Holistic Wastewater Management

Data analytics programs facilitate real-time performance management and help utilities maximize return on capital investment.

A new consolidated pumping station will enable CCUC to manage and equalize wastewater influent flow system-wide.

PHOTOS COURTESY OF BLACK & VEATCH

By Kent A. Lackey & Courtney Driver

Programs are designed to increase efficiency, optimize operations & provide future flexibility for North Carolina utility

In early 2013, Winston-Salem/Forsyth City/County Utility Commission (CCUC) took a significant step toward transforming the future of how it manages wastewater treatment by commissioning the South Fork Improvements Program. CCUC's wastewater system is the third largest in North Carolina, serving approximately 97,000 customers in the northwest part of the state. The system consists of two wastewater treatment plants, 49 sanitary sewer lift stations and more than 1,700 miles of gravity sewer.

Wastewater Treatment Interconnectivity

A key component of the program will be construction of a new consolidated influent pumping station at the 21-million-gal-per-day (mgd) Muddy Creek Wastewater Treatment Plant (MCWWTP). The new pumping station will receive two-thirds of the total system flow, provide preliminary screenings and grit removal and enable CCUC to pump wastewater influent to the MCWWTP or transfer it to the 30-mgd Archie Elledge Wastewater Treatment Plant (AEWWTP). Influent flow can be equalized in onsite day tanks or storm water equalization basins, thereby eliminating rapid flow variations and providing optimal flow management into either plant. The ability to transfer influent flows between plants provides CCUC with significant power in managing industrial user allocations on a system basis versus a plant basis, which gives it greater capacity to accept industrial growth throughout the system. The ability to manage treatment on a system-wide basis will allow CCUC to meet future treatment capacity needs and regulatory requirements by upgrading or expanding either plant depending on the most cost-effective overall solution.

"The ability to manage industrial waste load allocations and treatment capacity requirements on a system-wide basis will give us the flexibility to match total system needs with total treatment capacity," said Ron Hargrove, director of CCUC. "This will reduce the overall cost of treatment and provide a competitive advantage toward potential future wholesale customers."

Real-Time Cost of Treatment Flow Management

The interplant influent flow transfer system will include a new analytical performance application that uses online sampling and flow measurement coupled with individual plant energy consumption and performance data to calculate real-time cost of treatment at each plant. With this application, CCUC management can leverage cost of treatment, plant performance and effluent compliance information to monitor real-time treatment cost and guide the utility in selecting the optimal plant for treating the influent flow at the lowest cost while maintaining regulatory compliance. The application also is a powerful treatment planning tool because it will allow CCUC to run flow management scenarios and understand the impact on plant performance and cost of treatment before implementing improvements.

Creating Value Through Optimization

A second important component of the program was a multi-plant treatment optimization program focused on evaluating opportunities at the AEWWTP and MCWWTP that could reduce operating costs and improve sustainability of the wastewater treatment system. Black & Veatch worked with CCUC to evaluate opportunities such as:

- Aeration efficiency improvements (dissolved oxygen [DO] control or anoxic zone mixing);
- Sidestream ammonia and phosphorus treatment;
- Biogas utilization (combined heat and power, gas distribution, vehicle fuel);
- Chemical control automation (chlorine, magnesium hydroxide);
- Pump operation automation (equalization, hydraulic optimization, performance monitoring); and
- Demand management.

A critical evaluation of optimization opportunities helped establish an overall optimization program in which each opportunity was screened. High-value, short-return opportunities received additional consideration, whereas moderate-value opportunities were consolidated into future capital projects. This allowed the utility to leverage future project costs and reduce net project costs, thus decreasing the return period. The multi-plant optimization evaluations resulted in significant steps forward at both plants, including an aeration system upgrade at the AEWWTP and a combined heat and power (CHP) system at the MCWWTP.

"The multi-plant optimization program has supported our vision of holistic wastewater management, reducing our overall cost of operation and increasing the overall sustainability of our business practice," Hargrove said.

Aeration Optimization

Each of the four existing aeration basins at AEWWTP is outfitted with fine-bubble diffusers in 16 aerobic zones and three swing zones. The

existing air distribution piping configuration provides DO control via a single DO probe in the basin at a time. Because there is no means of effectively distributing air flow along the length of the basin, DO averages 5 mg/L throughout the basin, whereas typical residual DO in aeration basins would be expected to be 2 mg/L at average conditions. This provides significant excess air supply and wasted blower energy consumption. The project team used BIOWIN modeling and air demand calculations to evaluate a combination of aeration basin scenarios with different zones in order to identify the optimal configuration for air transfer rate and mixing capacity. The new aeration system will result in a projected reduction in air flow of 5,000 standard cu ft per minute (scfm) at average annual and 9,000 scfm at maximum month conditions under current conditions. The project power savings are approximately $117,000 per year, which yields a simple payback of six years.

Combined Heat & Power

The MCWWTP currently uses digester gas through gas-driven blowers; however, one blower engine is out of service and in need of replacement and the second is aging. Additionally, the existing gas-driven blowers are unable to fully utilize all digester gas produced in the plant's existing mesophilic anaerobic digesters. After evaluating alternative digester gas utilization opportunities in connection with the design of the new consolidation pumping station, the team identified installation of a CHP facility at the MCWWTP as a high-value opportunity for long-term energy reduction.

The new CHP system is currently in design and will be able to generate 800 kW of power off digester gas and 1.1 MW of emergency power with natural gas supplement. Providing a dual-fuel CHP system with emergency power capability enables CCUC to offset capital investment in new emergency diesel generators required for the new pumping station, yielding a significant reduction in realized capital cost for the CHP system. The system will supply electrical power directly to the power transmission grid and supply hot water for digester heating, thus offsetting plant power consumption and natural gas usage. Anticipated capital cost of the CHP system is $3.5 million with an expected simple payback of approximately eight years after offset for the emergency diesel power generator savings. The system also will generate an annual net revenue of approximately $250,000.

Upon completion, the new aeration system at CCUC's Archie Elledge WWTP is expected to yield energy savings of approximately $117,000 per year, which will provide a simple payback of six years.

Leveraging the Power of Integrated Analytics

Effective maintenance and monitoring of system operation and performance of critical processes, such as the aeration control system at the AEWWTP and the CHP system at the MCWWTP, are important for CCUC to continue to reap the most benefit from improvements.

The wastewater treatment facilities will therefore incorporate an integrated wastewater treatment performance management system that uses analytics to provide real-time energy management and maximize return on investment.

"Recent investments in the South Fork Improvements Program and the treatment optimization program support our vision for holistic wastewater management," Hargrove said. "Smart investment yields significant business advantages in meeting future needs and expanding our system to provide a high level of service at the lowest cost to our customers." w&wd

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