BACK ON FIRM FOOTING

By Steven London

Missouri city meets stringent regulations with new sewage treatment infrastructure

Sullivan's lagoon was a significant utility investment for the city to ensure adequate sewage treatment.

The intermittent-cycle extended aeration SBR system

City officials in Sullivan, Mo., were notably proud in 1988 when their new aerated wastewater treatment lagoon entered operation. The three-cell lagoon replaced a smaller facility at a different site and represented a significant utility investment for the city to ensure adequate sewage treatment.

The 950-by-500-by-12-ft lagoon was designed for an average flow rating of 1.25 million gal per day (mgd) and could hold up to 27.5 million gal of wastewater as it underwent biological treatment. Two synthetic membrane curtains spanning the width of the 10.9-acre lagoon created 15-, 9- and 6-million-gal cells. At the time, the new, larger lagoon was expected to maintain effluent standards and to ultimately serve a projected population of 14,350 by the end of its design life in 2008.

Within five years, however, the plant was essentially obsolete due to the reclassification of the effluent receiving stream—a rule change by the state's regulatory agency—and apprehension about the stability of the site's underpinning geology.

"If those concerns had existed a decade earlier, state regulators would not have approved the lagoon plant's design and operating permit," said City Engineer Robert Schaeffer, P.E., CFM. "These were unexpected issues for a city that just a few years earlier had made a relatively large investment in the new facility."

A Sign of the Times

The city of Sullivan's wastewater treatment plant is located south of Old Route 66, about three miles from Interstate 44, approximately 60 miles southwest of St. Louis. The area's rivers, woodlands and Meramec State Park are popular with canoeists and campers.

Caves are another attraction, including the commercial Meramec Cavern, the largest of Missouri's 6,000-plus surveyed caves. The voids were hewn beneath the topography by the ebb and flow of subterranean water over the course of millions of years. Guided walking tours through the world-class formations have made the large cavern a popular stop for travelers ever since Route 66 was a primary roadway across the state. Billboards and fading signage on barn roofs still promoting Meramec Cavern are as iconic in this part of the Midwest as the sequential rhymes of the Burma Shave signs of a bygone era.

A state assessment of the caves presented an unforeseen issue for the city of Sullivan.

Study Identifies Options

The city engaged the consulting firm of Crawford, Murphy & Tilly Inc. (CMT) to study the problem and present solutions. Schaffer recently revisited the findings presented to his predecessors when the earlier plant presented major environmental issues in the mid-1990s.

First, Winsel Creek, the receiving stream for Sullivan's treated effluent, was reclassified in 1992 as a "losing stream," which imposed stricter effluent limits for any continued use. A geologic assessment by the state also had concluded that a collapse potential existed in the honeycombed karst geology underlying the area. A sinkhole beneath the lagoon could damage the bottom of berms and allow leaks or an outright discharge of untreated water that could spread quickly underground and impair the drinking water supply for the area. Some would later refute the potential for a collapse, but perception about even the most remote possibility of a geologic failure was difficult to mute, according to Schaffer.

The city of Sullivan was not alone in facing this perceived problem for existing at-risk wastewater treatment lagoons in what many refer to as "The Cave State." Aerated wastewater treatment lagoons such as Sullivan's are common across much of Missouri. At the time of the state geologic study, sinkholes had occurred elsewhere due to geologic collapses. Enough lagoon treatment facilities across the state were cited as inadequate to meet stricter effluent quality limits and at structural risk that the Missouri Water Commission issued a rule change to buy the communities time to make the necessary corrections.

The facilities were allowed to continue operating as long as they met state effluent quality standards over the course of their design life. Sullivan's plant was among those kept afloat by a series of variances issued by the Missouri Department of Natural Resources (MDNR), but the lagoon had limited remaining design life. "But it became obvious that another lagoon would never earn a permit," Schaffer said.

Sullivan's challenges became even more pronounced when MDNR notified the city in 2004 that it had two options: Sullivan could either build wells to monitor whether the plant's discharge was having an adverse impact on the groundwater aquifer downstream, or it could replace the lagoon plant. Faced with an expiring design life of 2008, the city ruled out the wells and other alternatives to extend the use of a modified lagoon. Of equal importance was the reclassification of the receiving channel as a losing stream. This was expected to translate into lower effluent limits on total suspended solids, biological oxygen demand and ammonia-nitrogen. Disinfection, absent at the city's lagoon, was another process change on the horizon. The combined factors and the cost/benefit evaluation of eight alternatives in the CMT study precluded the use of aerated lagoon treatment.

The study identified a series of other needed upgrades after concluding that Sullivan would require a different, more advanced wastewater treatment process. The influent pump station would require expansion and modifications, including new flow measurement facilities; grit removal; a mechanically cleaned fine screen apparatus with companion compacting equipment; piping and electrical upgrades; a new effluent outfall; and provisions for flow control and distribution.

Eight alternative designs were evaluated for a new plant, including four based on a lagoon system and four based on an activated sludge biological treatment process. The study favored activated sludge biological treatment with disinfection as a link in the process chain. Aerobic digesters would be used to stabilize waste-activated sludge prior to disposal through land application. The plant's infrastructure had to deliver the desired capacity needed to fit within site limitations and had to accept future expansion.

An Advanced Process

Jacobs Eng. was selected to serve as design consultant for the replacement plant and related upgrades. From the eight process alternatives evaluated in the earlier study, the city had selected the Sanitaire Intermittent Cycle Extended Aeration System (ICEAS) Continuous Flow SBR system, which utilizes a modified activated sludge biological treatment. The ICEAS, related ultraviolet (UV) disinfection and subsequent pump equipment were supplied through Vandevanter Eng., a factory representative serving the area for Xylem.

The $7-million plant project was sized for an initial design capacity of 1.5-mgd average daily flow (ADF) and 6-mgd peak flow. The design and layout

will accommodate expansions in 1-mgd increments up to 3-mgd ADF. Each 1-mgd expansion would serve a corresponding increase of approximately 10,000 additional customer service connections. The existing lagoon's footprint offered an opportunity to develop diverted storm water storage whenever storm events increase the flow above 6 mgd. This required construction of a two-cell earthen basin that receives the excessive flow from over an influent weir and then later releases it back to the influent pump station for infusion into the process train. One-third of the original lagoon was preserved and retrofitted with a new fourth berm to create two 1.5-acre cells that can hold 4.3 million gal. The 40-mil polyethylene liner in the 180-by-150-by-10-ft facility can withstand high-pressure water cleaning.

These features provide a plant capacity that should serve an equivalent population of 21,000 projected by 2025.

The automated process is an enhanced variant of the activated sludge process that earned preferred specification based on the earlier study's cost-benefit analyses of the immediate and long-range considerations. The design option offered acceptable first cost, ability to handle the varied flow, and the flexibility to be operated to achieve nutrient removal with minimal operator interaction.

"The SBR technology has become increasingly common here in Missouri and is easy to operate," said P.K. Mathai, P.E., project engineer for Jacobs Eng. "Our firm has used the Sanitaire ICEAS Continuous Flow SBR and related equipment specified at Sullivan many times before because it has performed as expected."

Addition of future mixers and control adjustments can deliver denitrification. Provisions for upgraded electrical service and the aeration blowers are already in place, Mathai said.

A Hybrid of the Proven SBR Process

The major difference between the conventional activated sludge process and a conventional SBR cycle is the elimination of primary settling, aeration and secondary clarification in costly separate basins. SBRs perform these stages sequentially in the same basin, which reduces the plant footprint and contingent construction costs.

The storm water basin

Sullivan's system can potentially accommodate up to six times the average daily flow without degrading effluent quality.

The ICEAS system takes the process further by using continuous flow without the batch interruptions during the settling and decanting required in a conventional SBR operating cycle. Instead, the ICEAS system uses a time-controlled continuous repetition of three sequential phases: aeration, settle and decant. Flow equalization, oxidation, nitrification/denitrification, phosphorous removal and solids separation occur in a controlled manner within the same tank. The new-generation system thereby simplifies the entire process flow.

Sullivan's ICEAS system can potentially accommodate up to six times the ADF without degrading effluent quality. Moreover, an operator has the flexibility to adjust the sludge-wasting time and duration of the aeration for each cycle in response to varying load conditions, considered advantageous during startups normally characterized by low influent loading.

The plant's treatment cycle for nominal flows presently consists of two hours of aeration, one hour of settling and one hour of decanting, which allows six cycles per day. Wet weather conditions reduce the total cycle time by up to two hours, resulting in a total of 12 cycles per day.

The new Sullivan plant's disinfection system is a Xylem Wedeco brand UV system that operates in one open channel with two banks of 24 lamps each. Jacobs Eng. sized the equipment from the outset to treat the maximum flow of 6 mgd. The lamps revert to a lower power usage standby mode until water trips a float switch hung from the decanter weir to trigger the needed lamp warm up. The UV technology also offers savings because it can operate with one bank of lights during 2.25-mgd low-flow conditions. This is the projected volume for 97% of the time, which not only saves energy but extends the system's lamp life. The UV system accommodates still other control practices that reduce capital and O&M costs.

The plant's aerobic digestion stabilizes and thickens the sludge for removal and land application. The waste-activated sludge is pumped to an aerobic digester that uses the fourth SBR basin for the interim. The decant from the digester is piped to the influent sewer and across a Sanitaire fine bubble aeration system that aerates it for up to 12 hours per day. A new aerobic digester and digested sludge storage basin would be future enhancements.

Schaffer most recently upgraded the city's wastewater treatment infrastructure further by replacing the six existing 15-hp influent pumps with four 25-hp and two 15-hp, more energy-efficient Flygt pumps fitted with N-Impeller hydraulics. The $72,611 grant for the capital improvement was largely underwritten by a state program for energy-saving initiatives from Missouri's $43.8-million share of the Energy Efficiency and Conservation Block Grant program, which was funded by a portion of the $2.7 billion of American Recovery and Reinvestment Act monies added for block grants authorized by the Federal Energy Independence and Security Act of 2007.

Now equipped to leave earlier concerns about the increasingly stringent wastewater regulations, the city of Sullivan can again be proud of its new sewage treatment infrastructure. Only this time, the plant is better designed to respond to any unforeseen rule changes. WWD

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