Improved Efficiency for Aging Wastewater Plant
Upgrades Boost Capacity, Lower Costs

By John Mitchell, PE

While changes in discharge regulations, demand or ability to meet upgraded water quality standards can each require urgent improvements to a wastewater treatment facility, in the case of Wastewater Treatment Plant No. 20 in Kansas City, Kan., all three converged. The change agents included revised surface water quality standards in the state of Kansas, development of a NASCAR/IndyCar racetrack surrounded by new retailers and residential areas in Wyandotte County, Kan., and the deterioration of a nearly 30-year-old wastewater treatment plant. A goal of increasing energy efficiency added to the challenges, making the project one of the most complicated and later one of the most successful wastewater treatment plant upgrades in the region, with 1.7 million kilowatt-hours saved the year after the plant’s completion.

Stricter Water Quality Standards
Just before a 1998 study conducted on Wastewater Treatment Plant No. 20, the state of Kansas revised several surface-water quality standards affecting the Kansas River, into which the plant discharges (see Figure 1). Included were revised ammonia nitrogen and fecal coliform limits. Wastewater Treatment Plant No. 20’s original permit required only monitoring ammonia nitrogen and fecal coliform, while the revised permit imposes numeric limits for both. Initially, 19 milligrams per liter (mg/l) of ammonia nitrogen in the winter and 15.5 mg/l in the summer was included in the national pollutant discharge elimination system permit with the expectation that permit limits would be revised downward over subsequent permit renewals. A revised fecal coliform limit of 200 colonies per 100 milliliter of effluent was also imposed.

Spike in Demand
With the Kansas Speedway opening in June 2001, Wastewater Treatment Plant No. 20 needed significant modifications in order to handle increased wastewater flow. The volume was estimated to increase from 4.17 million gallon per day (mgd) to 9.21 mgd during a peak race-day event, the result of the tens of thousands of temporary users at the raceway. Because of the physical nature of the sparged air system, there wouldn’t be enough oxygen to support the nitrobacter and nitrosomonas bacteria that reduce ammonia nitrogen. This seasonal and instantaneous fluctuation in demand, coupled with the new retail and residential developments in the surrounding Wyandotte County area, required a unique aeration solution for this wastewater treatment plant.

Outdated and Deteriorated
Until this endeavor, Wastewater Treatment Plant No. 20 had not received any major updates since its 1978 construction. One of the processes needing replacement was the 900 hp, energy-draining sparged air system that consisted of eight 75-hp turbine mixers and two 150-hp multistage blowers. The increased flows of 9.2 mgd and peak wet weather flows of 21 mgd required a more energy-efficient aeration system. In addition, the main switchboard, which distributes power to the entire plant and serves as the motor control center for the solids handling and influent pump stations, had suffered critical deterioration due to hydrogen sulfide. All processes needed to be modernized in some fashion.

Additional Challenges
In addition to tightened aeration system and combined single-stage and multi-stage blowers created energy savings that left Water Pollution Control Division Director Jim Larkin smiling.

Figure 1: Replacing the sparged air system with a high-performance aeration system and combined single-stage and multi-stage blowers.
doubling of influent flows and antiquated equipment, upgrading Wastewater Treatment Plant No. 20 posed additional obstacles.

As is typical with wastewater treatment plants, the facility needed to continue operations throughout the construction process — so Burns & McDonnell engineered the new systems to be implemented in a tightly controlled, sequential manner.

The first step was to separate the power feeds at the switchboard into two components so one could be active while the other was de-energized for replacement. Further construction occurred in rigid sequences to allow continuous operation of the facility. This required exceptional planning, communication and cooperation among the engineering, operations and construction functions throughout the 14-month construction period. Finding room for both old and new equipment was another hurdle, as all updates needed to occur within the existing space.

**Process Improvements**

To accommodate the increased demand, all unit processes were improved to accommodate the increased daily flow and the peak wet weather flow. The old, energy-draining sparged-air system consumed up to 900 hp per day regardless of influent flows and oxygen demand. The new combined single-stage and multistage blowers, fine-bubble aeration and dissolved-oxygen control system now require only 300 hp to accommodate the increased demand. Part of the new aeration system — the single-stage blower that operates efficiently from full capacity down to 50% — handles the base load for the majority of the year and typically does not reach levels below 80% capacity while it functions as the lead blower. Sitting latent until it’s time to gear up for race days, a multistage blower takes over the base load, while the single stage handles the remaining demand.

This design maximizes power savings, as the multistage blower has limited efficiency at reduced capacity. During a peak demand event, such as a Kansas Speedway NASCAR race, the now-automated controls monitor and transfer between the single-stage and multistage blowers as needed. An additional multistage blower is present as backup to meet the redundancy requirement. Disinfection is accomplished using ultraviolet radiation. A conventional low-pressure, low-output system was selected. The selection process included evaluation of both capital and operating costs, as well as careful consideration of manufacturers’ local support capabilities.

Although the low-output system requires a significantly larger number of lamps, the efficiency of the lamps proved to be superior to competing systems and resulted in lower energy costs over the life expectancy of the installation. The system’s output — hence its power consumption — is automatically varied to match effluent flow rates, thus maximizing system efficiency.

The system was initially constructed to treat up to 10 mgd with infrastructure in place, to be upgraded to 21 mgd by installing additional lamp modules. An innovative level control system allows maintenance of water levels in the UV reactor regardless of backwater effects (see Figure 2). This approach allowed for elimination of an effluent pumping station that would have otherwise been required for the plant when the river is at the 100-year flood stage.

**Automated Processes**

Process controls at Wastewater Treatment Plant No. 20 are now almost completely automated, reducing the number of full-time staff required to operate the facility and thus creating cost savings for the Unified Government of Wyandotte County/Kansas City, Kan. The supervisory control and data acquisition (SCADA) monitoring system

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**Figure 2:** Automatic level control for UV disinfection eliminated the need for an effluent pumping station.
provides real-time monitoring and control capabilities for each unit process. SCADA information is transmitted from Wastewater Treatment Plant No. 20 to the Kaw Point Treatment Plant, which is staffed 24 hours per day, over a secure spread-spectrum radio system.

The system was designed with the capability to expand communication to more than 50 other pumping stations in the unified government’s collection system. Ultimately, this backbone of the radio communication system will allow phasing out the telephone communication system, which can become overloaded during heavy rain events when all remote pump stations transmit operating status simultaneously.

Energy-Efficient, Fast Payback

The most impressive effect of the reconfiguration and modernization of the plant is its staggering 300% energy savings, in spite of handling an increased capacity. In 2002, the Wyandotte County/Kansas City, Kan., Water Pollution Control Division’s energy use totaled about 19.6 million kilowatt hours for its three treatment plants and 52 pump stations, a significant drop from its 1999 total of around 21.3 million kilowatt hours. The decrease can be attributed solely to the improvements at Wastewater Treatment Plant No. 20 — an energy savings so dramatic that the municipality’s officials thought half the plant must have been shut down to reach that figure.

Improvements at Wastewater Treatment Plant No. 20 reached payback within the five-year projection despite lower-than-projected flows from the Kansas Speedway and lower-than-projected increases in utility power costs. The lower-than-projected flows from the Kansas Speedway fares well for the plant due to the continued development in the Wyandotte County area.

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