

By Tim Daily & Bradley Pferdehirt

Comparing the costs of four SBR system upgrades

COST COMPARISON

During the planning process, managers and engineers will use the ratio of cost in dollars per gallon of wastewater treated to compare the cost of various treatment plant size options. This article refers to this ratio as the Treated Construction Cost Factor. For smaller plants, this cost can rise dramatically as the treatment plant flow rating decreases. The following is a comparison of cost per gallon of wastewater treated for four sequencing batch reactor (SBR) activated sludge system upgrades that were constructed in Pennsylvania over the past six years. The SBR systems have average flow ratings that range from 250,000 gal per day (gpd) to 4.5 million gal per day (mgd).

Three of the four systems were upgraded for increased flow capacity and in response to tighter nutrient discharge limits. The fourth system was upgraded to address non-compliance issues. SBR technology was selected so that the upgrade footprints would fit inside the available area within the treatment plants. SBR technology also provides good biological nutrient removal and has a proven treatment track record of meeting the effluent permit concentrations for total nitrogen and phosphorous in conjunction with filtration.

The upgrades have the same basic treatment trains: screening, influent pumping, SBR biological nutrient removal activated sludge, alum addition, cloth media filtration and ultraviolet (UV) disinfection. Alum chemical addition is used for final phosphorous precipitation. The UV systems are sized for peak flow and arranged in series configurations. The four treatment plants have precast post-tensioned SBR tanks. For energy efficiency and control, the four plants use variable-frequency drives for the aeration blowers and transfer pumps.

The following four upgrade designs reused treatment tanks and equipment from their existing treatment plants.

Cheyney University WWTP, Cheyney, Pa.



This 280,000-gpd system treats wastewater generated by a small university. The former system was a fixed-film treatment plant that used primary rock

trickling filters, followed by rotating biological contactors. The upgraded system design was able to reuse the influent equalization tank and two sludge holding tanks from the existing system.

The upgraded system is a two-basin 360,000-gal SBR with diffuser aeration and floating mixers. The SBR tank incorporates a post equalization tank and sludge digester compartments. The headworks consists of a new rotating drum screen; two cloth disc filters provide effluent filtration; and effluent disinfection is provided by two UV units. The plant uses liquid sludge hauling for its disposal needs. Individual PLC control panels—reporting alarms to an autodialer—form the control system.

Ridley Creek Treatment STP, East Goshen, Pa.



This 740,000-gpd system almost exclusively treats domestic wastewater. The former system was a field-erected activated sludge plant rated for 275,000 gpd.

It used two concentric steel tanks with aeration and sludge digestion located in the outside ring and the clarifiers in the center of the tank. Other processes included a primary rotating screen,

influent equalization, duplex flow moving bed sand filters, UV disinfection and belt press dewatering. The system upgrade was able to reuse the former field-erected activated sludge plant for sludge digestion and post equalization.

The upgraded system is a four-basin, 1-million-gal SBR with jet aeration and mixing. The headworks consists of a new rotating drum screen and 3 mgd influent pump station. Two cloth disc filters provide effluent filtration. Effluent disinfection is provided by two UV units. A flocculation tank is placed upstream of the filters to promote additional phosphorous precipitation. Automated telescoping valves are used to decant the sludge digesters' supernatant to the influent pump station. A new 40-gal-per-minute (gpm) centrifuge was added for sludge dewatering. Like Cheyney University WWTP, the control system consists of individual PLC control panels reporting alarms to an autodialer.

Silver Spring Township Authority WWTP, Mechanicsburg, Pa.



This 1.2-mgd system also almost exclusively treats domestic wastewater. The former system was dual-basin constant-flow SBR activated sludge plant rated

for 600,000 gal. It was constructed with two effluent clarifiers for post-phosphorous precipitation and clarification. Primary treatment consisted of a rotating screen. The treatment system had gaseous chlorine disinfection and a belt press for sludge dewatering. The system used cast-in-place common wall construction. The tanks consisted of two SBR tanks and two aerobic digesters.

The upgraded system design reused a former SBR tank from the existing system as a post equalization tank, and the other SBR tank, also from the existing system, was reused as a third sludge digester. In addition, one of the former effluent clarifiers was reused as the foundation of the filtration building to house the filters and UV system.

The upgraded system is a three-basin 3-million-gal SBR with diffuser aeration and floating mixers. The headworks uses a previously installed rotating drum screen and aerated grit chamber. The influent pumps' flow rating was upgraded to 4.5-mgd pump station. Two cloth disc filters provide effluent filtration. Effluent disinfection is provided by two UV units. Manual telescoping valves are used to decant the sludge digesters' supernatant to the influent pump station. A new 60-gpm centrifuge was added for sludge dewatering. Individual PLC control panels are integrated into an Ethernet SCADA system.

Eastern Pennsylvania

This 4.5-mgd system treats a combination of domestic, industrial, commercial and recreational wastewater. The former system was a dual activated sludge plant rated for 2.2 mgd. Primary treatment consisted of a rotating screen and an aerated grit tank. The treatment tanks consisted of two 82-ft aeration tanks and two 100-ft concentric concrete tanks with sludge holding on the outside and center clarifiers. The treatment system had gaseous chlorine disinfection and a belt press for sludge dewatering.

This upgraded system's design was able to reuse the former activated sludge plant from the existing system for autothermal thermophilic aerobic digestion, post equalization and sludge holding.

The upgraded system is a four basin 7-mgd

ARTICLE SUMMARY

Challenge: Four Pennsylvania treatment plants required upgrades: Three required increased capacity and one needed to address noncompliance issues.

Solution: SBR technology was chosen to fit the sites' footprints, as well as for its biological nutrient removal capabilities and favorable effluent concentrations.

Conclusion: A cost comparison completed after the upgrades showed that as system capacity decreases, cost per gallon treated rises.

SBR with diffuser aeration and top entry hyperbolic mixers. A new 13-mgd headworks with three band screens, centrifugal grit removal, equalization tank and three feed pumps provides pretreatment. Three cloth disc filters provide effluent filtration. Effluent disinfection is provided by three UV units. Mechanical sludge thickening is used to thicken sludge solids prior to the sludge digesters. A new 1-meter belt press was added for sludge dewatering. The system has a complete odor control system. Individual PLC control panels are integrated into an Ethernet SCADA system.

Treated Construction Cost Factor

The upgrade costs as presented in Figure 1 are the final costs to complete the treatment system. The costs do not include engineering, inspections or construction management. The costs were factored using the Engineering News Record (ENR) Construction Cost Index to account for cost escalation over the past six years to March 2013 dollars. The ENR factor was normalized to 1 for March 2013.

Figure 1 presents the Treated Construction Cost Factor in dollars per gallon treated as a function of flow, showing that the cost per gallon treated rises dramatically as the system capacity decreases. Even with the increased costs, the smaller upgrade designs did not include design features such as an integrated SCADA systems, enhanced sludge digestion or sludge dewatering. www.wwd.com

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Figure 1. Upgrades' Constructed Costs Factored to March 2013 Dollars

Upgrade (mgd)	Project Bid Date	Final Cost	Normalized ENR CCI Factor	Adjusted Cost	Treated Construction Cost Factor
0.27	March 2013	\$5,300,000	1.00	\$5,300,000	\$19.63
0.75	Sept. 2008	\$8,839,400	0.10	\$9,682,293	\$12.91
1.20	Feb. 2008	\$9,340,163	1.18	\$11,024,241	\$9.19
4.50	Dec. 2010	\$34,600,000	1.03	\$35,696,096	\$7.93

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