

Appendix 7.1.1-3

Performance-Design Simulation for RO Plant  
(1)



DATA No.1

Standard RO : 8040-HSY-SWC1 PERFORMANCE

Rejection = 99.5% Flux 5000gpd

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.50 (1993)  
Calculation was made by: J I C A

12-16-93

Project name : SAUDI ARABIAN SEAWATER MODEL #1 Permeate flow : 10000 M3-D

Feedwater temperature : 25.0 C Recovery : 40.0%  
Raw water pH : 8.00 Element age : 0.0 years  
Acid dosage, ppm(100%): 19.9 H2SO4 Flux decline coefficient : -0.035  
Acidified feed CO2, ppm : 19.9 3-yr salt passage increase factor : 1.3

Feed pressure : 67.4 kg/cm2

Concentrate pressure : 66.6 kg/cm2

Pass	Feed Flow Total Vessel m3/h m3/h	Conc. Total m3/h	Flow Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5 6.4	625.5	3.9	1.04	66.6	8040-HSY-SWC1	972	162x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	1.3	0.1	790.8	39.4
Mg	1555.0	128.0	1555.0	128.0	4.4	0.4	2588.7	213.1
Na	13284.0	577.6	13284.0	577.6	180.1	7.8	22019.9	957.4
K	493.0	12.6	493.0	12.6	8.3	0.2	816.1	20.9
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.3	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	2.7	0.0	202.4	3.3
SO4	3675.0	76.6	3694.5	77.0	11.4	0.2	6149.9	128.1
Cl	23500.0	662.9	23500.0	662.9	290.4	8.2	38973.1	1099.4
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		498.7		71541.9	
pH	8.0		7.0		5.4		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp=100,%	27.4	27.5	51.0
SrSO4/Ksp=100,%	0.0	0.0	0.0
BaSO4/Ksp=100,%	0.0	0.0	0.0
SiO2 sat.,%	0.4	0.4	0.7
Langelier ind.	1.11	0.03	0.68
Stiff & Davis ind.	0.12	-0.96	-0.35
Ionic strength	0.89	0.89	1.53
Osmotic press.,psi	477.7	477.7	816.5

DATA No. 2

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.50 (1993)

12-16-93

Calculation was made by: J I C A

Project name : SAUDI ARABIAN SEAWATER MODEL #1 Permeate flow : 10000 M3-D

Feedwater temperature : 25.0 C Recovery : 40.0%  
 Raw water pH : 8.00 Element age : 0.0 years  
 Acid dosage, ppm(100%): 19.9 H2SO4 Flux decline coefficient : -0.035  
 Acidified feed CO2, ppm : 19.9 3-yr salt passage increase factor : 1.3

Feed pressure : 62.3 kg/cm2

Concentrate pressure : 61.7 kg/cm2

Pass	Feed Flow Total Vessel m3/h	Conc. Flow Total Vessel m3/h	Flow Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5	5.1	625.5	3.1	1.04	61.7	8040-HSY-SWC1	1218 203x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	1.7	0.1	790.5	39.4
Mg	1555.0	128.0	1555.0	128.0	5.5	0.5	2588.0	213.0
Na	13284.0	577.6	13284.0	577.6	225.3	9.8	21989.8	956.1
K	493.0	12.6	493.0	12.6	10.4	0.3	814.7	20.9
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	3.4	0.1	202.0	3.3
SO4	3675.0	76.6	3694.5	77.0	14.3	0.3	6148.0	128.1
Cl	23500.0	662.9	23500.0	662.9	363.3	10.2	38924.5	1098.0
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		624.0		71458.4	
pH	8.0		7.0		5.4		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp=100,%	27.4	27.5	51.0
SrSO4/Ksp=100,%	0.0	0.0	0.0
BaSO4/Ksp=100,%	0.0	0.0	0.0
SiO2 sat.,%	0.4	0.4	0.7
Langelier ind.	1.11	0.03	0.68
Stiff & Davis ind.	0.12	-0.96	-0.35
Ionic strength	0.89	0.89	1.53
Osmotic press.,psi	477.7	477.7	815.4

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.50 (1993)  
 Calculation was made by: J I C A

12-16-93

Project name : SAUDI ARABIAN SEAWATER MODEL #1 Permeate flow : 10000 M3-D

Feedwater temperature : 25.0 C Recovery : 40.0%  
 Raw water pH : 8.00 Element age : 0.0 years  
 Acid dosage, ppm(100%): 19.9 H2SO4 Flux decline coefficient : -0.035  
 Acidified feed CO2, ppm : 19.9 3-yr salt passage increase factor : 1.3

Feed pressure : 60.0 kg/cm2

Concentrate pressure : 59.6 kg/cm2

Pass	Feed Flow		Conc. Flow		Beta	Conc. Press.	Element Type	Element No.	Array
	Total m3/h	Vessel m3/h	Total m3/h	Vessel m3/h		kg/cm2			
1	1042.5	4.1	625.5	2.5	1.03	59.6	8040-HSY-SWC1	1524	254x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	2.2	0.1	790.2	39.4
Mg	1555.0	128.0	1555.0	128.0	7.1	0.6	2587.0	212.9
Na	13284.0	577.6	13284.0	577.6	288.1	12.5	21948.0	954.3
K	493.0	12.6	493.0	12.6	13.3	0.3	812.8	20.8
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	4.3	0.1	201.3	3.3
SO4	3675.0	76.6	3694.5	77.0	18.3	0.4	6145.3	128.0
Cl	23500.0	662.9	23500.0	662.9	464.5	13.1	38857.0	1096.1
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		797.8		71342.6	
pH	8.0		7.0		5.6		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp=100,%	27.4	27.5	51.0
SrSO4/Ksp=100,%	0.0	0.0	0.0
BaSO4/Ksp=100,%	0.0	0.0	0.0
SiO2 sat.,%	0.4	0.4	0.7
Langelier ind.	1.11	0.03	0.67
Stiff & Davis ind.	0.12	-0.96	-0.35
Ionic strength	0.89	0.89	1.53
Osmotic press.,psi	477.7	477.7	813.9

DATA No.4

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.50 (1993)

12-16-93

Calculation was made by: J I C A

Project name : SAUDI ARABIAN SEAWATER MODEL #1 Permeate flow : 10000 M3-D

Feedwater temperature : 30.0 C Recovery : 40.0%  
 Raw water pH : 8.00 Element age : 0.0 years  
 Acid dosage, ppm(100%): 19.9 H2SO4 Flux decline coefficient : -0.035  
 Acidified feed CO2, ppm : 19.9 3-yr salt passage increase factor :1.3

Feed pressure : 76.2 kg/cm2

Concentrate pressure : 74.7 kg/cm2

Pass	Feed Flow Total Vessel m3/h	Conc. Flow Total Vessel m3/h	Flow Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5	10.0	625.5	6.0	1.05	74.7	8040-HSY-SWC1	624 104x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	1.0	0.0	791.0	39.5
Mg	1555.0	128.0	1555.0	128.0	3.3	0.3	2589.5	213.1
Na	13284.0	577.6	13284.0	577.6	133.3	5.8	22051.1	958.7
K	493.0	12.6	493.0	12.6	6.2	0.2	817.5	21.0
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	2.0	0.0	202.9	3.3
SO4	3675.0	76.6	3694.5	77.0	8.5	0.2	6151.9	128.2
Cl	23500.0	662.9	23500.0	662.9	215.0	6.1	39023.4	1100.8
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		369.2		71628.2	
pH	8.0		7.0		5.2		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp=100,%	26.6	26.8	49.6
SrSO4/Ksp=100,%	0.0	0.0	0.0
BaSO4/Ksp=100,%	0.0	0.0	0.0
SiO2 sat.,%	0.4	0.4	0.6
Langelier ind.	1.22	0.14	0.79
Stiff & Davis ind.	0.20	-0.88	-0.26
Ionic strength	0.89	0.89	1.53
Osmotic press.,psi	485.8	485.7	831.3

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.50 (1993)  
 Calculation was made by: J I C A

12-16-93

Project name : SAUDI ARABIAN SEAWATER MODEL #1 Permeate flow : 10000 M3-

Feedwater temperature : 30.0 C Recovery : 40.0%  
 Raw water pH : 8.00 Element age : 0.0 years  
 Acid dosage, ppm(100%): 19.9 H2SO4 Flux decline coefficient : -0.03  
 Acidified feed CO2, ppm : 19.9 3-yr salt passage increase factor : 1.3

Feed pressure : 69.8 kg/cm2

Concentrate pressure : 68.6 kg/cm

Pass	Feed Flow		Conc. Flow		Beta	Conc. Press.	Element Type	Element No.	Array
	Total	Vessel	Total	Vessel		kg/cm2			
	m3/h	m3/h	m3/h	m3/h					
1	1042.5	8.0	625.5	4.8	1.04	68.6	8040-HSY-SWC1	780	130x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	1.2	0.1	790.8	39.4
Mg	1555.0	128.0	1555.0	128.0	4.1	0.3	2588.9	213.1
Na	13284.0	577.6	13284.0	577.6	166.9	7.3	22028.7	957.8
K	493.0	12.6	493.0	12.6	7.7	0.2	816.5	20.9
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	2.5	0.0	202.6	3.3
SO4	3675.0	76.6	3694.5	77.0	10.6	0.2	6150.4	128.1
Cl	23500.0	662.9	23500.0	662.9	269.1	7.6	38987.3	1099.8
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		462.1		71566.3	
pH	8.0		7.0		5.3		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp*100,%	26.6	26.8	49.6
SrSO4/Ksp*100,%	0.0	0.0	0.0
BaSO4/Ksp*100,%	0.0	0.0	0.0
SiO2 sat.,%	0.4	0.4	0.6
Langelier ind.	1.22	0.14	0.79
Stiff & Davis ind.	0.20	-0.88	-0.26
Ionic strength	0.89	0.89	1.53
Osmotic press.,psi	485.8	485.7	830.5

DATA No. 6

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.50 (1993)

12-16-93

Calculation was made by: J I C A

Project name : SAUDI ARABIAN SEAWATER MODEL #1 Permeate flow : 10000 M3-D

Feedwater temperature : 30.0 C Recovery : 40.0%  
 Raw water pH : 8.00 Element age : 0.0 years  
 Acid dosage, ppm(100%): 19.9 H2SO4 Flux decline coefficient : -0.035  
 Acidified feed CO2, ppm : 19.9 3-yr salt passage increase factor : 1.3

Feed pressure : 65.5 kg/cm2 Concentrate pressure : 64.7 kg/cm2

Pass	Feed Flow Total Vessel m3/h	Conc. Total m3/h	Flow Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5	6.4	625.5	3.9	1.04	64.7	8040-HSY-SWC1	972 162x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	1.6	0.1	790.6	39.4
Mg	1555.0	128.0	1555.0	128.0	5.1	0.4	2588.2	213.0
Na	13284.0	577.6	13284.0	577.6	210.0	9.1	22000.0	956.5
K	493.0	12.6	493.0	12.6	9.7	0.2	815.2	20.9
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	3.2	0.1	202.1	3.3
SO4	3675.0	76.6	3694.5	77.0	13.3	0.3	6148.6	128.1
Cl	23500.0	662.9	23500.0	662.9	338.5	9.5	38941.0	1098.5
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		581.4		71486.8	
pH	8.0		7.0		5.4		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp=100,%	26.6	26.8	49.6
SrSO4/Ksp=100,%	0.0	0.0	0.0
BaSO4/Ksp=100,%	0.0	0.0	0.0
SiO2 sat.,%	0.4	0.4	0.6
Langelier ind.	1.22	0.14	0.79
Stiff & Davis ind.	0.20	-0.88	-0.27
Ionic strength	0.89	0.89	1.53
Osmotic press.,psi	485.8	485.7	829.5



DATA No. 7

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.50 (1993)  
 Calculation was made by: J I C A

12-16-93

Project name : SAUDI ARABIAN SEAWATER MODEL #1 Permeate flow : 10000 M3-D

Feedwater temperature : 30.0 C Recovery : 40.0%  
 Raw water pH : 8.00 Element age : 0.0 years  
 Acid dosage, ppm(100%): 19.9 H2SO4 Flux decline coefficient : -0.035  
 Acidified feed CO2, ppm : 19.9 3-yr salt passage increase factor : 1.3

Feed pressure : 61.9 kg/cm2

Concentrate pressure : 61.3 kg/cm2

Pass	Feed Flow Total Vessel m3/h	Conc. Total m3/h	Flow Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5	5.1	625.5	3.1	1.03	61.3	8040-HSY-SWC1	1218 203x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	2.0	0.1	790.3	39.4
Mg	1555.0	128.0	1555.0	128.0	6.5	0.5	2587.3	212.9
Na	13284.0	577.6	13284.0	577.6	265.8	11.6	21962.8	954.9
K	493.0	12.6	493.0	12.6	12.3	0.3	813.5	20.9
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	4.0	0.1	201.6	3.3
SO4	3675.0	76.6	3694.5	77.0	16.9	0.4	6146.2	128.0
Cl	23500.0	662.9	23500.0	662.9	428.5	12.1	38881.0	1096.8
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5	0.0	0.5	0.0	0.0	0.0	0.8	0.0
TDS	43129.4		43124.6		736.0		71383.7	
pH	8.0		7.0		5.5		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp=100,%	26.0	26.6	49.6
SrSO4/Ksp=100,%	0.0	0.0	0.0
CaSO4/Ksp=100,%	0.0	0.0	0.0
SiO2 sat. %	0.4	0.4	0.6
Langelier ind.	1.22	0.14	0.78
Stiff & Davis ind.	0.20	-0.88	-0.27
Ionic strength	0.89	0.89	1.53
Osmotic press., psi	485.8	485.7	828.1

DATA No. 8

HYDRAUTICS DESIGN PROGRAM - VERSION 4.50 (1993)  
 Calculation was made by: J I C A

12-16-93

Project name : SAUDI ARABIAN SEAWATER MODEL #1 Permeate flow : 10000 M3-D

Feedwater temperature : 30.0 C Recovery : 40.0%  
 Raw water pH : 8.00 Element age : 0.0 years  
 Acid dosage, ppm(100%): 19.9 H2SO4 Flux decline coefficient : -0.035  
 Acidified feed CO2, ppm : 19.9 3-yr salt passage increase factor : 1.3

Feed pressure : 59.9 kg/cm2

Concentrate pressure : 59.5 kg/cm2

Pass	Feed Flow Total Vessel m3/h m3/h	Conc. Flow Total Vessel m3/h m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5 4.1	625.5 2.5	1.03	59.5	8040-HSY-SWC1	1524	254x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	2.5	0.1	790.0	39.4
Mg	1555.0	128.0	1555.0	128.0	8.3	0.7	2586.1	212.8
Na	13284.0	577.6	13284.0	577.6	340.1	14.8	21913.3	952.8
K	493.0	12.6	493.0	12.6	15.8	0.4	811.2	20.8
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	5.1	0.1	200.8	3.3
SO4	3675.0	76.6	3694.5	77.0	21.6	0.5	6143.1	128.0
Cl	23500.0	662.9	23500.0	662.9	548.4	15.5	38801.1	1094.5
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		941.9		71246.5	
pH	8.0		7.0		5.6		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp*100,%	26.6	26.8	49.6
SrSO4/Ksp*100,%	0.0	0.0	0.0
BaSO4/Ksp*100,%	0.0	0.0	0.0
SiO2 sat.,%	0.4	0.4	0.6
Langelier ind.	1.22	0.14	0.78
Stiff & Davis ind.	0.20	-0.88	-0.27
Ionic strength	0.89	0.89	1.52
Osmotic press.,psi	485.8	485.7	826.3

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.50 (1993)  
 Calculation was made by: J I C A

12-16-93

Project name : SAUDI ARABIAN SEAWATER MODEL #1 Permeate flow : 10000 M3-D

Feedwater temperature : 35.0 C Recovery : 40.0%  
 Raw water pH : 8.00 Element age : 0.0 years  
 Acid dosage, ppm(100%): 19.9 H2SO4 Flux decline coefficient : -0.035  
 Acidified feed CO2, ppm : 19.9 3-yr salt passage increase factor : 1.3

Feed pressure : 68.9 kg/cm2

Concentrate pressure : 67.8 kg/cm2

Pass	Feed Flow Total Vessel m3/h	Conc. Flow Total Vessel m3/h	Flow Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5	8.0	625.5	4.8	1.04	67.8	8040-HSY-SWC1	780 130x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	1.5	0.1	790.7	39.4
Mg	1555.0	128.0	1555.0	128.0	4.8	0.4	2588.5	213.0
Na	13284.0	577.6	13284.0	577.6	195.8	8.5	22009.5	956.9
K	493.0	12.6	493.0	12.6	9.1	0.2	815.6	20.9
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	3.0	0.0	202.3	3.3
SO4	3675.0	76.6	3694.5	77.0	12.4	0.3	6149.2	128.1
Cl	23500.0	662.9	23500.0	662.9	315.7	8.9	38956.2	1098.9
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		542.2		71512.9	
pH	8.0		7.0		5.4		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp*100,%	26.0	26.2	48.5
SrSO4/Ksp*100,%	0.0	0.0	0.0
BaSO4/Ksp*100,%	0.0	0.0	0.0
SiO2 sat.,%	0.3	0.3	0.6
Langelier ind.	1.33	0.25	0.89
Stiff & Davis ind.	0.31	-0.77	-0.14
Ionic strength	0.89	0.89	1.53
Osmotic press.,psi	493.8	493.7	843.5

DATA No.10

HYDRAUNAUTICS DESIGN PROGRAM -- VERSION 4.50 (1993)  
 Calculation was made by: J I C A

12-16-93

Project name : SAUDI ARABIAN SEAWATER MODEL #1      Permeate flow :      10000 M3-D  
 Feedwater temperature :      35.0 C      Recovery :      40.0%  
 Raw water pH :      8.00      Element age :      0.0 years  
 Acid dosage, ppm(100%):      19.9 H2SO4      Flux decline coefficient :      -0.035  
 Acidified feed CO2, ppm :      19.9      3-yr salt passage increase factor : 1.3

Feed pressure : 63.8 kg/cm2      Concentrate pressure : 63.0 kg/cm2

Pass	Feed Flow Total Vessel m3/h	Conc. Total m3/h	Flow Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5	6.4	625.5	3.9	1.03	63.0	8040-HSY-SWC1	972 162x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	1.8	0.1	790.5	39.4
Mg	1555.0	128.0	1555.0	128.0	6.0	0.5	2587.7	213.0
Na	13284.0	577.6	13284.0	577.6	243.5	10.6	21977.7	955.6
K	493.0	12.6	493.0	12.6	11.3	0.3	814.1	20.9
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	3.7	0.1	201.8	3.3
SO4	3675.0	76.6	3694.5	77.0	15.5	0.3	6147.2	128.1
Cl	23500.0	662.9	23500.0	662.9	392.6	11.1	38905.0	1097.5
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		674.2		71424.9	
pH	8.0		7.0		5.5		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp*100,%	26.0	26.2	48.5
SrSO4/Ksp*100,%	0.0	0.0	0.0
BaSO4/Ksp*100,%	0.0	0.0	0.0
SiO2 sat.,%	0.3	0.3	0.6
Langelier ind.	1.33	0.25	0.89
Stiff & Davis ind.	0.31	-0.77	-0.14
Ionic strength	0.89	0.89	1.53
Osmotic press.,psi	493.8	493.7	842.3

DATA No.11

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.50 (1993)  
 Calculation was made by: J I C A

12-16-93

Project name : SAUDI ARABIAN SEAWATER MODEL #1 Permeate flow : 10000 M3-D

Feedwater temperature : 35.0 C Recovery : 40.0%  
 Raw water pH : 8.00 Element age : 0.0 years  
 Acid dosage, ppm(100%): 19.9 H2SO4 Flux decline coefficient : -0.035  
 Acidified feed CO2, ppm : 19.9 3-yr salt passage increase factor : 1.3

Feed pressure : 61.7 kg/cm2 Concentrate pressure : 61.1 kg/cm2

Pass	Feed Flow Total Vessel m3/h	Conc. Flow Total Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5	5.1	625.5	3.1	1.03	61.1	8040-HSY-SWC1 1218 203x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	2.3	0.1	790.1	39.4
Mg	1555.0	128.0	1555.0	128.0	7.6	0.6	2586.6	212.9
Na	13284.0	577.6	13284.0	577.6	312.1	13.6	21931.9	953.6
K	493.0	12.6	493.0	12.6	14.5	0.4	812.0	20.8
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	4.7	0.1	201.1	3.3
SO4	3675.0	76.6	3694.5	77.0	19.8	0.4	6144.3	128.0
Cl	23500.0	662.9	23500.0	662.9	503.2	14.2	38831.2	1095.4
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		864.3		71298.2	
pH	8.0		7.0		5.6		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp*100,%	26.0	26.2	48.5
SrSO4/Ksp*100,%	0.0	0.0	0.0
BaSO4/Ksp*100,%	0.0	0.0	0.0
SiO2 sat.,%	0.3	0.3	0.6
Langelier ind.	1.33	0.25	0.89
Stiff & Davis ind.	0.31	-0.77	-0.15
Ionic strength	0.89	0.89	1.53
Osmotic press.,psi	493.8	493.7	840.7

DATA No.12

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.50 (1993)  
 Calculation was made by: J I C A

12-16-93

Project name : SAUDI ARABIAN SEAWATER MODEL #1 Permeate flow : 10000 M3-D

Feedwater temperature : 35.0 C Recovery : 40.0%  
 Raw water pH : 8.00 Element age : 0.0 years  
 Acid dosage, ppm(100%): 19.9 H2SO4 Flux decline coefficient : -0.035  
 Acidified feed CO2, ppm : 19.9 3-yr salt passage increase factor : 1.3

Feed pressure : 58.9 kg/cm2

Concentrate pressure : 58.5 kg/cm2

Pass	Feed Flow Total Vessel m3/h	Conc. Total m3/h	Flow Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5	4.1	625.5	2.5	1.03	58.5	8040-HSY-SWC1	1524 254x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	2.9	0.1	789.7	39.4
Mg	1555.0	128.0	1555.0	128.0	9.7	0.8	2585.2	212.8
Na	13284.0	577.6	13284.0	577.6	393.9	17.1	21877.4	951.2
K	493.0	12.6	493.0	12.6	18.2	0.5	809.5	20.8
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	5.9	0.1	200.3	3.3
SO4	3675.0	76.6	3694.5	77.0	25.1	0.5	6140.8	127.9
Cl	23500.0	662.9	23500.0	662.9	635.1	17.9	38743.3	1092.9
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		1090.8		71147.2	
pH	8.0		7.0		5.7		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp=100,%	26.0	26.2	48.5
SrSO4/Ksp=100,%	0.0	0.0	0.0
BaSO4/Ksp=100,%	0.0	0.0	0.0
SiO2 sat.,%	0.3	0.3	0.6
Langelier ind.	1.33	0.25	0.89
Stiff & Davis ind.	0.31	-0.77	-0.15
Ionic strength	0.89	0.89	1.52
Osmotic press.,psi	493.8	493.7	838.7

DATA No. 13

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.50 (1993)  
 Calculation was made by: J I C A

12-16-93

Project name : SAUDI ARABIAN SEAWATER MODEL #1 Permeate flow : 10000 M3-D

Feedwater temperature : 40.0 C Recovery : 40.0%  
 Raw water pH : 8.00 Element age : 0.0 years  
 Acid dosage, ppm(100%): 19.9 H2SO4 Flux decline coefficient : -0.035  
 Acidified feed CO2, ppm : 19.9 3-yr salt passage increase factor : 1.3

Feed pressure : 65.9 kg/cm2 Concentrate pressure : 64.8 kg/cm2

Pass	Feed Flow Total Vessel m3/h	Conc. Total m3/h	Flow Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5	8.0	625.5	4.8	1.04	64.8	8040-HSY-SWC1	780 130x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	1.7	0.1	790.6	39.4
Mg	1555.0	128.0	1555.0	128.0	5.5	0.4	2588.0	213.0
Na	13284.0	577.6	13284.0	577.6	223.3	9.7	21991.2	956.1
K	493.0	12.6	493.0	12.6	10.3	0.3	814.8	20.9
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	3.4	0.1	202.0	3.3
SO4	3675.0	76.6	3694.5	77.0	14.2	0.3	6148.0	128.1
Cl	23500.0	662.9	23500.0	662.9	360.0	10.2	38926.7	1098.1
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		618.3		71462.2	
pH	8.0		7.0		5.4		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp=100,%	25.5	25.6	47.5
SrSO4/Ksp=100,%	0.0	0.0	0.0
BaSO4/Ksp=100,%	0.0	0.0	0.0
SiO2 sat.,%	0.3	0.3	0.5
Langelier ind.	1.44	0.36	1.00
Stiff & Davis ind.	0.43	-0.65	-0.02
Ionic strength	0.89	0.89	1.53
Osmotic press.,psi	501.8	501.7	856.5

DATA No.14

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.50 (1993)  
 Calculation was made by: J I C A

12-16-93

Project name : SAUDI ARABIAN SEAWATER MODEL #1 Permeate flow : 10000 M3-D

Feedwater temperature : 40.0 C Recovery : 40.0%  
 Raw water pH : 8.00 Element age : 0.0 years  
 Acid dosage, ppm(100%): 19.9 H2SO4 Flux decline coefficient : -0.035  
 Acidified feed CO2,ppm : 19.9 3-yr salt passage increase factor :1.3

Feed pressure : 63.6 kg/cm2

Concentrate pressure : 62.8 kg/cm2

Pass	Feed Flow Total Vessel m3/h	Conc. Flow Total Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element Array No.
1	1042.5	6.4	625.5	3.9	1.03	62.8 8040-HSY-SWC1 972 162x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	2.1	0.1	790.2	39.4
Mg	1555.0	128.0	1555.0	128.0	7.0	0.6	2587.0	212.9
Na	13284.0	577.6	13284.0	577.6	284.4	12.4	21950.4	954.4
K	493.0	12.6	493.0	12.6	13.2	0.3	812.9	20.8
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	4.3	0.1	201.4	3.3
SO4	3675.0	76.6	3694.5	77.0	18.1	0.4	6145.4	128.0
Cl	23500.0	662.9	23500.0	662.9	458.5	12.9	38861.0	1096.2
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		787.6		71349.3	
pH	8.0		7.0		5.5		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp*100,%	25.5	25.6	47.5
SrSO4/Ksp*100,%	0.0	0.0	0.0
BaSO4/Ksp*100,%	0.0	0.0	0.0
SiO2 sat.,%	0.3	0.3	0.5
Langelier ind.	1.44	0.36	1.00
Stiff & Davis ind.	0.43	-0.65	-0.02
Ionic strength	0.89	0.89	1.53
Osmotic press.,psi	501.8	501.7	855.0



DATA No.15

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.50 (1993)  
 Calculation was made by: J I C A

12-16-93

Project name : SAUDI ARABIAN SEAWATER MODEL #1 Permeate flow : 10000 M3-D

Feedwater temperature : 40.0 C Recovery : 40.0%  
 Raw water pH : 8.00 Element age : 0.0 years  
 Acid dosage, ppm(100%): 19.9 H2SO4 Flux decline coefficient : -0.035  
 Acidified feed CO2, ppm : 19.9 3-yr salt passage increase factor : 1.3

Feed pressure : 60.5 kg/cm2 Concentrate pressure : 60.0 kg/cm2

Pass	Feed Flow Total Vessel m3/h m3/h	Conc. Flow Total Vessel m3/h m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5 5.1	625.5 3.1	1.03	60.0	8040-HSY-SWC1	1218	203x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	2.7	0.1	789.9	39.4
Mg	1555.0	128.0	1555.0	128.0	8.8	0.7	2585.8	212.8
Na	13284.0	577.6	13284.0	577.6	359.6	15.6	21900.3	952.2
K	493.0	12.6	493.0	12.6	16.7	0.4	810.6	20.8
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	5.4	0.1	200.6	3.3
SO4	3675.0	76.6	3694.5	77.0	22.9	0.5	6142.2	128.0
Cl	23500.0	662.9	23500.0	662.9	579.8	16.4	38780.1	1093.9
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		995.9		71210.5	
pH	8.0		7.0		5.6		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp=100,%	25.5	25.6	47.5
SrSO4/Ksp=100,%	0.0	0.0	0.0
BaSO4/Ksp=100,%	0.0	0.0	0.0
SiO2 sat.,%	0.3	0.3	0.5
Langelier ind.	1.44	0.36	1.00
Stiff & Davis ind.	0.43	-0.65	-0.02
Ionic strength	0.89	0.89	1.52
Osmotic press.,psi	501.8	501.7	853.1

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.50 (1993)

12-16-93

Calculation was made by: J I C A

Project name : SAUDI ARABIAN SEAWATER MODEL #1 Permeate flow : 10000 M3-D

Feedwater temperature : 40.0 C Recovery : 40.0%  
 Raw water pH : 8.00 Element age : 0.0 years  
 Acid dosage, ppm(100%): 19.9 H2SO4 Flux decline coefficient : -0.035  
 Acidified feed CO2,ppm : 19.9 3-yr salt passage increase factor :1.3

Feed pressure : 59.1 kg/cm2 Concentrate pressure : 58.7 kg/cm2

Pass	Feed Flow Total Vessel m3/h	Conc. Total m3/h	Flow Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5	4.1	625.5	2.5	1.02	58.7	8040-HSY-SWC1	1524 254x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	3.5	0.2	789.4	39.4
Mg	1555.0	128.0	1555.0	128.0	11.3	0.9	2584.1	212.7
Na	13284.0	577.6	13284.0	577.6	460.6	20.0	21833.0	949.3
K	493.0	12.6	493.0	12.6	21.3	0.5	807.4	20.7
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	6.9	0.1	199.6	3.3
SO4	3675.0	76.6	3694.5	77.0	29.3	0.6	6137.9	127.9
Cl	23500.0	662.9	23500.0	662.9	742.6	20.9	38671.6	1090.9
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		1275.5		71024.0	
pH	8.0		7.0		5.8		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp*100,%	25.5	25.6	47.6
SrSO4/Ksp*100,%	0.0	0.0	0.0
BaSO4/Ksp*100,%	0.0	0.0	0.0
SiO2 sat.,%	0.3	0.3	0.5
Langelier ind.	1.44	0.36	0.99
Stiff & Davis ind.	0.43	-0.65	-0.03
Ionic strength	0.89	0.89	1.52
Osmotic press.,psi	501.8	501.7	850.6

DATA No.17

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.50 (1993)  
 Calculation was made by: J I C A

12-16-93

Project name : SAUDI ARABIAN SEAWATER MODEL #1      Permeate flow : 10000 M3-D  
 Feedwater temperature : 45.0 C      Recovery : 40.0%  
 Raw water pH : 8.00      Element age : 0.0 years  
 Acid dosage, ppm(100%): 19.9 H2SO4      Flux decline coefficient : -0.035  
 Acidified feed CO2, ppm : 19.9      3-yr salt passage increase factor : 1.3

Feed pressure : 65.6 kg/cm2      Concentrate pressure : 64.5 kg/cm2

Pass	Feed Flow Total Vessel m3/h	Conc. Total m3/h	Flow Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5	8.0	625.5	4.8	1.03	64.5	8040-HSY-SWC1	780 130x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	1.9	0.1	790.4	39.4
Mg	1555.0	128.0	1555.0	128.0	6.4	0.5	2587.4	213.0
Na	13284.0	577.6	13284.0	577.6	259.5	11.3	21967.0	955.1
K	493.0	12.6	493.0	12.6	12.0	0.3	813.7	20.9
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	3.9	0.1	201.6	3.3
SO4	3675.0	76.6	3694.5	77.0	16.5	0.3	6146.5	128.1
Cl	23500.0	662.9	23500.0	662.9	418.4	11.8	38887.8	1097.0
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		718.6		71395.4	
pH	8.0		7.0		5.5		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp*100,%	25.0	25.2	46.7
SrSO4/Ksp*100,%	0.0	0.0	0.0
BaSO4/Ksp*100,%	0.0	0.0	0.0
SiO2 sat.,%	0.3	0.3	0.5
Langelier ind.	1.55	0.47	1.11
Stiff & Davis ind.	0.55	-0.53	0.11
Ionic strength	0.89	0.89	1.53
Osmotic press.,psi	509.8	509.7	869.3

DATA No.18

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.50 (1993)  
 Calculation was made by: J I C A

12-16-93

Project name : SAUDI ARABIAN SEAWATER MODEL #1 Permeate flow : 10000 M3-D

Feedwater temperature : 45.0 C Recovery : 40.0%  
 Raw water pH : 8.00 Element age : 0.0 years  
 Acid dosage, ppm(100%): 19.9 H2SO4 Flux decline coefficient : -0.035  
 Acidified feed CO2, ppm : 19.9 3-yr salt passage increase factor :1.3

Feed pressure : 63.6 kg/cm2

Concentrate pressure : 62.8 kg/cm2

Pass	Feed Flow Total Vessel m3/h	Conc. Total m3/h	Flow Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5	6.4	625.5	3.9	1.03	62.8	8040-HSY-SWC1	972 162x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	2.5	0.1	790.0	39.4
Mg	1555.0	128.0	1555.0	128.0	8.1	0.7	2586.3	212.9
Na	13284.0	577.6	13284.0	577.6	330.8	14.4	21919.5	953.0
K	493.0	12.6	493.0	12.6	15.3	0.4	811.5	20.8
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	5.0	0.1	200.9	3.3
SO4	3675.0	76.6	3694.5	77.0	21.0	0.4	6143.5	128.0
Cl	23500.0	662.9	23500.0	662.9	533.4	15.0	38811.1	1094.8
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		916.1		71263.6	
pH	8.0		7.0		5.6		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp*100,%	25.0	25.2	46.7
SrSO4/Ksp*100,%	0.0	0.0	0.0
BaSO4/Ksp*100,%	0.0	0.0	0.0
SiO2 sat.,%	0.3	0.3	0.5
Langelier ind.	1.55	0.47	1.10
Stiff & Davis ind.	0.55	-0.53	0.10
Ionic strength	0.89	0.89	1.52
Osmotic press.,psi	509.8	509.7	867.5

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.50 (1993)  
 Calculation was made by: J I C A

12-16-93

Project name : SAUDI ARABIAN SEAWATER MODEL #1 Permeate flow : 10000 M3-d

Feedwater temperature : 45.0 C Recovery : 40.0%  
 Raw water pH : 8.00 Element age : 0.0 years  
 Acid dosage, ppm(100%): 19.9 H2SO4 Flux decline coefficient : -0.035  
 Acidified feed CO2, ppm : 19.9 3-yr salt passage increase factor : 1.3

Feed pressure : 60.7 kg/cm2

Concentrate pressure : 60.2 kg/cm2

Pass	Feed Flow Total Vessel m3/h	Conc. Total m3/h	Flow Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5	5.1	625.5	3.1	1.03	60.2	8040-HSY-SWC1	1218 203x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	3.1	0.2	789.6	39.4
Mg	1555.0	128.0	1555.0	128.0	10.3	0.8	2584.8	212.7
Na	13284.0	577.6	13284.0	577.6	418.3	18.2	21861.1	950.5
K	493.0	12.6	493.0	12.6	19.4	0.5	808.8	20.7
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	6.3	0.1	200.0	3.3
SO4	3675.0	76.6	3694.5	77.0	26.6	0.6	6139.7	127.9
Cl	23500.0	662.9	23500.0	662.9	674.5	19.0	38717.0	1092.2
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		1158.6		71102.0	
pH	8.0		7.0		5.7		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp=100,%	25.0	25.2	46.7
SrSO4/Ksp=100,%	0.0	0.0	0.0
BaSO4/Ksp=100,%	0.0	0.0	0.0
SiO2 sat.,%	0.3	0.3	0.5
Langelier ind.	1.55	0.47	1.10
Stiff & Davis ind.	0.55	-0.53	0.10
Ionic strength	0.89	0.89	1.52
Osmotic press.,psi	509.8	509.7	865.3

DATA No. 20

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.50 (1993)  
 Calculation was made by: J I C A

12-17-93

Project name : SAUDI ARABIAN SEAWATER MODEL #1 Permeate flow : 10000 M3-D

Feedwater temperature : 33.0 C Recovery : 30.0%  
 Raw water pH : 8.00 Element age : 0.0 years  
 Acid dosage, ppm(100%): 19.9 H2SO4 Flux decline coefficient : -0.035  
 Acidified feed CO2, ppm : 19.9 3-yr salt passage increase factor : 1.3

Feed pressure : 55.4 kg/cm2

Concentrate pressure : 54.4 kg/cm2

Pass	Feed Flow Total Vessel m3/h m3/h	Conc. Flow Total Vessel m3/h m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1389.9 6.8	973.0 4.8	1.03	54.4	6040-HSY-SWC1	1218	203x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	2.1	0.1	677.7	33.8
Mg	1555.0	128.0	1555.0	128.0	6.8	0.6	2218.5	182.6
Na	13284.0	577.6	13284.0	577.6	276.1	12.0	18858.8	819.9
K	493.0	12.6	493.0	12.6	12.8	0.3	698.8	17.9
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.1	0.0
HCO3	146.4	2.4	122.5	2.0	4.2	0.1	173.3	2.8
SO4	3675.0	76.6	3694.5	77.0	17.5	0.4	5270.3	109.8
Cl	23500.0	662.9	23500.0	662.9	445.1	12.6	33380.7	941.6
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.7	
TDS	43129.4		43124.6		764.4		61279.0	
pH	8.0		7.0		5.5		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp=100,%	26.0	26.2	40.3
SrSO4/Ksp=100,%	0.0	0.0	0.0
BaSO4/Ksp=100,%	0.0	0.0	0.0
SiO2 sat.,%	0.3	0.3	0.5
Langelier ind.	1.33	0.25	0.70
Stiff & Davis ind.	0.31	-0.77	-0.34
Ionic strength	0.89	0.89	1.30
Osmotic press.,psi	493.8	493.7	714.9

DATA No. 21

HYDRAUNAUTICS DESIGN PROGRAM - VERSION 4.50 (1993)  
 Calculation was made by: J I C A

12-17-93

Project name : SAUDI ARABIAN SEAWATER MODEL #1 Permeate flow : 10000 M3-D

Feedwater temperature : 35.0 C Recovery : 35.0%  
 Raw water pH : 8.00 Element age : 0.0 years  
 Acid dosage, ppm(100%): 19.9 H2SO4 Flux decline coefficient : -0.035  
 Acidified feed CO2, ppm : 19.9 3-yr salt passage increase factor : 1.3

Feed pressure : 58.3 kg/cm2 Concentrate pressure : 57.6 kg/cm2

Pass	Feed Flow Total Vessel m3/h	Conc. Flow Total Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1191.4	5.9	774.4	3.8	1.03	57.6	8040-HSY-SWC1 1218 203x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	2.2	0.1	729.6	36.4
Mg	1555.0	128.0	1555.0	128.0	7.1	0.6	2388.5	196.6
Na	13284.0	577.6	13284.0	577.6	290.8	12.6	20280.3	881.8
K	493.0	12.6	493.0	12.6	13.5	0.3	751.2	19.3
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.1	0.0
HCO3	146.4	2.4	122.5	2.0	4.4	0.1	186.2	3.1
SO4	3675.0	76.6	3694.5	77.0	18.5	0.4	5673.9	118.2
Cl	23500.0	662.9	23500.0	662.9	468.8	13.2	35901.4	1012.7
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		805.3		65912.0	
pH	8.0		7.0		5.6		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp=100,%	26.0	26.2	44.1
SrSO4/Ksp=100,%	0.0	0.0	0.0
BaSO4/Ksp=100,%	0.0	0.0	0.0
SiO2 sat.,%	0.3	0.3	0.5
Langelier ind.	1.33	0.25	0.79
Stiff & Davis ind.	0.31	-0.77	-0.25
Ionic strength	0.89	0.89	1.40
Osmotic press.,psi	493.8	493.7	772.7

DATA No. 22

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.50 (1993)  
 Calculation was made by: J I C A

12-17-93

Project name : SAUDI ARABIAN SEAWATER MODEL #1 Permeate flow : 10000 M3-D

Feedwater temperature : 35.0 C Recovery : 45.0%  
 Raw water pH : 8.00 Element age : 0.0 years  
 Acid dosage, ppm(100%): 19.9 H2SO4 Flux decline coefficient : -0.035  
 Acidified feed CO2, ppm : 19.9 3-yr salt passage increase factor : 1.3

Feed pressure : 65.6 kg/cm2 Concentrate pressure : 65.1 kg/cm2

Pass	Feed Flow Total Vessel m3/h	Conc. Total m3/h	Flow Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	926.6	4.6	509.6	2.5	1.03	65.1	8040-HSY-SWC1	1218 203x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	2.5	0.1	861.6	43.0
Mg	1555.0	128.0	1555.0	128.0	8.2	0.7	2820.6	232.1
Na	13284.0	577.6	13284.0	577.6	335.0	14.6	23878.7	1038.2
K	493.0	12.6	493.0	12.6	15.5	0.4	883.7	22.7
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	5.0	0.1	218.7	3.6
SO4	3675.0	76.6	3694.5	77.0	21.3	0.4	6699.8	139.6
Cl	23500.0	662.9	23500.0	662.9	540.1	15.2	42285.4	1192.8
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.9	
TDS	43129.4		43124.6		927.7		77649.4	
pH	8.0		7.0		5.6		7.3	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp=100,%	26.0	26.2	53.8
SrSO4/Ksp=100,%	0.0	0.0	0.0
BaSO4/Ksp=100,%	0.0	0.0	0.0
SiO2 sat.,%	0.3	0.3	0.6
Langelier ind.	1.33	0.25	1.00
Stiff & Davis ind.	0.31	-0.77	-0.04
Ionic strength	0.89	0.89	1.67
Osmotic press.,psi	493.8	493.7	921.8



Rejection = 99.75% Flux 5000gpd

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.05 (1990)  
 Calculation was made by: J I C A

12-17-93

Project name : SAUDI ARABIAN SEAWATER MODEL #1 Permeate flow : 10000 M3-D

Feedwater temperature : 35.0 C Recovery : 40.0%  
 Raw water pH : 8.00 Element age : 0.0 years  
 Acid dosage, ppm(100%): 19.9 H2SO4 Flux decline coefficient : -0.035  
 Acidified feed CO2, ppm : 19.9 3-yr salt passage increase factor : 1.3

Feed pressure : 62.8 kg/cm2 Concentrate pressure : 62.3 kg/cm2

Pass	Feed Flow Total Vessel m3/h	Conc. Flow Total Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5	5.1	625.5	3.1	1.02	62.3	SEAWATER RO#8S 1218 203x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	1.2	0.1	790.9	39.4
Mg	1555.0	128.0	1555.0	128.0	3.9	0.3	2589.1	213.1
Na	13284.0	577.6	13284.0	577.6	159.5	6.9	22033.7	958.0
K	493.0	12.6	493.0	12.6	7.4	0.2	816.7	20.9
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	2.4	0.0	202.6	3.3
SO4	3675.0	76.6	3694.5	77.0	10.1	0.2	6150.7	128.1
Cl	23500.0	662.9	23500.0	662.9	257.1	7.3	38995.3	1000.0
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		441.6		71580.0	
pH	8.0		7.0		5.3		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp=100,%	26.0	26.2	48.5
SrSO4/Ksp=100,%	0.0	0.0	0.0
BaSO4/Ksp=100,%	0.0	0.0	0.0
SiO2 sat.,%	0.3	0.3	0.6
Langelier ind.	1.33	0.25	0.90
Stiff & Davis ind.	0.31	-0.77	-0.14
Tonic strength	0.89	0.89	1.53
Osmotic press.,psi	493.8	493.7	844.4

DATA No. 24

IDEAL RO PERFORMANCE Specification

Rejection = 99.60% Flux 5000gpd

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.05 (1990)  
Calculation was made by: J I C A

12-17-93

Project name : SAUDI ARABIAN SEAWATER MODEL #1 Permeate flow : 10000 M3-D

Feedwater temperature : 35.0 C Recovery : 40.0%  
Raw water pH : 8.00 Element age : 0.0 years  
Acid dosage, ppm(100%): 19.9 H2SO4 Flux decline coefficient : -0.035  
Acidified feed CO2, ppm : 19.9 3-yr salt passage increase factor : 1.3

Feed pressure : 62.8 kg/cm2 Concentrate pressure : 62.3 kg/cm2

Pass	Feed Flow Total Vessel m3/h	Conc. Flow m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5	5.1	625.5	3.1	1.02	62.3	SEAWATER RO#9S 1218 203x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	1.9	0.1	790.4	39.4
Mg	1555.0	128.0	1555.0	128.0	6.2	0.5	2587.5	213.0
Na	13284.0	577.6	13284.0	577.6	254.9	11.1	21970.0	955.2
K	493.0	12.6	493.0	12.6	11.8	0.3	813.8	20.9
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	3.8	0.1	201.7	3.3
SO4	3675.0	76.6	3694.5	77.0	16.2	0.3	6146.7	128.1
Cl	23500.0	662.9	23500.0	662.9	411.0	11.6	38892.6	1097.1
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		706.0		71403.7	
pH	8.0		7.0		5.5		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp*100,%	26.0	26.2	48.5
SrSO4/Ksp*100,%	0.0	0.0	0.0
BaSO4/Ksp*100,%	0.0	0.0	0.0
SiO2 sat.,%	0.3	0.3	0.6
Langelier ind.	1.33	0.25	0.89
Stiff & Davis ind.	0.31	-0.77	-0.14
Ionic strength	0.89	0.89	1.53
Osmotic press.,psi	493.8	493.7	842.1

DATA No. 25

IDEAL RO PERFORMANCE Specification

Rejection = 99.50% Flux 5000gpd

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.05 (1990)  
Calculation was made by: J I C A

12-17-93

Project name : SAUDI ARABIAN SEAWATER MODEL #1 Permeate flow : 10000 M3-D

Feedwater temperature : 35.0 C Recovery : 40.0%  
Raw water pH : 8.00 Element age : 0.0 years  
Acid dosage, ppm(100%): 19.9 H2SO4 Flux decline coefficient : -0.035  
Acidified feed CO2, ppm : 19.9 3-yr salt passage increase factor : 1.3

Feed pressure : 62.8 kg/cm2

Concentrate pressure : 62.3 kg/cm2

Pass	Feed Flow Total Vessel m3/h	Conc. Total m3/h	Flow Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5	5.1	625.5	3.1	1.02	62.3 SEAWATER RO#0S	1218	203x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	2.4	0.1	790.1	39.4
Mg	1555.0	128.0	1555.0	128.0	7.8	0.6	2586.5	212.9
Na	13284.0	577.6	13284.0	577.6	318.5	13.8	21927.7	953.4
K	493.0	12.6	493.0	12.6	14.8	0.4	811.8	20.8
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	4.8	0.1	201.0	3.3
SO4	3675.0	76.6	3694.5	77.0	20.3	0.4	6144.0	128.0
Cl	23500.0	662.9	23500.0	662.9	513.5	14.5	38824.3	1095.2
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		882.0		71286.4	
pH	8.0		7.0		5.6		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp*100,%	26.0	26.2	48.5
SrSO4/Ksp*100,%	0.0	0.0	0.0
BaSO4/Ksp*100,%	0.0	0.0	0.0
SiO2 sat.,%	0.3	0.3	0.6
Langelier ind.	1.33	0.25	0.89
Stiff & Davis ind.	0.31	-0.77	-0.15
Ionic strength	0.89	0.89	1.53
Osmotic press.,psi	493.8	493.7	840.5

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.05 (1990)

12-17-93

Calculation was made by: J I C A

Project name : SAUDI ARABIAN SEAWATER MODEL #1 Permeate flow : 10000 M3-D

Feedwater temperature : 35.0 C Recovery : 40.0%  
 Raw water pH : 8.00 Element age : 0.0 years  
 Acid dosage, ppm(100%): 19.9 H2SO4 Flux decline coefficient : -0.035  
 Acidified feed CO2, ppm : 19.9 3-yr salt passage increase factor : 1.3

Feed pressure : 62.8 kg/cm2

Concentrate pressure : 62.3 kg/cm2

Pass	Feed Flow Total Vessel m3/h	Conc. Total m3/h	Flow Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5	5.1	625.5	3.1	1.02	62.3 SEAWATER RO#1S	1218	203x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	2.6	0.1	789.9	39.4
Mg	1555.0	128.0	1555.0	128.0	8.6	0.7	2585.9	212.8
Na	13284.0	577.6	13284.0	577.6	350.2	15.2	21906.5	952.5
K	493.0	12.6	493.0	12.6	16.2	0.4	810.9	20.8
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	5.3	0.1	200.7	3.3
SO4	3675.0	76.6	3694.5	77.0	22.3	0.5	6142.6	128.0
Cl	23500.0	662.9	23500.0	662.9	564.7	15.9	38790.2	1094.2
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		969.9		71227.8	
pH	8.0		7.0		5.6		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp=100,%	26.0	26.2	48.5
SrSO4/Ksp=100,%	0.0	0.0	0.0
BaSO4/Ksp=100,%	0.0	0.0	0.0
SiO2 sat.,%	0.3	0.3	0.6
Langelier ind.	1.33	0.25	0.89
Stiff & Davis ind.	0.31	-0.77	-0.15
Ionic strength	0.89	0.89	1.52
Osmotic press.,psi	493.8	493.7	839.7

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.05 (1990)

12-17-93

Calculation was made by: J I C A

Project name : SAUDI ARABIAN SEAWATER MODEL #1 Permeate flow : 10000 M3-

Feedwater temperature : 35.0 C Recovery : 40.0%  
 Raw water pH : 8.00 Element age : 0.0 years  
 Acid dosage, ppm(100%): 19.9 H2SO4 Flux decline coefficient : -0.03  
 Acidified feed CO2, ppm : 19.9 3-yr salt passage increase factor : 1.3

Feed pressure : 62.8 kg/cm2 Concentrate pressure : 62.3 kg/cm2

Pass	Feed Flow Total Vessel m3/h	Conc. Flow Total Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5	5.1	625.5	3.1	1.02	62.3	SEAWATER RO#2S 1218 203x1

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	2.9	0.1	789.8	39.4
Mg	1555.0	128.0	1555.0	128.0	9.4	0.8	2585.4	212.8
Na	13284.0	577.6	13284.0	577.6	382.0	16.6	21885.4	951.5
K	493.0	12.6	493.0	12.6	17.7	0.5	809.9	20.8
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	5.8	0.1	200.4	3.3
SO4	3675.0	76.6	3694.5	77.0	24.3	0.5	6141.3	127.9
Cl	23500.0	662.9	23500.0	662.9	615.9	17.4	38756.1	1093.3
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		1057.8		71169.2	
pH	8.0		7.0		5.7		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp=100,%	26.0	26.2	48.5
SrSO4/Ksp=100,%	0.0	0.0	0.0
BaSO4/Ksp=100,%	0.0	0.0	0.0
SiO2 sat.,%	0.3	0.3	0.6
Langelier ind.	1.33	0.25	0.89
Stiff & Davis ind.	0.31	-0.77	-0.15
Ionic strength	0.89	0.89	1.52
Osmotic press.,psi	493.8	493.7	838.9

Rejection = 99.35% Flux 5000gpd

HYDRANAUTICS DESIGN PROGRAM -- VERSION 4.05 (1990)

12-17-93

Calculation was made by: J I C A

Project name : SAUDI ARABIAN SEAWATER MODEL #1 Permeate flow : 10000 M3-D

Feedwater temperature : 35.0 C Recovery : 40.0%  
 Raw water pH : 8.00 Element age : 0.0 years  
 Acid dosage, ppm(100%): 19.9 H2SO4 Flux decline coefficient : -0.035  
 Acidified feed CO2, ppm : 19.9 3-yr salt passage increase factor : 1.3

Feed pressure : 62.8 kg/cm2 Concentrate pressure : 62.3 kg/cm2

Pass	Feed Flow Total Vessel m3/h	Conc. Flow Total Vessel m3/h	Flow Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5	5.1	625.5	3.1	1.02	62.3	SEAWATER RO#4S	1218 203x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	3.1	0.2	789.6	39.4
Mg	1555.0	128.0	1555.0	128.0	10.1	0.8	2584.9	212.7
Na	13284.0	577.6	13284.0	577.6	413.7	18.0	21864.2	950.6
K	493.0	12.6	493.0	12.6	19.2	0.5	808.9	20.7
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	6.2	0.1	200.1	3.3
SO4	3675.0	76.6	3694.5	77.0	26.3	0.5	6139.9	127.9
Cl	23500.0	662.9	23500.0	662.9	667.0	18.8	38722.0	1092.3
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		1145.7		71110.6	
pH	8.0		7.0		5.7		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp=100,%	26.0	26.2	48.5
SrSO4/Ksp=100,%	0.0	0.0	0.0
BaSO4/Ksp=100,%	0.0	0.0	0.0
SiO2 sat.,%	0.3	0.3	0.6
Langelier ind.	1.33	0.25	0.88
Stiff & Davis ind.	0.31	-0.77	-0.15
Ionic strength	0.89	0.89	1.52
Osmotic press.,psi	493.8	493.7	638.2

Rejection = 99.30% Flux 5000gpd

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.05 (1990)

12-17-93

Calculation was made by: J I C A

Project name : SAUDI ARABIAN SEAWATER MODEL #1 Permeate flow : 10000 M3-D

Feedwater temperature : 35.0 C Recovery : 40.0%  
 Raw water pH : 8.00 Element age : 0.0 years  
 Acid dosage, ppm(100%): 19.9 H2SO4 Flux decline coefficient : -0.035  
 Acidified feed CO2, ppm : 19.9 3-yr salt passage increase factor : 1.3

Feed pressure : 62.8 kg/cm2

Concentrate pressure : 62.3 kg/cm2

Pass	Feed Flow Total Vessel m3/h	Conc. Total m3/h	Flow Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5	5.1	625.5	3.1	1.02	62.3	SEAWATER RO#3S	1218 203x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	3.3	0.2	789.4	39.4
Mg	1555.0	128.0	1555.0	128.0	10.9	0.9	2584.4	212.7
Na	13284.0	577.6	13284.0	577.6	445.4	19.4	21843.1	949.7
K	493.0	12.6	493.0	12.6	20.6	0.5	607.9	20.7
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	6.7	0.1	199.8	3.3
SO4	3675.0	76.6	3694.5	77.0	28.4	0.6	6138.6	127.9
Cl	23500.0	662.9	23500.0	662.9	718.2	20.3	38687.9	1091.3
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		1233.5		71052.0	
pH	8.0		7.0		5.7		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp=100.%	26.0	26.2	48.5
SrSO4/Ksp=100.%	0.0	0.0	0.0
BaSO4/Ksp=100.%	0.0	0.0	0.0
SiO2 sat. %	0.3	0.3	0.6
Langelier ind.	1.33	0.25	0.88
Stiff & Davis ind.	0.31	-0.77	-0.15
Ionic strength	0.89	0.89	1.52
Osmotic press., psi	493.8	493.7	837.4

Rejection = 99.25% Flux 5000gpd

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.05 (1990)

12-17-93

Calculation was made by: J I C A

Project name : SAUDI ARABIAN SEAWATER MODEL #1 Permeate flow : 10000 M3-D

Feedwater temperature : 35.0 C Recovery : 40.0%  
 Raw water pH : 8.00 Element age : 0.0 years  
 Acid dosage, ppm(100%): 19.9 H2SO4 Flux decline coefficient : -0.035  
 Acidified feed CO2,ppm : 19.9 3-yr salt passage increase factor : 1.3

Feed pressure : 62.8 kg/cm2

Concentrate pressure : 62.3 kg/cm2

Pass	Feed Flow Total Vessel m3/h	Conc. Flow Total Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5	5.1	625.5	3.1	1.02	62.3	SEAWATER RO#5S 1218 203x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	3.6	0.2	789.3	39.4
Mg	1555.0	128.0	1555.0	128.0	11.7	1.0	2583.9	212.7
Na	13284.0	577.6	13284.0	577.6	477.1	20.7	21822.0	948.8
K	493.0	12.6	493.0	12.6	22.1	0.6	806.9	20.7
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	7.2	0.1	199.5	3.3
SO4	3675.0	76.6	3694.5	77.0	30.4	0.6	6137.2	127.9
Cl	23500.0	662.9	23500.0	662.9	769.3	21.7	38653.8	1090.4
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		1321.3		70993.5	
pH	8.0		7.0		5.8		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp*100,%	26.0	26.2	48.5
SrSO4/Ksp*100,%	0.0	0.0	0.0
BaSO4/Ksp*100,%	0.0	0.0	0.0
SiO2 sat.,%	0.3	0.3	0.6
Langelier ind.	1.33	0.25	0.88
Stiff & Davis ind.	0.31	-0.77	-0.15
Ionic strength	0.89	0.89	1.52
Osmotic press.,psi	493.8	493.7	836.6



DATA No. 31

IDEAL RO PERFORMANCE Specification

Rejection = 99.20% Flux 5000gpd

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.05 (1990)  
Calculation was made by: J I C A

12-17-93

Project name : SAUDI ARABIAN SEAWATER MODEL #1 Perwaste flow : 10000 M3-D

Feedwater temperature : 35.0 C Recovery : 40.0%  
Raw water pH : 8.00 Element age : 0.0 years  
Acid dosage, ppm(100%): 19.9 H2SO4 Flux decline coefficient : -0.035  
Acidified feed CO2, ppm : 19.9 3-yr salt passage increase factor : 1.3

Feed pressure : 62.8 kg/cm2 Concentrate pressure : 62.3 kg/cm2

Pass	Feed Flow Total Vessel m3/h	Conc. Total m3/h	Flow Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5	5.1	625.5	3.1	1.02	62.3	SEAWATER RO#6S	1218 203x6

Ion	Raw water		Feed water		Perwaste		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	3.8	0.2	789.1	39.4
Mg	1555.0	128.0	1555.0	128.0	12.5	1.0	2583.3	212.6
Na	13284.0	577.6	13284.0	577.6	508.7	22.1	21800.8	947.9
K	493.0	12.6	493.0	12.6	23.5	0.6	806.0	20.7
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	7.7	0.1	199.1	3.3
SO4	3675.0	76.6	3694.5	77.0	32.4	0.7	6135.9	127.6
Cl	23500.0	662.9	23500.0	662.9	820.3	23.1	38619.8	1089.4
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		1409.0		70935.0	
pH	8.0		7.0		5.8		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp=100,%	26.0	26.2	48.5
SrSO4/Ksp=100,%	0.0	0.0	0.0
BaSO4/Ksp=100,%	0.0	0.0	0.0
SiO2 sat.,%	0.3	0.3	0.6
Langelier ind.	1.33	0.25	0.88
Stiff & Davis ind.	0.31	-0.77	-0.15
Tonic strength	0.89	0.89	1.52
Osmotic press.,psi	493.8	493.7	835.8

Rejection = 99.00% Flux 5000gpd

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.05 (1990)  
 Calculation was made by: J I C A

12-17-93

Project name : SAUDI ARABIAN SEAWATER MODEL #1 Permeate flow : 10000 M3-D

Feedwater temperature : 35.0 C Recovery : 40.0%  
 Raw water pH : 8.00 Element age : 0.0 years  
 Acid dosage, ppm(100%): 19.9 H2SO4 Flux decline coefficient : -0.035  
 Acidified feed CO2, ppm : 19.9 3-yr salt passage increase factor : 1.3

Feed pressure : 62.8 kg/cm2 Concentrate pressure : 62.3 kg/cm2

Pass	Feed Flow Total Vessel m3/h	Conc. Total m3/h	Flow Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5	5.1	625.5	3.1	1.02	62.3	SEAWATER RO#7S	1218 203x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	4.8	0.2	788.5	39.3
Mg	1555.0	128.0	1555.0	128.0	15.6	1.3	2581.2	212.4
Na	13284.0	577.6	13284.0	577.6	635.2	27.6	21716.5	944.2
K	493.0	12.6	493.0	12.6	29.4	0.8	802.1	20.6
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.1	0.0
HCO3	146.4	2.4	122.5	2.0	9.5	0.2	197.9	3.2
SO4	3675.0	76.6	3694.5	77.0	40.5	0.8	6130.5	127.7
Cl	23500.0	662.9	23500.0	662.9	1024.3	28.9	38483.8	1085.6
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		1759.4		70701.4	
pH	8.0		7.0		5.9		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp*100, %	26.0	26.2	48.6
SrSO4/Ksp*100, %	0.0	0.0	0.0
BaSO4/Ksp*100, %	0.0	0.0	0.0
SiO2 sat., %	0.3	0.3	0.6
Langelier ind.	1.33	0.25	0.87
Stiff & Davis ind.	0.31	-0.77	-0.16
Ionic strength	0.89	0.89	1.51
Osmotic press., psi	493.8	493.7	832.7

Appendix 7.1.1-4

Performance-Design Simulation for RO Plant  
(2)



DATA No. 33

IDEAL RO PERFORMANCE Specification

Rejection = 99.50% Flux 4000gpd

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.05 (1990)

01-07-93

Calculation was made by: J I C A

Project name : SAUDI ARABIAN SEAWATER MODEL #1 Perwate flow : 10000 M3-D

Feedwater temperature : 35.0 C Recovery : 40.0%  
 Raw water pH : 8.00 Element age : 0.0 years  
 Acid dosage, ppm(100%): 19.9 H2SO4 Flux decline coefficient : -0.035  
 Acidified feed CO2, ppm : 19.9 3-yr salt passage increase factor : 1.3

Feed pressure : 65.1 kg/cm2

Concentrate pressure : 64.5 kg/cm2

Pass	Feed Flow Total Vessel m3/h	Conc. Total m3/h	Flow Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5	5.1	625.5	3.1	1.03	64.5 SEAWATER RO12S	1218	203x6

Ion	Raw water		Feed water		Perwate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	1.9	0.1	790.4	39.4
Mg	1555.0	128.0	1555.0	128.0	6.1	0.5	2587.6	213.0
Na	13284.0	577.6	13284.0	577.6	251.0	10.9	21972.7	955.3
K	493.0	12.6	493.0	12.6	11.6	0.3	813.9	20.9
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	3.8	0.1	201.7	3.3
SO4	3675.0	76.6	3694.5	77.0	15.9	0.3	6146.9	128.1
Cl	23500.0	662.9	23500.0	662.9	404.6	11.4	38896.9	1097.2
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		695.0		71411.1	
pH	8.0		7.0		5.5		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp=100,%	26.0	26.2	48.5
SrSO4/Ksp=100,%	0.0	0.0	0.0
BaSO4/Ksp=100,%	0.0	0.0	0.0
SiO2 sat.,%	0.3	0.3	0.6
Langelier ind.	1.33	0.25	0.89
Stiff & Davis ind.	0.31	-0.77	-0.14
Ionic strength	0.89	0.89	1.53
Osmotic press.,psi	493.8	493.7	842.2

DATA No. 34

IDEAL RO PERFORMANCE Specification

Rejection = 99.50% Flux 4500gpd

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.05 (1990)  
 Calculation was made by: J I C A

01-07-93

Project name : SAUDI ARABIAN SEAWATER MODEL #1 Permeate flow : 10000 M3-D

Feedwater temperature : 35.0 C Recovery : 40.0%  
 Raw water pH : 8.00 Element age : 0.0 years  
 Acid dosage, ppm(100%): 19.9 H2SO4 Flux decline coefficient : -0.035  
 Acidified feed CO2, ppm : 19.9 3-yr salt passage increase factor : 1.3

Feed pressure : 63.8 kg/cm2

Concentrate pressure : 63.3 kg/cm2

Pass	Feed Flow Total Vessel m3/h	Conc. Total m3/h	Flow Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5	5.1	625.5	3.1	1.03	63.3 SEAWATER RO10S	1218	203x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	2.1	0.1	790.2	39.4
Mg	1555.0	128.0	1555.0	128.0	7.0	0.6	2587.0	212.9
Na	13284.0	577.6	13284.0	577.6	284.6	12.4	21950.2	954.4
K	493.0	12.6	493.0	12.6	13.2	0.3	812.9	20.8
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	4.3	0.1	201.4	3.3
SO4	3675.0	76.6	3694.5	77.0	18.1	0.4	6145.4	128.0
Cl	23500.0	662.9	23500.0	662.9	458.9	12.9	38860.7	1096.2
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		788.3		71348.9	
pH	8.0		7.0		5.5		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp=100,%	26.0	26.2	48.5
SrSO4/Ksp=100,%	0.0	0.0	0.0
BaSO4/Ksp=100,%	0.0	0.0	0.0
SiO2 sat.,%	0.3	0.3	0.6
Langelier ind.	1.33	0.25	0.89
Stiff & Davis ind.	0.31	-0.77	-0.14
Ionic strength	0.89	0.89	1.53
Osmotic press.,psi	493.8	493.7	841.3

DATA No. 35

IDEAL RO PERFORMANCE Specification

Rejection = 99.50% Flux 5500gpd

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.05 (1990)

01-07-93

Calculation was made by: J I C A

Project name : SAUDI ARABIAN SEAWATER MODEL #1 Permeate flow : 10000 M3-D

Feedwater temperature : 35.0 C Recovery : 40.0%  
 Raw water pH : 8.00 Element age : 0.0 years  
 Acid dosage, ppm(100%): 19.9 H2SO4 Flux decline coefficient : -0.035  
 Acidified feed CO2, ppm : 19.9 3-yr salt passage increase factor : 1.3

Feed pressure : 62.0 kg/cm2 Concentrate pressure : 61.4 kg/cm2

Pass	Feed Flow Total Vessel m3/h	Conc. Flow Total Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5	5.1	625.5	3.1	1.02	61.4	SEAWATERRO #9S 1216 203x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	2.6	0.1	789.9	39.4
Mg	1555.0	128.0	1555.0	128.0	8.6	0.7	2585.9	212.8
Na	13284.0	577.6	13284.0	577.6	352.4	15.3	21905.0	952.4
K	493.0	12.6	493.0	12.6	16.3	0.4	810.8	20.8
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	5.3	0.1	200.7	3.3
SO4	3675.0	76.6	3694.5	77.0	22.4	0.5	6142.6	128.0
Cl	23500.0	662.9	23500.0	662.9	568.3	16.0	38787.8	1094.2
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		976.0		71223.7	
pH	8.0		7.0		5.6		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp=100,%	26.0	26.2	48.5
SrSO4/Ksp=100,%	0.0	0.0	0.0
BaSO4/Ksp=100,%	0.0	0.0	0.0
SiO2 sat.,%	0.3	0.3	0.6
Langelier ind.	1.33	0.25	0.89
Stiff & Davis ind.	0.31	-0.77	-0.15
Ionic strength	0.89	0.89	1.52
Osmotic press.,psi	493.8	493.7	839.7

DATA No. 36

IDEAL RO PERFORMANCE Specification

Rejection = 99.50% Flux 6000gpd

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.05 (1990)

01-07-93

Calculation was made by: J I C A

Project name : SAUDI ARABIAN SEAWATER MODEL #1 Permeate flow : 10000 M3-D

Feedwater temperature : 35.0 C Recovery : 40.0%  
 Raw water pH : 8.00 Element age : 0.0 years  
 Acid dosage, ppm(100%): 19.9 H2SO4 Flux decline coefficient : -0.035  
 Acidified feed CO2, ppm : 19.9 3-yr salt passage increase factor : 1.3

Feed pressure : 61.3 kg/cm2

Concentrate pressure : 60.7 kg/cm2

Pass	Feed Flow Total Vessel m3/h	Flow Vessel m3/h	Conc. Total m3/h	Flow Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5	5.1	625.5	3.1	1.02	60.7	SEAWATERRO #8S	1218	203x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	2.9	0.1	789.7	39.4
Mg	1555.0	128.0	1555.0	128.0	9.5	0.8	2585.4	212.8
Na	13284.0	577.6	13284.0	577.6	386.5	16.8	21882.4	951.4
K	493.0	12.6	493.0	12.6	17.9	0.5	809.7	20.8
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	5.8	0.1	200.4	3.3
SO4	3675.0	76.6	3694.5	77.0	24.6	0.5	6141.1	127.9
Cl	23500.0	662.9	23500.0	662.9	623.1	17.6	38751.2	1093.1
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		1070.3		71160.9	
pH	8.0		7.0		5.7		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp=100,%	26.0	26.2	48.5
SrSO4/Ksp=100,%	0.0	0.0	0.0
BaSO4/Ksp=100,%	0.0	0.0	0.0
SiO2 sat.,%	0.3	0.3	0.6
Langelier ind.	1.33	0.25	0.89
Stiff & Davis ind.	0.31	-0.77	-0.15
Ionic strength	0.89	0.89	1.52
Osmotic press.,psi	493.8	493.7	838.8



DATA No. 37

IDEAL RO PERFORMANCE Specification

Rejection = 99.50% Flux 6500gpd

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.05 (1990)  
Calculation was made by: J I C A

01-07-93

Project name : SAUDI ARABIAN SEAWATER MODEL #1 Permeate flow : 10000 M3-D

Feedwater temperature : 35.0 C Recovery : 40.0%  
Raw water pH : 8.00 Element age : 0.0 years  
Acid dosage, ppm(100%): 19.9 H2SO4 Flux decline coefficient : -0.035  
Acidified feed CO2, ppm : 19.9 3-yr salt passage increase factor : 1.3

Feed pressure : 60.7 kg/cm2 Concentrate pressure : 60.1 kg/cm2

Pass	Feed Flow Total Vessel m3/h	Conc. Flow Total Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5	5.1	625.5	3.1	1.01	60.1	SEAWATER RO11S 1218 203x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	3.2	0.2	789.6	39.4
Mg	1555.0	128.0	1555.0	128.0	10.3	0.8	2584.8	212.7
Na	13284.0	577.6	13284.0	577.6	420.6	18.3	21859.6	950.4
K	493.0	12.6	493.0	12.6	19.5	0.5	808.7	20.7
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	6.3	0.1	200.0	3.3
SO4	3675.0	76.6	3694.5	77.0	26.8	0.6	6139.6	127.9
Cl	23500.0	662.9	23500.0	662.9	678.1	19.1	38714.6	1092.1
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		1164.7		71097.9	
pH	8.0		7.0		5.7		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp*100,%	26.0	26.2	48.5
SrSO4/Ksp*100,%	0.0	0.0	0.0
BaSO4/Ksp*100,%	0.0	0.0	0.0
SiO2 sat.,%	0.3	0.3	0.6
Langelier ind.	1.33	0.25	0.88
Stiff & Davis ind.	0.31	-0.77	-0.15
Ionic strength	0.89	0.89	1.52
Osmotic press.,psi	493.8	493.7	838.0

