Waukesha Clean Water Plant Improvements

STRAND ASSOCIATES

2018 APWA Public Works Project of the Year Award

Client: City of Waukesha, WI
Category: Environment, Division: $25-$75 Million
Entrant: Strand Associates, Inc.®

Waukesha Clean Water Plant Improvements

Project Background and Overview

In 2010, the City of Waukesha hired Strand Associates, Inc.® (Strand) with the primary goals of enhancing the energy efficiency of the biological treatment process, modernizing the biosolids stabilization and dewatering processes, implementing automatic process monitoring and control capabilities, improving the reliability of the electrical infrastructure, planning for future stringent nutrient limits, and replacing outdated equipment at its aging wastewater treatment plant.

Strand worked with the City to assign priority to needs and developed a four-phase capital improvement plan to provide top quality wastewater treatment for the plant and the sewer system for the next 20 years at a cost the city ratepayers could afford. Since parts of the plant were repurposed and reused to the greatest extent possible as part of the new, innovative concept, outstanding project management was critical. The first two phases of construction were completed on schedule, in 2016, and under budget for a total of $41.5 million.

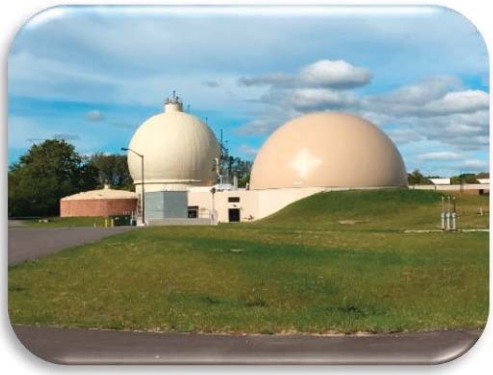
Phase one included:

- Construction of a 1.1-million-gallon egg-shaped digester.
- Conversion of an existing digester to a centrate storage tank.
- Installation of a digester membrane gas storage dome to provide additional biogas storage for a future cogeneration project.
- Installation of state-of-the-art high-speed turbo aeration blowers to improve process control and energy savings.
- Implementation of an aeration monitoring and control system.
- Rehabilitation of the effluent sand filters and effluent water elevated storage tank.
- Rehabilitation and expansion of the existing administration building.
- Replacement of the three existing belt filter presses with one dewatering centrifuge.
- Upgrade of approximately $1.5 million of process equipment.

Phase two included:

- Replacement of the facility's under-capacity ultraviolet light (UV) disinfection system.
- Replacement of the facility's existing postaeration system.
- Provision for future construction of effluent pumping and piping to return water back to the Great Lakes watershed.

As the prime consultant, Strand was responsible for plan development, design, and construction administration for this project. Black and Veatch was responsible for process and structural design of the digestion facilities and limited construction administration related to these facilities. Black and Veatch performed 26 percent of the design services and 10 percent of the construction administration services.



This project transformed a treatment plant into a modernized clean water plant and provided a critical component in the City's quest for a quality, dependable water supply.

STRAND ASSOCIATES®

Completion Date & Time Extensions

All parties involved were focused on delivering a top-quality project at a cost the ratepayers could afford. These efforts contributed to on-budget (total actual: $41.5 million, total budgeted: $41.8 million) project delivery. Time extensions were granted to the contractor because of unforeseen issues with equipment deliveries.

Construction Schedule, Management, and Control Techniques Used

The construction schedule developed by the contractor was a result of a collaboration between the general contractor, the mechanical and electrical subcontractors, and the egg-shaped digester manufacturer. Sequencing of the construction of the egg-shaped digester was a critical component of the overall project schedule because of its impact on the contractor's ability to renovate the rest of the digestion complex. The digestion complex renovations were the critical path of the project. The contractor's other activities, including a significant expansion and reconstruction of the Administration Building and extensive equipment replacement throughout the facility, were dovetailed into the digester construction activities to minimize staffing variations throughout the project.

Timely submittal and approval of shop drawings is essential to keep any project on schedule; one of this magnitude and complexity required significant coordination between the contractor, subcontractors, equipment suppliers, and engineer. The time required for review of larger submittals can be substantial and, if multiple reviews are needed, the necessary time for approval is multiplied, with late or incomplete submittals potentially causing major impacts to the schedule. Provisions were included in the project specifications to require that all shop drawings be submitted and approved by 25 percent completion of the project, as measured by payment, to encourage timely submittals and hopefully reduce the potential for the entire project schedule to be derailed by the shop drawing submittal process. Likewise, the contract required that operation and maintenance manuals be submitted prior to 50 percent completion to ensure that the City would have the necessary information to operate the new equipment prior to equipment startup.

Use of Alternative Materials, Practices of Funding that Demonstrates a Commitment to Sustainability

In addition to the sustainable project elements described later in the environmental considerations section, both execution and funding of the stormwater improvements on the site showed the City's commitment to sustainability. Construction of the bioretention basins required over excavation, decompaction, and reconstruction with 36 inches of engineered soil. The engineered soil was developed using a mixture that included composted leaves from the City's composting facility, which is adjacent to the Clean Water Plant. Design and construction of the stormwater features on site were paid for, in part, by a grant from the Wisconsin Department of Natural Resources.

The administration building incorporated many sustainable practices including an intensive, easily accessible green roof.

The administration building also incorporated sustainable practices, including recyclable carpet tile with a high recycled content, 100% pre-consumer recycled wood fiber in the particle board for all the cabinetry, and an intensive green roof.

Safety Performance

The safety program was maintained by the contractor and followed company-established procedures. There were no recorded lost-time injuries during construction and the contractor complied with OSHA standards for the duration of construction.

Environmental Considerations

Utilizing existing structures to the greatest extent possible was a significant portion of the project, and several design elements positively impacted plant operations from an economic and sustainable perspective. These include:

- New energy-efficient turbo blowers and an aeration control system for the activated sludge secondary treatment process
- Repurposing of a digester tank as a centrate storage tank
- Installation of one centrifuge in place of the three existing belt filter presses
- Modification of the dewatering operation
- Construction of a green roof for the administration building addition
- Addition of biogas storage
- Implementation of several sustainable stormwater enhancements throughout the site

Prior to this project, the blower system that supplied air to the activated sludge treatment consisted of two 350 hp older centrifugal blowers and three outdated 700 hp multi-stage centrifugal blowers. The 350 hp blowers were used under most operating conditions, with the 700 hp blowers used under heavy loading conditions or during maintenance of the smaller blowers. Starting just one of the 700 hp blowers, for even a short time, drastically increased electrical usage. The new design replaced the antiquated 700 hp blowers with high-speed turbo blowers and the 350 hp blowers were retained for backup capacity. The turbo blowers are 20 percent more efficient, drastically reducing the energy used for the aeration process. Control valves and the dissolved oxygen monitoring system were also replaced and a new aeration control system was installed to better regulate blower operation so that it more closely matches oxygen demand in the tanks, further reducing energy use.

Use of efficient high-speed turbo blowers in place of the existing 700 hp and 350 hp aeration blowers will provide a significant energy reduction for the plant.

Repurposing one of the existing 55-foot digesters as a centrate storage tank was another opportunity to reduce the plant's energy consumption during the aeration process. Prior to the rehabilitation, biosolids dewatering was performed in a batch process where digested biosolids were stored in a storage tank until full, and then the belt filter presses were operated 24 hours-a-day until the tank was empty (usually 1 week). Because the dewatered biosolids (centrate) have a high ammonia concentration, a significant amount of oxygen is required for treatment

when the centrate is returned to the activated sludge system. This procedure exerted a heavy demand on the aeration tanks for 1 week each month and required staff to work overtime, both leading to higher operating costs. The new design replaces the belt filter presses with a dewatering centrifuge that processes biosolids over 5, 8-hour days. The updated process uses the repurposed digester to store the centrate produced from the centrifuge so that it can then be slowly fed into the activated sludge system. This update not only reduces the peak oxygen demand, and, therefore, power usage, but also significantly decreases costs associated with staff overtime.

Another benefit of the centrifuge is that it produces high concentrate dewatered biosolids, reducing the volume of material hauled and spread on agricultural fields, further reducing costs and the overall carbon footprint of the plant. The total economic impact of the changes to the dewatering process is expected to be a savings of more than $100,000 annually.

Other sustainable components of this project included repurposing and expanding the administration building and the addition of a membrane gas holding cover in anticipation of future use of biogas as part of a combined heat and power (CHP) system to further reduce the overall carbon footprint of the plant. The City will be undertaking a biogas study in 2018 to determine the most advantageous beneficial use of the biogas.

Finally, with the approval by the Great Lakes Compact of diversion of Lake Michigan water to the City for its drinking water supply, the public's perception of the treated wastewater quality is critical since it requires the return of treated effluent back to the Great Lakes watershed via the Root River. As this is the first such approval under the Great Lakes Compact, public scrutiny from the entire Great Lakes region of the quality of the treated effluent will likely never be greater. With this future attention in mind, decisions regarding equipment replacements within the facility from the headworks (beginning of the treatment process) forward, rehabilitation of the effluent filters, and the design of the phase two expansion of UV disinfection system were all carefully vetted. During design, the team engaged key stakeholders from the Waukesha Water Utility (WWU) and the Wisconsin Department of Natural Resources (WDNR) to identify and address critical project goals, such as incorporating UV disinfection for all water discharged to the Lake Michigan basin. In addition, while the return water pumping station was not constructed during the first two phases, provisions for addition of the pumping station and effluent piping were incorporated.

Community Relations

Located in the 7th most populated city in Wisconsin, the Waukesha Clean Water Plant renovation and expansion delivered a sustainable, environmentally conscious, well-planned project, while being a good steward of public finances by continually seeking more efficient, cost-effective ways to provide services -- all goals of the City's strategic plan. Providing reliable and economical wastewater treatment was paramount in decisions related to phasing improvements over the next 20 years.

One of the main social impacts of this project is on the City's ongoing potable water situation, as citizens throughout the country are closely scrutinizing the quality and availability of their local water supply. After 10 years of extensive searching for local and regional alternative water supplies, the City's best hope was Lake Michigan water. To secure this source through the Great Lakes Compact, the City would have to commit to returning an equal quantity of water to the Great Lakes watershed, which could only happen through improvements to its wastewater treatment plant. Therefore, the design of any plant improvements needed to take into consideration this potential eventuality. Now, the plant has the capability to enable the City to meet its critical obligation of returning high quality effluent back to the Great Lakes watershed, thereby giving the residents of Waukesha the peace of mind that they will now have access to one of the largest high quality, freshwater supplies in the world.

The quality of effluent discharged from the plant is critical, as the City is required to return an equal quantity of water to the Great Lakes watershed via the Root River.

Unusual Accomplishments

All plant modifications were completed while continuing to meet WPDES treatment requirements. Replacement of the entire electrical distribution system, including the service entrance switchgear, distribution switchgear, and switchboards required meticulous planning and design efforts. All the high voltage conductors on the site were also replaced, in some locations using the existing conduits and duct banks, a feature of the design that significantly reduced costs, but complicated construction. Significant planning and cooperation were required for an orderly transition from the old, deteriorated system to the new system, which greatly improves reliability, a critical mission of the facility.

Full implementation of the facility's new supervisory control and data acquisition (SCADA) system also presented challenges. The plant's existing system was able to monitor conditions of treatment processes and operation of plant equipment, but was not able to automatically operate the equipment in response to changing conditions. The new system enables automatic control of all processes from the new control room in the updated administration building, and provides flexibility for remote monitoring of the plant after hours when staff is not on site.

Making significant modifications to the anaerobic digestion process while maintaining stabilized biosolids treatment required a very complex plan to phase construction. In addition to construction of the egg shaped digester (ESD) in the footprint of one of the existing digesters and cleaning and rehabilitating the existing 90-foot digesters, the sludge heating system was converted from a complicated and inefficient steam-water hybrid system to a hot-water sludge heat-exchange system. This system included new boilers and conversion to a pumped mix and recirculation system. All of the biogas handling equipment, including the biogas flare, was replaced as well.

The expanded UV disinfection facilities were designed anticipating future addition of the Lake Michigan effluent return flow pumping station.

Finally, the second-phase UV disinfection improvement project needed to be done without violating WPDES permit

STRAND ASSOCIATES®

requirements, which meant that it had to be completed within a small window during the fall and winter when disinfection was not required.

Additional Considerations

Extensive discussions with City staff during the planning process focused on alternatives to the existing inefficient biosolids stabilization system that consisted of two 55-foot and two 90-foot diameter digesters. The alternatives considered included continued use of the existing system with in-kind equipment replacement, temperature-phased anaerobic digestion, and replacement of portions of the digestion tankage with one or more conventional or egg-shaped digesters (ESD). After thorough evaluation, replacement and refurbishment of the two 90-foot digesters and replacement of the two 55-foot digesters with one ESD emerged as the best alternative toward achieving plant goals.

An ESD was chosen because of anticipated process improvements, operational benefits, and overall cost of ownership. Because of its unique shape, the ESD enhances mixing of the digester contents and reduces deposition of solids in the bottom of the digester, which plagued the plant. Previously, the four digesters worked in parallel with timed feeding of each, in turn, in proportion to its capacity. With the new design, the ESD is the primary digester, receiving all of the biosolids feed, both primary and thickened waste activated sludge. In the past, operations staff struggled with a workable strategy to feed the digesters in a way that minimized foaming, but now with the ESD, foam management has significantly improved.

An egg-shaped digester was chosen over traditional technologies, as it alleviated solids deposition, improved processes, and provided operational benefits.

As the second ESD installation in Wisconsin, this project provides other engineers with valuable insights into the efficacy and cost-effectiveness, and their value for facilities with grit, foaming, similar operational issues, and potential site constraints, as this design reduced the overall footprint of the digester process.

Modifications to the existing administration building is another critical component exceeding the City's needs. The old building was cramped and did not meet current building codes. Creative solutions, including moving the elevator, reorienting the laboratory, a locker room expansion, and adding a dedicated plan room, records room, conference room, and space on the front of the building for a SCADA office provide the City with a more useful space that has exceeded expectations. Addition of a training room that can also serve as a backup emergency control facility in the event of a natural disaster provides additional value to the City. The new façade with an open atrium entryway, green roof, and rooftop patio enhance the appearance and sustainability of the expanded structure.

The new administration building is now a functional space for plant staff and provides a backup shelter in emergency situations for the public.

Through the collaborative efforts of City staff, the Strand project team, and numerous contractors, this project transformed a treatment plant into a modernized clean water plant and provided a critical component in the City's quest for a quality, dependable water supply. The project embodies the triple bottom line concept of financial, social, and environmental performance measures, and despite innovate design elements that can bring higher costs, the project fell well below the industry standard for change orders on a project of this magnitude. "Waukesha's Clean Water Plant project is undoubtedly a success story in our infrastructure history," said Dr. Fred Abadi, director of public works for the City of Waukesha. "The technology and treatment processes designed by Strand will serve the needs of our community well into the future, while continuing to provide high quality wastewater treatment and protection for the environment."

STRAND ASSOCIATES®