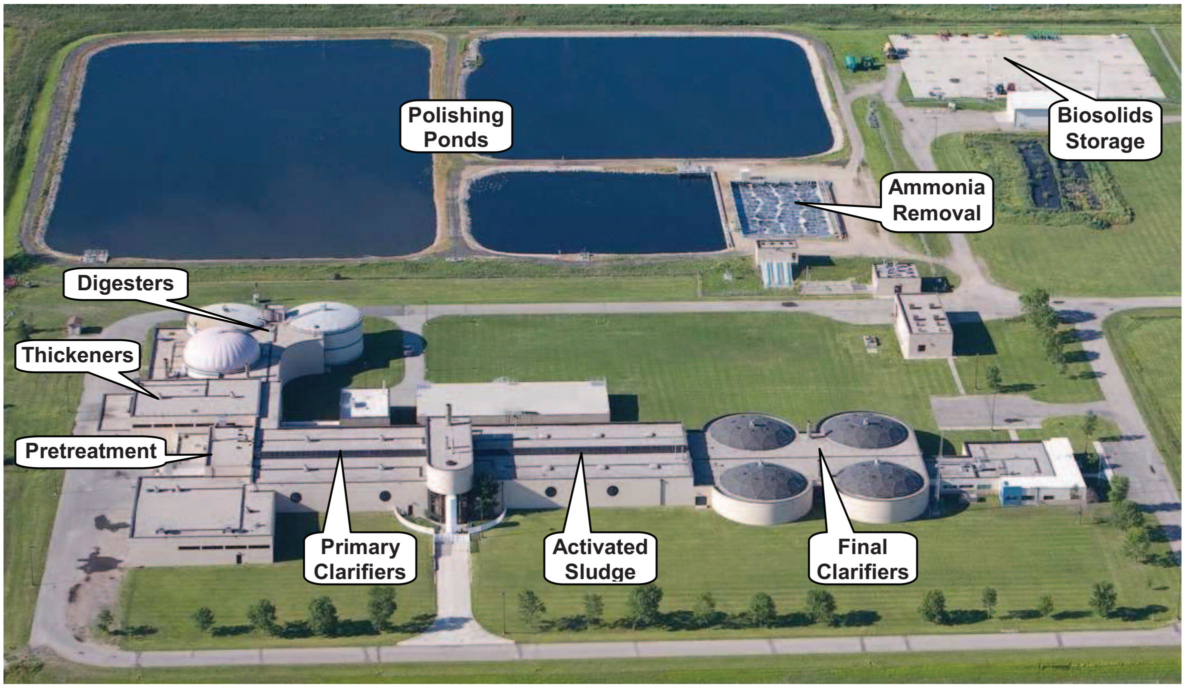
Wastewater Treatment Facility (2012)



OVERVIEW

Whenever a home, business, or industry uses water, the resulting wastewater drains from the home or building through the building's sewer, flows off the property, and discharges into a sanitary sewer main. Eventually, the network of sewer mains transport the wastewater into larger pipes (interceptors) and lift stations before finally being pumped to the Moorhead Wastewater Treatment Facility (MWWTF). Wastewater from Moorhead, Dilworth, and the Town of Oakport is treated at the MWWTF in order to protect public health and water quality in the Red River of the North. Annual operation and maintenance costs for the facility and sewer system are approximately $6.4 million, including $2.5 million per year of debt service for large projects. In order to meet State and Federal discharge regulations and maintain the system, the Moorhead Wastewater Treatment Facility (MWWTF) and staff must:

- collect, pump, and treat 4.5 million gallons of wastewater per day on average;
- operate, maintain, and clean approximately 180 miles of sanitary sewer main and 49 lift stations;
- maintain and service the MWWTF equipment and infrastructure;
- collect and analyze samples to ensure water quality limits are met;
- monitor and regulate significant industrial discharges; and
- complete all required State and Federal reporting requirements.

In addition to the wastewater system, MWWTF staff maintain and operate the stormwater system (storm sewers, ponds, and lift stations) and much of the flood-control infrastructure (pumping stations, gates, and valves).

HISTORY

Construction of the MWWTF began in 1980 and was completed in 1983. The old treatment facility was located next to the Red River on 15th Ave N and served the area since 1933. However, the old facility was deteriorated, outdated, overloaded, susceptible to flooding, and close to residential neighborhoods. The MWWTF (located at 2121 28th St N) is situated well above the 100-yr flood plain and away from residential areas. Total project cost in 1983 dollars was in excess of $27 million. The replacement cost, including facility upgrades since 1983, would approach $100 million today.

UPGRADES

<u>Disinfection Upgrade (1987, $1.0 million)</u> – Replaced ozone disinfection with chlorine disinfection due to technology and equipment reliability concerns.
<u>Biosolids Storage Facility (1994, $2.8 million)</u> – Constructed a 3.6 million gallon tank to store Class B biosolids prior to land application, meet new regulatory requirements, and better coordinate application timing with agricultural practices.
<u>Nitrification Basin (2003, $3.4 million)</u> – Constructed a moving bed biofilm reactor (MBBR) nitrification process to comply with new regulatory limits for ammonia.
<u>Headworks and Hydraulics Improvements (2005, $6.6 million)</u> – Replaced equipment at the end of it's useful life, made improvements to the facility headworks, and improved plant-wide hydraulics to address increases in flow due to recent and expected future growth.
<u>Solids Handling Upgrade, Admin Expansion (2009, $12.4 million)</u> – Solids handling processes and equipment at the end of their useful life were upgraded, rehabilitated, or replaced to increase capacity and reliability. Additionally, the original administration building was expanded to increase office, laboratory, and meeting space.
<u>Lift Station and Large Collection System Projects (1995 – 2003, $14.9 million)</u> – Included construction of several large lift stations and large sewer interceptors to accommodate growth.

WASTEWATER TREATMENT PROCESS

Treatment is divided into two main areas – treatment of the wastewater and treatment of the solids removed or generated during wastewater treatment. The MWWTF utilizes processes that naturally occur in the environment, such as settling and biodegradation, but would overwhelm and degrade the Red River without treatment. To prevent interruptions to City water use and the treatment process, the MWWTF is designed with two parallel treatment trains and other redundancies to accommodate improvements, maintenance, and any other treatment disruptions. The following outlines the wastewater treatment process at the MWWTF.

Pretreatment: Mechanical bar screens remove large materials from the wastewater flow. After the bar screens, wastewater flows into two aerated grit chambers for removal of grit and sand. Air is injected in the wastewater at a rate which allows smaller and lighter solids to remain in suspension while sand and grit settles to the tank bottom. After grit removal, wastewater flows to primary treatment. During times of the day when flow is high, a portion of the wastewater spills into an equalization basin to be pumped back to pretreatment at night while flows are lower. Equalizing the flow rate in this manner helps to improve the capacity and efficiency of all treatment processes.

Primary Treatment: Two 300,000 gallon primary settling tanks (clarifiers) are used to settle out solids. Each clarifier is equipped with a traveling bridge scraper/skimmer for scum and sludge removal. Sludge from this treatment stage, termed "primary sludge", is pumped to the anaerobic digesters for processing. The primary clarifiers remove approximately 60% of the suspended solids and 30% of the BOD (Biochemical Oxygen Demand, a measure of biodegradable pollutants), from the pretreated wastewater flow.

Secondary Treatment: A self-generating biological culture of beneficial bacteria, protozoa, and other microorganisms is used to remove and degrade the dissolved and fine suspended materials remaining in the effluent from the primary clarifiers. This culture, called "activated sludge" requires oxygen to survive. Instead of air, high purity oxygen is produced on site to provide a more efficient and dependable process. Treatment occurs in two 500,000 gallon activated sludge tanks where incoming wastewater mixes with the biological culture.

After the activated sludge tanks, the mixture of treated wastewater and microorganisms flows into one of four "final clarifiers" to settle out and separate the microorganisms from the treated wastewater. Microorganisms that settle out in the final clarifiers are recirculated by pumps back to the activated sludge tank to maintain the culture. Since the microorganisms are always growing and multiplying as new wastewater enters the process, a side stream of microorganisms is diverted from the return line as "waste activated sludge." By the time the wastewater leaves the final clarifiers, suspended solids and BOD have been reduced enough to comply with effluent discharge standards.

Ammonia Removal: An 800,000 gallon "Moving Bed Biofilm Reactor" or MBBR is used to remove ammonia from the treated wastewater. The reactor is filled approximately 30% full with small plastic media (0.83 inch diameter, see photo) that move throughout the reactor with the mixing action caused by the aeration system. The media provides a substrate for ammonia-removing bacteria to grow on while a screen on the discharge keeps the media in the reactor.

Polishing Ponds: Three ponds (1.0, 3.0 and 4.9 acres) provide "polishing" of effluent prior to discharge. One pond is located upstream of the MBBR while two are downstream. The ponds are helpful in further reducing BOD and suspended solids concentrations to assure enhanced treatment and allow additional oxygen from the atmosphere to dissolve in the treated effluent.

Disinfection: Before discharge to the Red River, disinfection with chlorine kills harmful organisms that may still be present. Since chlorine is toxic to aquatic life, dechlorination with sulfur dioxide removes residual chlorine from the plant effluent after disinfection.

Outfall: A two-mile long, 42 inch diameter underground pipeline conveys treated effluent from the facility to the Red River of the North. The submerged outfall discharges at the river bed elevation and can discharge at river elevations up to the 100-year river flood stage.

SOLIDS TREATMENT PROCESS

All settled, skimmed, and generated solids (sludges) from the wastewater treatment process must be handled, treated, and stored prior to ultimately being applied as a soil amendment and fertilizer on agricultural land. "Biosolids" is the term used to describe solids that are treated and meet Federal and State requirements to be safe for reuse.

Sludge Thickening: Waste activated sludge (WAS) is thickened before treatment to reduce volume and increase treatment efficiency. Gravity Belt Thickeners (GBTs) are used to separate water from the WAS (see photo). Polymer conditions the sludge for thickening by causing the sludge particles to "cling" together into large particles and allow better separation of the water from the solids. The conditioned sludge is passed over a porous belt where water is able to drain by gravity through the belt while the large sludge particles are scraped off. Thickening improves the performance of the anaerobic digesters and reduces pumping and heating costs.

Sludge Treatment to Biosolids: Two heated and mixed primary anaerobic digesters biochemically treat or "stabilize" the primary sludge (5% total solids) and thickened WAS (6% total solids) for about 50 days. Microorganisms utilize the organic matter as a food source, decomposing it in the absence of oxygen to an end product called "biosolids." Many solids break down into liquid compounds which decreases the thickness to about 2.5% total solids. During decomposition, carbon dioxide (CO_2), hydrogen sulfide (H_2S) and methane (CH_4) gas is generated. Digester gas (approximately 65% methane) is burned in a boiler to heat the digesters to 95ºF. Excess gas is used to heat buildings or is flared off. Biosolids overflow from the primary digesters to a secondary digester for temporary storage. A flexible membrane within the dome-shaped cover on the secondary digester maximizes storage and reuse of digester gas, which reduces the need to purchase natural gas for heating.

Biosolids Storage and Dewatering: Biosolids are pumped from the digesters to a 3.6 million gallon storage tank. During storage, the biosolids thicken by gravity settling and the thinner liquid on top is decanted and pumped to pretreatment. Typically, storage and decanting reduce the volume of biosolids by 60%, to 6.5% total solids or about the consistency of thin gravy.

Land Application of Biosolids: Ultimately, biosolids must either be landfilled, incinerated, or land applied. Due to the need for additional thickening and drying required for landfilling or incineration, the proximity of available land, and a variety of other factors, the MWWTF recycles biosolids through agricultural land application. Since biosolids are rich in nutrients and organic matter, land application fortifies the soil and reduces the need to purchase fertilizer. Treated biosolids meet all Federal and State rules with regard to pollutant concentrations and application requirements. Approximately 400 to 800 acres of land receive biosolids from the MWWTF each year, depending on the nutrient demands of the crop rotation and soil characteristics.

NOTABLE FEATURES

Automated Control: The majority of the MWWTF treatment units are designed to function automatically with a minimum of hands-on control. Programmable Logic Controllers (PLCs), or industrial computers, provide automatic control, monitor system status, and log alarm conditions. The MWWTF PLCs are connected to computers where staff can view treatment units and process data, make operational changes, and troubleshoot. An alarm system provides notification of process and/or system malfunctions. Due to this automation, the City controls costs by eliminating the need for staffing beyond a normal 40-hour work week.

Lift stations in the collection system are also continuously monitored for malfunctions, such as a power outage or pumping system failure. A monitoring system at each site communicates lift station status via radio to a master control unit located at the MWWTF. Staff is notified of an alarm condition within minutes.

During hours outside of the normal work week, "on-call" staff responds to alarm conditions. A cell phone and laptop are used to communicate with the MWWTF control systems at any time.

Oxygen Utilization: The use of high purity oxygen in the activated sludge process results in high dissolved oxygen levels and allows for a higher concentration of microorganisms available to consume organic matter. Aeration tanks can be sized smaller and treat higher pollutant loadings. High purity oxygen is produced on site. A Pressure-Swing Adsorption (PSA) system uses three sealed tanks which work in a manner similar to a water softener. Operating at low pressures, a proprietary adsorbent material inside the tanks removes carbon dioxide (CO_2) and nitrogen (N_2) gas from supply air to produce a 90 - 95% high purity oxygen product gas. During a regeneration cycle, the adsorbent bed is purged – releasing the CO_2 and N_2 gas back to the atmosphere. When the PSA system is down for maintenance or repair, liquid oxygen, stored on site, is vaporized to gaseous oxygen to provide continuity in operation.

Ammonia MBBR: When the MBBR went online in 2003, it was the first post-secondary treatment installation of a MBBR in the United States. Since that time, the technology has expanded and gained wide acceptance. The MWWTF conducted pilot testing to aid in the design of the full scale unit and there is continued interest in the performance and operation of the MWWTF MBBR from wastewater professionals.

MWWTF FACTS AND FIGURES

- Number of employees: 18
- Design treatment capacity: 6.0 million gallons per day (average)
- Peak flow capacity: 18.0 million gallons per day
- Average treatment time: 14 hours (facility) + 4.5 days (polishing ponds)
- Treatment efficiency: 97% removal of BOD and suspended solids
- MBBR efficiency: 90% removal of ammonia
- Biosolids recycled: 700 dry tons per year
- Facility natural gas and electric: $53,000 per month (avg)
- Electric for lift stations: $20,000 per month (avg)

Annual Wastewater Budget