Life Cycle Analysis of Tertiary Filters for Rerate Expansions

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Faced with aging tertiary sand filters and increasing flows, the San Antonio Water System (SAWS) opted to upgrade the filter technology at two of their Water Recycling Centers (WRCs), Leon Creek WRC and Dos Rios WRC to diamond cloth media filters. Upon completion, Dos Rios WRC will be the largest installation of diamond cloth media filters in the world.

INTRODUCTION

As part of anticipating growth projections over the next 50 years and ultimate flow diversions, SAWS has been focusing on economical treatment upgrades for both the Dos Rios WRC and Leon Creek WRC, which treat the majority of wastewater produced by the City of San Antonio, Texas as well as providing recycled water for one of the nation's largest recycled water system. The tertiary filtration system is a critical process to these plants, and is in need of immediate upgrade in order to continue meeting recycled water demands and long-term permit requirements. The existing tertiary filters are traveling bridge sand media filters, which have aged and have become inefficient, hard to maintain, and unreliable. SAWS contracted with CP&Y, Inc. to design the filter upgrades for both facilities, including an increase in filter capacity from an average performance capacity of 100 million gallons per day (MGD) to 170 MGD at Dos Rios WRC and from 37 MGD to 59 MGD at Leon Creek WRC. CP&Y developed a phasing plan that not only met requirements for the immediate future, but also considered long-term expansion goals.

Dos Rios WRC

Dos Rios WRC was placed in operation in 1987 as a state-of-the-art advanced secondary treatment facility, and has been recognized as an outstanding wastewater treatment plant by the Water Environment Association of Texas. Dos Rios WRC currently holds a Type I reuse permit for up to 16 MGD. The aerial plant view can be seen in Figure 1.

The tertiary filtration system at Dos Rios WRC consists of ten traveling bridge sand media filter basins, each approximately 230 feet long. Each filter basin can treat an average daily flow (ADF) of approximately 10 MGD, and a peak two-hour flow (P2HF) of approximately 20 MGD. The current efficiency of the filters has deteriorated over the years, and is currently limited due, in part, to the age and condition of the equipment.

Figure 1. Dos Rios WRC

Leon Creek WRC

Leon Creek WRC, a conventional activated sludge facility, was placed into service in 1965. Tertiary filtration was constructed and placed into operation in 1988. In recent years, SAWS has evaluated the long-term goals for this facility. Similar to the Dos Rios WRC, Leon Creek WRC holds a Type I water recycling permit. Current long term plans call for peak flows to bypass the Leon Creek WRC, and be diverted to the Dos Rios WRC.

Leon Creek WRC currently has eight traveling bridge sand media filters, each approximately 100 feet long. Each filter is capable of treating an ADF of approximately 4.6 MGD, and a P2HF of approximately 9.3 MGD. Similar to the Dos Rios WRC, the filters have deteriorated resulting in decreased treatment efficiency and through-put. The aerial plant view can be seen in Figure 2.

Figure 2. Leon Creek WRC

TECHNOLOGY EVALUATION

Many advanced wastewater treatment facilities with tertiary filtration utilize sand media filters for additional removal of total suspended solids (TSS) and particulate biochechemical oxygen demand (BOD). Recent innovations in filtration technology have resulted in the development of cloth media filters that are capable of achieving high removal rates at significantly higher hydraulic loading rates

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than the traditional sand media filters. Cloth media filters and the latest technology of traveling bridge sand media filters were evaluated for their suitability to retrofit the two facilities.

Sand Media Filters

Low-head sand media filters are the most common type of tertiary treatment units installed today. Figure 3 demonstrates the low-head sand filter technology. Both Dos Rios WRC and Leon Creek WRC have low-head traveling bridge sand filters installed downstream of their secondary (biological) treatment processes. While the basic operation of most low-head filters is fairly similar, a number of variations to the technology have been made to distinguish manufacturers and to improve the long-term operation of the filter system.

Each sand media filter bed contains multiple parallel cells, which contain sand media supported by a porous plate above an underdrain system. Wastewater enters the filter bed above the media via influent ports in the side walls of the influent channel, and flows by gravity through the media to the underdrain system below.

The media grain size, the total filtration surface area, and the desired level of treatment affect the filter design and operation. The filter media at the Dos Rios and Leon Creek WRCs tertiary filters consists of a single 10-inch layer of sand with a 0.65 mm nominal grain particle diameter. Typical grain sizes for wastewater applications range from 0.4 mm to 0.8 mm, with media depths from 8 to 24 inches.

Filtration efficiency is highly dependent on the solids loading rate. The hydraulic loading rate that the filter can handle depends on the influent TSS concentration and the required TSS removal. In general, conventional activated sludge systems can produce a quality of wastewater with less than 20 mg/L of TSS. It is not uncommon for well operated conventional activated sludge processes to reliably produce secondary effluent with less than 10 mg/L TSS. The hydraulic loading rate of low-head sand filters typically ranges from 2.0 gallons per minute per square foot of filter surface area (gpm/ft2) to 3.0 gpm/ft2 under average flow conditions.

As the voids in the filter media become clogged, the headloss through the filter increases, resulting in an increased water surface elevation across the filter bed. Filter backwashing refreshes the filter media by reversing the flow through the filter bed, removing the trapped particles. Backwashing is initiated automatically by a Programmable Logic Control (PLC) based control system, based on water level in the filter or after a pre-set period of time. During a backwash cycle, only one or two of the individual filter cells is backwashed at a time. The remaining filter cells continue to filter the wastewater.

The most common low-head filter system includes a dual-pump backwash system configuration, mounted on a motorized platform, a traveling bridge, which moves along the length of the basin on rails during a backwash cycle. The traveling bridge supports a hood suspended below it, which engages with each filter cell during backwashing. A backwash pump located in the effluent channel pushes filtered effluent back through the effluent port and up through each cell. Effective backwashing occurs when the filter media within the filter cell is expanded about 20% to remove the captured particles. As the filter media fluidizes and the particles are released, another pump mounted on the hood pulls the dirty water from the filter cell, and discharges it into a backwash trough mounted on the side of the filter basin. The typical backwash rate for this type of system is 300 gpm per pump. At Dos Rios and Leon Creek WRCs, the backwash water flows by gravity to a backwash pump station, which pumps the backwash water to the head of the plant for treatment. The two critical factors for the success of this type of configuration include the integrity of the seal, or boot, located around the effluent port of the backwash pump and the ability of the two pumps to consistently move the same volume of water through the filter cell.

The long-term reliability of the low-head filter technology depends heavily on the integrity of the porous plates and the underdrain system. As a result, many of the variations in equipment designs have been associated with these components. The initial equipment design consisted of porous plates supported on the underdrain support beams. This configuration resulted in a large quantity of caulking between the plates to seal the system. The caulking tends to deteriorate over time, which results in media loss and short circuiting. This is the one of the most common problems associated with the low-head filters.

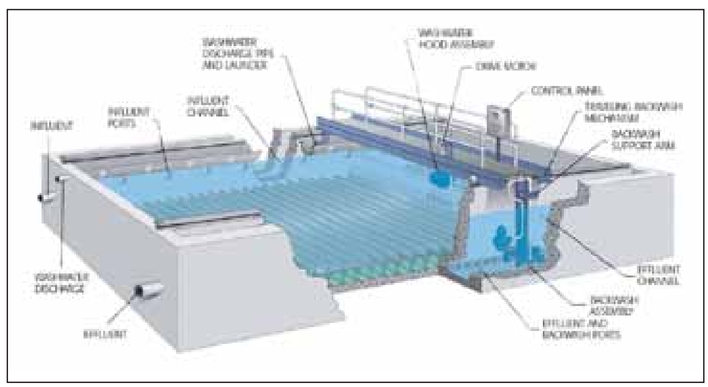

Figure 3. Low Head Traveling Bridge Filter
(Courtesy Infilco Degremont)

Cloth Media Filters

The principles of filtration with cloth media are similar to sand media. A random weave pile fabric filter media removes very fine particulate matter. The depth of the woven pile enables the capture of additional solid particles. As flow passes through the cloth membranes, solids are retained on and within the cloth pile, forming a mat, providing an additional filter layer that enhances filtration. As solids build up on the membrane surface, backwashing is initiated automatically, and accomplished by vacuuming the cloth media surface.

Aqua-Aerobic Systems, Inc. manufactures a cloth media diamond filter specifically designed for retrofit applications in existing sand filter beds. Long laterals covered with pile-fabric media are suited for converting long rectangular basins into cloth media diamond filtration units. Horizontal rows of diamond-shaped laterals are mounted on the basin bottom. Figure 4 is a good illustration of this kind of retrofit.

During the filtration cycle, solids deposit on the outer surface of the submerged laterals as filtered effluent collects inside and flows to discharge by gravity. Backwashing is initiated automatically by a PLC-based control system, based on water level in the filter or after a pre-selected period of time. Backwashing is accomplished by a traveling bridge that moves a suction manifold across the cloth media diamond filter. During backwash, a pump provides suction to the vacuum heads that remove the particles captured on and within the cloth media diamond filter as the bridge platform moves down the length of the diamond laterals. Suction headers on the traveling bridge also collect settled solids from the basin bottom. As with the low-head sand media filters, the filtration process is not interrupted during the backwash cycles.

The cloth media filter area is designed to achieve the required TSS removal and effluent quality of the water at an average hydraulic loading rate of 3.25 gpm/ft2, and a peak solids loading rate of 1.9 lbs TSS/ft2 filter media.

The traveling bridge for the diamond cloth media filter backwash mechanisms can travel at two different speeds. The normal travel time is 30 feet per minute. With a four-pass backwash cycle, an 80-foot long filter would be backwashed in 10.7 minutes. During normal conditions, at 30 feet per minute, the backwash rate is 450 gpm.

Figure 4 - Existing Traveling Bridge Sand Filter Converted to Cloth Media Diamond Filter

Comparison

The project team compared the two technologies based on a number of key criteria including filtration expandability and land requirement, treatment efficiency, treatment reliability, and 20-year life cycle cost for the Dos Rios and Leon Creek WRCs characteristics and treatment goals. Table 1 summarizes the advantages and disadvantages of both technologies.

Between the two facilities, the Leon Creek WRC filter facility site was determined to be more constricted in terms

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of area for future expansion. Therefore, it was critical that the filtration capacity increase could be achieved using the existing structures. However, because cloth media filters are capable of treating a wider range of flows, it was determined that they could be installed at both facilities within the existing structures and could still meet the treatment capacities for future flows. This reduced the overall footprint and eliminated the need for more structures. The installation of new sand filters would have required the construction of additional filter basins to meet the required filtration capacities.

Both sand media filters and cloth media filters have been shown to reliably produce filtered effluent below 10 mg/L TSS and in many cases, below 5 mg/L. However, media backwashing is a more efficient process in the cloth media filters than with the sand filters. As a result, the cloth filters are able to recover more quickly from a spike in solids loading.

Sand filters are a well-known technology in wastewater treatment, which many operators are familiar with. Due to the widespread use of this type of filter and the number of installations and manufacturers, operations and maintenance issues are easily addressed. Because the diamond cloth media filters are a relatively new technology, the design team conducted a thorough research of the other installations in the United States to determine the quality of the equipment and its treatment reliability in the time period they have been installed. The design team found from this research that, with the recent advancements in technology, the filter equipment has been reliably operating with only few problems.

The project team also conducted a thorough 20-year life cycle cost analysis on the use of the two technologies at each facility. The electrical requirements associated with the number of traveling brides operating at a time, in addition to the maintenance required impacted the annual operation and maintenance costs. The new structures that would be required for the sand filter basins and the higher equipment cost for the cloth media filters also played into the overall life cycle cost analysis. The results of the life cycle cost analysis indicated that although the initial capital cost of the sand media filters and cloth media filters for plant expansion would be comparable, the 20-year net present worth of the cloth media filters was significantly lower due to considerably lower operational and maintenance costs.

After a comprehensive economic and non-economic factor analysis of both technologies, the cloth media filters emerged as the best technology for both Dos Rios WRC and Leon Creek WRC, for both short- and long-term benefit to SAWS.

Sand Media Filters		Cloth Media Filters	
Advantages	Disadvantages	Advantages	Disadvantages
Identical technology, employee familiarity.	Technology history supports operational efficiency decline within years of initial operation.	Double the capacity in the same footprint.	Technology variation from existing system.
Technology advancements continue to target known system vulnerabilities.	Reduced backwash recovery time.	Reduced backwash water volume.	Newer technology.
No existing system modifications with the replaced equipment.	Requires additional footprint for plant expansion.	Increased backwash recovery time.	Single manufacturer.
Equipment competition.	Produces large volumes of backwash water that requires treatment.	Single backwash pump.	
	Dual-pump backwash configuration requires increased maintenance.		

Table 1. Advantages and Disadvantages of Sand Media and Cloth Media Filters for Dos Rios and Leon Creek WRC

DESIGN

The diamond cloth media filters will be installed at Dos Rios WRC, in five existing sand media filter basins. These improvements will increase the ADF filtration capacity from 100 MGD to 170 MGD. At Leon Creek WRC, three existing sand media filters will be replaced with three new diamond cloth media filters, increasing the ADF from 37 MGD to 59 MGD.

As part of the filter improvements, the backwash pump stations at both facilities will be upgraded with new pumps and discharge valves. However, the backwash pumping capacity will not be modified at either site.

Challenges

The design team faced several challenges during the project design phase, including developing a filter configuration to accommodate the non-standard filter basin length at Dos Rios WRC, meeting hydraulic requirements, incorporating lessons learned from previous installations, and managing construction sequencing.

The diamond cloth media filters manufactured by Aqua Aerobics are a propriety design intended for easy installation into existing low-head sand filter basins. The Leon Creek WRC site was an ideal application site due to the length of the existing filter basins. Because the filter basins at Dos Rios WRC are more than double the 80-foot length of the standard diamond cloth media filter, a unique configuration was developed to accommodate the cloth media filter installation.

The existing filter basins will be divided into two separate cells so that two cloth filter units can be installed in a back-to-back configuration where one sand filter existed. The design engineers developed an innovative layout utilizing the existing influent and effluent troughs to route flows to and from the diamond cloth media filters. This will make the Dos Rios WRC the only installation of back-to-back diamond cloth media filters in the world.

As part of the filter improvements, the engineers designed a structural walkway that will cross the width of the filters. The new walkway will provide additional access to the mechanical components of the new filters.

During the preliminary stages of design, the engineers conducted a conditions assessment to determine the integrity of existing components. They determined that the existing festoon supports and slide gates are in good condition and can be reused, which significantly reduced the construction cost.

Backwashing was designed to be controlled by a PLC mounted on the traveling bridge of each filter. This PLC will control the bridge-mounted valves and pumps, and will initiate backwash cycles based on water level or preset time intervals. Human Machine Interface (HMI) operator panels will be installed for every two new filters to provide information to assist the operators in assessing the status of the filter system. The HMI panels will display all alarms as well as operational parameters such as water level, backwash time and cycles, drive motor run time, and backwash pump motor run time.

Hydraulics

The cloth media filters are capable of treating approximately twice the amount of flow as the sand filters. The design engineers generated hydraulic models and performed a thorough hydraulic analysis to develop a design that would ensure that the system could accommodate the new flows. The new design modified the lengths and heights of the influent and effluent weirs to maintain the required water levels in the filters at all times.

Lessons Learned from Previous Installations

Cloth media filters are a relatively new technology to the wastewater treatment industry. As a result, some of the mechanical features are still being fine-tuned. With the help of Aqua Aerobics, the design team used the experience gained from the staff at Trinity River Authority's (TRA) Central Regional Wastewater System (CRWS) facilities to develop the design that best suites SAWS. Many of the new design features incorporated into the filter system for the SAWS facilities were developed after the filters were installed at TRA CRWS. In general, these features will ensure that the moving components of the cloth media filters operate smoothly.

FUTURE EXPANSION

Future expansion at both facilities to ultimate treatment capacity will involve converting the remaining sand filters to cloth media filters. Current and future hydraulic impacts were considered in the design. The new cloth media filters will not require further modification for future flows. It is anticipated that by converting the remaining sand media filters to cloth media filters, each facility will be able to accommodate the projected peak two-hour flows.

CONSTRUCTION

Construction of the filtration facilities started in February, 2010, with an anticipated completion date of August, 2011.

Change for the Future

By Gordon Koblitz

By now many of have seen (and hopefully participated in) the WEAT Scholarship Committee's "Change for the Future" fundraising efforts. Thanks to Cathy Sieger for keeping our committee successfully moving along, the scholarship fund has been growing and reaching many others who chose to help out. Our particular interest at CH2M HILL was to honor Ron Sieger who sadly passed away several years ago. Ron was a valued, well liked and long-term employee as well as an integral part of WEF/WEAT/NTS activities over the years and a highly respected expert in our profession.

We held a fundraiser in our Dallas and Fort Worth offices for the Ron Sieger Endowment Fund with a $500 match for employee contributions. We're happy to report that change, cash and checks filled the containers over the course of two weeks during luncheon meetings and folks stopping by the office. We celebrated the addition of $1,167.24 to Ron's Endowment Fund with an ice cream party in each office.

More ideas are coming forth by the committee members on ways to build the related scholarship funds to serve our WEAT members and help their dependants gain a college education. We hope you'll support the fundraisers in your office, WEAT or Section meetings. It's a great investment for our members and profession's future!! If you would like to help or learn more about the scholarship program, please contact Cheryl or Julie at WEAT Office at 512-693-0060 or toll free at 866-406-WEAT (9328).

New Deadline – July 1st – for Scholarship Fund

WEAT currently has two endowments within the V.M. Ehlers Foundation, the Bob Derrington and Ronald Sieger Scholarship. If you have a son or daughter who is attending college and pursuing a course of study which is related to the water utilities industry, they can submit an application for a scholarship.

Application and more information can be found on the WEAT website at www.weat.org.

Deadline to submit application for Scholarship is JULY 1st. The application must be postmarked by that date. The Texas Water Golf tournament funds the scholarships. You can also give directly to the fund which is tax deductible. Information is on the WEAT website.