An Innovative and Cost-Effective Solution for Updating Reclaimed Filter Needs

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Palm Bay is located in east central Florida and situated in the southern portion of Brevard County. The city occupies approximately 97 sq mi, with a current population of over 104,000. The city's wastewater treatment facilities consist of two individually permitted treatment plants located adjacent to each other on Troutman Boulevard. The City of Palm Bay Utilities Department (Utility) operates a wastewater treatment plant (WWTP), which has a permitted capacity of 4 mil gal per day (mgd) and a water reclamation facility (WRF) that has a permitted capacity of 1.2 mgd.

The WWTP, which was acquired from General Development Utilities Inc. in 1992, is a 4-mgd conventional activated sludge treatment plant with effluent disposal via a 5-mgd deep injection well (DIW) . The sidestream processes included aerobic digestion, sludge dewatering, and sludge disposal via land application.

The WRF is a 1.2-mgd extended aeration activated sludge facility with effluent filtration, followed by high-level disinfection, on-site effluent, and reclaimed water storage. Secondary effluent from the WWTP is transferred to the WRF tertiary treatment system to produce reclaimed water, which the Utility sells to its reclaimed water customers. Table 1 shows permitted capacity information for the WWTP, the WRF, the reuse system, and the facility's DIW.

Major Operational Components

Wastewater Treatment Plant

The WWTP is a conventional activated sludge treatment plant that includes pretreatment (screening and grit removal), aeration, and secondary clarification. This facility includes one aeration basin, which has a total volume of approximately 1.3 mil gal (MG). Oxygen transfer and mixing for the aeration basin is accomplished with two 100-horsepower surface mechanical aerators. Hydraulic detention in the aeration basin is approximately 8 hours at the design flow rate of 4 mgd. Effluent from the aeration basin overflows into an adjustable effluent weir and flows by gravity into a secondary clarifier. The clarifier is a 100-ft diameter center feed unit, with a sidewater depth of 13.5 ft. The clarifier has a surface area of 9,500 sq ft (ft^2) and a design overflow rate (average daily flow) of approximately 420 gal per min per sq ft (gpm/ft^2).

From the secondary clarifier, effluent flows by gravity to the DIW pump station. Prior to discharge into the pump station, the clarified effluent can receive basic disinfection, although it is not required. A transfer pumping station, installed in 1993, is used to pump effluent across the street to either the DIW or the tertiary treatment process at the WRF for reuse. During periods of peak flow, the station operates under automatic float control and pumps effluent directly to the tertiary filters at the WRF. At nonpeak flow times, the station is manually de-energized and all effluent flow is sent to the DIW. Should the injection well be shut down for any length of time (e.g., during mechanical integrity testing), two effluent holding ponds are located on the main WWTP site and are available for effluent storage (capacity = 5.1 MG). The ponds can be operated in parallel or in series.

In addition to raw wastewater from the collection system, the WWTP also treats brine (concentrate) waste from the Utility's reverse osmosis (RO) water treatment plant, which is located adjacent to the WWTP. Due to the nature of the RO water treatment process, the brine is free of suspended solids and organics and only contributes a hydraulic load to the WWTP.

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Water Reclamation Facility

The Utility's water reclamation facility is permitted to treat 1.2 mgd on an annual average daily flow basis. This facility is an extended aeration activated sludge facility that disposes of tertiary effluent to a nonrestricted public access reuse system. Components of the liquid train treatment process include pretreatment (screening), aeration, secondary clarification, filtration, and high-level disinfection. A process flow schematic for the water reclamation facility is presented in Figure 1.

Raw wastewater received at the WRF is pumped from lift stations in the collection and transmission system, which are manifolded into the plant pretreatment structure. Screening facilities at the WRF consist of one channel grinder and one manually cleaned bar rack. The screened wastewater passes into a flow splitter box that splits flow between the two treatment plants and directs flows to an online surge tank. From the splitter box, wastewater flows by gravity to the aeration basin. The biological process at the WRF is operated in the extended aeration mode with a design capacity of 1.2 mgd. Mixed liquor from the aeration basin flows by gravity to the 60-ft diameter secondary clarifier, which has a sidewater depth of 10.79 ft.

The WRF was originally designed with four DynaSand® upflow sand filters, which were gravity-fed from the plant's secondary clarifiers, with flow distributed to each filter via a common influent channel. These filters were rated for an average daily flow of 0.67 mgd or 470 gpm (total flow = 2.68 mgd). The interior dimensions of each filter tank are 12.7 ft long by 8.2 ft wide, with an approximate depth of 15 ft.

Table 1. Permitted Facility Capacities

Facility/System Component	Permitted Capacity	Flow Basis
Wastewater Treatment Plant	4.0 mgd	AADF
Water Reclamation Facility	1.2 mgd	AADF
Reuse System	2.3 mgd	AADF
Deep Injection Well	5.0 mgd	Max. Flow

Filtered effluent flows by gravity to the chlorine contact chamber (CCC), which consists of two parallel basins, each with a volume of approximately 13,600 gal. Based on a required contact time of 15 minutes, the CCC has a total capacity of 2.65 mgd, but is permitted to treat 2.3 mgd. Liquid sodium hypochlorite is injected into the effluent flow upstream of the CCC to provide the necessary disinfection. Valving also allows for injection of sodium hypochlorite upstream of the filter units to prevent algal growth.

Chlorinated effluent from the CCC flows over a V-notch weir into the wet well at the transfer pump station. Two effluent transfer pumps, each rated at 1,850 gpm, pump chlorinated effluent to either the 1-MG reclaimed water storage tank or the 1.5-MG effluent tank. Reclaimed water is pumped from the holding tank to the reuse irrigation distribution systems and disposal sites.

In December 2010, the Utility inactivated the primary and secondary treatment processes of the WRF in an effort to consolidate its process treatment (due to a lower capacity demand) and to reduce plantwide energy consumption. Since that time, secondary effluent from the WWTP has been transferred directly to the WRF tertiary treatment system to produce reclaimed water.

Public Access Reuse System

Following filtration and chlorination, plant effluent is pumped to either a 1.5-MG water tank or a 1-MG reclaimed water storage tank. The reclaimed water pump station at the WRF consists of three high-service pumps (two vertical can pumps each with variable frequency drives and one constant speed horizontal split-case pump) and a 3,000-gal hydropneumatic tank. This pump station has a firm capacity of 3,000 gpm at a design operating pressure range of 74 to 82 pounds per sq in. (psi). Normal operating pressure ranges from 60 to 65 psi. Users of the reclaimed water transmission system are summarized in Table 2.

New Filtration Needs

In 2007, the Utility determined that replacement of the existing four upflow sand filters was needed due to maintenance concerns with the existing upflow sand filters and to provide more capacity for its reclaimed water system based on projected future flows. It was determined that a significant cost savings could be realized if the structural basins (or tankage that housed the existing filters) could be utilized in a rehabilitation of the filtration system. With this in mind, it was also determined that three filters would require rehabilitation (keeping two filters in service from a reliability standpoint), while the fourth filter bank could be used as an equipment room or pump room.

Anticipated future peak flows for the facilities were estimated to be 4.4 mgd. Based on the regulatory definition of "reliability," new filters would need to be sized to pass 75 percent of the peak day flow, with the largest unit out of service. Therefore, any filter redesign would need to accommodate one-half of 3.3

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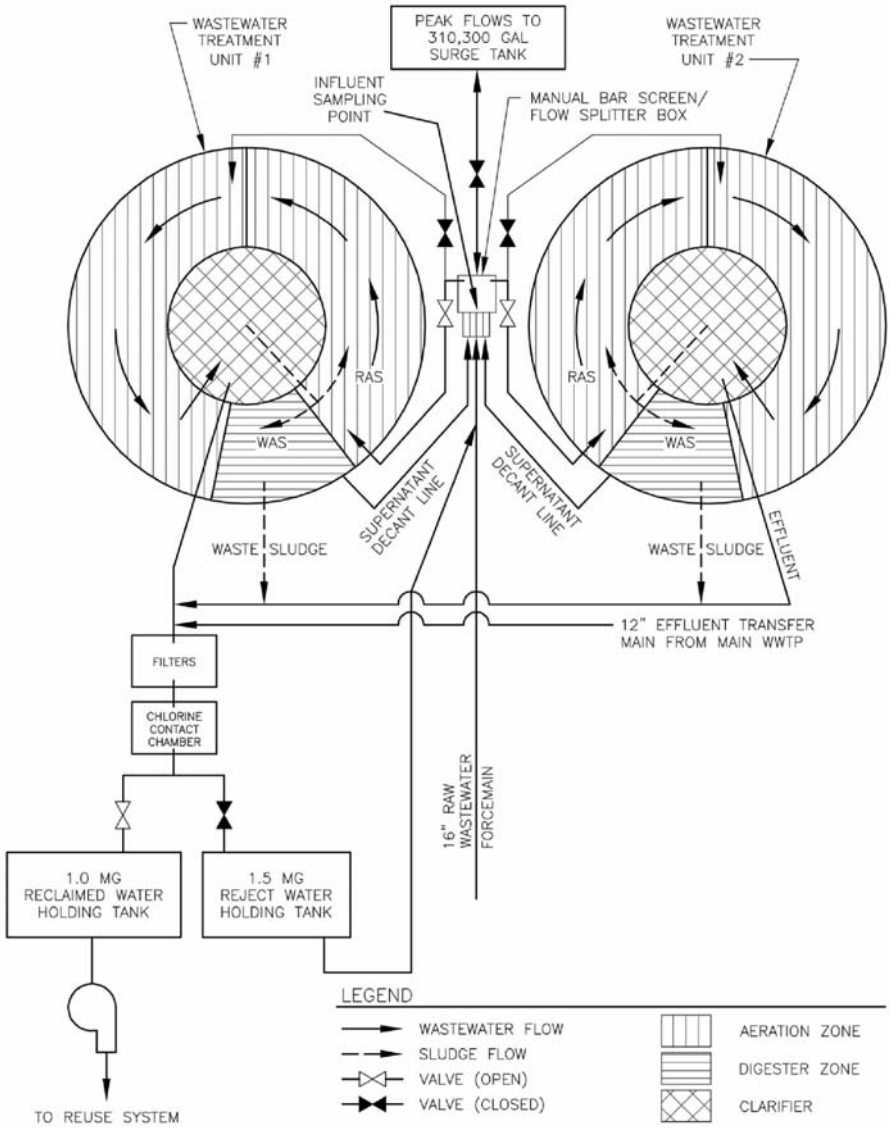

Figure 1. Process Flow Schematic for the Palm Bay Water Reclamation Facility

Table 2. Palm Bay Utilities Reclaimed Water Users

User	User Type	Capacity (mgd)
Harris Corporation	Irrigation	0.570
Intersil	Irrigation & Cooling Tower	0.440
Sandy Pines (Phase I, II & III)	Irrigation	0.260
Palm Bay WWTP and WRF	Irrigation	0.100
Palm Bay Greens	Future Development	0.210
Knecht Park	Irrigation	0.097
	TOTAL REUSE	**1.677**

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mgd (75 percent of 4.4 mgd) or 1.65 mgd to accommodate future growth.

Hydraulic Requirement

As previously mentioned, a primary goal for the undertaking of this filter retrofit project was to utilize the tankage of the existing upflow sand filters to save capital costs, as well as reduce overall downtime for construction. To accomplish this objective, maintaining the existing hydraulic profile was a primary objective when rehabilitating only a portion of the equipment (in the case of a single filter unit), while keeping the remaining units in service as originally designed.

To maintain the operation of the existing upflow sand filters with the proposed new filter equipment, the new equipment was to be constructed within the existing tankage. The overall dimensions of the new filter equipment would also need to allow for piping clearances, maintenance, etc. Ideally, the new filter unit would need to operate in a submerged or partially submerged state to maintain the flow as close to the original hydraulic profile as possible, with minimal disruptions or differences in operation of the existing filter units. Operating the new filter(s) in a submerged state would also eliminate any additional maintenance of an upgraded filter unit with an open-top.

Filter Evaluations

Three filter manufacturers were evaluated for this upgrade project: Kruger, Nova Water Technologies (Nova), and Aqua-Aerobic Systems (Aqua-Aerobic). At the time of the evaluation, only two manufacturers (Aqua-Aerobic and Kruger) had multiple installations in Florida and across the United States, while the third manufacturer (Nova) had a verifiable track record of installations in Europe, with only one project under construction in the U.S. (Note: Nova has since conducted pilot studies that demonstrate compliance with California Title 22 requirements at hydraulic loading rates ranging from 6 to16 gpm/ft^2).

The Kruger/Hydrotech Discfilter has been used in upgrading DynaSand® filters in the past; however, the filter had not been used to retrofit one filter while the remaining filters stay in service. Flows through the Kruger filter are done using an "inside-out" stream, which is where flow enters the center of the filter system and flows outwards through the fine mesh screens. Evaluation of the Kruger filter indicated that the stainless steel tankage would not fit into the existing tankage while maintaining the existing hydraulic profile. To accommodate these requirements would require extensive tank structural modifications to raise the floor elevation (of the existing tankage).

Similar to the Kruger unit, the Nova unit is a "canned" unit, where the filter disks are inside a stainless steel tank and water flows through the disks and out a side discharge port. The submerged unit submitted by the manufacturer and evaluated as part of this project had a design capacity of 800 gpm. Dimension-wise, the 800 gpm unit's overall width (8.6 ft) was too wide to fit into the existing sand filter tank structure. To meet flow capacity for the future, a larger Nova unit sized at 1,190 gpm would be required; however, the overall length of this unit was approximately one-half-ft larger than the available tank length. Similar to the Kruger unit, because of the need to maintain the existing hydraulic profile and the required structural modifications needed to allow the filter unit to be used with the existing tankage, this unit was not considered for this application.

Aqua-Aerobic manufactures the AquaDisk® tertiary filter unit, which consists of a series of vertically mounted cloth media disks with an automatic backwash system. The AquaDisk® filter system was the only filter unit that could be installed directly into the existing filter concrete basin and operate in a fully submerged environment. With the filters submerged, water flows through the cloth media into a central collection chamber and is conveyed out of the filter system. Installing the disk filters in a submerged state provided a major advantage over the other units since the hydraulic profile of the existing filter bank can be maintained. Furthermore, the structural modifications required for each tank were minimal, since raising the tank floor would lead to more efficient flow-through.

Figure 2 illustrates the hydraulic profile for both average daily flow and peak-hour flow rates (shown in parentheses) for three primary sections: the influent channel, the filter basin itself, and the effluent channel (prior to discharge to the chlorine contact basin).

Installing the Aqua-Aerobic disk filters in a submerged state was advantageous since it allowed for maintaining the hydraulic profile of the existing filter bank. As a result, no modification of the influent channel would be required, with the exception of installing weir boxes on the inside face of the influent channel. These weir boxes allow for even flow distribution among the filters and avoid any hydraulic overloading on a single filter unit.

For this application, the future design could be accomplished using the Aqua-Aerobic disk filters. A six-disk filter unit will have a design capacity of 1.5 mgd, with each filter having a flow rating of 0.25 mgd. Peak-hour flow rating for the six-disk unit is 3 mgd. Total filter area provided with two six-disk units is approximately 646 ft^2. Based on the future flows requirements previously identified, three filter basins retrofitted with the AquaDisk® units (six disks each) would provide an average daily flow capacity of 4.5 mgd, with a firm peak hourly flow capacity of 6 mgd. The average hydraulic loading rate of the filters was estimated to equal 3.25 gpm/ft^2 on an average daily flow basis (1.5 mgd per filter). The maximum hydraulic loading rate was estimated to equal 6.5 gpm/ft^2 on a peak hourly flow rate (3 mgd per filter).

In summary, the Aqua-Aerobic equipment was selected to be utilized with the existing filtration units for the following reasons:

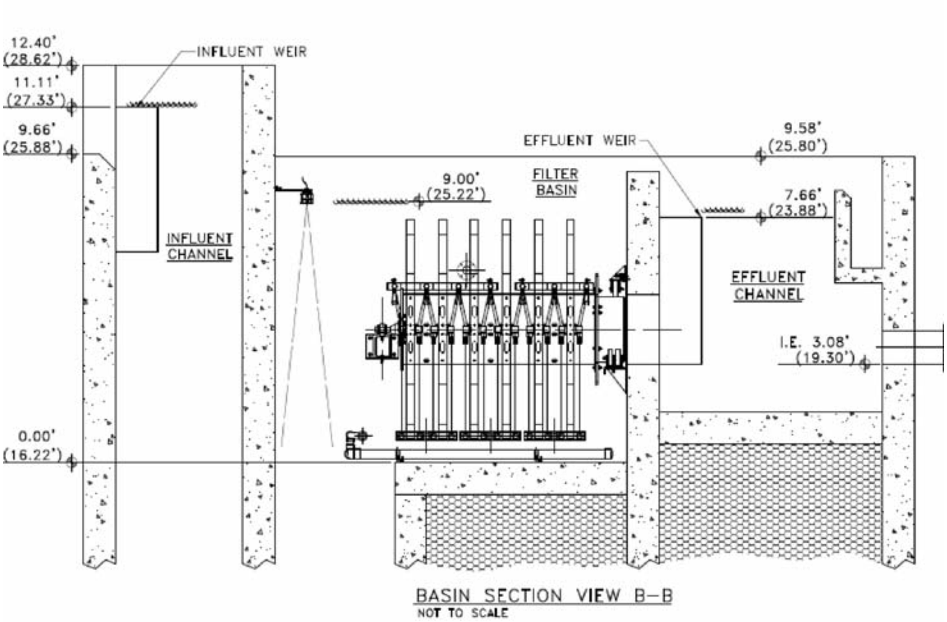

Figure 2. Hydraulic Profile for Filter Configuration at Palm Bay Utilities Water Reclamation Facility

1. The equipment could be retrofitted into the existing filter basins with minimal structural or piping modifications.
2. Minimal changes were needed to the upstream flow scheme with the installation of four weir boxes, and no significant costs were involved with modification of the influent channel.
3. The downstream hydraulics of the existing filters would not be impacted.
4. The Aqua-Aerobic filters have more filter surface area per disk; therefore, future design flow needs could be accommodated with this expansion project.

Filter Upgrade Project

Initially, the Utility opted for retrofitting only two of the four existing upflow sand filters, whereby the third filter unit would be retrofitted at a future date. In the interim, the Utility retained the use of one of the remaining DynaSand® upflow sand filters for redundancy. The DynaSand® filter has a rated capacity of 0.67 mgd at a filtration rate of 4.55 gpm/ft² and can be removed and replaced with another disc filter unit to meet future flow conditions. Based on this decision, the Utility proceeded with the negotiation of pricing directly with Aqua-Aerobic for two AquaDisk® cloth media filters and completed a prepurchase of the equipment. A purchase order for the equipment was issued in January 2008.

A permit application was submitted in October 2007 to the Florida Department of Environmental Protection (FDEP) to replace the existing upflow sand filters with two AquaDisk® cloth media filters. The FDEP issued a notice of intent in December 2007 and a permit for the project was issued in January 2008.

Construction of the project was initiated in spring 2009 and completed in October of that year. Construction activities consisted of demolishing the two existing sand filter units, removing the media, and retrofitting the filters with two units of fully submerged, vertically mounted cloth media filter disk filter (AquaDisk®), each having an automatically operated vacuum backwash. Each new unit is capable of operating at an average flow of 1.5 mgd and a peak hourly flow rate of 3 mgd.

Table 3. Annual Flow (Annual Average Daily Flows) Summary: 2002-2012

Year	AADF (MGD)			
	WWTP Influent	WRF Influent	Combined Influent	Reclaimed Water
2002	1.780	0.930	2.710	0.819
2003	1.602	1.205	2.807	1.177
2004	1.960	1.080	3.040	1.079
2005	2.278	1.049	3.327	0.984
2006	2.596	0.881	3.477	0.836
2007	2.584	0.979	3.563	0.729
2008	2.443	1.029	3.472	0.927
2009	2.261	0.828	3.090	0.814
2010	2.149	0.789	2.937	0.768
2011	2.999	0.000	2.999	0.723
2012	3.052	0.000	3.052	0.713
Average	2.337	0.797	3.142	0.870
Maximum	2.999	1.205	3.563	1.177
Max Year	2011	2003	2007	2003

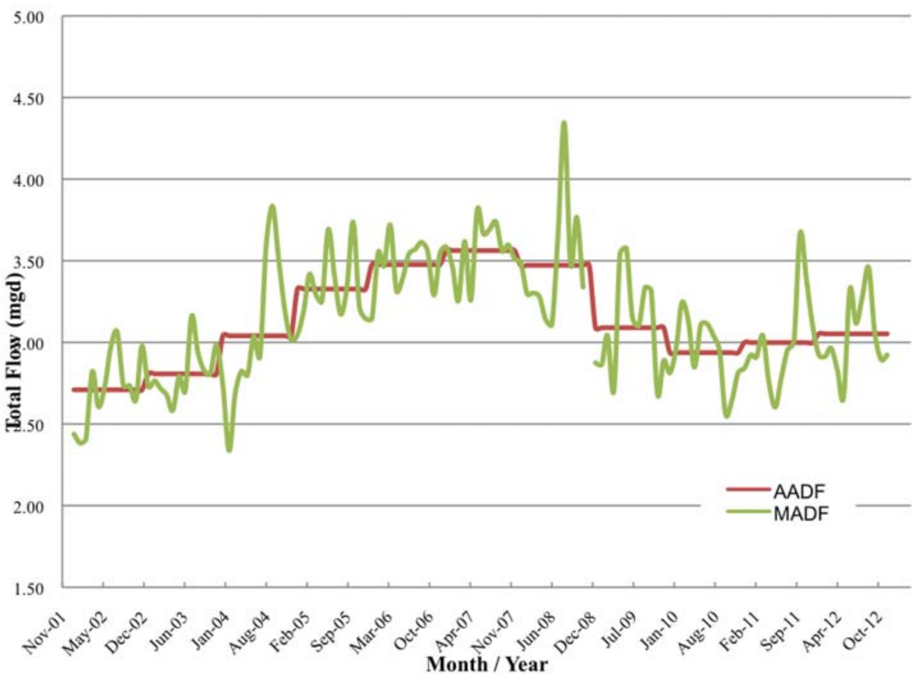

Figure 3. Combined Influent Flows (2002–2012): Annual Average Daily Flows and Monthly Average Daily Flows

Loading Data and Water Quality Analysis

A summary of monthly flow data for both the WWTP and the WRF is presented in Table 3 for the period of record from January through December 2012. Monthly average daily flows (MADF), three-month average daily flows (TMADF), and annual average daily flows (AADF) are reported for influent, effluent reuse, and effluent disposal to the DIW. Combined influent flows over the 11-year period ranged from 2.34 to 4.34 mgd on a maximum average daily flow basis, and from 2.41 to 3.86 mgd on a three-month average daily flow basis.

Combined influent monthly flow data for the WWTP and the WRF are illustrated in Figure 3. The highest monthly flows at the facilities were experienced in 2007 (3.5 mgd) and have since leveled out at around 3.0 mgd (2010 -2012).

On an annual average basis, carbonaceous biochemical oxygen demand ($CBOD_5$) loading at the WRF has ranged from 854 to

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1,471 lbs/day, with an overall average of approximately 1,270 lbs/day. Total suspended solids (TSS) ranged from approximately 600 to 1,200 lbs/day, averaging 970 lbs/day over the same nine-year period of record (2002-2012). Both $CBOD_5$ and TSS loadings at the WRF during this period were approximately 50 percent of the design loading rates for this treatment facility (2,502 lbs/day).

Figure 4 presents effluent $CBOD_5$ and TSS water quality data measured after filtration at the WRF for a 15-year period of record (1998-2012). As illustrated in the graphic, TSS has remained consistently below 5 mg/L for the observed data period. Average filtered effluent TSS concentrations over the 15-year period of record were less than 2 mg/L. Likewise, filtered effluent water quality for $CBOD_5$ ranged from 1 to 10 mg/L for the majority of the same period of monitoring. Average filtered effluent $CBOD_5$ at the WRF during this period was 3.1 mg/L.

Capital Costs

Capital costs for this project consisted of three primary components: (1) engineering design, permitting, and construction services; (2) direct purchase by the Utility of the filter treatment equipment unit; and (3) contractor costs associated with construction and installation of the filter units.

The direct purchase of the AquaDisk® cloth media filters equipment included freight and supervision services during the contractor's installation of the units. Major components included with this direct purchase were:

- Two filter units consisting of six disks per unit, with a total filter area of 646 ft.
- Influent flow assemblies with 304 stainless steel influent level weir and flow separation baffles.
- Effluent flow assemblies consisting of 304 stainless steel effluent weir/flow separation baffles.
- Centertube and drive system assemblies.
- Backwash system assemblies, backwash pumps, and backwash valves.
- Ultrasonic transceiver and transducer assemblies.
- Ethernet compatible control panel package with soft starts for pumps and drive motor.

Contractor costs for the project included all material, labor, and equipment associated with the following key elements for construction of the project:

- Demolition of the existing filter.
- Removal of the existing filter sand media.
- Removal of the existing concrete hoppers.
- Wall forming and concrete pour required for new filter units.
- Installation of two six-disc cloth media Aqua-Aerobic filter units.
- Electrical and programmable logic controller (PLC) programming.
- Equipment startup and commissioning.

Several pieces of heavy equipment were provided for construction of the project, including a vac truck and crane. Additional fabrication work was also commissioned for the walkways needed on each filter basin. Total cost for the filter rehabilitation project was approximately \$526,000, which included engineering and permitting for the project. Project costs are summarized in Table 5.

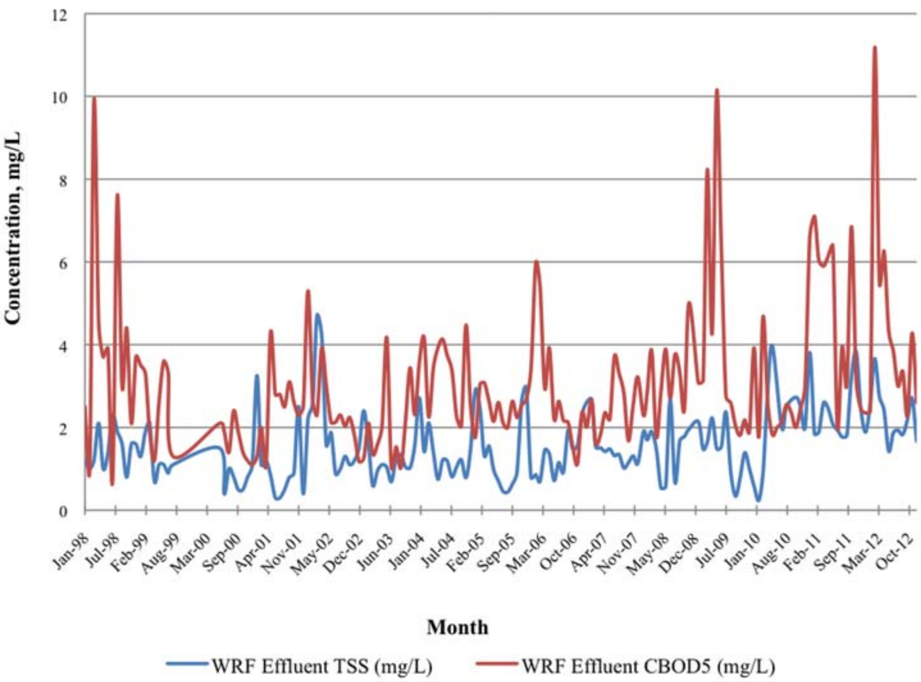

Figure 4. Water Reclamation Facility Effluent: Carbonaceous Biochemical Oxygen Demand and Total Suspended Solids Data (1998–2012)

Table 5. Palm Bay Utilities Filter Rehabilitation Project Costs

Project Component	Cost
(1) Filter Units (2) – Owner Purchased	\$362,500
(2) Contractor Costs	\$84,900
(3) Engineering Design, Permitting, Bidding and Construction Services	\$68,900
(4) Miscellaneous Fabrication Work	\$10,000
Total Project Cost	**\$526,300**

Conclusion

This filter rehabilitation project realized economical savings, while providing the Utility and its reclaimed water customers with overall improved filtration at the water reclamation facility in Palm Bay. The primary cost savings were realized from the utilization of the existing filtration tankage and the ability to maintain the existing hydraulic profile through the treatment plant facility without making any significant structural modifications at the treatment plant facility. The new filter units have also proved to have fewer maintenance issues than were previously experienced by Utility staff with the upflow sand filters. Use of the AquaDisk® filters has resulted in both an economical and environmental savings to the City as a consequence of less water and energy used during backwashing. When future demands for wastewater treatment and resulting reclaimed water increase, the City plans to convert the remaining upflow sand filter for the needed additional capacity.