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PROCESS CONVERSION OF THE CITY OF SARASOTA'S REVERSE OSMOSIS WATER TREATMENT PLANT

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ABSTRACT

The City of Sarasota recently implemented a membrane process conversion replacement program at it's water treatment facility. The City owns and operates a 12 million gallon per day (MGD) water treatment facility, which is comprised of an ion-exchange process and a hollow-fiber reverse osmosis process. Over the past several years the City has implemented membrane replacement of the membrane process trains with DuPont® B-9-Twin™ 10-inch diameter hollow fiber configurations also to DuPont® Double Cartridge™ configuration, an 8-inch diameter modified version that provided superior performance over previous hollow fiber membrane configurations. However, because a business decision made by DuPont®, to not move forward with mass production of the newer 8-inch bundle technology, the City decided to convert the entire process to spiral-wound technology and end its reliance on hollow-fiber technology to meet its desalting treatment requirements. Consequently, in 1999 a construction program was initiated to replace the hollow-fiber process with low-energy spiral-wound technology.

WATER TREATMENT FACILITY DESCRIPTION AND OVERVIEW

This City of Sarasota Water Treatment Facility (WTF) is comprised of two major water treatment plants: a reverse osmosis water treatment plant (ROWTP), and an ion exchange (IX) water treatment plant. The facility, located at 1642 12th Street, Sarasota, Florida serves the residents of the City of Sarasota that live within the incorporated city limits. The 12 mgd capacity WTF results from a combination of 4.5 mgd from the ROWTP and 7.5 mgd that is provided by the ion-exchange plant, of which 2.3 mgd is a blended bypass water. Figure 1 presents a flow diagram of the City's existing ROWTP.

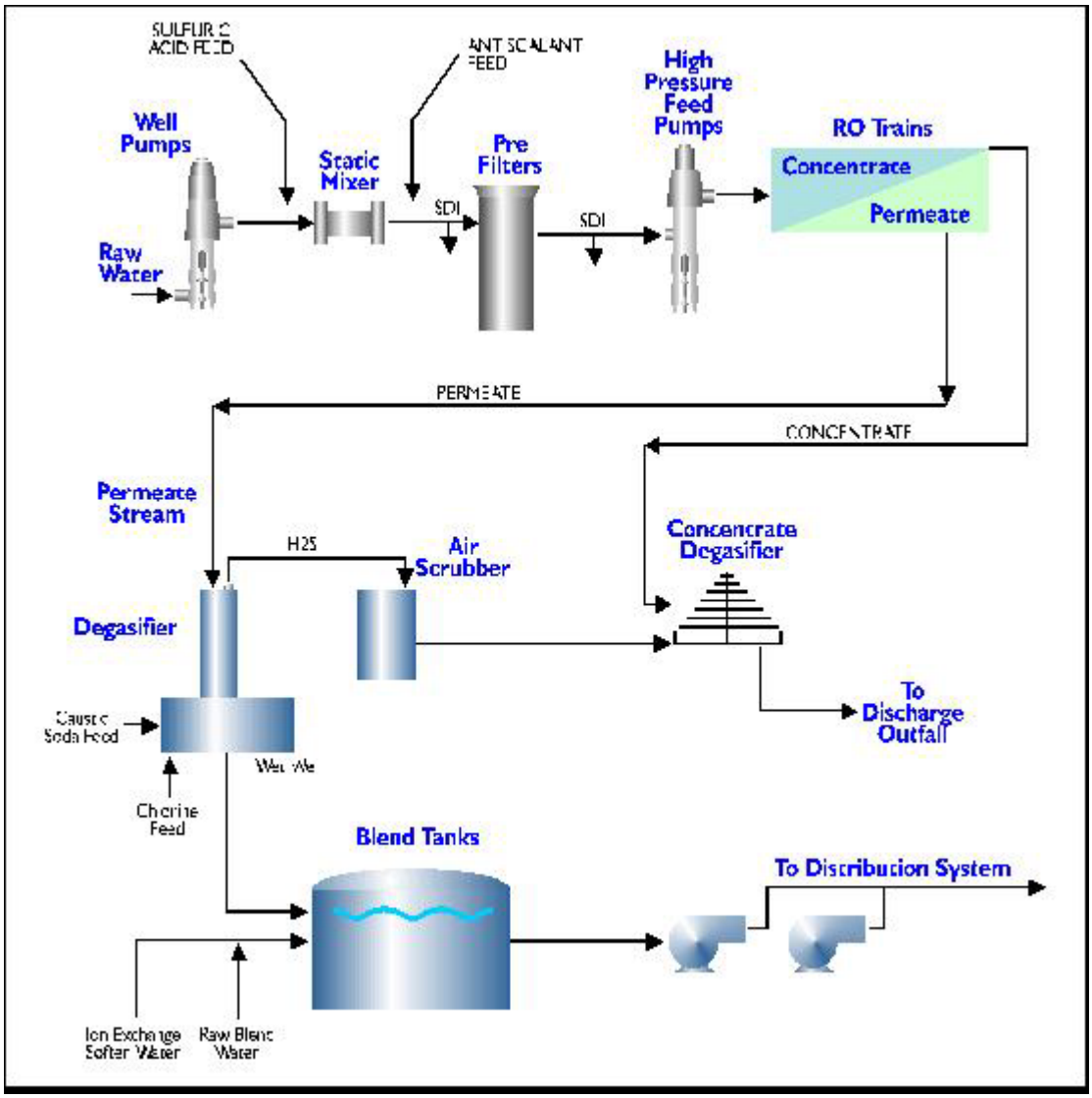

Figure 1. City of Sarasota ROWTP Flow Diagram

Table 1 provides an overview of the raw water quality of the City's raw water supply. The City's ROWTP system is supplied by a network of eight wells. These wells are located within the downtown city limits. The ROWTP system is permitted to withdraw 6.0 mgd on average and up to 6.5 mgd on a peak month basis. The wells pump into a common manifolded well piping network which feeds into the RO system.

The City's ROWTP was placed on-line in 1982, originally configured using DuPont Permasep® Products B-9™ polyaramid hollow fiber membrane assemblies. This desalting plant historically has been the largest operating drinking water treatment facility in the United States that relies upon hollow-fiber membranes. The City's RO system was composed of three separate sections or trains. Each train was originally designed to produce 1.5 mgd of permeate from 2.0 mgd of raw water at a recovery of 75 percent and a total plant capacity of 4.5 mgd. All trains had the capability of operating independently from the others, and each train is composed of two stages.

As part of the City's *Water Supply and Treatment System Improvements Program*, the City desired exploring opportunities available to them as a result of recent advances in membrane technology. In 1997 two of the three trains were remembraned with DuPont® B-9™ twin membranes bundles. Subsequent pilot testing that compared DuPont's new cartridge fiber bundles with spiral-wound membranes indicated that the cartridge bundle technology was a cost-effective retrofit alternative; such that, in July 1999 one of the process trains was successfully converted from the 10-inch B-9™ configuration to the new 8-inch Double Cartridge™ configuration. This work has been reported elsewhere (Boyle Engineering Corporation 1998; Duranceau et.al. 2000).

Investigations completed after by the City and Boyle resulted in a change in scale inhibitor from polyacrylate-based scale inhibitor to sodium hexametaphosphate, which was found to have improved performance. In addition, based on work implemented by DuPont® the City successfully implemented sodium hypochlorite cleaning (pH 12) to rectify the declining performance of the new permeators (Myers 1999). The results of the change from the original hollow-fiber membranes to DuPont's® newest double-cartridge hollow-fiber technology for one of the City's three membrane process trains had been reported elsewhere (Duranceau et al 2000).

In 1999, DuPont announced the company's decision not to accept any new hollow-fiber membrane orders for new projects beginning November 18, 1999 (Water Desalination Report 1999). Hence the plans to retrofit the remaining trains with the new DuPont® Double Cartridge™ configuration were cancelled. At this point in time the decision was made to implement an entire process conversion from hollow-fiber to spiral-wound technology in order to maintain process reliability for the City's ROWTP.

Table 1.

Raw Water Analysis

Parameter	Median	Standard Deviation	Range
Turbidity (ntu)	0.04	0.03	0.02 - 0.08
Alkalinity (mg/L as $CaCO_3$)	130	1.0	129 - 131
pH	7.14	0.01	7.13 - 7.15
Total Organic Carbon (mg/L)	2.0	0.14	1.84 - 2.11
Total Iron (mg/L)	0.01	0.0	< 0.005 – 0.006
Total Hardness (mg/L as $CaCO_3$)	1202	72.1	1125 – 1269
Bromide (mg/L)	0.11	0.09	0.06 – 0.24
Total Suspended Solids (mg/L)	1.70	0.98	< 0.2 – 1.7
Total Dissolved Solids (mg/L)	2210	26.5	2200 – 2250
Sulfate (mg/L)	1000	41.6	996 – 1070
Chloride (mg/L)	352	2.52	349 – 354
Fluoride (mg/L)	1.20	0.06	1.1 – 1.2
Strontium (mg/L)	21	12.7	0.05 – 23
Silica (mg/L)	23	2.31	19 – 23
Magnesium (mg/L)	122	3.1	118 - 124

CONSTRUCTION PERMITTING PROCESS FOR ON-LINE PRODUCTION

The permitting process was integral to the construction of the ROWTP retrofit. Implementing the retrofit activities in phases to keep the plant operational became a complicated approach to permitting. The City of Sarasota was mandated to compliance with the primary and secondary drinking water standards required by the Florida Department of Environmental Protection (FDEP) and the United States Environmental Protection Agency (USEPA). The primary FDEP rules and regulations that applied to the City of Sarasota ROWTP are Chapters 62-550, 62-551, 62-555 and 62-560, of the Florida Administrative Code (FAC). The regulations are implemented by the Sarasota County Department of Health (DOH).

Required permits and letters are listed in Table 2. The first step in implementing the construction process was to obtain a drinking water system construction permit which was required and regulated by the DOH. For the City's project, a multi-phased permitting approach was used in order to maintain desalting water production while implementing construction. Following the completion of each phase of construction the DOH issued a Letter of Clearance for each new membrane skid as the older skids were retired.. The DOH was also interested in the City's plan for security of the facility during construction so that additional measures were placed on the Contractor for coordinating their on-site activities.

PROCESS RETROFIT

A process retrofit design was implemented and bidding documents prepared. Once the City had selected the most qualified best priced Contractor team (Cardinal Constructors- Harn R/O Systems, Inc.) a construction contract was executed. Preliminary evaluations concluded two viable options available relative to process train configurations. It was also determined that it would be necessary to remove and replace the existing high-pressure RO pumps. Additionally, due to the space limitations in the process room, the length of the spiral-wound pressure vessels was limited to no more than 6 elements per pressure vessel.

The retrofit option selected called for a two-stage spiral-wound membrane process configuration of 28:14 array using Hydranautics CPA-3 membranes in the first stage and Hydranautic ESPA-2 membranes in the second stage. Each pressure vessel would contain 6 elements. Preliminary start-up testing result indicate a normal membrane plant operation. At the time of this publication, the spiral-wound process experienced a 0.44 gal/day permeate capacity decline representing a cleaning frequency of 321 days. Initial water quality data is presented in Table 3 and initial process information is presented in Table 4.

Process information for the first few months of operation of one of the spiral-wound process trains are presented in Figure 2 and Figure 3 and 4. Figure 2 shows pressure as a function of time for the initial period of operation. The small deviations in data are a direct result of normal construction activities in that adjustment to the process skids occur from time to time. Figure 3 shows total permeate production as a function of time. System recovery was maintained at 75 percent water recovery, and salt passage consistently remained 0.8 percent.

Table 2.

ROWTP Required Permits/Letters

Phase	Description	Type of Permit/Letter
1. Permitting	Project design and specifications provided to FDEP.	Drinking Water System Construction Permit [(1)]
2. Raw Water Line	Temporary and permanent raw water bypass line.	Letter of Clearance
3. Temporary Skid	Temporary skid; Scale Inhibitor Chemical feed system	Letter of Clearance
4. Train C Replacement	Train C Demo/Construction Partial DCS system	Letter of Clearance
5. Train B Replacement	Train B Demo/Construction/Partial DCS system	Letter of Clearance
5. Train A Replacement	Train A Demo/Construction/Partial DCS system	Letter of Clearance
7. Instrumentation/Controls	Completion of DCS system integration to existing facility	Letter of Clearance
8. Final Certification	Included record drawings	Letter of Clearance

This permit had several special conditions requiring additional letters of clearance.

Table 3.

Preliminary Water Quality Results

Parameter	Units	Raw Feed	Treated Feed	Permeate	Concentrate
Date		11/20/2002	11/20/2002	11/20/2002	11/20/2002
Time		8:14	8:33	8:50	9:02
Temperature	C	27.6	27.6	28.0	28.1
Conductivity	us/cm	2870	2870	45.8	9480
Turbidity	NTU	0.08	0.09	0.09	0.12
pH	SU	7.15	5.95	5.47	6.31
Total coliform	P/A	A	A	A	P
Fecal coliform	P/A	A	A	A	A
TSS	mg/l	<1	<1	<1	<1
HPC	CFU/ml	<1	<1	2	11
Yeast/Mold/Fungi	CFU/100ml	no fungal growth isolated	no fungal growth isolated	no fungal growth isolated	no fungal growth isolated
TOC	mg/l	1.8	1.93	0.52	5.88
UV 254	cm-1	0.065	0.034	0.001	0.125
TDS	mg/l	1970	1990	64	8120
Alkalinity	mg/l as CaCO3	129	48	8.5	142
Total Hardness	mg/l as CaCO3	1111	1137	1.5	4430
Ca	mg/l	262	264	0.34	1050
Na	mg/l	210	201	9	770
Dissolved Fe	mg/l	0.058	0.060	0.051	0.115
Total Fe	mg/l	0.060	0.062	0.042	0.113
Mg	mg/l	111	116	0.15	439
Mn	mg/l	<.005	<.005	<.005	0.01
K	mg/l	6.6	6.7	0.29	27
Sr	mg/l	24.21	23.21	<.03	107.2
Ba	mg/l	0.04	0.06	<.03	0.22
Dissolved SiO2	mg/l	18.6	19.2	0.327	31.3
Total SiO2	mg/l	22.4	22.1	0.232	85.2
Fluoride	mg/l	1.5	1.5	0.49	4.8
Total P	mg/l as PO4	<.3	<.3	<.3	0.46
Ortho P	mg/l as P	<.01	0.01	0.01	0.02
Sulfide	mg/l as H2S	2.8	3.3	4.9	1.9
Chloride	mg/l	445	460	3	1690
Sulfate	mg/l	737	820	<1	3400
Nitrate	mg/l as N	<.02	<.02	<.02	<.02

Table 4.

Preliminary Process Operations Summary

Parameter	Skid B			Skid C	
	Start-up in the Temp Skid 10/30/02	Moved Membranes from Temp Skid to Skid B 1/22/03	As of 2/11/03	Start-up 12/23/02	As of 2/11/03
Feed Pressure, psi	152	160	174	175	180
Interstage Pressure, psi	132	139	153	150	152
Permeate Pressure, psi	11	6.5	18.6	12.8	17.2
Concentrate Pressure, psi	111	139	132	129	130
Permeate Flow, gpm (1^{st} Stage/2^{nd} Stage)	1,047 (757/290)	1,140 (753/287)	1,043 (751/292)	1,046 (736/310)	1,044 (731/313)
Feed Conductivity, umohs	2730	2810	2810	2970	2810
Permeate Conductivity, umohs	44.8	45.2	44	52.6	45
Rejection Rate	98.4	98.4	98.4	98.2	98.4
Recovery	75%	75%	75%	75%	75%

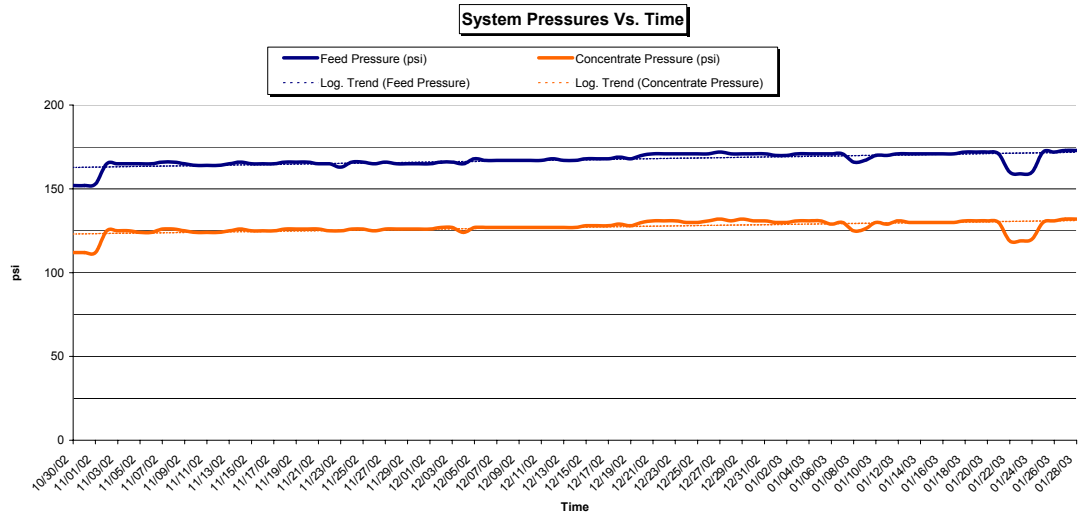

Figure 2. Spiral-Wound Skid Pressure as a Function of Time

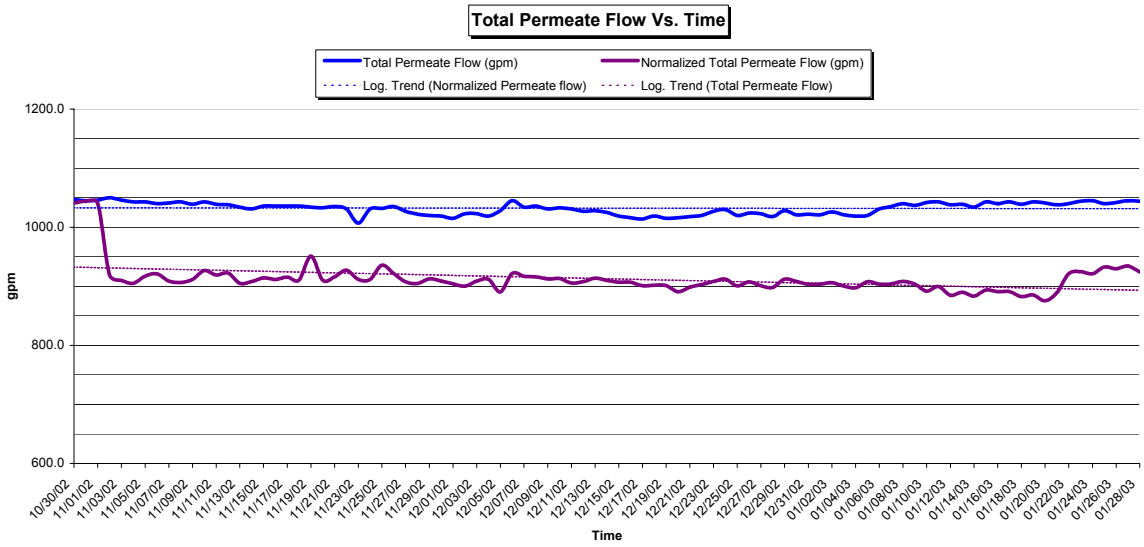

Figure 3. Total Permeate Flow as a Function of Time

SUMMARY

A retrofit conversion of a desalting facility from hollow-fiber to spiral-wound membrane technology was successfully implemented by the City of Sarasota. Preliminary start-up testing result indicate a normal membrane plant operation. System recovery was maintained at 75 percent water recovery, approximately 950 gpm permeate flow and salt passage consistently remained 0.8 percent. At the time of this publication, the spiral-wound process experienced minimal permeate capacity decline representing a cleaning frequency approaching one year.

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