Sheboygan Regional Wastewater Treatment Facility, Sheboygan, WI

In a concerted effort to clean up our rivers and lakes by the mid-1980s, communities in Wisconsin and throughout the nation started working to meet stringent state and federal water quality standards. The Sheboygan Regional Wastewater Treatment Facility plays an important part in this continuing battle for cleaner water. The high quality of the effluent discharged into Lake Michigan is evidence of the positive action that has been taken to restore and maintain the lake's chemical, physical, and biological integrity. Residents of Sheboygan and the surrounding area can be proud of their wastewater treatment facilities.

HISTORY OF THE SHEBOYGAN REGIONAL WASTEWATER TREATMENT FACILITIES

The City of Sheboygan first constructed a wastewater treatment plant on the present site in 1937. This original plant provided primary treatment, which essentially consisted of removal of large suspended solids. In 1957, the plant was upgraded to provide secondary treatment through the removal of additional suspended solids and soluble organic material.

By 1970, Sheboygan had outgrown the upgraded treatment facilities, and the city authorized an engineering study to assess the community's wastewater treatment needs. Before design and construction of a plant addition could begin; however, Congress enacted the *Federal Water Pollution Control Act Amendments of 1972, Public Law 92-500*. In response to these new requirements, a feasibility study was conducted which indicated that a single wastewater treatment plant would be the most cost-effective and environmentally sound method of treating wastewater produced in the region. The regional facilities would serve the Cities of Sheboygan and Sheboygan Falls, the Village of Kohler, the Town of Sheboygan, and portions of the Towns of Sheboygan Falls, Lima, and Wilson.

The sanitary sewer system analysis and the wastewater treatment facilities plan were completed in 1975 and 1976, respectively. The facilities plan called for expansion of the existing Sheboygan wastewater treatment facilities and the abandonment of the treatment facilities in Kohler and Sheboygan Falls. Many components of the previous Sheboygan treatment plant were incorporated into the new facilities, which resulted in lower construction costs. This plan also included construction within the City of Sheboygan of the west interceptor to convey wastewater from Sheboygan Falls and Kohler. Other projects included a sanitary sewer rehabilitation and combined sewer (storm and sanitary) elimination program, and the upgrading of Sheboygan's two major wastewater-pumping stations located at North Avenue and N. 3rd Street and at Kentucky Avenue and S. 7th Street.

In 1977, the Wisconsin Department of Natural Resources (WDNR) gave final approval of the plans and specifications for the regional wastewater treatment facilities. The City of Sheboygan received federal funding for 75 percent of the project cost, with the WDNR providing approximately five percent of the project cost. The remaining cost of the project was funded locally.

In January 1978, construction of the $23.9 million regional treatment facilities commenced. The liquids handling portion became operational in December 1979 and the solids handling portion in the fall of 1981. Construction of the $1.04 million west interceptor, $810,000 sanitary sewer rehabilitation, and $1.55 million upgrading of the North Avenue and Kentucky Avenue pump stations was concurrent with construction of the treatment facilities.

In 1998, work was completed on the North/South Interceptor sanitary sewer project. The North/South Interceptor was a major project identified in the 1970s during the sanitary sewer system analysis. The North/South Interceptor was built to provide adequate sanitary sewer capacity to the northwest quadrant of the regional planning area (the Town of Sheboygan and the Town of Sheboygan Falls) when development reached adequate size to necessitate construction of the larger sanitary sewer pipe and wastewater pump station. The process of acquiring easements for the project began in 1994 and continued into 1996. The $3.1 million project was funded through a State Revolving Fund (Clean Water Fund) loan with a subsidized interest rate under 3.2 percent.

CURRENT TREATMENT FACILITY AND PROCESS SUMMARY

Today the Sheboygan Regional Wastewater Treatment Facility (WWTF) is a state of the art activated sludge treatment facility which cleans the wastewater for over 68,000 residents in seven local communities. The WWTF operates five major lift stations and an advanced treatment facility which treats wastewater and reclaims an average of 11 million gallons per day of clean water. The facility is operated and maintained by 15 dedicated professionals who come from diverse backgrounds and incorporate multiple disciplines and skills including, administration, natural science, process operations, mechanical engineering, maintenance, metal fabrication, electrical, process controls, computer programing, network engineering, and environmental and federal pretreatment program regulations.

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In 2016, the Sheboygan Regional WWTF reclaimed over 4 billion gallons of water and returned it to Lake Michigan. The reclaimed water is cleaner than the lake water. The treatment processes removed 99% of the organic pollutants, 95% of the ammonia, and 86% of the phosphorus. The nitrogen and phosphorus in the wastewater were recovered in the solids and used as a natural fertilizer. Approximately 9 million gallons of liquid solids were applied on agricultural fields and 1,300 tons of dried solids were produced and used on residential lawns and gardens and agricultural fields. The WWTF recovered enough energy from the treatment processes to produce almost 70% of the facility's electrical needs and 90% of the heating demand. The Sheboygan Regional WWTF is a true environmental leader in sustainability and protecting our most valuable resource, WATER.

RAW PUMPS

Raw wastewater, which enters the plant via large underground pipes, is pumped to the screening process by two raw wastewater pumps driven by 200 HP electric motors with VFDs and three 250 HP electric motors with eddy-current drives. Each pump has a capacity of 11,800 gallons per minute (gpm).

SCREENING

Upgrades in 2008 included replacing the Wiessman® center-flow band screens with Brackett Green® self-cleaning center-flow fine screens with 5 mm openings. The screenings process is designed to remove large and small non-biodegradable debris from the wastewater flow. The screenings collected by the fine screens are processed through a JWC "Muffin Monster"® washer/compactor before being placed in a waste roll-off container. The collected screenings are transported to a landfill for final disposal.

GRIT REMOVAL

In 1997, one 20-foot diameter, cyclone grit separator was installed to remove sand and silt from the influent wastewater. Sand and silt enters the waste stream with the inflow/infiltration of rainwater and clear-water into the sanitary sewer collection system. In 2007 a Huber® vortex grit washer was installed that washes the grit, removing any remaining organic matter from the grit before it is deposited in the waste roll-off with the screenings collected by the fine screens.

PRIMARY CLARIFIERS

Four primary clarifiers (90 ft. x 90 ft. x 12 ft) provide 6.2 hours detention at 11.0 million gallons per day (MGD) average daily flow. Heavy suspended solids settle out by gravity. The settled primary sludge solids are pumped to the anaerobic digestion process for further treatment before thickening and land application as fertilizer.

BIOLOGICAL NUTRIENT REMOVAL

In 1999, two unused aeration basins (50 ft. X 100 ft. X 26 ft.) were modified to allow for Biological Nutrient Removal (BNR). Baffle walls were installed to direct the flow into an N shaped path that increased the detention time in the basin, thereby creating anaerobic (without oxygen) conditions for the specialized bacteria required in the BNR process. Eight submersible mixers were added to each basin to keep the solids from settling in the basin. Detention time is 4.1 hours at average daily flow.

AERATION BASINS

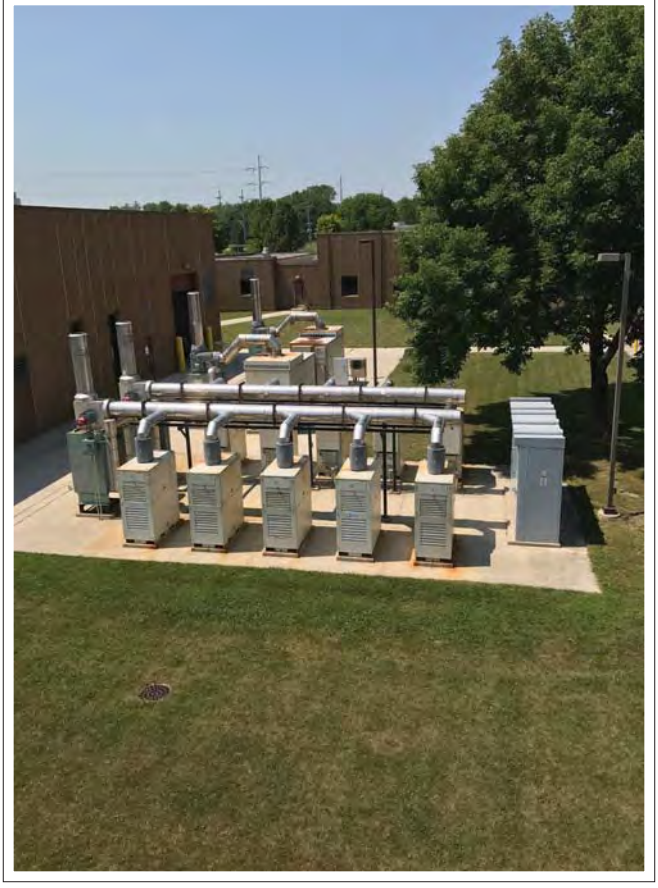
The four remaining aeration basins (50 ft. x 100 ft. x 26 ft. deep) each contain 1500 submerged fine bubble diffusers. In 2006, two 350 horsepower high-efficiency Turblex® centrifugal air blowers operating at 3,500 rpms were installed. The Turblex® Blowers use dissolved oxygen (D.O.) meters and modulating valves to control the amount of D.O. available for the microorganisms. The blowers provide the mixing and oxygen necessary to maintain the Activated Sludge process. This process consists of providing the right environment for the bacteria and other microorganisms that consume the organic matter in the wastewater. Detention time in the aeration basins is 8.2 hours at average daily flow.

FINAL CLARIFIERS

Four final clarifiers (105 ft. x 105 ft. x 14 ft), providing 7.8 hours detention at average daily flow, settle out the Activated Sludge by gravity. A major portion of the activated sludge is returned to the plant flow upstream of the BNR basins. The activated sludge is returned to the plant flow in order to maintain a high concentration of bacteria and microorganisms within the process. A portion of activated sludge, known as waste activated sludge, is pumped to a point upstream of the primary clarifiers where it is co-mingled with the raw wastewater and settles with the primary clarifier sludge.

EFFLUENT DISINFECTION

The treated wastewater is disinfected with sodium hypochlorite in the chlorine contact basins followed by dechlorination with sodium



bisulfite prior to discharge to Lake Michigan. The reclaimed clean water flows through a 60-inch diameter concrete outfall pipe that extends 1,570 feet into Lake Michigan. Detention time in the contact basins is two hours at average daily flow.

SLUDGE DIGESTION (STABILIZATION)

Waste activated sludge (WAS) is pumped to the primary influent splitter box for co-settling with raw wastewater in the primary clarifiers. The resulting primary sludge/WAS mixture is pumped directly into one of three primary anaerobic digesters that are heated and mixed by Linear Motion mixers. After the sludge is stabilized it is transferred to one secondary anaerobic digester for final stabilization. The primary and secondary digesters have a total volume of 4,855,000 gallons. While the sludge is in the primary digesters, the sludge is heated and mixed to create the appropriate environment for the anaerobic bacteria to stabilize the sludge. The methane gas produced is beneficially used as a fuel to heat the digesters, plant buildings, generate electricity, and further process the biosolids. The WWTF augments its digester gas production through a high strength waste receiving program that feeds hauled in waste directly to the primary anaerobic digesters.

BIOSOLIDS PROCESSING

The WWTF thickens the digested anaerobic sludge from 2.5 percent to 6.0 percent solids via a two-meter and/or three-meter gravity belt thickener. The thickened liquid sludge is transferred to two 2 MG storage tanks that were added to the plant in 1996. The biosolids are stored until it can be applied on farmland located throughout Sheboygan County.

Starting in 2014, a portion of the liquid biosolids stored in the storage tanks are further dewatered by two Huber® 800.2 Screw Presses and dried to a moisture content of less than 10% via Huber® Medium Temperature Belt Dryer. The dryer uses biogas produced in the anaerobic digestion process and the waste heat from the plant's microturbines to heat the dryer to approximately 204 degrees Fahrenheit. The design of the dryer is simple; slow moving belts, drive systems using standard market components, and all stainless steel components where moisture or wear may occur. The dryer utilizes indirect heat so there is no ignition source of any kind within the dryer; therefore, it provides a safe operating environment. There is very little dust produced by the drying operation due to the slow moving belt technology and no dry recycle of any kind. The dryer has a low electrical demand and uses a cascading air technology and state-of-the-art controls which provide optimal energy efficiency. The dryer's enclosed system maintains a negative pressure to ensure minimal odor emissions.

The final product is a pellet sized dry product that has a very high agronomic value and is safe to use on lawns, shrubs, trees, flowers, vegetables, and as a general soil amendment. The final product has virtually no salts, so it will not burn plants. The nitrogen and phosphorus are released slowly into the soil and plants, which allows for even growth and better root development.

Sheboygan's dryer is designed to dry approximately half of the biosolids produced by the facility's treatment processes. By drying half of the liquid biosolids produced, the Sheboygan Regional WWTF was able to diversify the biosolids disposal and reuse options, while minimizing capital and construction cost. The liquid biosolids are land applied via injection into agricultural fields as a natural and beneficial fertilizer. Land application of the liquid biosolids is limited by season, weather conditions, and field availability. The dried biosolids are an Exceptional Quality, Class A product that can be used in residential and agricultural applications, as well as, landfilled if necessary.

COMBINED HEAT AND POWER

The WWTF also operates a Combined Heat & Power (CHP) System which uses the biogas produced in the anaerobic codigestion process to produce electricity and heat. The CHP

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System has 700kWh of electrical generating capacity and over 2.4 million BTU per hour of heat recovery. In 2006, the WWTF partnered with Alliant Energy to install ten 30 kW CapstoneTM Microturbines and Heat Exchangers capable of recovering 1,000,000 BTU of heat energy. The high strength waste and codigestion program resulted in more biogas than the WWTF could use so in 2010 the WWTF installed two 200 kW CapstoneTM Microturbines and Heat Exchangers capable of recovering an additional 1,400,000 BTU per hour.

The WWTF has essentially one heating loop which provides the necessary energy to heat the digesters, the biosolids dyer, and the buildings. The heat energy to the loop is provided by two biogas boilers, one dual fuel natural gas and biogas boiler, and the Combined Heat and Power systems. The WWTF currently produces 70 percent of its electrical needs and 90 percent of its heating needs.

CHEMICAL SYSTEMS

Two 10,000-gallon chemical storage tanks and one chemical feed pump are used to add ferric chloride to the influent wastewater to control odor and to reduce the influent phosphorus load to the BNR process. Two chemical feed pumps also add ferric chloride to the aeration basins, as needed, when the BNR process does not reduce the phosphorus levels in the wastewater stream below the discharge permit requirement. A separate chemical mix and feed system adds polymer to the digested sludge to condition it before dewatering on the gravity belt thickeners.

INSTRUMENTATION

The instrumentation system is capable of monitoring equipment and processes over the entire plant and at the five-wastewater pump stations located throughout the City of Sheboygan. Programmable Logic Controllers (PLCs) control, monitor, and record the operating status of all critical equipment at the wastewater treatment plant. The data collected by the PLCs are sent to a centralized industrial server that logs the data and displays it graphically on a video monitor. The plant operators can examine the operating status of all process equipment throughout the treatment facility, as well as, the wastewater pump stations from one central location at the wastewater treatment plant.

LABORATORY

The advanced wastewater laboratory uses modern analytical equipment to monitor the quality and character of the wastewater as required by the WDNR and U.S. EPA. One wastewater laboratory technician analyzes samples daily to monitor the influent and effluent quality. The wastewater laboratory also analyzes plant process samples for the plant operators, who then make process adjustments, as required, to improve process operations and enhance effluent quality. In addition, the wastewater laboratory analyzes raw wastewater samples collected by the member communities served by the Sheboygan Regional Wastewater Treatment Facility. The result of each community's raw wastewater sample analysis is used when billing them for wastewater treatment provided by the City of Sheboygan. CS