (e.g. chlorine) in the membrane structure.

Example of negative (left) and positive (right) Fujiwara color change

Full Element Wet Testing

Additional full element wet testing was performed on element SN C7520228 (P2-S1-4), which performed most similarly to SN C7520230 during the initial wet test performed upon arrival. The purpose of the additional testing was to investigate element performance following extended rinse-up time. Element performance was analyzed after the first five minutes of rinse-up, then once more after 20 minutes.

SN C7520228	**Flow (gpm)**	**Rejection (%)**	**Pressure Drop (psi)**
Initial Wet Test	1.20	88.8	4
5 Minutes Rinse-Up	1.20	94.5	4
20 Minutes Rinse-Up	**1.20**	**99.3**	**4**
Manufacturer's Specifications	1.39 to 1.88	99.0 to 99.2	≤15

Certification by Laboratory

Report Number	Report Content	Element Serial Number	Report Date
WO#053018-5	Standard Spiral Autopsy	KM8048229-7015 **C7520230**	June 25, 2018

We the undersigned being the technical specialists in membrane autopsy and related testing procedures and protocol for Avista Technologies certify to the best of our knowledge and belief that the tests listed in this report have been conducted following Avista's standard testing practices and that the results are accurate and complete.

By signing this certificate neither the laboratory employees nor their employer makes any warranty, expressed or implied, concerning the cleaning study results.

Date: 06/25/2018

Signed:

Megan Lee
Laboratory Services Manager

Arnell Abad
Laboratory Services Chemist

Membrane Autopsy Report

Completed for:

Brown & Caldwell

Scottsdale Water Campus

SN KM8048229-7015

P1-6

06/25/2018 WO#053018-5

CORPORATE OFFICES

Avista Technologies, Inc.
Global Headquarters
+1.760.744.0536
info@avistatech.com

Avista Technologies (UK) Ltd
+44 (0) 131 449 6677
info@avistatech.co.uk

Creative Chemistry. Smart Solutions.

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Executive Summary

Background

Brown & Caldwell provided 6 Koch SR200-4040 nanofiltration (NF) and 12 Hydranautics ESPA4-LD-4040 reverse osmosis (RO) membrane elements from Scottsdale Water Campus to Avista Technologies for wet testing. Element Serial Number (SN) KM8048229-7015 (Koch SR200-4040) and SN C7520230 (Hydranautics ESPA4-LD-4040) were selected for dissection and analysis to identify foulant constituents, as well as other causes for loss of performance. SN KM8048229-7015 was noted as position "P1-6" while SN C7520230 was from position "P2-S2-5". The remainder of this report pertains to SN KM8048229-7015 (P1-6).

Initial Element Testing

The element produced lower than normal flow (81% of normal), lower than normal rejection (97.6%) and a differential pressure of 6 psi. Testing was conducted using an aqueous solution containing 2,000 ppm $MgSO_4$. The element passed integrity testing, indicating the absence of damage to the internal components of the spiral wound element.

External Inspection

The fiberglass casing was in good mechanical condition and the brine seal was intact. Damages to the permeate tube ends and interior were not observed. The feed (brine seal end) and concentrate (opposite brine seal) ATDs were clear of visible damages and foulant.

Internal Inspection

The feed scroll end had light deposits of brown-colored foulant material while the concentrate scroll end was more heavily fouled, containing a higher density of the foulant. The exposed membrane surfaces were coated with a layer of smooth, brown-colored foulant. The foulant layer was evenly unevenly distributed and followed a gradient pattern which increased in prevalence from the feed to the concentrate end of the membrane. Physical damages (e.g. abrasion, delamination) to the membrane surface were not immediately apparent. The feed spacers contained a light, uneven coating of the brown-colored foulant. Granular material was present on the feed end glue lines, breaching partially into the active membrane surface. The permeate spacers and membrane backing were uniform in color and no foulant was present on the interior surfaces.

Cell Testing Results

Flat sheet samples harvested from the full element produced 82% of normal water passage and lower than normal $MgSO_4$ rejection (97.5%) upon baseline cell testing. Testing was conducted using an aqueous solution containing 2,000 ppm $MgSO_4$.

Foulant Analysis

The loss on ignition (organic content) for the foulant material removed from the membrane surface was 81.7%, which indicates the foulant contained primarily organic material. Foulant density on the membrane surface could not be determined due to the uneven distribution of the material. Acid testing was negative for the presence of carbonates; however, a slight yellow color change was observed which indicates the presence of metals (e.g. iron). Microscope imaging displayed amorphous organic material (e.g. bio-slime) containing an abundance of Gram-negative bacteria. Also present were algae and various particulate materials, as well as a lesser amount of Gram-negative bacteria. Fourier-Transform Infrared (FT-IR) spectroscopy performed on foulant removed from the membrane surfaces resulted in a broad peak at the 1000 cm^{-1} range, which is characteristic of the presence of both organic material (e.g. carbohydrates – polysaccharides) and phosphate compounds (e.g. calcium phosphate). A smaller double peak at the 1650-1500 cm^{-1} range was also present, which is associated with the presence of proteins (e.g. amino acids from microorganisms).

The Energy Dispersive Spectroscopy (EDS) analysis detected calcium and phosphorus as the primary inorganic constituents of the foulant material. Lesser amounts of magnesium, iron and aluminum were also detected. The sulfur weight percentage (4.86 wt%) indicates that the foulant layer did not contribute to notable masking of the membrane surface as Avista's analysis of new polyamide membranes typically detects between 5.00 and 7.00 wt% sulfur. Scanning Electron Microscope (SEM) imaging (150x) displayed a cracked layer of smooth foulant containing fine-granular deposits. Close-up imaging (5000x) provided a clearer representation of the amorphous topography of the foulant layer. Chromatic Elemental Imaging℠ (CEI℠) identified the bulk of the foulant layer to be comprised of organic material (represented by the element carbon) and calcium phosphate. Separate deposits of calcium were also present. The membrane surface is depicted by the element sulfur and was visible through cracks in the foulant layer.

Based on the analysis, it was determined that the foulant present on the membrane surface was primarily a combination of organics and calcium phosphate.

Cleaning Study

Flat sheet samples were cleaned with RoClean P111 (2% by weight in RO/DI water, heated to approximately 35 degrees Celsius and circulated) for 2 hours. Complete visual foulant removal was achieved and flow was restored to the manufacturer's specification.

Testing for Flat Sheet Damage

The full element and flat sheet samples produced lower than normal MgSO4 rejection. Fujiwara testing was negative for the presence of halogens (e.g. chlorine) in the membrane structure. Dye testing revealed pinhole-sized areas of heavy dye uptake on the membrane surface. The pinholes maintained a symmetrical, rounded shape which can indicate chemical damage caused by foulant. A pattern of lesser dye uptake was displayed in the areas corresponding to the feed spacer contact points, representing some degree of physical abrasion. Additionally, the dye appeared to penetrate through the pinholes to the membrane backing, signifying that the damage was severe.

Initial Element Test Results

Element Weight

All elements are weighed prior to autopsy as weight is often indicative of the degree of fouling. New eight-inch elements weigh approximately 30 to 35 pounds. Additionally, elements in excess of 50 pounds cannot be wet tested.

SN KM8048229-7015 weighed 10 pounds.

Wet Test

The element was wet tested using an aqueous solution containing 2,000 ppm $MgSO_4$. Wet test results were normalized to the manufacturer's published test conditions.

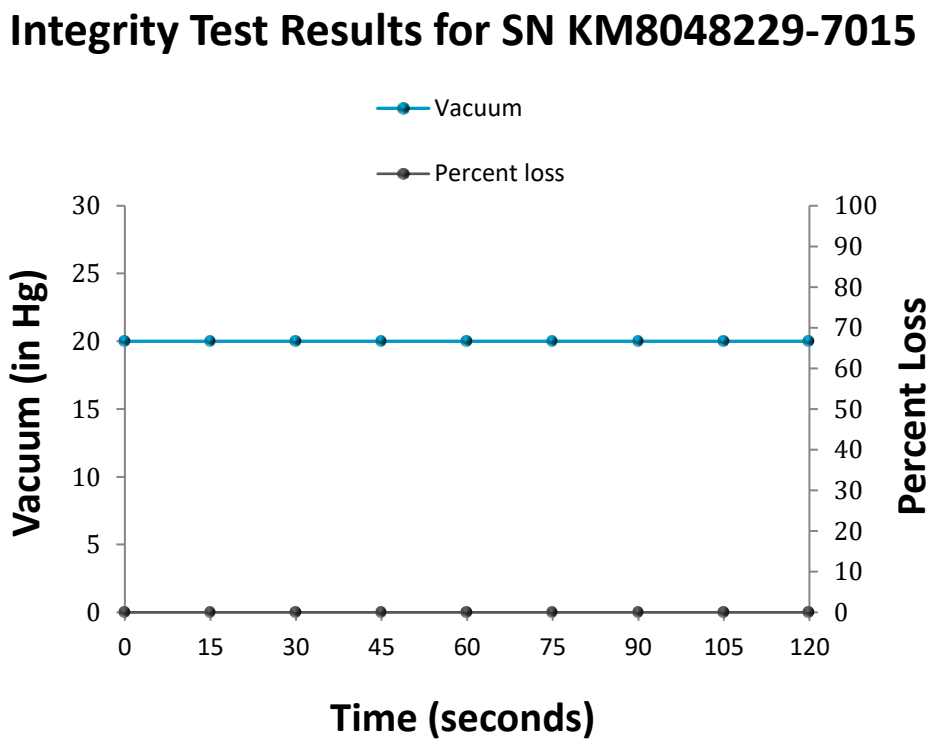
Koch 4040-SR200	**Flow (gpm)**	**Rejection (%)**	**Pressure Drop (psi)**
SN KM8048229-7015	0.61	97.6	6
Manufacturer's Specifications	0.75 to 1.06	99.0 to 99.4	≤10

Element wet testing

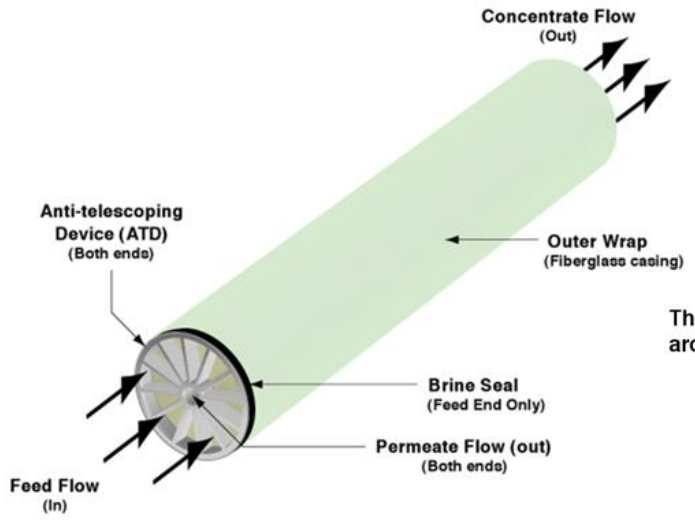
Integrity Test

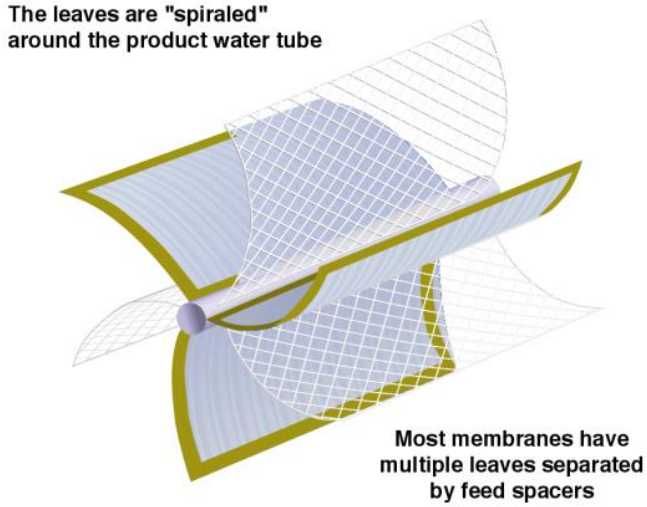
Integrity testing is performed to identify mechanical damage to the internal components of the spiral wound element. In this test, a vacuum of approximately 22 inches Mercury (in. Hg) is applied to the permeate side of the membrane and the membrane is then sealed. The vacuum is monitored for a duration of 120 seconds. Any loss of vacuum indicates the presence of damage; however, membranes that lose over 35% of the vacuum within the 120 second period have severe physical damage.

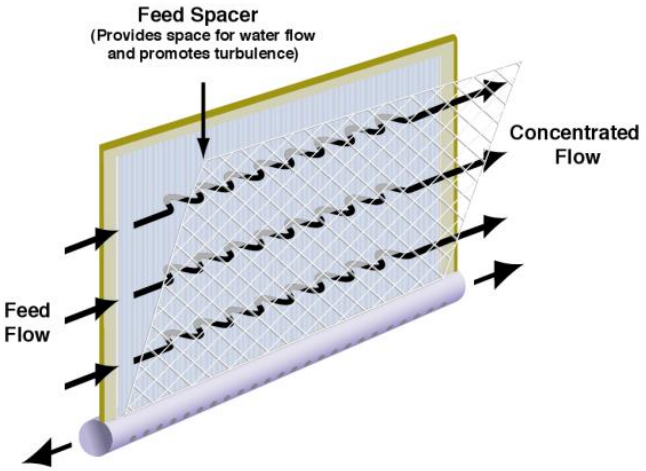
The element maintained stable vacuum pressure, passing the integrity test.

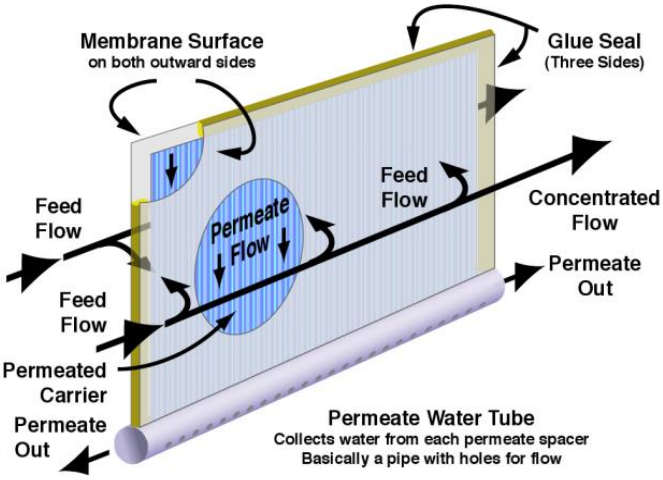


Membrane Construction Diagrams







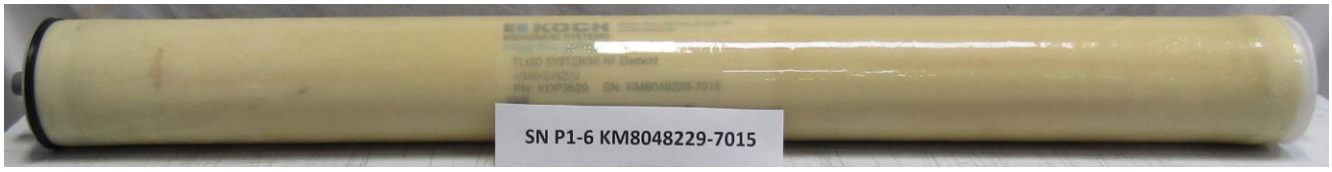


External Inspection

Fiberglass Casing

The purpose of the fiberglass casing is to ensure that the various membrane components are held in their correct position for optimum performance. Damage to the casing can be an indication of rough handling or damage from excessive differential pressure across the element.

The fiberglass casing was in good mechanical condition.



Fiberglass casing of SN KM8048229-7015

Brine Seal

The brine seal is used to seal against the inside diameter of the pressure vessels and the outside diameter of the membrane to ensure that all the feed water passes through the element. Feed water passing on the exterior of the element can result in higher pressures, which can cause cracking of the fiberglass casing.

The brine seal was intact.

Permeate Tube

The permeate tube is a pipe that is located at the center of the element. It contains lines of holes and is bonded to each membrane leaf allowing permeate water to travel from the leaves into the permeate tube to be collected. Damage to the ends of the permeate tube can lead to o-ring failures, causing bypass of feed or concentrate water into the permeate stream. Cracking of the permeate tube can also result in permeate contamination.

Damages to the permeate tube ends and interior were not observed.

Anti-Telescoping Devices (ATDs)

The function of the ATDs are to stabilize the components of the element. This helps to prevent shifting of the internal mechanical components under pressure, also known as telescoping. Telescoping may still occur if pressures exceed the manufacturer's specifications.

The feed and concentrate ATDs were clear of visible damages and foulant.

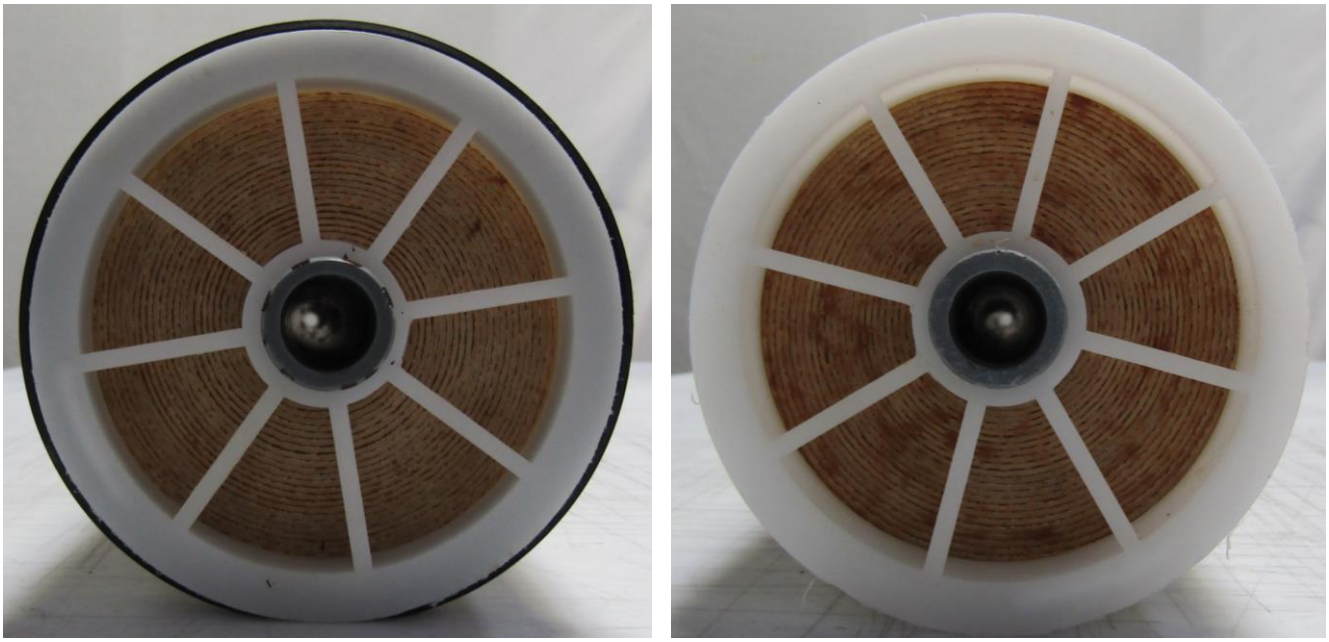


Image of the feed (left) and concentrate (right) ATD of SN KM8048229-7015

Internal Inspection

Scroll Ends

The ends of the element are called scroll ends. They are examined for the presence of foulant debris and mechanical damage (e.g. gapping, feed spacer extrusion). The presence of foulant on the scroll ends can cause elevated delta pressures while gapping and feed spacer extrusion indicate uneven hydraulics (high flow/low flow regions). In addition, each scroll end is examined for telescoping, the gradual axial shift of the membrane leaves from the outer diameter of the element towards the permeate tube. Telescoping is often caused by the development of high differential pressure (greater than the manufacturer's specification) across the element or when pressure is applied too quickly, causing a water hammer effect.

The feed scroll end had light deposits of brown-colored foulant material. The concentrate scroll end was more heavily fouled, containing a higher density of the brown-colored foulant.

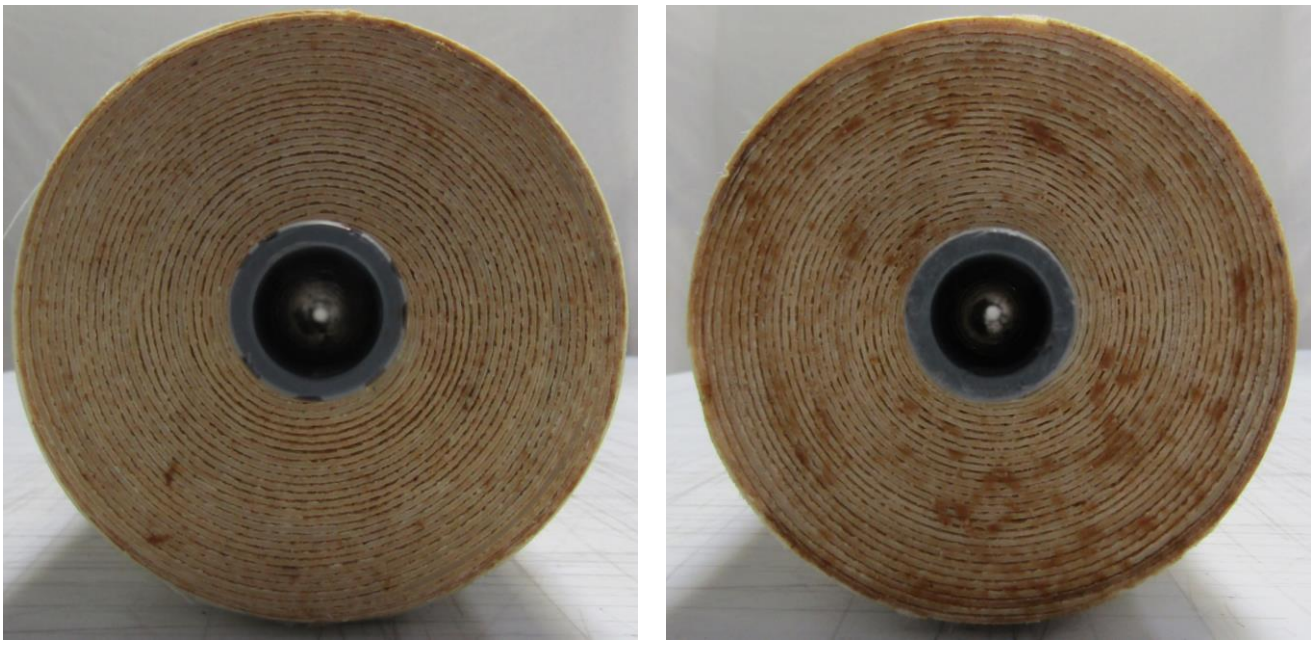


Image of feed scroll end (left) and concentrate scroll end (right) of SN KM8048229-7015

Membrane Surface

New membrane surfaces are uniform and shiny. Foulant can often be detected through visual examination; however, membrane appearance can be misleading as some foulants are not visible. The presence of foulant on the membrane surface can cause elevated delta pressure, loss in flow and damage if the foulant is abrasive. Additionally, the membrane surface is inspected for damage such as delamination. Delamination is the lifting of the thin-film membrane from the support layer and often occurs due to a positive pressure on the permeate side of the element.

The exposed membrane surfaces were coated with a layer of smooth, brown-colored foulant. The foulant layer was evenly unevenly distributed and followed a gradient pattern which increased in prevalence from the feed to the concentrate end of the membrane. Physical damages (e.g. abrasion, delamination) to the membrane surface were not immediately apparent.

Exposed membrane surface of SN KM8048229-7015

Exposed membrane surface from feed end of SN KM8048229-7015

Feed Spacers

The feed spacer is a plastic net material designed to separate the membrane leaves, forming a flow path, and to promote turbulence within the feed water channels. Foulant blocking the feed channels causes more resistance for the feed water flowing through the element and results in higher than normal delta pressures.

The feed spacers contained a light, uneven coating of the brown-colored foulant.

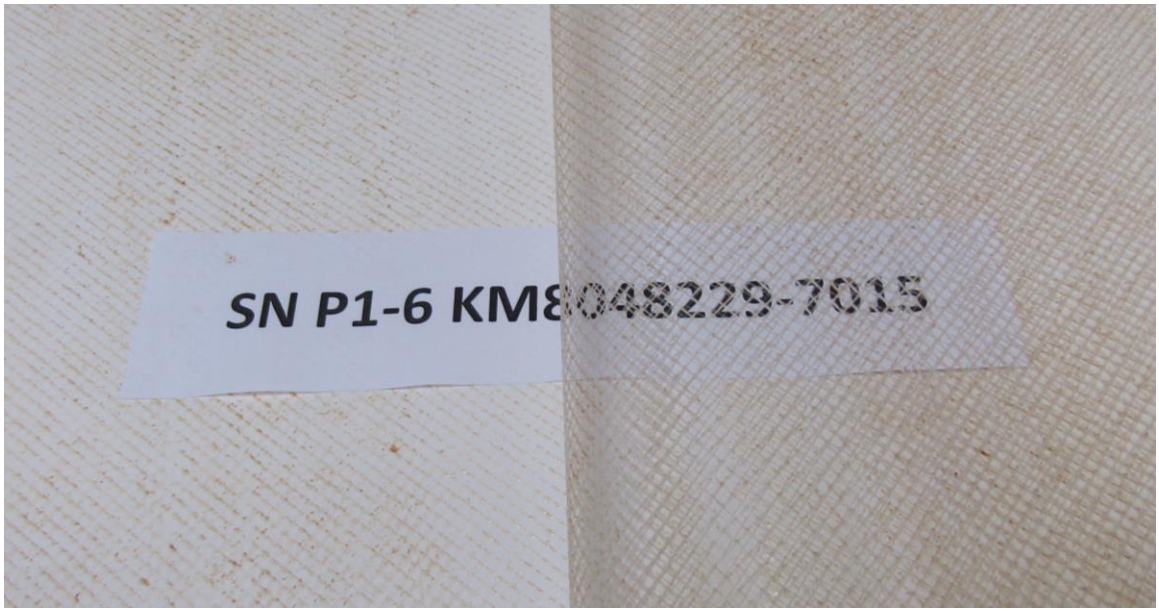


Image of feed spacer

Glue Lines

Membrane leaves are glued on three sides to separate the feed and permeate streams. The glue lines are inspected for specific damage, including glue flaps and pouching. Glue flaps refer to excess inactive membrane material located closest to the ends of the element. Flaps found on the feed end of the element can flair during operation, blocking the feed channels on the scroll end, potentially causing increased differential pressure. Pouching of the glue line, which is often a result of delamination, allows feed water to pass through the inactive membrane at the glue line, contaminating the permeate stream.

Granular material was present on the feed end glue lines, breaching partially onto the active membrane surface.

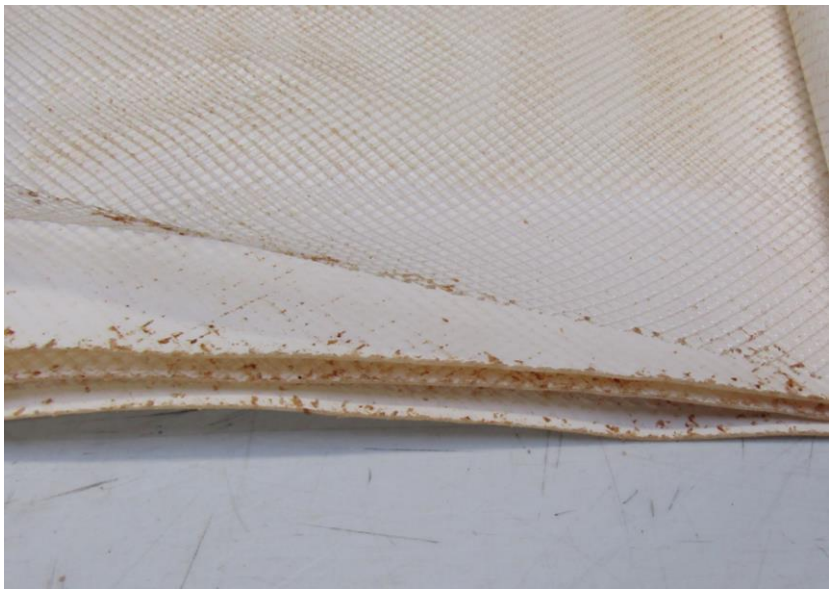


Image of the granular material present on the feed end glue lines

Permeate Spacers and Membrane Backing

The permeate spacers provide a path for permeate water to flow towards the permeate tube, which minimizes permeate-side pressure losses. New permeate spacers and membrane backing are uniform in color. Foulant found on the permeate side of the membrane leaves indicates contamination of the permeate stream.

The permeate spacers and membrane backing were uniform in color and no foulant was present on the interior surfaces.

Cell Test for Permeate Water & Salt Passage

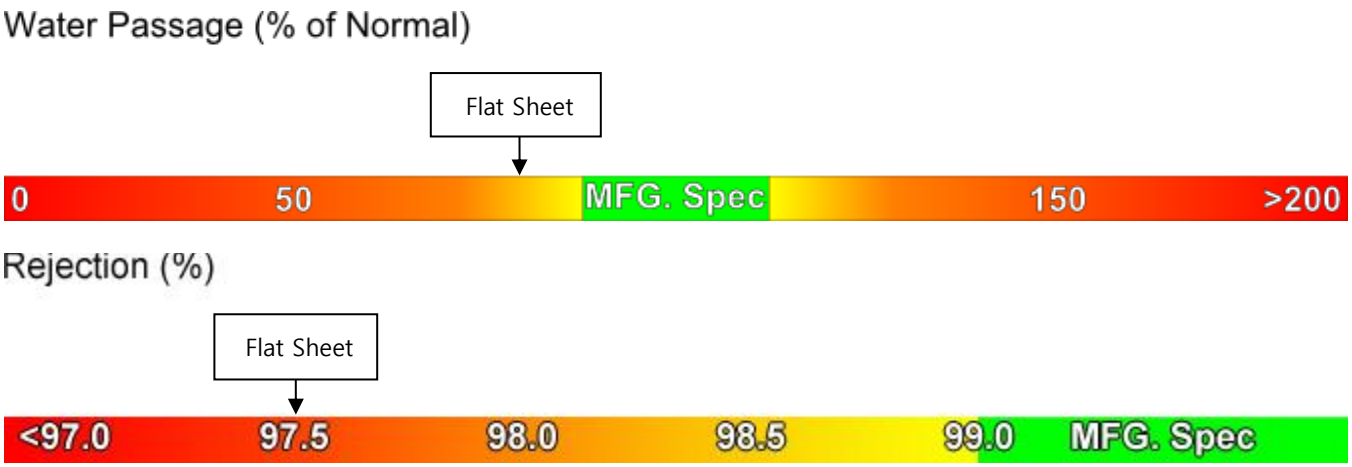
To determine membrane performance characteristics, membrane samples are tested in a cell test apparatus. The water passage constant is expressed as the "A" value, and the salt passage constant is expressed as the "B" value. Both constants are functions of the chemical-physical properties of the membrane and any fouling layer present.

"A" and "B" value constants are also independent of operating parameters such as pressure, temperature and salt content of the feed stream. "A" value units are cm/sec/atm. "B" value units are cm/sec.

The flat sheet performance is normalized to the manufacturer's specifications so the flat sheet performance can be compared to that of the full element. The results are shown in the table below.

SN KM8048229-7015	**Water Passage Constant "A" Value**	**$MgSO_4$ Rejection (%)**
Flat Sheet Membrane	0.91E-04 82% of Normal	97.5
Manufacturer's Specifications	1.11 to 1.57E-04 Normal Range	99.0 to 99.4

Note: testing conducted using an aqueous solution containing 2,000 ppm MgSO4.

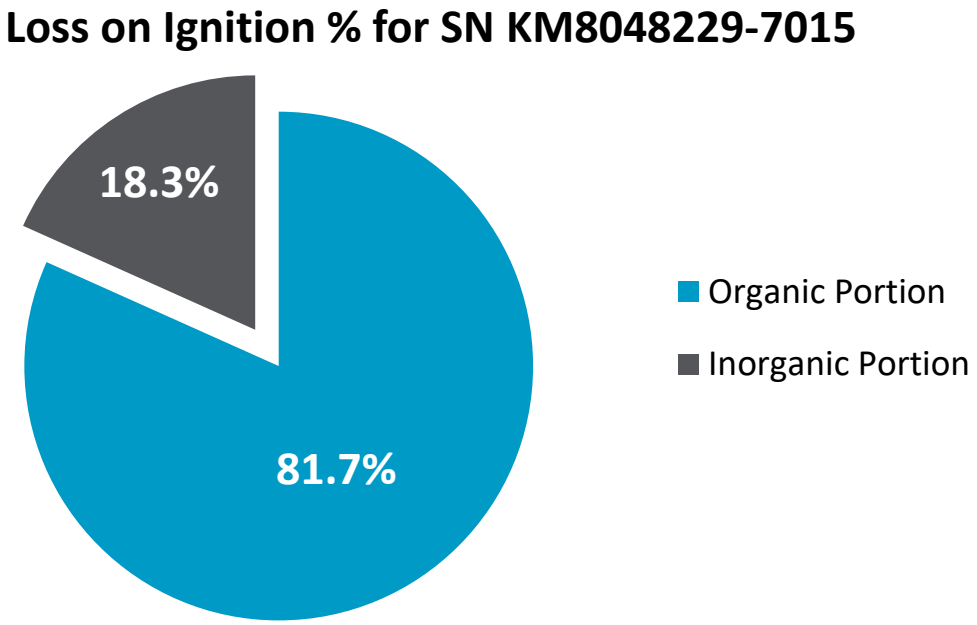


Foulant Analysis

Organic Content Testing

Loss on ignition (LOI) testing gives an approximation of the organic content of the foulant. Values higher than 65% represent notable organic fouling.

Organic content for SN KM8048229-7015 is shown in the graph below.



Foulant Density Measurement

The foulant density is the weight of dry foulant per area of membrane surface. The foulant densities determined from past autopsies at Avista Technologies range from 0.02 to 5.23 mg/cm^2 with an average of 0.45 mg/cm^2.

Foulant density could not be calculated due to the uneven distribution of the foulant material.

Acid Testing

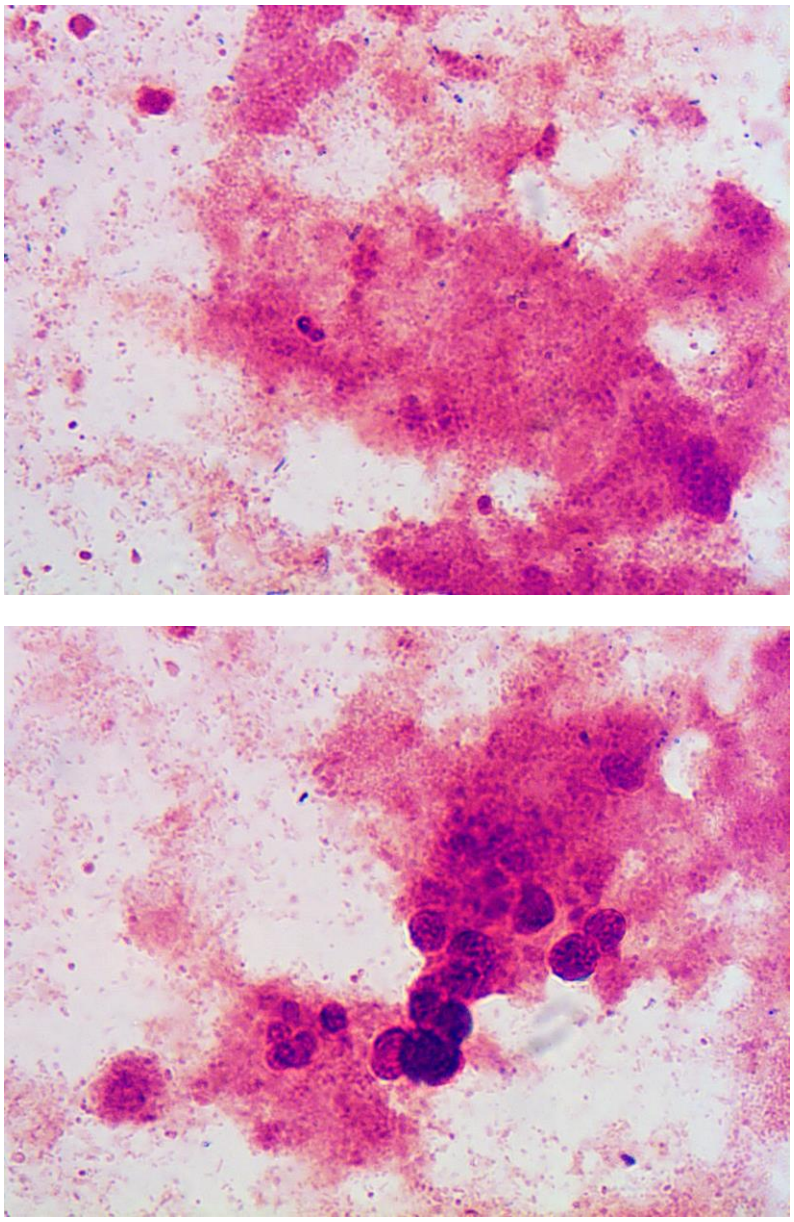
Acid testing is used to determine the presence of carbonates and metals on the membrane surface. In this test, several drops of dilute hydrochloric acid were placed on the foulant surfaces. Effervescing indicates the presence of carbonates while a color change is associated with the presence of metals.

Acid testing was negative for the presence of carbonates; a yellow color change occurred which is indicative of the presence of metals.

Microbiological Analysis

This analysis is performed to identify the biological activity of foulant removed from the membrane surface. Foulant samples are stained and examined with a light microscope at 1000x using an oil immersion lens. Gram positive bacteria are stained purple while Gram negative bacteria are stained pink.

Microscope imaging displayed amorphous organic material (e.g. bio-slime) containing an abundance of Gram-negative bacteria. Also present were algae and various particulate materials, as well as a lesser amount of Gram-negative bacteria.



Light microscope images (1000x) of foulant scraped from SN KM8048229-7015

Zeta Potential Testing

The zeta potential is the charge that resides at the double layer boundary of colloids. Most naturally occurring colloids are negatively charged. A goal of coagulation is to neutralize the colloids to form floc prior to filtration. If an excess of coagulant is present, the charge of the colloids switches from negative to positive.

The zeta potential of the foulant present on the membrane surface is measured to determine if coagulant is being overfed. Two grams of wet foulant is required for this test.

The foulant material of SN KM8048229-7015 had a zeta potential of -23.4 mV indicating there was no coagulant on the membrane surface.

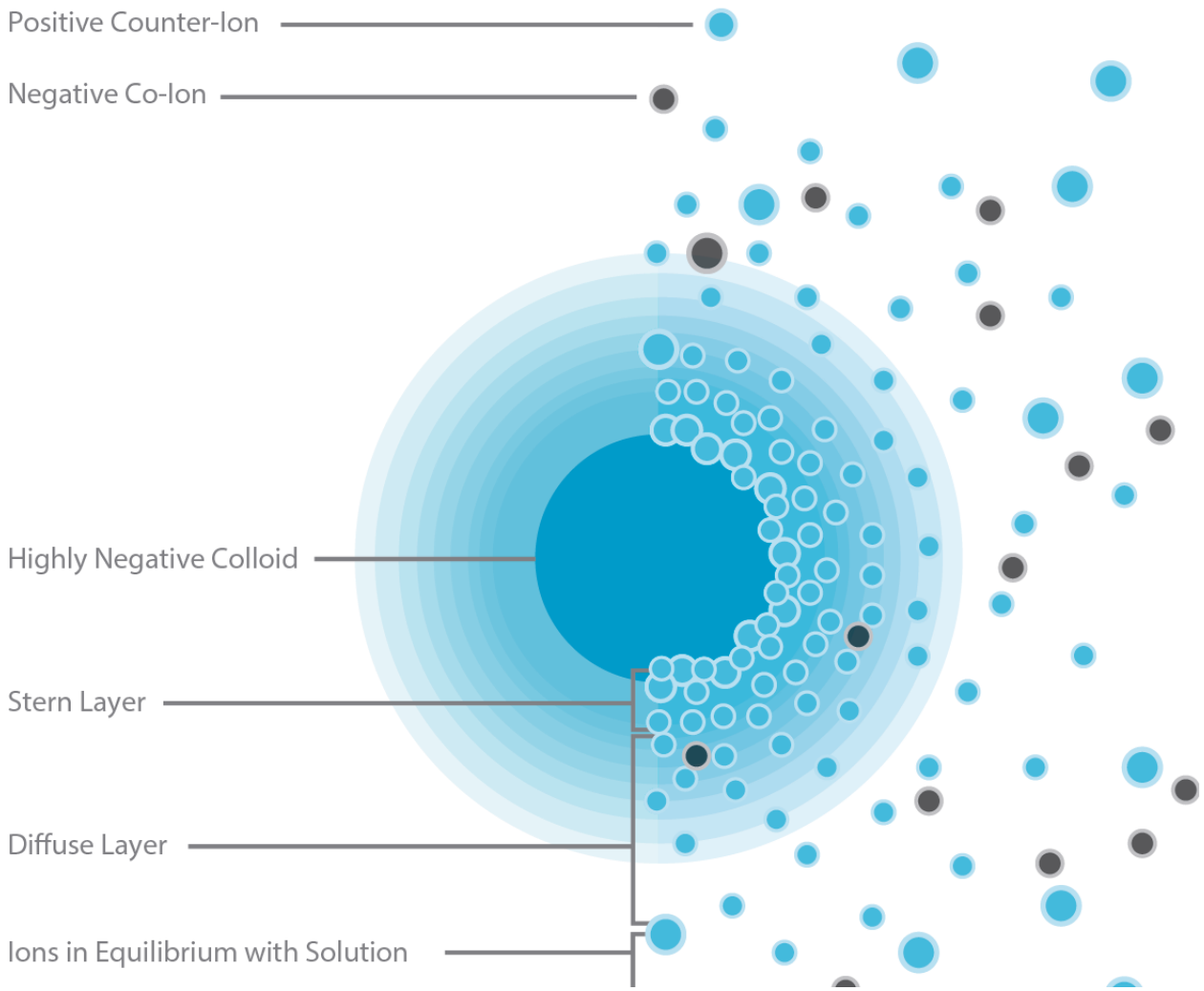
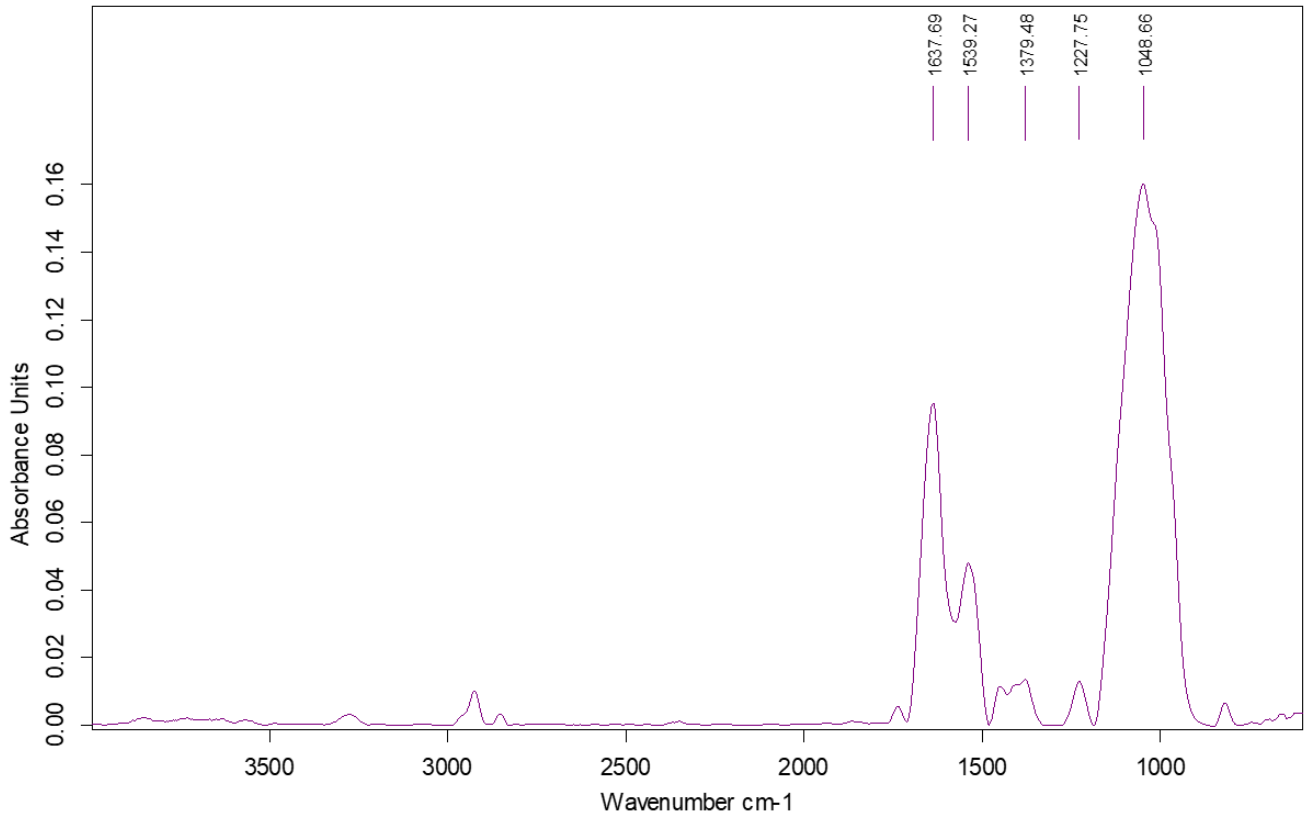


Image based on diagram from Particle Characterization Laboratories, Inc.

Fourier Transform Infrared Spectroscopy Analysis

Fourier Transform Infrared Spectroscopy (FT-IR) is an analytical technique used to identify functional groups (specific groups of atoms or bonds within molecules). Infrared radiation passes through a sample, with some of the radiation absorbed and some transmitted. A measurement and interpretation of this data produces a spectrum which can then be compared and matched to the known spectra for functional groups based on the wavenumber at which bands appear and their respective shapes (e.g. sharp, broad, strong, weak).

FT-IR spectroscopy performed on foulant removed from the membrane surfaces resulted in a broad peak at the 1000 cm^{-1} range, which is characteristic of the presence of both organic material (e.g. carbohydrates – polysaccharides) and phosphate compounds (e.g. calcium phosphate). A smaller double peak at the 1650-1500 cm^{-1} range was also present, which is associated with the presence of proteins (e.g. amino acids from microorganisms).



FT-IR spectral image of foulant removed from the membrane surface of SN KM8048229-7015

Energy Dispersive Spectroscopy (EDS) Analysis

Energy Dispersive Spectroscopy analysis is used to determine the relative concentration of elements present in a sample. EDS analysis is performed on a dry membrane sample. The element sulfur is at least in part associated with the membrane support material (polysulfone) rather than a foulant layer. Avista's analysis of new membranes typically detects between 5.00 and 7.00 weight percentage. Relative concentrations below 5.00 percent indicate the presence of a foulant layer masking the membrane surface.

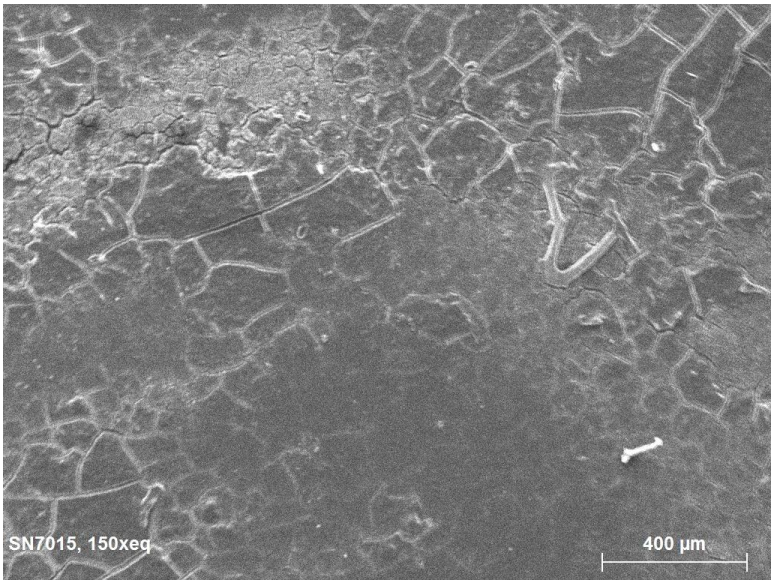
EDS analysis detected calcium and phosphorus as the primary inorganic constituents of the foulant material. Lesser amounts of magnesium, iron and aluminum were also detected. The sulfur weight percentage (5.86 wt%) indicates that the foulant layer did not contribute to notable masking of the membrane surface.

Elements	**SN KM8048229-7015** **Weight Percent (wt%)**
Carbon	65.22
Oxygen	17.96
Sulfur	5.86
Calcium	4.97
Phosphorus	4.04
Magnesium	0.80
Iron	0.70
Aluminum	0.45

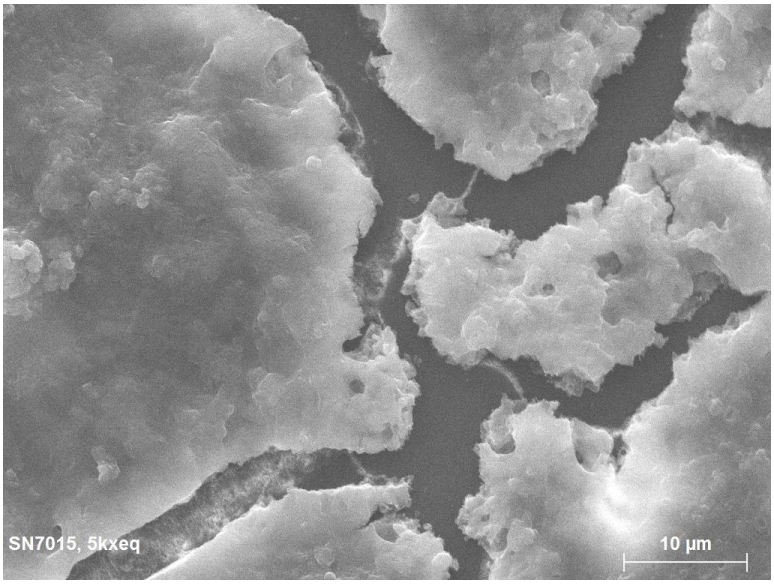
Scanning Electron Microscope (SEM) Imaging

SEM imaging is performed on the membrane surface to observe the topography of the foulant material. Foulant morphology can be an indicator of the type of foulant.

SEM imaging (150x) displayed a cracked layer of smooth foulant containing fine-granular deposits. Close-up imaging (5000x) provided a clearer representation of the amorphous topography of the foulant layer.



SEM image (150x) of the membrane surface of SN KM8048229-7015



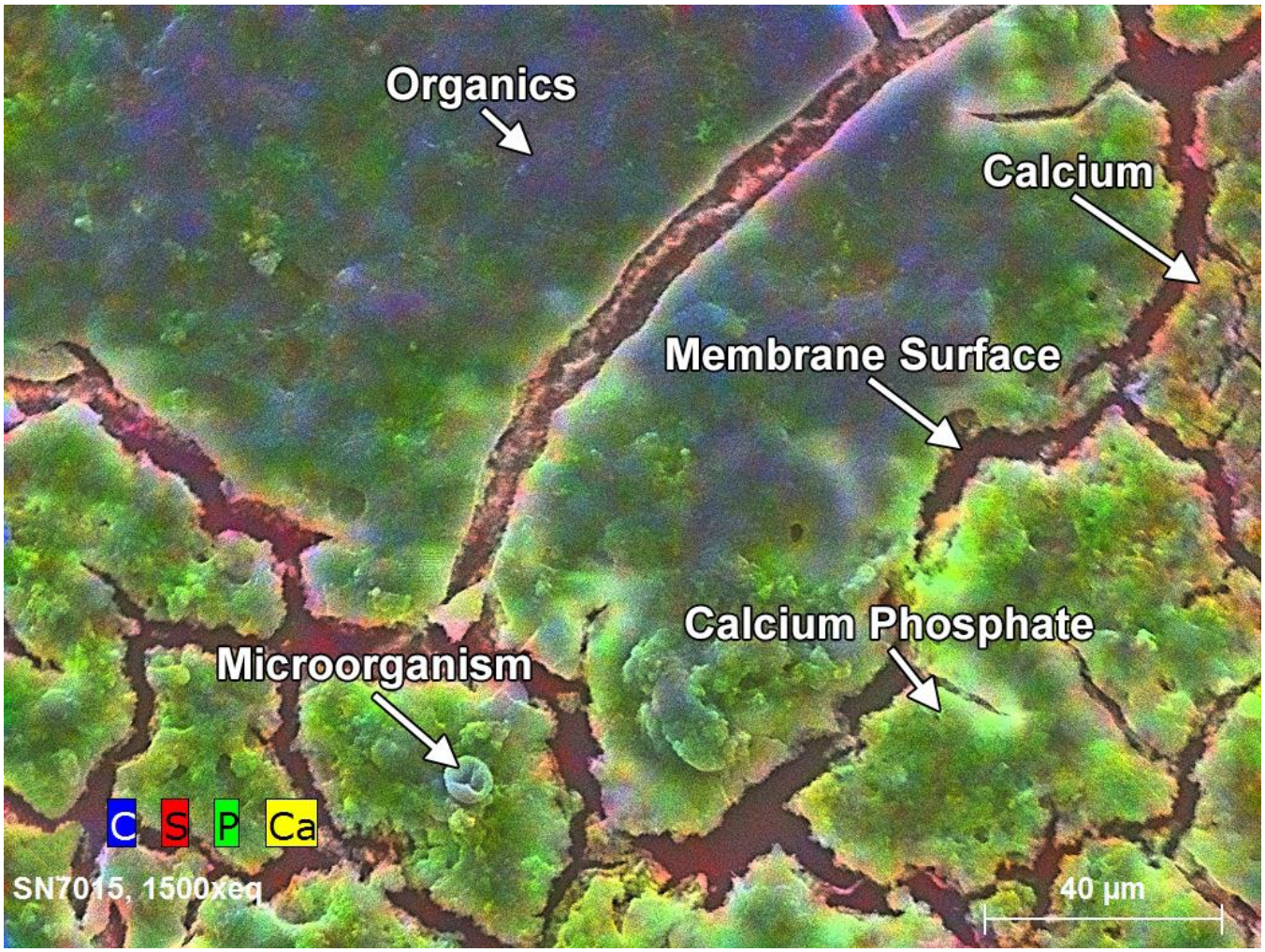
Close-up SEM image (5000x) of the membrane surface of SN KM8048229-7015

Chromatic Elemental Imaging℠ (CEI℠)

CEI is an analytical technique used to determine the spatial distribution of elements in a foulant sample. In this technique, a beam of focused electrons is accelerated across the surface of a foulant sample and interacts with the sample's inorganic elements by causing the elements to emit electrons. An element's electron emission from its atomic shell generates a characteristic X-ray spectrum that allows for its identification. CEI assigns each element a color (colors for each element are shown in a legend on the bottom left corner of the CEI image) and provides a high-resolution image where the colors correspond to the exact location of the elements in the sample. An element's color intensity in a CEI is largely influenced by its concentration in the foulant sample; i.e. elements present with higher relative concentrations are displayed with greater color intensity in the image. CEI can uniquely identify the distinct elements in a mixed foulant sample.

CEI image (1500x) of the membrane surface

CEI[SM] identified the bulk of the foulant layer to be comprised of organic material (represented by the element carbon – dark blue) and calcium phosphate (combination of yellow and green). Separate deposits of calcium (yellow) were also present. The membrane surface is depicted by the element sulfur (red) and was visible through cracks in the foulant layer.



CEI image (1500x) of the membrane surface with labels

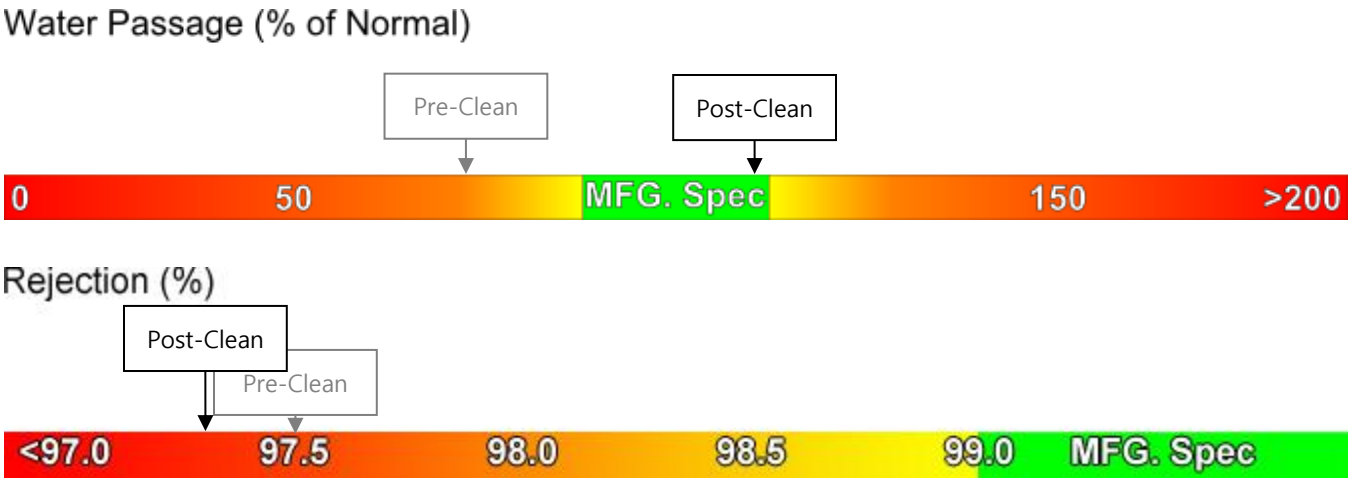
Cell Test & Laboratory Clean-in-Place Study

Flat sheet membrane samples harvested from the full element are placed in a cell test apparatus and cleaned with various Avista chemicals to determine the most effective cleaner combinations and contact times. The most effective cleaner is chosen based on overall improvement in water and salt passage and visual foulant removal.

The table below shows performance data for the optimum cleaning. Flat sheet samples were cleaned with RoClean P111 (2% by weight in RO/DI water, heated to approximately 35 degrees Celsius and circulated) for 2 hours. Complete visual foulant removal was achieved and flow was restored to the manufacturer's specification.

SN KM8048229-7015	**Water Passage Constant "A" Value**	**$MgSO_4$ Rejection (%)**
Pre-Clean	0.91E-04 82% of Normal	97.5
Post-Clean	**1.55E-04** **Normal**	**97.3**
Manufacturer's Specifications	1.11 to 1.57E-04 Normal Range	99.0 to 99.4

Note: testing conducted using an aqueous solution containing 2,000 ppm MgSO4.



Pre-Clean

Post-Clean

Testing to Determine Damage to Flat Sheet Samples

Fujiwara Testing

Fujiwara testing is a qualitative analysis which determines if a polyamide (PA) thin-film membrane has been exposed to an oxidizing halogen, such as chlorine, bromine, or iodine. If the solution changes color to pink or red, the element is declared positive for the presence of oxidizing halogens. A color change does not occur if the membranes has not been exposed to halogens. Common symptoms of halogen oxidation include increased flow and loss in permeate quality.

Fujiwara testing was negative for the presence of halogens (e.g. chlorine) in the membrane structure.

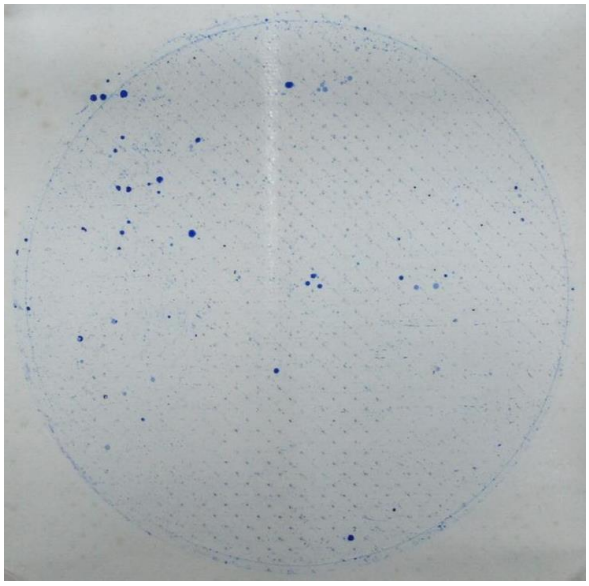
Example of negative (left) and positive (right) Fujiwara color change

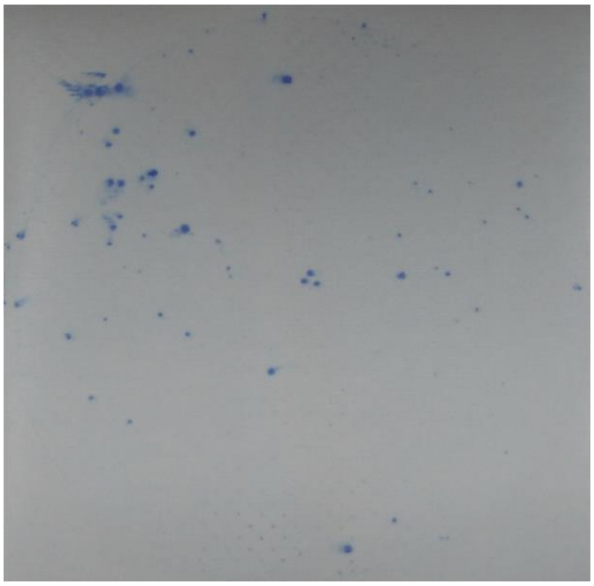
Testing to Determine Physical Damage to Flat Sheet Samples

Dye Test

Cleaned flat sheet samples were exposed to dye in a cell test apparatus at 100 psi for 15 minutes. Physically and/or chemically damaged membranes will absorb the dye on the membrane surface. Dye penetration through the membrane backing indicates severe physical and/or chemical damage.

Dye testing revealed pinhole-sized areas of heavy dye uptake on the membrane surface. The pinholes maintained a symmetrical, rounded shape which can indicate chemical damage caused by foulant. A pattern of lesser dye uptake was displayed in the areas corresponding to the feed spacer contact points, representing some degree of physical abrasion. Additionally, the dye appeared to penetrate through the pinholes to the membrane backing, signifying that the damage was severe.





Example of dye uptake on the membrane surface (left) and penetration to the membrane backing (right)

Certification by Laboratory

Report Number	Report Content	Element Serial Number	Report Date
WO#053018-5	Standard Spiral Autopsy	**KM8048229-7015** C7520230	June 25, 2018

We the undersigned being the technical specialists in membrane autopsy and related testing procedures and protocol for Avista Technologies certify to the best of our knowledge and belief that the tests listed in this report have been conducted following Avista's standard testing practices and that the results are accurate and complete.

By signing this certificate neither the laboratory employees nor their employer makes any warranty, expressed or implied, concerning the cleaning study results.

Date: 06/25/2018

Signed:

Megan Lee
Laboratory Services Manager

Arnell Abad
Laboratory Services Chemist

APPENDIX F

Nanofiltration Membrane Element Data Sheets

FILMTEC™ Membranes

FILMTEC NF270 Nanofiltration Elements for Commercial Systems

Features

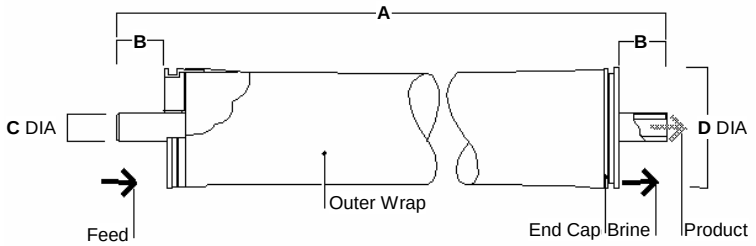
The FILMTEC™ NF270 membrane elements are ideal for removing a high percentage of TOC and THM precursors with medium to high salt passage and medium hardness passage. The FILMTEC NF270 membrane is an ideal choice for surface water and ground water where good organic removal is desired with partial softening.

Product Specifications

Product	Part Number	Active Area ft^2 (m^2)	Applied Pressure psig (bar)	Permeate Flow Rate gpd (m^3/d)	Stabilized Salt Rejection (%)
NF270-2540	149986	28 (2.6)	70 (4.8)	850 (3.2)	>97.0
NF270-4040	149987	82 (7.6)	70 (4.8)	2,500 (9.5)	>97.0

1. Permeate flow and salt rejection based on the following test conditions: 2,000 ppm $MgSO_4$, 77°F (25°C) and 15% recovery at the pressure specified above.
2. Permeate flows for individual NF270-2540 elements may vary by -20% / +30%. NF270-4040 individual elements may vary -15% / +50%.
3. Developmental products available for sale.

Figure 1



FilmTec sells coupler part number 89055 for use in multiple element housings. Each coupler includes two 2-210 EPR o-rings, FilmTec part number 89255.

Product	Dimensions – Inches (mm) A	B	C	D
NF270-2540	40.0 (1,016)	1.19 (30)	0.75 (19)	2.4 (61)
NF270-4040	40.0 (1,016)	1.05 (27)	0.75 (19)	3.9 (99)

1. Refer to FilmTec Design Guidelines for multiple-element systems.
2. NF270-2540 has a tape outer wrap. NF270-4040 has a fiberglass outer wrap.

1 inch = 25.4 mm

Operating Limits

- Membrane Type — Polyamide Thin-Film Composite
- Maximum Operating Temperature — 113°F (45°C)
- Maximum Operating Pressure — 600 psi (41 bar)
- Maximum Feed Flow Rate - 4040 elements — 16 gpm (3.6 m^3/hr)
  - 2540 elements — 6 gpm (1.4 m^3/hr)
- Maximum Pressure Drop - tape wrapped — 13 psig (0.9 bar)
  - fiberglassed — 15 psig (1.0 bar)
- pH Range, Continuous Operation[a] — 2 - 11
- pH Range, Short-Term Cleaning (30 min.)[b] — 1 - 12
- Maximum Feed Silt Density Index — SDI 5
- Free Chlorine Tolerance[c] — < 0.1 ppm

[a] Maximum temperature for continuous operation above pH 10 is 95°F (35°C).
[b] Refer to Cleaning Guidelines in specification sheet 609-23010 for NF90.
[c] Under certain conditions, the presence of free chlorine and other oxidizing agents will cause premature membrane failure. Since oxidation damage is not covered under warranty, FilmTec recommends removing residual free chlorine by pretreatment prior to membrane exposure. Please refer to technical bulletin 609-22010 for more information.

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Important Information

Proper start-up of reverse osmosis water treatment systems is essential to prepare the membranes for operating service and to prevent membrane damage due to overfeeding or hydraulic shock. Following the proper start-up sequence also helps ensure that system operating parameters conform to design specifications so that system water quality and productivity goals can be achieved.

Before initiating system start-up procedures, membrane pretreatment, loading of the membrane elements, instrument calibration and other system checks should be completed.

Please refer to the application information literature entitled “Start-Up Sequence” (Form No. 609-02077) for more information.

Operation Guidelines

Avoid any abrupt pressure or cross-flow variations on the spiral elements during start-up, shutdown, cleaning or other sequences to prevent possible membrane damage. During start-up, a gradual change from a standstill to operating state is recommended as follows:

- Feed pressure should be increased gradually over a 30-60 second time frame.
- Cross-flow velocity at set operating point should be achieved gradually over 15-20 seconds.
- Permeate obtained from first hour of operation should be discarded.

General Information

- Keep elements moist at all times after initial wetting.
- If operating limits and guidelines given in this bulletin are not strictly followed, the limited warranty will be null and void.
- To prevent biological growth during prolonged system shutdowns, it is recommended that membrane elements be immersed in a preservative solution.
- The customer is fully responsible for the effects of incompatible chemicals and lubricants on elements.
- Maximum pressure drop across an entire pressure vessel (housing) is 30 psi (2.1 bar).
- Avoid static permeate-side backpressure at all times.

FILMTEC™ Membranes
For more information about FILMTEC membranes, call the Dow Liquid Separations business:

North America:	1-800-447-4369
Latin America:	(+55) 11-5188-9222
Europe:	(+32) 3-450-2240
Pacific:	+60 3 7958 3392
Japan:	+813 5460 2100
China:	+86 21 2301 9000

http://www.filmtec.com

Notice: The use of this product in and of itself does not necessarily guarantee the removal of cysts and pathogens from water. Effective cyst and pathogen reduction is dependent on the complete system design and on the operation and maintenance of the system.

Notice: No freedom from any patent owned by Seller or others is to be inferred. Because use conditions and applicable laws may differ from one location to another and may change with time, Customer is responsible for determining whether products and the information in this document are appropriate for Customer’s use and for ensuring that Customer’s workplace and disposal practices are in compliance with applicable laws and other governmental enactments. Seller assumes no obligation or liability for the information in this document. NO WARRANTIES ARE GIVEN; ALL IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE ARE EXPRESSLY EXCLUDED.

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Form No. 609-00519-1206

NE4040-40

High productivity NF element

CSM®

SPECIFICATIONS:

General Features

Permeate flow rate[1]:	2,100 GPD (7.9 m^3/day)
Monovalent ion rejection (NaCl) :	20 –40%
Effective membrane area:	85 ft^2 (7.9 m^2)

1. The stated product performance is based on data taken after 30 minutes of operation at the following monovalent test conditions:

   - **2,000 mg/L NaCl solution at 75 psig (0.5 MPa) applied pressure**
   - **15% recovery**
   - **77 °F (25 °C)**
   - **pH 6.5–7.0**

2. Permeate flow rate for each element may vary but will be no more than 15%.
3. All elements are vacuum sealed in a polyethylene bag containing 1.0% SBS (sodium bisulfite) solution and individually packaged in a cardboard box.

Membrane type:	Thin-Film Composite
Membrane material:	Polyamide (PA)
Element configuration:	Spiral-Wound, FRP Wrapping

Dimensions

Model Name	A	B	C	D	E
NE4040-40	40.0 inch (1,016.0 mm)	4.0 inch (101.6 mm)	0.75 inch (19.1 mm)	1.61 inch (40.9 mm)	1.61 inch (40.9 mm)

1. Each membrane element supplied with one brine seal, one interconnector (coupler) and four o-rings.
2. All NE4040 elements fit nominal 4.0 inch (101.6 mm) I.D. pressure vessels.

The information provided in this document is solely for informative purposes. It is the user's responsibility to ensure the appropriate usage of this product. Toray Chemical Korea Inc. assumes no obligation, liability or damages incurred for the misuse of the product or for the information provided in this document. This document does not express or implies any warranty as to the merchantability or fitness of the product.

NE4040-40

High productivity NF element

CSM®

APPLICATION DATA:

Operating Limits	· Max. Pressure Drop / Element	15 psi (0.1 MPa)
	· Max. Pressure Drop / 240" Vessel	60 psi (0.41 Mpa)
	· Max. Operating Pressure	600 psi (4.14 MPa)
	· Max. Feed Flow Rate	18 gpm (4.09 m^3/hr)
	· Min. Concentrate Flow Rate	4 gpm (0.91 m^3/hr)
	· Max. Operating Temperature	113 °F (45 °C)
	· Operating pH Range	2.0–11.0
	· CIP pH Range	1.0–13.0
	· Max. Turbidity	1.0 NTU
	· Max. SDI (15 min)	5.0
	· Max. Chlorine Concentration	< 0.1 mg/L
Design Guidelines for Various Water Sources	· Wastewater Conventional (SDI < 5)	8–12 gfd
	· Wastewater Pretreated by UF/MF (SDI < 3)	10–14 gfd
	· Seawater, Open Intake (SDI < 5)	7–10 gfd
	· Seawater, Beach Well (SDI < 3)	8–12 gfd
	· Surface Water (SDI < 5)	12–16 gfd
	· Surface Water (SDI < 3)	13–17 gfd
	· Well water (SDI < 3)	13–17 gfd
	· RO permeate (SDI < 1)	21–30 gfd
Saturation Limits (Using Antiscalants)†	· Langlier Saturation Index (LSI)	<+1.5
	· Stiff and Davis Saturation Index (SDSI)	<+0.5
	· $CaSO_4$	230% saturation
	· $SrSO_4$	800% saturation
	· $BaSO_4$	6,000% saturation
	· SiO_2	100% saturation

†The above saturation limits are typically accepted by proprietary antiscalant manufacturers. It is the user's responsibility to ensure proper chemical(s) and concentration are dosed ahead of the membrane system to prevent scale formation anywhere within the membrane system. Membrane elements fouled or damaged due to scale formation are not covered by the limited warranty.

GENERAL HANDLING PROCEDURES

- Elements contained in the boxes must be kept dry at room temperature (7–32°C; 40–95°F) and should not be stored in direct sunlight. If the polyethylene bag is damaged, a new preservative solution (sodium bisulfite) must be added and air-tight sealed to prevent drying and biological growth.
- Permeate from the first hour of operation should be discarded to flush out the preservative solution.
- Elements should be immersed in a preservative solution during storage, shipping and system shutdowns to prevent biological growth and freezing. The standard storage solution contains 1% by weight sodium bisulfite or sodium metabisulfite (food grade). For short term storage (i.e. one week or less) 1% by weight sodium metabisulfite solution is adequate for preventing biological growth.
- Keep elements moist at all times after initial wetting.
- Avoid excessive pressure and flow spikes.
- Only use chemicals compatible with the membrane elements and components. Use of such chemicals may void the element limited warranty.
- Permeate pressure must always be equal or less than the feed/concentrate pressure. Damage caused by permeate back pressure voids the element limited warranty.

Membrane Element NANO-BW-4040

Performance:

$MgSO_4$

Permeate Flow (Nominal):	2,000 gpd (7.6 m^3/d)
$MgSO_4$ Rejection (Nominal):	99.7% (99.5% minimum)

Type

Configuration:	Spiral Wound
Membrane Polymer:	Composite Polyamide
Nominal Membrane Area:	75 ft^2 (7 m^2)
Feed/Brine Spacer Thickness:	34 mil (0.87 mm) with HYDRAblock ™ Technology

Application Data*

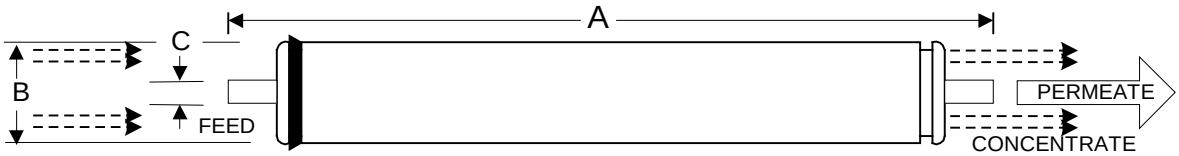
Maximum Applied Pressure:	600 psig (4.14 MPa)
Maximum Chlorine Concentration:	< 0.1 PPM
Maximum Operating Temperature:	113 °F (45 °C)
pH Range, Operation (Cleaning):	3.0 - 9.0 (1.0 – 11.5) *
Maximum Feedwater Turbidity:	1.0 NTU
Maximum Feedwater SDI (15 mins):	5.0
Maximum Feed Flow:	16 GPM (3.6 m^3/h)
Minimum Ratio of Concentrate to Permeate Flow for any Element:	5:1
Maximum Pressure Drop for Each Element:	15 psi

***** The limitations shown here are for general use. For specific projects, operating at more conservative values may ensure the best performance and longest life of the membranes. See Hydranautics Technical Bulletins for more detail on operation limits, cleaning pH, and cleaning temperatures.

Test Conditions

The stated performance is based on the following test conditions:

2000 ppm $MgSO_4$
130 psi (0.9 MPa) Applied Pressure
77 °F (25 °C) Operating Temperature
15% Permeate Recovery
6.5 – 7.0 Feed pH



A, inches (mm)	B, inches (mm)	C, inches (mm)	Weight, lbs. (kg)
40.00 (1016)	3.95 (100.3)	0.75 (19.1)	8 (3.6)

Notice: Permeate flow for individual elements may vary + or - 20 percent. All membrane elements are supplied with a brine seal, interconnector, and o-rings. All membrane elements are supplied with a brine seal, interconnector, and o-rings. Elements are enclosed in a sealed polyethylene bag and then packaged in a cardboard box.

Hydranautics believes the information and data contained herein to be accurate and useful. The information and data are offered in good faith, but without guarantee, as conditions and methods of use of our products are beyond our control. Hydranautics assumes no liability for results obtained or damages incurred through the application of the presented information and data. It is the user's responsibility to determine the appropriateness of Hydranautics' products for the user's specific end uses.

3/06/15

Hydranautics Corporate: 401 Jones Road, Oceanside, CA 92058
1-800-CPA-PURE Phone: 760-901-2500 Fax: 760-901-2578 info@Hydranautics.com

SR200 4” NANOFILTRATION ELEMENTS

Hard Overwrap Low Pressure, Selective Rejection Elements

PRODUCT DESCRIPTION

Membrane Chemistry:	Proprietary TFC® polyamide chemistry
Membrane Type:	SR200 - selective rejection nanofiltration
Molecular weight cut-off:	200 Daltons
Construction:	Spiral wound with fiberglass outerwrap
Applications:	Separation of higher molecular weight components (>200 Dalton) and multivalent ions from various feed solutions, hardness and sulfate removal from seawater and chloralkali process stream

SPECIFICATIONS

Part Number	Model	Nominal Permeate Flow gpd (m^3/d)	Nominal Rejection	Active Membrane Area ft^2 (m^2)	Feed Spacer mil (mm)
KDP3529	4040-SR200	1,275 (4.8)	99.4%	85 (7.9)	28 (0.7)

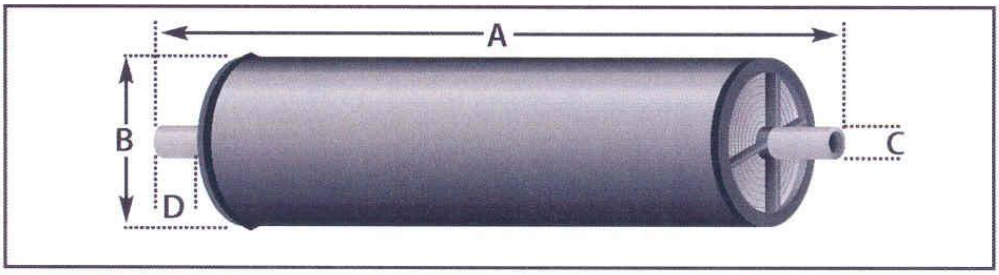
Test Conditions: 5,000 mg/l $MgSO_4$ in deionized water at 95 psi (655 kPa) applied pressure, 15% recovery, 77°F (25°C), pH 7.5

OPERATING AND DESIGN INFORMATION*

Typical Operating Pressure:	200 - 600 psi (1,380 - 4,140 kPa)
Maximum Operating Pressure:	600 psi (4,140 kPa)
Maximum Operating Temperature:	122°F (50°C)
Maximum Cleaning Temperature:	113°F (45°C)
Maximum Continuous Free Chlorine:	< 0.1 mg/l
Allowable pH – Continuous Operation:	4 - 10
Allowable pH – Short Term Cleaning:	1.7 – 11.5
Maximum Differential Pressure Per Element:	10 psi (69 kPa)
Maximum Differential Pressure Per Vessel:	60 psi (414 kPa)
Maximum Feed Turbidity:	1 NTU
Maximum Feed SDI (15 minute test):	5

* Consult Process Engineering Group for specific information.

NOMINAL DIMENSIONS*



Model	A inches (mm)	B inches (mm)	C inches (mm)	D inches (mm)	Part Numbers Interconnector	O-ring	Brine Seal
4040-SR200	40 (1,016)	4 (101.6)	0.75 (19.0)	1.0 (25.4)	0035267	0035458	0035702

* Dimensions are provided for reference only and should not be interpreted as accurate specifications.

Performance:
Performance specifications shown on the front side of this document are nominal values. Individual element permeate flows may vary +20/-15% from the values shown. Minimum magnesium sulfate rejection is 99.0% at the conditions shown.

Selective Rejection (SR200) nanofiltration membrane performance is highly dependent on feed chemistry, temperature, pH, and solution concentration. Performance can only be accurately known through pilot study. KMS strongly recommends that the appropriate pilot studies be conducted to determine suitability for a given application.

Operating Limits:

- **Operating Pressure:** Maximum operating pressure is 600 psi (4,140 kPa). Typical operating pressure for SR200 systems is in the range of 150 psi (1,035 kPa) to 250 psi (1,725 kPa). Actual operating pressure is dependent upon system flux rate (appropriate for feed source) as well as feed salinity, recovery and temperature conditions.
- **Permeate Pressure:** Permeate pressure should not exceed feed-concentrate pressure by more than 5 psi (34 kPa) at any time (on-line, off-line and during transition).
- **Differential Pressure**: Maximum differential pressure limits are 10 psi (69 kPa) per element. Maximum differential pressure for pressure vessel is 60 psi (414 kPa).
- **Temperature**: Maximum operating temperature is 122°F (50°C). Maximum cleaning temperature is 113°F (45°C).
- **pH:** Allowable range for continuous operation is pH 4-10. Allowable range for short term cleaning is pH 1.7-11.5. It is recommended to limit the exposure of the SR200 membrane to the extended pH range to 4 hours, once per month.
- **Turbidity and SDI:** Maximum feed turbidity is 1 NTU. Maximum feed Silt Density Index (SDI) is 5.0 (15 minute test) while recommended SDI_{15} of feed is 3 or less. Experience has shown that feedwater with turbidity greater than 0.2 NTU generally results in frequent cleanings.
- **Recovery**: Maximum recovery is site and application specific. In general, single element recovery is approximately 15% per element.

Chemical Tolerance:

- **Chlorine:** Exposure of SR200 membrane to free chlorine or other oxidizing agents such as permanganate, ozone, bromine and iodine is not recommended. SR200 membrane has a free chlorine tolerance of approximately 2,000 ppm-hours based on testing at 77°F (25°C), pH 8. This tolerance may be significantly reduced if catalyzing metals such as iron are present or if the pH and/or temperature are different. Sodium metabisulfite (without catalysts such as cobalt) is the preferred reducing agent. SR200 membrane has a chloramine tolerance of approximately 60,000 ppm-hours in the absence of free chlorine based on testing at 77°F (25°C), pH 8.
- **Cationic (Positively Charged) Polymers and Surfactants:** SR200 membrane may be irreversibly fouled if exposed to cationic (positively charged) polymers or surfactants. Exposure to these chemicals during operation or cleaning is not recommended.

Lubricants:
For element loading, use only the recommended silicone lubricant (or approved equivalent), water or glycerin to lubricate O-rings and brine seals. The use of petroleum based lubricants or vegetable based oils may damage the element and void the warranty.

Service and Ongoing Technical Support:
KMS has an experienced staff of professionals available to assist end users and OEM's for optimization of existing systems and support with the development of new applications. Along with the availability of supplemental technical bulletins, KMS also offers a complete line of KOCHKLEEN® membrane cleaners, RO pretreatment and maintenance chemicals.

The information contained in this publication is believed to be accurate and reliable, but is not to be construed as implying any warranty or guarantee of performance. We assume no responsibility, obligation or liability for results obtained or damages incurred through the application of the information contained herein. Refer to Standard Terms and Conditions of Sale and Performance Warranty documentation for additional information.

Koch Membrane Systems, Inc., www.kochmembrane.com
Corporate Headquarters: 850 Main Street, Wilmington, Massachusetts 01887-3388 USA. Tel.: 1-888-677-KOCH.
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