Appendix E

Summary of

Costs of Treatment and Concentrate Disposal

Contents

Page

Summary of Costs of Treatment and Concentrate Disposal E-1
Selection of Three Concentration Disposal Alternatives E-1
Evaluation of Cost Savings with GAC E-2
Summary of Costs with No Blending E-2

Tables

Page

1 Cost summary of treatments and concentrate disposal alternatives for 50-, 100-, and 150-MGD RO plants E-6
2 Cost summary of treatments and selected concentrate disposal alternatives for 50-, 100-, and 150-MGD RO plants: E-12
3 Summary of flows, concentrations, and costs for a 50-MGD reverse osmosis plant E-15
4 Summary of flows, concentrations, and costs for a 100-MGD reverse osmosis plant E-16
5 Summary of flows, concentrations, and costs for a 150-MGD reverse osmosis plant E-17

Figures

Page

1 Costs of treatment and concentrate disposal E-3
2 Costs of RO treatment and concentrate disposal E-5

Summary of

Costs of Treatment and Concentrate Disposal

All cost estimates developed in this study are the additional costs for "enhanced" treatment of Central Arizona Project water and associated concentrate disposal. Costs described include:

1. Costs of recommended modifications to the Hayden Udall Water Treatment Facility (WTF)
2. Costs of reverse osmosis (RO) treatment of Hayden Udall WTF product
3. Costs of granular activated carbon (GAC) treatment of Hayden Udall WTF product for possible blending with RO product water
4. Costs for disposal of RO concentrate

This study considers three RO plant sizes, a host of concentrate disposal alternatives, and cost of parallel treatment with GAC.

Appendix C describes costs for recommended modifications to the Hayden Udall WTF and for RO treatment of Hayden Udall WTF product. Appendix D describes concentrate disposal alternatives and costs. This appendix summarizes these costs, selects three concentrate disposal alternatives, and evaluates cost savings of using GAC treatment in parallel to RO.

Table 1 (all tables are located at the end of this appendix) summarizes the costs for treatment by RO with and without blending of GAC product for the three plant sizes and with the concentrate disposal alternatives developed in appendix D.

Selection of Three Concentration Disposal Alternatives

From table 1, the following concentrate disposal alternatives were selected to represent the range of costs for concentrate disposal:

a. Pipeline to Puerto Penasco
b. Central Arizona Salinity Interceptor (CASI) pipeline to Yuma
c. 50-million gallons per day (MGD) plant: blend with waste water treatment plant (WWTP) effluent (with 26-MGD pipeline)
   100- and 150-MGD plant: future CASI canal to Yuma

For alternative a, a pipeline was selected for the route to Penasco in anticipation of greater difficulty in obtaining a right-of-way from the Tohono O'dham Nation for a canal.

In alternative b, a low-volume CASI pipeline to Yuma was selected to represent the highest cost alternative, but one that could be implemented most rapidly. Additional CASI partners are expected to lower the cost share of this alternative for the city of Tucson to be less than for the Puerto Penasco route.

For alternative c, a 26-MGD capacity pipeline is specified to carry the 9-MGD flow from a 50-MGD plant in anticipation that the same pipeline will serve to transport concentrate from a 150-MGD plant to a future CASI canal.

The future high-volume CASI canal in alternative c is the lowest cost of the three alternatives but requires planning and construction that would delay the construction of 100- and 150-MGD RO plants.

Sufficient partners to construct a high-volume CASI are not expected for perhaps 20 to 30 years. Therefore, use of the lower-cost high-volume CASI canal anticipates building a 100- to 150-MGD RO plant in stages. A 50-MGD plant is built first with concentrate discharged by pipeline to the Santa Cruz River near Tangerine Road in Marana. There it blends with pipeline-conveyed effluent from the Ina and Roger Road wastewater treatment plants. With the experiences gained from operating the 50-MGD plant, a 100- or 150-MGD plant would then be built. The second stage of construction would necessarily coincide with the proposed construction of the CASI canal, perhaps around the year 2030.

Evaluation of Cost Savings with GAC

Table 2 summarizes the costs for the three selected concentrate disposal alternatives.

Figure 1 summarizes the cost per thousand gallons of enhanced treatment for three RO plant sizes, with and without blending of GAC-treated product, and for the three concentrate disposal alternatives.

As figure 1 indicates, there is, at most, a 10-percent cost advantage to blending with GAC product.

Summary of Costs with No Blending

Because there appears to be little or no cost advantage to blending RO product with GAC product, the recommended treatment is to use RO without blending.

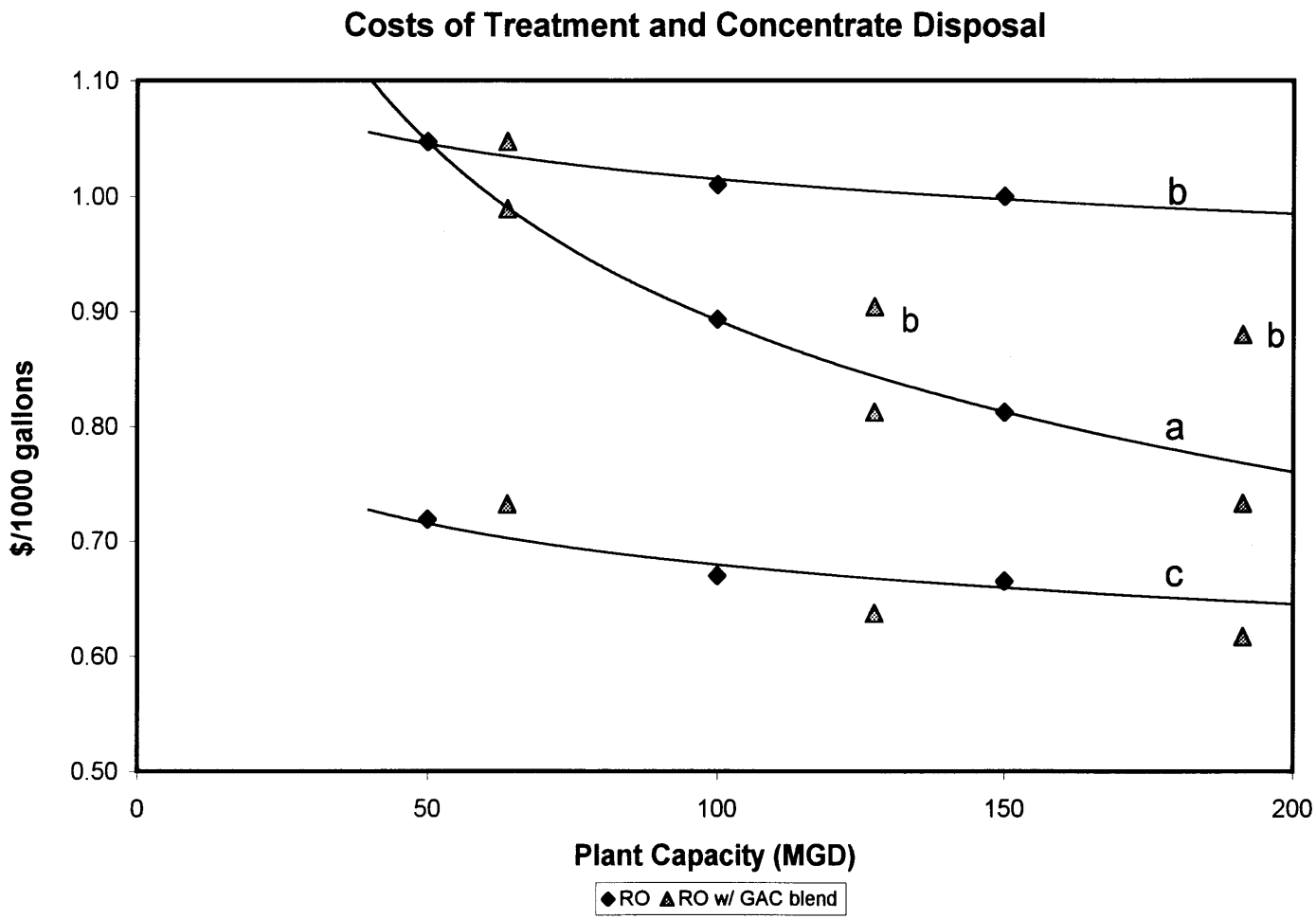

Figure 1.—Costs of treatment and concentrate disposal. The cost curves are for RO without GAC. Plant sizes are 50-, 100-, and 150-MGD. Concentrate disposal alternatives are: a. pipeline to Puerto Penasco, b. low-volume CASI pipeline, and c. high-volume CASI canal.

If the 47- to 76-milligram per liter (mg/L) RO product total dissolved solids (TDS) level appears too low for taste and product stabilization considerations, then lower rejection RO or nanofiltration membranes can be used either for the entire plant or only in RO stage 1. No savings in capital costs and only slight savings in energy costs are anticipated, however, if lower-rejection membranes are used.

Tables 3, 4, and 5, and figure 2 summarize the water costs of RO treatment and concentrate disposal. The highest cost is $1.05 per thousand gallons for a 50-MGD plant with concentrate disposal to either Puerto Penasco or to a low-volume CASI pipeline. The lowest cost is $0.66 per thousand gallons for a 150-MGD plant with concentrate disposal to a high-volume CASI canal.

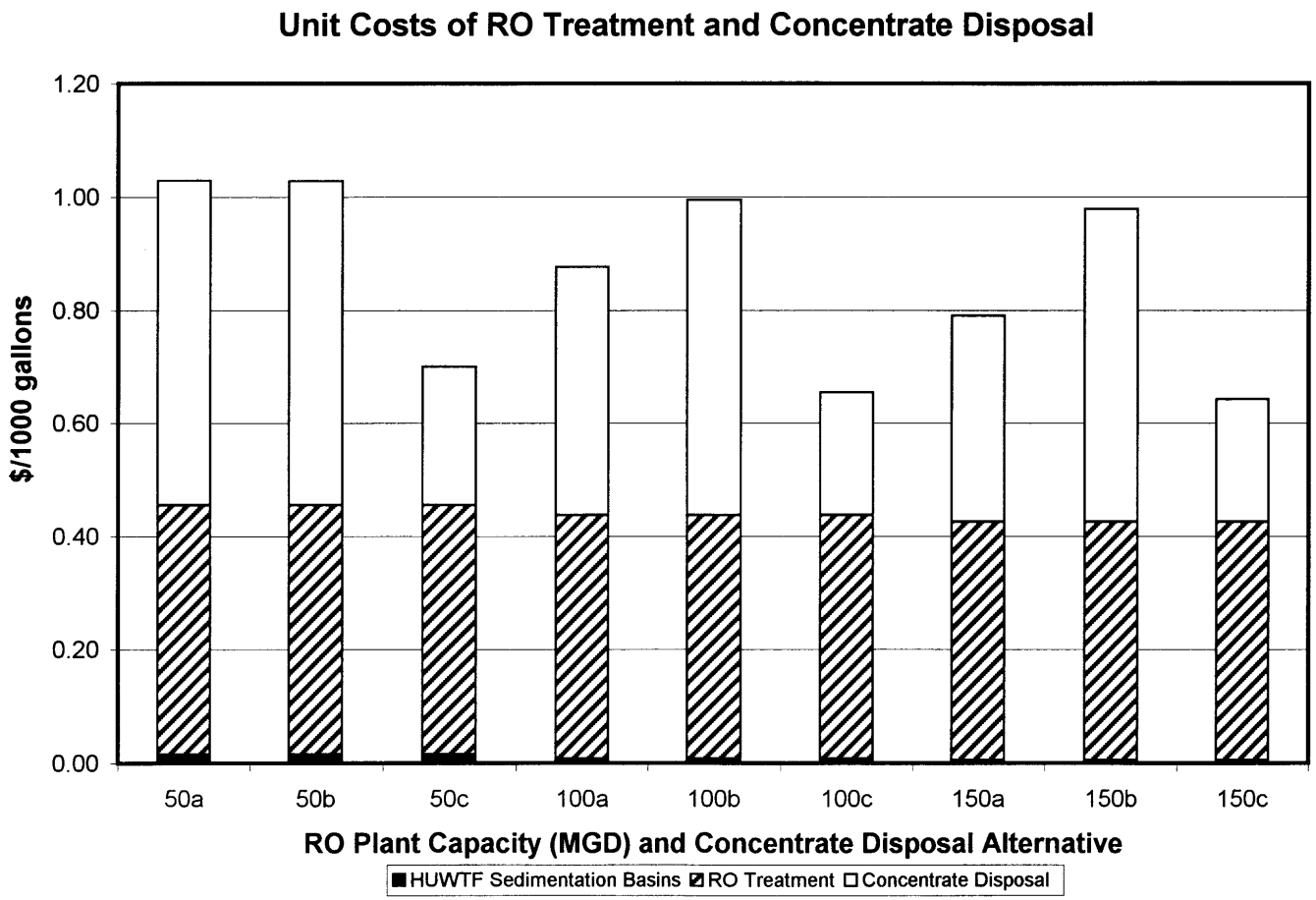

Figure 2.—Costs of RO treatment and concentrate disposal. X-axis text lists the the RO plant sizes (50-, 100-, and 150-MGD) and concentrate disposal alternatives. Concentrate disposal alternatives are: a. pipeline to Puerto Penasco, b. low-volume CASI pipeline, and c. for a 50-MGD plant: blend with WWTP effluent; for 100- and 150-MGD plants: high-volume CASI canal.

Table 1.—Cost summary of treatments and concentrate disposal alternatives for 50-, 100-, and 150-MGD RO plants

Treatment description	Water production			Product water quality					Concentrate production			
	RO MGD	GAC MGD	Total MGD	Month	Temp. C	TDS mg/L	Hardness mg/L	TOC mg/L	RO MGD	TDS mg/L	TDS removed tons/d	TDS removed tons/yr
50-MGD RO with no blending	50	0	50	Avg.	22.4	60	8.3	0.14	8.82	4382	17.1	5945
				Jan.	14.4	47	7.4	0.11				
				Aug.	30.8	76	10.9	0.18				

Concentrate disposal alternative	Costs of treatments and concentrate disposal															
	Capital costs (million $)					Annual costs (million $/yr)							Unit costs ($ per:)			
						Amortized capital cost	Annual O&M costs					Total annual costs	Product water			ton of TDS removed
	HUWTF Sed.Bas.	RO	GAC	Conc. disposal	Total		HUWTF Sed.Bas.	RO	GAC	Conc. disposal	O&M total		1000 gal	Ccf	13 Ccf	
Pipeline to Puerto Penasco	3.4	46.4	0.0	109.0	158.8	12.28	0.00	3.92	0.00	1.97	5.89	18.17	1.05	0.78	10.18	3056
Canal to Puerto Penasco				76.6	126.4	9.81				2.36	6.28	16.09	0.93	0.69	9.02	2707
Blend w/ WWTP effluent (with 9-MGD pipeline)				27.7	77.5	6.09				1.76	5.68	11.77	0.68	0.51	6.60	1980
Blend w/ WWTP effluent (with 9-MGD canal)				25.2	75.0	5.90				1.89	5.81	11.71	0.68	0.50	6.56	1970
Blend w/ WWTP effluent (with 26-MGD pipeline)				36.7	86.5	6.78				1.78	5.70	12.48	0.72	0.54	6.99	2099
Blend w/ WWTP effluent (with 26-MGD canal)				31.6	81.4	6.39				1.94	5.86	12.25	0.71	0.53	6.87	2060
CASI pipeline to Yuma				109.0	158.8	12.28				1.97	5.89	18.17	1.05	0.78	10.18	3056
CASI canal to Yuma				68.5	118.3	9.20				2.23	6.15	15.35	0.88	0.66	8.60	2582

Table 1.—Cost summary of treatments and concentrate disposal alternatives for 50-, 100-, and 150-MGD RO plants—continued

Treatment description	Water production			Product water quality					Concentrate production			
	RO MGD	GAC MGD	Total MGD	Month	Temp. C	TDS mg/L	Hardness mg/L	TOC mg/L	RO MGD	TDS mg/L	TDS removed tons/d	TDS removed tons/yr
50-MGD RO w/ GAC blend to 210 mg/L TDS in August	50	13.8	63.8	Avg.	22.4	197	77.3	0.20	8.82	4382	17.1	5945
				Jan.	14.4	187	76.6	0.17				
				Aug.	30.8	210	79.3	0.23				

Concentrate disposal alternative	Costs of treatments and concentrate disposal															
	Capital costs (million $)					Annual costs (million $/yr)							Unit costs ($ per:)			
						Amortized capital cost	Annual O&M costs					Total annual costs	Product water			ton of TDS removed
	HUWTF Sed.Bas.	RO	GAC	Conc. disposal	Total		HUWTF Sed.Bas.	RO	GAC	Conc. disposal	O&M total		1000 gal	Ccf	13 Ccf	
Pipeline to Puerto Penasco	3.4	46.4	35.2	109.0	194.0	15.10	0.00	3.92	0.90	1.97	6.78	21.88	0.99	0.74	9.62	3681
Canal to Puerto Penasco				76.6	161.6	12.63				2.36	7.17	19.81	0.90	0.67	8.71	3332
Blend w/ WWTP effluent (with 9-MGD pipeline)				27.7	112.7	8.91				1.76	6.57	15.49	0.70	0.52	6.81	2605
Blend w/ WWTP effluent (with 9-MGD canal)				25.2	110.2	8.72				1.89	6.70	15.43	0.70	0.52	6.78	2595
Blend w/ WWTP effluent (with 26-MGD pipeline)				36.7	121.7	9.60				1.78	6.59	16.19	0.73	0.55	7.12	2724
Blend w/ WWTP effluent (with 26-MGD canal)				31.6	116.6	9.21				1.94	6.75	15.96	0.72	0.54	7.02	2685
CASI pipeline to Yuma				109.0	158.8	12.28				1.97	5.89	18.17	1.05	0.78	10.18	3056
CASI canal to Yuma				68.5	118.3	9.20				2.23	6.15	15.35	0.88	0.66	8.60	2582

Table 1.—Cost summary of treatments and concentrate disposal alternatives for 50-, 100-, and 150-MGD RO plants—continued

Treatment description	Water production			Product water quality					Concentrate production			
	RO MGD	GAC MGD	Total MGD	Month	Temp. C	TDS mg/L	Hardness mg/L	TOC mg/L	RO MGD	TDS mg/L	TDS removed tons/d	TDS removed tons/yr
100-MGD RO with no blending	100	0	100	Avg.	22.4	60	8.3	0.14	17.6	4382	34.3	11890
				Jan.	14.4	47	7.4	0.11				
				Aug.	30.8	76	10.9	0.18				

Concentrate disposal alternative	Costs of treatments and concentrate disposal															
	Capital costs (million $)					Annual costs (million $/yr)							Unit costs ($ per:)			
						Amortized capital cost	Annual O&M costs					Total annual costs	Product water			ton of TDS removed
	HUWTF Sed.Bas.	RO	GAC	Conc. disposal	Total		HUWTF Sed.Bas.	RO	GAC	Conc. disposal	O&M total		1000 gal	Ccf	13 Ccf	
Pipeline to Puerto Penasco	3.4	88.1	0.0	159.0	250.5	19.43	0.00	7.77	0.00	3.79	11.56	30.98	0.89	0.67	8.68	2606
Canal to Puerto Penasco				112.0	203.5	15.85				4.35	12.12	27.96	0.81	0.60	7.84	2352
CASI pipeline to Yuma				211.0	302.5	23.38				3.91	11.68	35.06	1.01	0.76	9.82	2948
CASI canal to Yuma				124.0	215.5	16.76				4.35	12.12	28.88	0.83	0.62	8.09	2429
Future CASI pipeline to Yuma				111.0	202.5	15.77				3.66	11.43	27.20	0.78	0.59	7.62	2287
Future CASI canal to Yuma				57.0	148.5	11.66				3.83	11.60	23.26	0.67	0.50	6.52	1956

Table 1.—Cost summary of treatments and concentrate disposal alternatives for 50-, 100-, and 150-MGD RO plants—continued

Treatment description	Water production			Product water quality					Concentrate production			
	RO MGD	GAC MGD	Total MGD	Month	Temp. C	TDS mg/L	Hardness mg/L	TOC mg/L	RO MGD	TDS mg/L	TDS removed tons/d	TDS removed tons/yr
100-MGD RO w/ GAC blend to 210 mg/L TDS in August	100	27.5	127.5	Avg.	22.4	197	77.3	0.20	17.6	4382	34.3	11890
				Jan.	14.4	187	76.6	0.17				
				Aug.	30.8	210	79.3	0.23				

Concentrate disposal alternative	Costs of treatments and concentrate disposal															
	Capital costs (million $)					Annual costs (million $/yr)							Unit costs ($ per:)			
						Amortized capital cost	Annual O&M costs					Total annual costs	Product water			ton of TDS removed
	HUWTF Sed.Bas.	RO	GAC	Conc. disposal	Total		HUWTF Sed.Bas.	RO	GAC	Conc. disposal	O&M total		1000 gal	Ccf	13 Ccf	
Pipeline to Puerto Penasco	3.4	88.1	41.1	159.0	291.6	22.72	0.00	7.77	1.64	3.79	13.19	35.91	0.81	0.61	7.89	3020
Canal to Puerto Penasco				112.0	244.6	19.14				4.35	13.75	32.89	0.74	0.56	7.23	2766
CASI pipeline to Yuma				211.0	343.6	26.68				3.91	13.31	39.99	0.90	0.68	8.79	3363
CASI canal to Yuma				124.0	256.6	20.06				4.35	13.75	33.81	0.76	0.57	7.43	2843
Future CASI pipeline to Yuma				111.0	243.6	19.07				3.66	13.06	32.13	0.73	0.54	7.06	2702
Future CASI canal to Yuma				57.0	189.6	14.96				3.83	13.23	28.19	0.64	0.48	6.19	2371

Table 1.—Cost summary of treatments and concentrate disposal alternatives for 50-, 100-, and 150-MGD RO plants—continued

Treatment description	Water production			Product water quality					Concentrate production			
	RO MGD	GAC MGD	Total MGD	Month	Temp C	TDS mg/L	Hardness mg/L	TOC mg/L	RO MGD	TDS mg/L	TDS removed tons/d	TDS removed tons/yr
150-MGD RO with no blending	150	0	150	Avg.	22.4	60	8.3	0.14	26.5	4382	51.4	17835
				Jan.	14.4	47	7.4	0.11				
				Aug.	30.8	76	10.9	0.18				

Concentrate disposal alternative	Costs of treatments and concentrate disposal															
	Capital costs (million $)					Annual costs (million $/yr)							Unit costs ($ per:)			
						Amortized capital cost	Annual O&M costs					Total annual costs	Product water			ton of TDS removed
	HUWTF Sed.Bas.	RO	GAC	Conc. disposa	Total		HUWTF Sed.Bas.	RO	GAC	Conc. disposal	O&M total		1000 gal	Ccf	13 Ccf	
Pipeline to Puerto Penasco	3.4	129.4	0.0	189.0	321.8	25.02	0.00	11.65	0.00	5.59	17.24	42.26	0.81	0.61	7.89	2369
Canal to Puerto Penasco				132.0	264.8	20.68				6.26	17.91	38.59	0.74	0.55	7.21	2164
CASI pipeline to Yuma				314.0	446.8	34.53				5.89	17.54	52.07	1.00	0.75	9.73	2920
CASI canal to Yuma				178.0	310.8	24.18				6.52	18.17	42.35	0.81	0.61	7.91	2375
Future CASI pipeline to Yuma				167.0	299.8	23.35				5.52	17.17	40.51	0.78	0.58	7.57	2272
Future CASI canal to Yuma				86.0	218.8	17.18				5.78	17.43	34.61	0.66	0.50	6.47	1941

Table 1.—Cost summary of treatments and concentrate disposal alternatives for 50-, 100-, and 150-MGD RO plants—continued

Treatment description	Water production			Product water quality					Concentrate production			
	RO MGD	GAC MGD	Total MGD	Month	Temp C	TDS mg/L	Hardness mg/L	TOC mg/L	RO MGD	TDS mg/L	TDS removed tons/d	TDS removed tons/yr
150-MGD RO w/ GAC blend to 210 mg/L TDS in August	150	41.3	191.3	Avg.	22.4	197	77.3	0.20	26.5	4382	51.4	17835
				Jan.	14.4	187	76.6	0.17				
				Aug.	30.8	210	79.3	0.23				

Concentrate disposal alternative	Costs of treatments and concentrate disposal															
	Capital costs (million $)					Annual costs (million $/yr)							Unit costs ($ per:)			
						Amortized capital cost	Annual O&M costs					Total annual costs	Product water			ton of TDS removed
	HUWTF Sed.Bas.	RO	GAC	Conc. disposa	Total		HUWTF Sed.Bas.	RO	GAC	Conc. disposal	O&M total		1000 gal	Ccf	13 Ccf	
Pipeline to Puerto Penasco	3.4	129.4	50.4	189.0	372.2	29.06	0.00	11.65	2.33	5.59	19.56	48.62	0.73	0.55	7.12	2726
Canal to Puerto Penasco				132.0	315.2	24.72				6.26	20.23	44.95	0.68	0.51	6.59	2520
CASI pipeline to Yuma				314.0	497.2	38.57				5.89	19.86	58.43	0.88	0.66	8.56	3276
CASI canal to Yuma				178.0	361.2	28.22				6.52	20.49	48.71	0.73	0.55	7.14	2731
Future CASI pipeline to Yuma				167.0	350.2	27.38				5.52	19.49	46.88	0.71	0.53	6.87	2628
Future CASI canal to Yuma				86.0	269.2	21.22				5.78	19.75	40.97	0.62	0.46	6.00	2297

Table 2.—Cost summary of treatments and selected concentrate disposal alternatives for 50-, 100-, and 150-MGD RO plants

Treatment description	Water production			Product water quality					Concentrate production			
	RO MGD	GAC MG	Total MGD	Month	Temp. C	TDS mg/L	Hardnes mg/L	TOC mg/L	RO MGD	TDS mg/L	TDS removed tons/d	TDS removed tons/yr
50-MGD RO with no blending	50	0	50	Avg.	22.4	60	8.3	0.14	8.82	4382	17.1	5945
				Jan.	14.4	47	7.4	0.11				
				Aug.	30.8	76	10.9	0.18				

Concentrate disposal alternative	Costs of treatments and concentrate disposal															
	Capital costs (million $)					Annual costs (million $/yr)							Unit costs ($ per:)			
						Amortized capital cost	Annual O&M costs					Total annual costs	Product water			ton of TDS removed
	HUWTF Sed.Bas.	RO	GAC	Conc. disposal	Total		HUWTF Sed.Bas.	RO	GAC	Conc. disposal	O&M total		1000 gal	Ccf	13 Ccf	
a. Pipeline to Puerto Penasco	3.4	46.4	0.0	109.0	158.8	12.28	0.00	3.92	0.00	1.97	5.89	18.17	1.05	0.78	10.18	3056
b. CASI pipeline to Yuma				109.0	158.8	12.28				1.97	5.89	18.17	1.05	0.78	10.18	3056
c. Blend w/ WWTP effluent (with 26-MGD pipeline)				36.7	86.5	6.78				1.78	5.70	12.48	0.72	0.54	6.99	2099

Treatment description	Water production			Product water quality					Concentrate production			
	RO MGD	GAC MG	Total MGD	Month	Temp. C	TDS mg/L	Hardnes mg/L	TOC mg/L	RO MGD	TDS mg/L	TDS removed tons/d	TDS removed tons/yr
50-MGD RO w/ GAC blend to 210 mg/L TDS in August	50	13.8	63.8	Avg.	22.4	197	77.3	0.20	8.82	4382	17.1	5945
				Jan.	14.4	187	76.6	0.17				
				Aug.	30.8	210	79.3	0.23				

Concentrate disposal alternative	Costs of treatments and concentrate disposal															
	Capital costs (million $)					Annual costs (million $/yr)							Unit costs ($ per:)			
						Amortized capital cost	Annual O&M costs					Total annual costs	Product water			ton of TDS removed
	HUWTF Sed.Bas.	RO	GAC	Conc. disposal	Total		HUWTF Sed.Bas.	RO	GAC	Conc. disposal	O&M total		1000 gal	Ccf	13 Ccf	
a. Pipeline to Puerto Penasco	3.4	46.4	35.2	109.0	194.0	15.10	0.00	3.92	0.90	1.97	6.78	21.88	0.99	0.74	9.62	3681
b. CASI pipeline to Yuma				109.0	158.8	12.28				1.97	5.89	18.17	1.05	0.78	10.18	3056
c. Blend w/ WWTP effluent (with 26-MGD pipeline)				36.7	121.7	9.60				1.78	6.59	16.19	0.73	0.55	7.12	2724

Table 2.—Cost summary of treatments and selected concentrate disposal alternatives for 50-, 100-, and 150-MGD RO plants—continued

Treatment description	Water production			Product water quality					Concentrate production			
	RO MGD	GAC MG	Total MGD	Month	Temp. C	TDS mg/L	Hardness mg/L	TOC mg/L	RO MGD	TDS mg/L	TDS removed tons/d	TDS removed tons/yr
100-MGD RO with no blending	100	0	100	Avg.	22.4	60	8.3	0.14	17.6	4382	34.3	11890
				Jan.	14.4	47	7.4	0.11				
				Aug.	30.8	76	10.9	0.18				

Concentrate disposal alternative	Costs of treatments and concentrate disposal															
	Capital costs (million $)					Annual costs (million $/yr)							Unit costs ($ per:)			
						Amortized capital cost	Annual O&M costs					Total annual costs	Product water			ton of TDS removed
	HUWTF Sed.Bas.	RO	GAC	Conc. disposal	Total		HUWTF Sed.Bas.	RO	GAC	Conc. disposal	O&M total		1000 gal	Ccf	13 Ccf	
a. Pipeline to Puerto Penasco	3.4	88.1	0.0	159.0	250.5	19.43	0.00	7.77	0.00	3.79	11.56	30.98	0.89	0.67	8.68	2606
b. CASI pipeline to Yuma				211.0	302.5	23.38				3.91	11.68	35.06	1.01	0.76	9.82	2948
c. Future CASI canal to Yuma				57.0	148.5	11.66				3.83	11.60	23.26	0.67	0.50	6.52	1956

Treatment description	Water production			Product water quality					Concentrate production			
	RO MGD	GAC MG	Total MGD	Month	Temp. C	TDS mg/L	Hardness mg/L	TOC mg/L	RO MGD	TDS mg/L	TDS removed tons/d	TDS removed tons/yr
100-MGD RO w/ GAC blend to 210 mg/L TDS in August	100	27.5	127.5	Avg.	22.4	197	77.3	0.20	17.6	4382	34.3	11890
				Jan.	14.4	187	76.6	0.17				
				Aug.	30.8	210	79.3	0.23				

Concentrate disposal alternative	Costs of treatments and concentrate disposal															
	Capital costs (million $)					Annual costs (million $/yr)							Unit costs ($ per:)			
						Amortized capital cost	Annual O&M costs					Total annual costs	Product water			ton of TDS removed
	HUWTF Sed.Bas.	RO	GAC	Conc. disposal	Total		HUWTF Sed.Bas.	RO	GAC	Conc. disposal	O&M total		1000 gal	Ccf	13 Ccf	
a. Pipeline to Puerto Penasco	3.4	88.1	41.1	159.0	291.6	22.72	0.00	7.77	1.64	3.79	13.19	35.91	0.81	0.61	7.89	3020
b. CASI pipeline to Yuma				211.0	343.6	26.68				3.91	13.31	39.99	0.90	0.68	8.79	3363
c. Future CASI canal to Yuma				57.0	189.6	14.96				3.83	13.23	28.19	0.64	0.48	6.19	2371

Table 2.—Cost summary of treatments and selected concentrate disposal alternatives for 50-, 100-, and 150-MGD RO plants—continued

Treatment description	Water production			Product water quality					Concentrate production			
	RO MGD	GAC MGD	Total MGD	Month	Temp C	TDS mg/L	Hardness mg/L	TOC mg/L	RO MGD	TDS mg/L	TDS removed tons/d	TDS removed tons/yr
150-MGD RO with no blending	150	0	150	Avg.	22.4	60	8.3	0.14	26.5	4382	51.4	17835
				Jan.	14.4	47	7.4	0.11				
				Aug.	30.8	76	10.9	0.18				

Concentrate disposal alternative	Costs of treatments and concentrate disposal															
	Capital costs (million $)					Annual costs (million $/yr)							Unit costs ($ per:)			
						Amortized capital cost	Annual O&M costs					Total annual costs	Product water			ton of TDS removed
	HUWTF Sed.Bas.	RO	GAC	Conc. disposal	Total		HUWTF Sed.Bas.	RO	GAC	Conc. disposal	O&M total		1000 gal	Ccf	13 Ccf	
a. Pipeline to Puerto Penasco	3.4	129.4	0.0	189.0	321.8	25.02	0.00	11.65	0.00	5.59	17.24	42.26	0.81	0.61	7.89	2369
b. CASI pipeline to Yuma				314.0	446.8	34.53				5.89	17.54	52.07	1.00	0.75	9.73	2920
c. Future CASI canal to Yuma				86.0	218.8	17.18				5.78	17.43	34.61	0.66	0.50	6.47	1941

Treatment description	Water production			Product water quality					Concentrate production			
	RO MGD	GAC MGD	Total MGD	Month	Temp C	TDS mg/L	Hardness mg/L	TOC mg/L	RO MGD	TDS mg/L	TDS removed tons/d	TDS removed tons/yr
150-MGD RO w/ GAC blend to 210 mg/L TDS in August	150	41.3	191.3	Avg.	22.4	197	77.3	0.20	26.5	4382	51.4	17835
				Jan.	14.4	187	76.6	0.17				
				Aug.	30.8	210	79.3	0.23				

Concentrate disposal alternative	Costs of treatments and concentrate disposal															
	Capital costs (million $)					Annual costs (million $/yr)							Unit costs ($ per:)			
						Amortized capital cost	Annual O&M costs					Total annual costs	Product water			ton of TDS removed
	HUWTF Sed.Bas.	RO	GAC	Conc. disposal	Total		HUWTF Sed.Bas.	RO	GAC	Conc. disposal	O&M total		1000 gal	Ccf	13 Ccf	
a. Pipeline to Puerto Penasco	3.4	129.4	50.4	189.0	372.2	29.06	0.00	11.65	2.33	5.59	19.56	48.62	0.73	0.55	7.12	2726
b. CASI pipeline to Yuma				314.0	497.2	38.57				5.89	19.86	58.43	0.88	0.66	8.56	3276
c. Future CASI canal to Yuma				86.0	269.2	21.22				5.78	19.75	40.97	0.62	0.46	6.00	2297

Table 3.—Summary of flows, concentrations, and costs for a 50-MGD reverse osmosis plant

Reverse osmosis plant size	HUWTF product (RO feed)				RO product				RO concentrate			
	Flow MGD	TDS mg/L	Hardness mg/L	TOC mg/L	Flow MGD	TDS mg/L	Hardness mg/L	TOC mg/L	Flow MGD	TDS mg/L	TDS removed tons/day	TDS removed tons/yr
50-MGD	58.8	697	328	2.1	50	60	8.3	0.14	8.8	4,382	17.1	5,945

Concentrate disposal alternative	Costs of RO treatment and concentrate disposal													
	Capital costs (million $)				Annual costs (million $/yr)						Unit costs ($ per:)			
						Annual O&M costs					Product water			
	HUWTF Sed. Bas.	RO	Conc. disposal	Total	Amortized capital cost	HUWTF Sed. Bas.	RO	Conc. disposal	O&M total	Total annual costs	1,000 gal.	Ccf	13 Ccf	Ton of TDS removed
a. Pipeline to Puerto Penasco	3.4	46.4	109.0	158.8	12.28	0.00	3.92	1.97	5.89	18.17	1.05	0.78	10.18	3,056
b. CASI pipeline to Yuma	3.4	46.4	109.0	158.8	12.28	0.00	3.92	1.97	5.89	18.17	1.05	0.78	10.18	3,056
c. Blend w/WWTP effluent (with 26-MGD pipeline)	3.4	46.4	36.7	86.5	6.78	0.00	3.92	1.78	5.70	12.48	0.72	0.54	6.99	2,099

Table 4.—Summary of flows, concentrations, and costs for a 100-MGD reverse osmosis plant

Reverse osmosis plant size	HUWTF product (reverse osmosis feed)				Reverse osmosis product				Reverse osmosis concentrate			
	Flow MGD	TDS mg/L	Hardness mg/L	TOC mg/L	Flow MGD	TDS mg/L	Hardness mg/L	TOC mg/L	Flow MGD	TDS mg/L	TDS removed tons/day	TDS removed tons/yr
100-MGD	117.6	697	328	2.1	100	60	8.3	0.14	17.6	4,382	34.3	11,890

Concentrate disposal alternative	Costs of reverse osmosis treatment and concentrate disposal													
	Capital costs (million $)				Annual costs (million $/yr)						Unit costs ($ per)			
						Annual O&M costs					Product water			
	HUWTF Sed. Bas.	RO	Conc. disposal	Total	Amortized capital cost	HUWTF Sed. Bas.	RO	Conc. disposal	O&M total	Total annual costs	1,000 gal.	Ccf	13 Ccf	Ton of TDS removed
a. Pipeline to Puerto Penasco	3.4	88.1	159.0	250.5	19.43	0.00	7.77	3.79	11.56	30.98	0.89	0.67	8.68	2,606
b. CASI pipeline to Yuma	3.4	88.1	211.0	302.5	23.38	0.00	7.77	3.91	11.68	35.06	1.01	0.76	9.82	2,948
c. Future CASI canal to Yuma	3.4	88.1	57.0	148.5	11.66	0.00	7.77	3.83	11.60	23.26	0.67	0.50	6.52	1,956

Table 5.—Summary of flows, concentrations, and costs for a 150-MGD reverse osmosis plant

Reverse osmosis plant size	HUWTF product (reverse osmosis feed)				Reverse osmosis product				Reverse osmosis concentrate			
	Flow MGD	TDS mg/L	Hardness mg/L	TOC mg/L	Flow MGD	TDS mg/L	Hardness mg/L	TOC mg/L	Flow MGD	TDS mg/L	TDS removed tons/day	TDS removed tons/yr
150-MGD	176.5	697	328	2.1	150	60	8.3	0.14	26.5	4,382	51.4	17,835

Concentrate disposal alternative	Costs of reverse osmosis treatment and concentrate disposal													
	Capital costs (million $)				Annual costs (million$/yr)						Unit costs ($ per)			
						Annual O&M costs					Product water			
	HUWTF Sed. Bas.	RO	Conc. disposal	Total	Amortized capital cost	HUWTF Sed. Bas.	RO	Conc. disposal	O&M total	Total annual costs	1,000 gal.	Ccf	13 Ccf	Ton of TDS removed
a. Pipeline to Puerto Penasco	3.4	129.4	189.0	321.8	25.02	0.00	11.65	5.59	17.24	42.26	0.81	0.61	7.89	2,369
b. CASI pipeline to Yuma	3.4	129.4	314.0	446.8	34.53	0.00	11.65	4.89	16.54	51.07	0.98	0.73	9.54	2,864
c. Future CASI canal to Yuma	3.4	129.4	86.0	218.8	17.18	0.00	11.65	5.78	17.43	34.61	0.66	0.50	6.47	1,941