

The Flexibility of the Severn Trent DeepBed® Filter System

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INTRODUCTION

The key to the success of a wastewater reuse program is employing tertiary filtration technology capable of producing a consistently high quality effluent. Good filtration offers the following benefits:

- Lowers total suspended solids (TSS), turbidity and BOD to help meet discharge permits.
- Enhances disinfection processes, both chlorination and UV.
- Improved water quality increases public acceptance of reuse.

Over the past four decades Severn Trent Water Purification, Inc. (STWP) has successfully used a deep-bed filter technology to produce high quality industrial and municipal wastewater effluents for discharge and reuse. With minor modifications, this proven filter design offers the added flexibility to also serve as a denitrification filter.

DEEPBED® FILTRATION

Performance differences of various filter types become clear over time. In a wastewater environment, day-to-day operating requirements and long-term reliability distinguish one type of filter from another. DeepBed® filtration of the type used by STWP offers the following additional benefits:

- Design suited to wastewater with no nozzles, screens, or small orifices to clog.
- Long run times between backwashes due to high solids holding capacities.
- Higher solids loading capacity better able to contain process upsets within the plant while preventing the loss of beneficial biomass.
- Inlet TSS concentrations up to 1000 mg/l have been filtered effectively, with effluent concentrations as low as 1 mg/l achieved. (Source: WEF MOP8, Vol II, page 1027)
- Excellent removal of fat/oil/grease, viruses, Giardia and Cryptosporidium.
- Ability to handle shock hydraulic loads
- Ideal design for denitrification within the filter.
- Less chance of short circuiting due to depth of bed.
- Lower backwash water consumption, usually 2 to 4 % of forward flow.
- Virtually no media loss.
- Use of single sand media and combined air/water backwash gives far superior cleaning using lower water rates (only 6 gpm/ft²).
- Mudballing and algae binding of filter media prevented.
- Floatables on top of filter are expelled with each backwash.
- No need to chlorinate to maintain filter bed condition.
- A great long term track record is developing, with filter facilities operating at least 25 years before bed maintenance is needed.

The DeepBed® filter used by STWP contains 4 to 6 feet of coarse rounded silica sand, with an effective size of 2-3 mm, selected for its ability to hold solids in the voids between particles during filtration and clean up quickly during backwash. Operation is down flow with the water usually being distributed by concrete weirs running the length of the filter at the top. The weirs of all filters are at the same elevation to allow for equal flow splitting. Water level slowly rises in the filter as it becomes loaded with suspended solids and is an indicator of need for backwash.

Five layers of gravel support the filter sand and help distribute backwash air and water flow. Underneath the gravel is a layer of arched high density polyethylene encased concrete underdrain blocks. These have large side and upward passages for unrestricted flow. The underdrain blocks are laid without grout on the filter concrete floor. They cover and protect rows of stainless steel pipes with spaced orifices that ensure even distribution of backwash air across the entire bottom of the filter during backwash. A slotted channel cast into the floor under the blocks collects effluent during filtration and distributes backwash water during backwash. Backwashing is done with filtered effluent at 6 gpm/ft² and low pressure air at 5 icfm/ft² simultaneously.

STWP's filter design was developed for demanding steel mill use first in Germany then in the US after World War II. STWP began applying its heavy duty filters to the tertiary filtration of municipal wastewater after 1960. It was found that the filters could handle a varying loading of TSS while still producing a very consistent low TSS, low turbidity effluent. The deep sand bed allows maximum ability for the solids to coagulate on their own. Chemical coagulants are rarely needed on municipal wastewaters. Typical effluents range from 1 – 3 mg/l TSS with turbidity usually from 0.4 to 0.7 NTU.

The coarse rounded sand allows the penetration and retention of heavy solids loadings within the filter bed and long run times with hydraulic loadings of 2 – 8 gpm/ft². The vigorous backwash using simultaneous air and water ensures that any accumulation can be quickly broken up and removed in a concentrated form which is easy to handle. The vigorous backwash also prevents algae from binding up the sand, so chlorination of the filter is not required.

The characteristics of the filter sand and the ability to consistently backwash out accumulated solids in a reliable manner are keys to the proven success of this technology.

DEEPBED® FILTER ADVANTAGES

The three major advantages for a STWP DeepBed® filter are:

1. Unparalleled ability to remove pathogens, grease, and shock loadings of TSS with outstanding effluent quality. This effluent meets or exceeds all US reuse standards of 2 NTU or less (California Title 22). See plant design data in Table 1. Filter effluent turbidity is typically 0.4 NTU for a TSS removal filter and about 0.7 NTU for a denitrification filter.
2. Backwash water usage is typically only 2% to 4% of forward flow for the STWP filter. This is far better than the average performance of other filter types, which averaged 11% and ranged from 7% to 15% in an actual survey. Lower

backwash water consumption and recycle cuts plant operating costs dramatically and increases plant capacity.

3. The STWP DeepBed® filter has the flexibility to be converted to a denitrification filter with minor modifications that do not require the filter to be taken out of service. This allows for simultaneous TSS and NO₃-N removal capability.

HIGH FLOW RATE FILTRATION EXPERIENCE

Partial Installation List

<u>Plant</u>	<u>Filter Area (ft²)</u>	<u>Flow (gpm)</u>	<u>Unit Rate (gpm/ft²)</u>
Algoma Steel	10,000	62,500	6.25
Jessop Steel	480	2,500	5.21
Shell Oil	1,538	7,000	4.55
Fayetteville, NC	4,608	14,000	3.10
Largo, FL	3,000	9,800	3.00
Orlando, FL	3,600	See below	

Orlando's Iron Bridge plant has two parallel filtration systems. When the traveling bridge filters are overloaded or down for repairs, the STWP filters, designed for 12.0 MGD, have handled much higher flows while giving great performance.

CITY OF ORLANDO IRON BRIDGE AWTP SUMMER 1994

<u>Month</u>	<u>Flow (MGD)</u>	<u>TSS out (mg/l)</u>	<u>Turbidity</u>	<u>Rate (gpm/ft²)</u>
July	23.76	<2.05	<1 NTU	4.58
August	29.40	<2.05	<1 NTU	5.68
September	27.22	<2.12	<1 NTU	5.25

Iron Bridge's 3600 ft² of STWP DeepBed® filters basically replaced 10,000 ft² of traveling bridge filters. During the summer of 1994 the peak flow was 33 MGD or a filter rate of 6.37 gpm/ft². In 1995 Orlando/Iron Bridge won the Florida Phelps Award for the best treatment plant in the entire state of Florida. This successful performance encouraged Iron Bridge to double the STWP filter plant to 7200 ft² in 2001 and decommission the traveling bridge filters.

HIGH SOLIDS REMOVAL EXPERIENCE

During a period of clarifier upsets at the Largo, Florida WWTP the Denite® filters handled very high solids loadings (max of 200 mg/L reduced to 2.4 mg/L TSS) while great denitrification performance was maintained. Daily data from November 1992:

TEMPERATURE		LARGO, FLORIDA OPERATIONAL DATA												
BEG 28.0 °C		MONTH: NOVEMBER YEAR: 1992												
END 26.0 °C		FLOW - (MGD)					CBOD		TOTAL SUSPENDED SOLIDS				pH	
DATE	PLANT 1	PLANT 2	PLANT 3	SURFACE WATER DISCHARGE	FLOW EFFLUENT REUSE	TOTAL PLANT EFFLUENT	MG/L		MG/L				pH	
							INF	EFF	INF	EFF	TR STA	REUSE	INF	EFF
1	2.39	5.06	5.11	6.97	4.44	11.40	164	2.90	183	1.1	27.3	0.6	7.2	7.4
2	2.43	5.20	5.40	7.40	4.70	12.10	116	1.28	196	0.8	67.3	0.8	7.3	7.2
3	2.20	5.32	5.48	7.36	4.97	12.33	107	2.92	214	1.4	51.0	0.6	7.3	7.1
4	2.36	4.83	5.57	6.88	5.07	11.95	170	3.32	220	1.4	35.7	0.6	7.2	7.2
5	2.42	5.18	5.58	7.44	4.81	12.25	148	2.86	165	1.4	26.7	1.2	7.2	7.3
6	2.41	5.40	5.55	8.05	4.49	12.54	149	2.05	200	1.4	162.0	0.8	7.3	7.2
7	2.35	5.31	5.39	7.89	4.51	12.40	96	1.67	142	1.2	7.0	4.0	7.1	7.0
8	2.42	5.30	5.50	7.35	4.83	12.18	119	1.58	182	1.3	48.7	1.2	7.2	7.2
9	2.32	5.46	5.47	6.90	5.36	12.26	136	2.71	219	0.6	86.0	1.0	7.3	7.4
10	2.44	5.66	5.67	6.43	6.29	12.72	131	3.13	188	1.2	140.0	0.6	7.2	7.3
11	2.40	5.50	5.68	7.31	4.34	11.65	149	2.31	181	0.2	148.0	0.4	7.3	7.3
12	2.52	5.61	5.47	8.07	2.95	11.02	145	2.08	193	0.6	89.0	1.2	7.3	7.2
13	2.46	5.59	5.43	8.30	3.62	11.93	133	3.04	200	1.8	28.3	1.4	7.2	7.3
14	2.51	5.39	5.33	7.74	4.76	12.50	134	2.98	200	2.0	56.3	1.6	7.2	7.2
15	2.65	5.13	5.09	6.96	4.70	11.66	131	1.90	190	1.8	50.0	1.0	7.2	7.4
16	2.42	5.31	4.65	7.14	4.29	11.43	162	1.67	205	2.4	200.0	1.2	7.3	7.2
17	2.20	5.36	4.79	7.13	4.21	11.35	129	1.43	175	1.4	116.0	1.6	7.3	7.3
18	2.17	5.27	5.04	7.06	4.20	11.26	164	2.05	217	3.2	8.3	1.4	7.2	7.5
19	2.57	5.40	5.13	7.55	4.22	11.77	148	3.62	173	1.9	28.3	0.6	7.3	7.3
20	2.42	5.05	4.92	6.81	4.26	11.07	173	2.38	181	1.2	14.0	1.8	7.3	7.3
21	2.49	4.95	5.20	7.43	4.36	11.79	122	2.35	115	0.8	30.3	5.4	7.1	6.9
22	2.59	5.46	5.43	7.65	4.45	12.09	161	2.51	170	1.4	16.7	1.8	7.2	7.3
23	2.58	5.33	5.36	7.66	3.41	11.07	158	3.10	250	1.6	11.3	1.8	7.2	7.4
24	2.63	5.43	5.42	7.17	4.29	11.45	163	2.81	223	1.4	13.0	1.0	7.1	7.2
25	2.28	5.43	5.39	6.62	5.45	12.07	167	2.91	141	1.4	89.5	1.2	7.2	7.1
26	2.54	5.21	5.27	5.94	5.88	11.82	171	2.95	192	1.3	17.3	1.8	7.1	7.4
27	2.38	5.20	5.42	6.44	5.75	12.19	147	2.00	151	2.0	25.3	1.6	7.2	7.2
28	2.41	5.41	5.39	7.00	5.58	12.58	133	1.96	167	2.0	23.3	6.4	7.1	7.0
29	2.44	5.35	5.30	7.22	5.23	12.45	140	1.53	158	1.6	17.6	3.7	7.2	7.1
30	2.45	5.50	5.10	6.68	5.70	12.37	169	1.84	185	2.1	8.7	3.0	7.3	7.5
31														
TOTAL	72.85	159.60	159.53	216.55	141.11	357.66	*****	*****	*****	*****	*****	*****	*****	*****
AVG	2.43	5.32	5.32	7.22	4.70	11.92	145	2.39	186	1.5	54.8	1.7	7.2	7.2

Configuration: Five 10' x 60' TETRA Deep Bed Filters = 3000 ft²
 Nitrate results for month: 7.0 mg/L on, 0.1 mg/L off

↑ ↑
 OFF ON

TABLE 1 -- PLANT DESIGN DATA

Tampa Bay Area Plants 1993	Filters used in Denite® Mode	Biological Process Upstream of Filters	Filters Placed in Service	Avg. Design Flow (mgd)	Peak Design Flow (mgd)	Actual Avg. Flow (mgd)	Actual Peak Flow (mgd)	Total No. of Filters	Area Per Filter (ft²)	Design Filtration Rates (gpm/ft²)	
										Avg.	Peak
Howard F. Curren	Yes	PO2	1977	96	192	70	100	32	1050	1.98	3.97
Mid County	Yes	AS	1992	1	2	0.8	1.3	3	123	1.88	NA
Dunedin	Yes	A2O	1991	6	12	4.5	12	4	500	2.08	4.17
Largo	Yes	A2O	1990	12	24	17	22	5	600	2.77	5.55
Bradenton	Yes	Car	1991	6	15	6	10	4	500	2.08	5.21
South County	No	E/A	1988	6	15	2.2	6	4	500	2.08	5.21
Falkenburg	No	AX/O	1988	6	12	3	8	5	500	1.67	3.33
Valrico	No	AX/O	1989	3	6	2.5	6	3	500	1.39	2.78
Dale Mabry	Seasonal	AX/O	1989	6	15	3	10	5	650	1.28	NA

OPERATING DATA

Tampa Bay Area Plants	Plant	CBOD (mg/L)	Effluent Quality			Turbidity (ntu)	Backwash Freq. (hours)	Bumping Freq. (hours)	Methanol to NO ₃ -N Ratio	Nitrate Monitoring Frequency (hours)	Actual % of Forward Flow for Backwash
			TSS (mg/L)	NO ₃ -N (mg/L)	NO ₃ -N (mg/L)						
Howard F. Curren	Howard F. Curren	2.5	1.9	0.9	0.7	24	2.5	3.0	1	--	
Mid County	Mid County	2.2	1.5	1.9	0.7	36	3	3.2	2.5	3.9	
Dunedin	Dunedin	1.0	1.0	0.9	0.6	32	3	2.7	2	4.3	
Largo	Largo	3.8	1.6	0.1	0.8	20	2	3.3	2	2.3	
Bradenton	Bradenton	2.8	2.5	0.1	0.7	58	4	3.2	2	4.3	
South County	South County	1.2	1.0	--	0.4	84	--	--	--	3.4	
Falkenburg	Falkenburg	2.6	2.0	0.1	0.3	60	--	--	--	4.3	
Valrico	Valrico	1.3	0.7	1.2	0.4	84	--	--	--	2.2	
Dale Mabry	Dale Mabry	1.9	1.0	1.9	0.4	84	4	--	--	4.0	

Acronyms:	A2O	Anaerobic/Anoxic/Oxic	E/A	Extended Aeration
AS	Activated Sludge <th>PO2</th> <td>Pure Oxygen</td>	PO2	Pure Oxygen	
AX/O	Anoxic/Oxic	--	Not Applicable	
Car	Carousel	NA	Data Not Available	



DENITE® DENITRIFICATION FILTERS

Through pilot testing in the 1970's STWP discovered that the DeepBed® filter was an excellent environment for encouraging the growth of fixed-film denitrifying bacteria. A carbon source, usually methanol, is fed proportionally to flow and nitrate into the filter influent. This provides a food source for the denitrifiers while nitrate and nitrite provides the oxygen. The result is the removal of oxidized nitrogen from the wastewater down to 1.0 mg/l or less, generation of nitrogen gas, carbon dioxide, and biomass. Methanol use in a denitrification filter is much more efficient than in stirred tank systems, due to the higher concentration of biomass possible in the filter. Two full scale filter systems also successfully used acetic acid as a carbon source for extended periods. The process of simultaneous denitrification and suspended solids removal was patented and bears the trademark name Denite®. A partial list of current Denite® systems:

<u>Plant</u>	<u>Flow (MGD)</u>	<u>Year</u>
Howard Curren AWTP, Tampa, FL	100	1990
Bradenton, FL	6	1991
Fiesta Village, FL	5	1986
Padre Dam, Santee, CA	3	1996
Scituate, MA	1.67	1998
H.L. Mooney, Woodridge, VA	18	2000
West Palm Beach, FL	10	2000
Fruitville Road, Sarasota, FL	1.5	2005
Pilgrim's Pride, Lake City, FL	2	2006

Further development work by STWP established guidelines for Denite® filter sizing, seeding and startup, the dosing of methanol, and optimum backwash frequency. Filtration efficiency and biomass concentration is maintained by the proper backwash duration and frequency. Recent data from several full-scale municipal installations shows that dirty backwash water returned to the front of the plant has been averaging only 2 to 4% of forward flow. The average for other denitrification filters can be as high as 10%.

TETRAPACE™

STWP offers a proprietary chemical dosing control system to minimize denitrification carbon source usage and operator attention. The system can be easily adapted to existing installations. The control system uses filtration flow and online inlet and effluent NO₃-N to vary dosage continuously and keep nitrogen removal at the desired set point at all times. This has completely automated the Denite® process, eliminating the need for frequent manual testing with significant time and labor savings. This system was estimated to save 30% on methanol consumption at Havelock, NC (source: Pushing the Limits of Technology: Performance and Operations Considerations for Plants Operating High Level Nitrogen Removal Processes, Christine DeBarbadillo, PE, et al, WEFTEC Proceedings 2006)

PROCESS AND EQUIPMENT IMPROVEMENTS

SpeedBump™ is a patented nitrogen release cycle that quickly and seamlessly degasses a group of filters while minimizing valve movements, water use, and filter down time.

SpeedWash™ is a patented rolling backwash cycle for stormwater filters and other filters facing extreme loadings. It quickly removes solids buildups, keeping throughput high.

The patented TBlock™ underdrain block provides strong open support and protection for filter gravel above the block and backwash air piping beneath the block. It resists upset and clogging and promotes even filtration and backwashing.

STWP's patented filter weir block promotes laminar flow down the filter walls to minimize turbulence and dissolved oxygen pickup. This reduces the amount of carbon source needed for denitrification by as much as 10%.

HIGH NITRATE REMOVAL EXPERIENCE

In April 1986 an extensive pilot program was conducted and proved that columnar biological denitrification of nitrate wastewater was effective for effluent from a munitions plant operate by Olin Chemical Company at the Badger Army Ammunition Plant in Baraboo, Wisconsin. Inlet nitrate-nitrogen averaged 90 mg/L in Phase I, with a Phase II range of 93 to 208 mg/L. Both conditions were evaluated with single-stage Denite® at rates of 1 to 1.5 gpm/ft², then with two-stage Denite® at rates of 2.5 to 3.5 gpm/ft². Ethanol was used as the carbon source. At an EOH:NO₃-N ratio of 2.5, a 90% denitrification efficiency was achieved.

OIL AND GREASE REMOVAL

Deep bed filters are excellent for removing fats, oils and greases (FOG) from water. Some of the most demanding and highest flow applications are in steel mills which use a wide variety of organic and inorganic lubricants. 90% removal of FOG compounds are achievable. Typical results from two facilities follow:

	<u>Filter Inlet FOG</u>	<u>Filter Outlet FOG</u>	<u>Flow</u>
Algoma Steel	9 mg/L	1 mg/L	6 gpm/ft ²
Weirton Steel	50 mg/L	5 mg/L	7 gpm/ft ²

VIRUS REMOVAL

Viruses are up to 100 times smaller than other pathogens in wastewater and present quite a removal challenge. Evaluating deep bed filtration for virus removal began in Florida in 1984 with investigations led by Dr. Flora Mae Wellings, Chief Epidemiologist and Director of the Florida Department of Health and Rehabilitative Services (HRS). A 9 week HRS virus removal pilot study was conducted that year at Altamonte Springs. This showed a 1.5 log reduction in viruses across deep bed filters. As a result of this study, a full scale filtration plant using STWP filters was constructed and put online in 1986. Six months of repetitive testing showed no virus in the new plant effluent. Since then Altamonte Springs has produced a consistently good reuse quality effluent.

GIARDIA AND CRYPTOSPORIDIUM REMOVAL

Removal of protozoan pathogens from wastewater, especially reuse or reclaimed water, is becoming a higher priority to prevent the transmission of waterborne disease. Studies by Dr. Joan Rose in 1992 pointed to the effectiveness of deep bed filters in removing these extremely small pathogens. In that year California accepted this technology to meet its stringent Title 22 Reuse Standard.

Dr. David B. York, PE has also conducted many important comparative studies which show the effectiveness of deep bed filter pathogen removal. Florida's annual Award for best reuse quality is now named in honor of Dr. York.

In 1999, Florida enacted regulations requiring wastewater plants to regularly report concentrations of protozoan pathogens, especially Giardia and Cryptosporidium. These plant reports have increased understanding of the occurrence and required treatment of these pathogens. The concentrations of these pathogens in untreated wastewater was found to be higher than previously estimated, with Giardia cysts more prevalent than Cryptosporidium oocysts.

The Florida Department of Environmental Protection (DEP) directly inspects and advises facilities that report more than 5 cysts or oocysts per 100 L sample of their effluent. From the results from many plants, it is becoming increasingly clear that the best arrangement for minimizing these pathogens is a well-run, nitrifying pure-oxygen or extended aeration plant, with effective deep bed filtration and UV disinfection.

In 2003, the Florida DEP conducted a specific study of Giardia and Cryptosporidium pathogen removal at the Altamonte Springs Water Reclamation Facility. Data from four sampling events is shown below. This shows that the greatest removal, up to a three log reduction, is across the filters:

Pathogen Results for March 11, 2003 Sampling Event at Altamonte Springs WRF

Sampling Location	<i>Cryptosporidium</i> Concentration (oocysts/100 L)	<i>Giardia</i> Concentration (cysts/100 L)	Turbidity (NTU)	TSS (mg/L)	CL ₂ Residual (mg/L)	Volume Tested (L)	Time Collected
Post Clarifier	27.0	2277.0	2.0	4.0	<0.1	11.2	12:52
Post Filter	2.0	<2.0	0.3	1.0	0.3	53.3	12:26
Post Disinfection	<2.0	<2.0	0.4	1.0	*0.06	53.3	11:25
Distribution Site 1 (San Sebastian)	<2.0	<2.0	0.2	<1.0	0.5	60.0	09:43
Distribution Site 2 (Robin Road)	<2.0	<2.0	0.2	1.0	0.4	60.0	10:25

* Sample taken after dechlorination

Pathogen Results for April 8, 2003 Sampling Event at Altamonte Springs WRF

Sampling Location	<i>Cryptosporidium</i> Concentration (oocysts/100 L)	<i>Giardia</i> Concentration (cysts/100 L)	Turbidity (NTU)	TSS (mg/L)	CL ₂ Residual (mg/L)	Volume Tested (L)	Time Collected
Post Clarifier	10.0	2000.0	1.6	2.0	<0.1	10.0	15:35
Post Filter	<2.0	<2.0	1.5	<1.0	<0.1	50.0	15:15
Post Disinfection	<1.8	<1.8	0.4	<1.0	1.8	54.0	13:30
Distribution Site 1 (San Sebastian)	<1.9	<1.9	0.2	<1.0	0.3	53.0	10:45
Distribution Site 2 (Robin Road)	<2.0	<2.0	0.2	<1.0	0.2	50.0	11:50

Pathogen Results for April 30, 2003 Sampling Event at Altamonte Springs WRF

Sampling Location	<i>Cryptosporidium</i> Concentration (oocysts/100 L)	<i>Giardia</i> Concentration (cysts/100 L)	Turbidity (NTU)	TSS (mg/L)	CL ₂ Residual (mg/L)	Volume Tested (L)	Time Collected
Post Clarifier	10.0	830.0	2.4	5.0	<0.1	10.0	15:08
Post Filter	<2.0	<2.0	0.6	<1.0	<0.1	50.0	14:50
Post Disinfection	1.9	<1.9	0.3	<1.0	2.2	51.5	13:50
Distribution Site 1 (San Sebastian)	<2.0	<2.0	0.5	1.0	0.3	50.0	11:55
Distribution Site 2 (Robin Road)	<2.0	<2.0	0.6	<1.0	0.3	50.0	12:25

Pathogen Results for May 13, 2003 Sampling Event at Altamonte Springs WRF

Sampling Location	<i>Cryptosporidium</i> Concentration (oocysts/100 L)	<i>Giardia</i> Concentration (cysts/100 L)	Turbidity (NTU)	TSS (mg/L)	CL ₂ Residual (mg/L)	Volume Tested (L)	Time Collected
Post Clarifier	7.0	1698.2	1.3	1.0	<0.1	14.2	10:52
Post Filter	<2.0	<2.0	0.3	1.0	<0.1	50.2	10:06
Post Disinfection	<2.0	<2.0	0.6	<1.0	1.89	50.5	09:45
Distribution Site 1 (San Sebastian)	2.0	<2.0	0.3	<1.0	0.2	50.0	14:49
Distribution Site 2 (Robin Road)	2.0	<2.0	0.4	<1.0	0.2	50.0	14:25

Source of above data: "Removal of Cryptosporidium and Giardia at a Central Florida Water Reclamation Facility," Lauren Walker-Coleman, Florida Department of Environmental Protection. The full report is available on the FL DEP website.

All of the protozoan pathogen plant effluent test results came in well below the Florida DEP's guideline of 5 counts per 100 L. In 2004, Altamonte Springs won the David P. York Reuse Award. STWP filters work well and work well for decades.

CALCULATING PRESENT WORTH COST OF A NEW FILTRATION SYSTEM

The Design Professional is often in the position of determining capital equipment costs and operating costs. STWP suggests the following calculation format for Present Worth Life Cycle Cost which combines capital and operating costs. The present worth multiplier for 20 years at 5% interest is 12.4.

	STWP	TBF ¹	Upflow ²
Initial Capital Cost			
Operating Costs:			
Power for pumps, blowers & air compressor = ____ kwh annually X \$0.10/kwh x 12.4			
Media loss = ____ tons/yr x \$200/ton delivered x 12.4			
Backwash cost = ____ gal/day x 365 x \$0.75/1000 gal x 12.4			
Repair and maintenance cost = Annual ____% of capital cost x capital cost x 12.4			
Chemical cost = ____ annual cost of filter coagulant, chlorine, and carbon source x 12.4			
Operator labor cost = ____ annual cost x 12.4			
TOTAL EVALUATED COST:			

Note 1:

On the previous Largo WWTP data table, 4000 ft² of traveling bridge filters (TBF's) were replaced by 3000 ft² of STWP Denite® Deep Bed Filters (DBF's). 30 day side-by-side tests were done at 13 MGD. The daily backwash water consumption for the TBF's was 1 MGD or 7.8% of forward flow. STWP's DBF used 390,000 gal/day or 3% of forward flow for backwash. The initial TBF plant design was 12 MGD ADF for TSS-only removal at 2 gpm/ft² (12 x 695/4000 ft²). The TBF's could not run properly without chlorination and would plug if chlorine was withheld for more than 5 days. The expansion was to 15 MGD and full denitrification, with STWP's filters sized at 3.5 gpm/ft² (15 x 695/3000 ft²).

Note 2:

Of all three filter types, the upflow filter produces the worst effluent turbidity and often needs chemical coagulants. The STWP DBF gives the best turbidity and uses no chemical. The upflow filter operation can only be adjusted by air lift rate and reject rate. This is not automatic and requires close operator attention. Thus variations in flow or concentration often give poor effluent quality, and a cycle of catch-up is perpetuated. Upflow filters are typically sized at low loading rates under 3 gpm/ft², much less than STWP DBF's. The major USA Engineering Consultants consider the upflow filter a large consumer of backwash water. Several lifecycle cost evaluations of upflow filters using actual data (Boynton, FL 8%; Jacksonville, FL 10%; Apollo Beach, FL 9.5-13%) have shown their backwash percent of forward flow to be much more than for a STWP DBF.

The difference in backwash water consumption when evaluated on a life cycle basis by itself often nearly exceeds the initial capital cost. There is a large differential between a 10 MGD STWP DBF at 4% of forward flow and another filter type at 8% forward flow at

typical treatment costs of \$0.75 per 1000 gallons. The less efficient filter choice yields a recurring unnecessary expense and diminished plant flow capacity from increased recycling of backwash water:


$$10 \times 10^6 \text{ gal/day} \times 0.08\text{-}0.04 (\%) \times 365 \text{ day/yr} \times \$0.75/1000 \text{ gal} \times 12.4 = \$1,357,800/\text{yr}$$

The cost delta in backwashing different types of filters is significant and should not be overlooked since for this same size the typical TBF installed cost is:

$$10 \text{ MGD} \times 695 \text{ gpm/MGD} \times \$450/\text{ft}^2 \text{ installed cost} / 2 \text{ gpm/ft}^2 = \$1,575,000$$

Selecting a filter system without performing a life cycle evaluation is like choosing a car without considering fuel consumption, durability, and repair ratings.

CONCLUSIONS

 STWP DeepBed® and Denite® filters have been successfully used for over four decades in the US and have continued to impress clients with their rugged, no-moving parts construction. The DeepBed® and Denite® filters have never had a failed application or failed to pass a performance test.

Plants with STWP filters have won the Phelps Award for 10 of the last 14 years. 35% of all Florida reuse goes through a STWP filter. Actual STWP reuse is currently 500 MGD in FL with a total capacity of 1.3 Billion gallons/day. This reuse water is made much safer for the environment and for people due to the highly effective removal of waterborne pathogens by STWP filters.

The single greatest factor in favor of the STWP DeepBed® filter is its flexibility. On a cost/benefit evaluated basis it is a winner due to its unparalleled ability to handle shock loads, using less backwash water than any other filter in the industry, and having the dual ability to remove TSS and NO₃-N as needed.