Metropolitan Wastewater Treatment Plant, St. Paul, MN

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The Metro WWTP is owned and operated by the Metropolitan Council Environmental Services (MCES). MCES is responsible for wastewater collection and treatment in the seven-county Twin Cities metropolitan region. This includes over 600 miles of collection system and eight wastewater treatment plants.

The Metropolitan Wastewater Treatment Plant is the largest plant in the MCES division. The original plant was built in 1938 with Works Progress Administration funds to protect public health. At the time the Mississippi River was highly polluted. The situation became much worse in 1917 when Lock and Dam #1 was constructed, creating stagnant pools where sludge settled and accumulated. In 1926 the First Mississippi River water quality and fisheries survey was conducted by the U.S. Bureau of Fisheries. The river was inventoried from St. Paul to Red Wing, dissolved oxygen levels measured at less than 1 mg/l and only three live fish were collected.

The original plant consisted of bar screens, grit chambers, flow metering, primary treatment, chlorine disinfection, vacuum filters and incineration. It's hard for us to believe that primary treatment alone was a major environmental achievement at one time.

THE METRO PLANT TODAY

There have been many upgrades and expansions of the plant since 1938 to accommodate the growing population and increasingly strict regulatory requirements. The plant currently has a design capacity of 250 million gallons per day (MGD) with

Metro Plant (1938).

Metro Plant effluent channel.

AerationTanks.

typical flows around 170-200 MGD and a hydraulic capacity of 720 MGD. The Metro Plant serves a population of 1.8 million people who reside in 65 individual communities. The collection system for this plant contains 318 miles of gravity sewers, 63 miles of force mains, 25 lift stations and 134-meter sites. The entire MCES collection system is operated and maintained by a staff of 60.

Approximately 300 staff are stationed at the Metro plant. Of these, 80 are operations personnel generally working a 12-hour shift and providing coverage 24/7. In addition, there are approximately 100 maintenance staff housed at the plant covering machinists, pipefitters, electricians, painters and maintenance operators. The plant is also the base for about 120 support services employees who work to monitor, troubleshoot, and assure regulatory compliance for the wastewater treatment process at all MCES plants. Groups within Support Services are: Performance Systems, Process Computer, Process Engineering, Process Information, Industrial Waste & Pollution Prevention, Research and Development, and Laboratory Services.

TREATMENT PROCESSES

Pretreatment

Bar Screens: Eight half-inch and two one-inch bar screens prevent large items (trash, rags, bottles, etc.) from damaging downstream treatment equipment. Each screen is equipped with an automatic raking device that scrapes the screenings onto a conveyor belt, which then carries the screenings to a truck for landfill disposal.

Aerated Grit Chambers: Each bar screen is matched with an aerated grit chamber. These long tanks allow grit to settle to the bottom where it is removed and disposed of in a landfill. Agitation air is added to the chamber to encourage a spiral-roll pattern of flow and enhances particle settling. Settled grit is collected with a chain and scraper mechanism, washed to clean off any organics, and landfilled.

Primary Treatment

Eight rectangular primary settling tanks 2,800,000 gallons each allow solids to settle to the bottom and fats to float to the surface. Chain and scraper mechanisms move along the top and bottom of the tank to collect separated material for further processing. Floatable material is removed and separated for dewatering and land fill disposal. Due to the large volume, average removal for total suspended solids (TSS) is 70-85% and 50-60% for Biological Oxygen Demand (BOD) removal.

Secondary Treatment

An advanced biological process is employed to treat the wastewater, removing organic material and nutrients from the liquid. The Metro Plant uses 16 aeration tanks, each tank consisting of four passes and multiple baffled zones that provide different environments to facilitate nutrient removal.

Each aeration tank contains approximately 5,000,000 gallons of activated sludge with 18,000 ceramic or flexible membrane diffusers. The first zone in the aeration process is RAS re-aeration where a dissolved oxygen (DO) concentration of 1 mg/l is maintained to supplement cold weather nitrification. This is followed by an anoxic zone with subsurface mixing to reduce both dissolved and chemically bound oxygen. Next are two anaerobic

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zones where secondary influent is added and which drives uptake of organics by phosphorous accumulating organisms. The remaining two-thirds of the tank volume is utilized for aeration treatment and the oxidation of BOD compounds, phosphorous uptake, and nitrification.

After aeration, 24 rectangular final clarifiers separate secondary solids from treated liquid. Approximately 85-90% of the secondary solids are returned to the aeration tanks as Return Activated Sludge (RAS) with the remainder of the solids diverted to solids processing.

The Metro plant has seven compressors ranging between 3,000 horsepower (60,000 ft^3/min) and 5,500 horse power (100,000 ft^3/min) to provide air for the secondary process to support aerobic microorganisms and provide mixing. Much work has been invested in reducing the demand for air since these compressors were responsible for approximately 60% of the plant energy consumption. Over the past 10 years, we have instituted a diffuser cleaning and replacement strategy, adjusted DO set points along the aeration tank to better correspond to biological demand, upgraded DO monitoring, lowered DO set points to the minimum required and reduced mixing air. As a result of these efforts, annual aeration energy demand has decreased by more than 20% and saves approximately $1,000,000 annually.

Disinfection

Disinfection is required during the months of April through October to reduce the number of disease causing pathogens. The addition is seasonal because there is limited recreational use of the Mississippi River outside these months and that it is likely cold enough to limit the presence of pathogens in the wastewater.

At the Metro Plant, disinfection is achieved through the addition of liquid sodium hypochlorite (bleach) solution. Generally, chlorine dose is maintained around 1.45 mg/l and consumes approximately 900 gallons per day.

Excess chlorine is an aquatic toxin and sodium bisulfite is added at the end of the chlorine contact channel to eliminate the chlorine residual. Approximately 450 gallons of bisulfite are used daily and chlorine residual is generally maintained well below 0.28 mg/l.

Effluent Pumping

The final effluent usually flows by gravity, however, if the elevation of the river reaches 693.5' elevation (seven feet above normal river level) the effluent needs to be pumped up to the river. The pumping station typically runs about 15 days during minor flood years and 60 days during moderate to major flood years. The Mississippi River typically crests in mid-April at about 693'. It reached major flood stage at or above 702' during ten years: 1951 1952, 1965, 1969 (prior to construction of flood protection) and in 1987, 1993, 1997, 2001, 2010 and 2011 (after construction of flood protection).

There are six effluent pumps each with 930 horse power motors and pumping capacity of 120 MGD. Under low river flow conditions pumps are also turned on to generate turbulence in order to provide more dissolved oxygen in the river. This was especially necessary during the 1988 drought.

Solids Processing

Solids collected from the primary clarifiers are processed in gravity thickeners where the solids concentration is increased from 1% to 5-6 % total solids. Secondary solids from the final clarifiers are thickened in dissolved air flotation thickeners to produce a 4-5% total solids product. Primary and secondary solids are stored and handled separately until right before thickening in order to minimize phosphorus release.

The objective of dewatering is to achieve a 28-30% total solids product that will combust with minimal additional fuel in the incineration process. This is achieved with a set of high-speed counter-current, solid-bowl centrifuges. The centrifugal force created by the rotating bowl causes the solids to collect on the inside of the bowl as "cake." The cake is moved through the bowl by the scroll to the discharge point while the liquid moves the other way and discharges at the other end. To aid dewatering, polymer is added to the sludge.

The Solids Management Building (SMB) contains all the equipment necessary to dewater and incinerate biosolids including three new state-of-the-art fluidized-bed incinerators, energy recovery and pollution control systems, and improved solids processing equipment. With a processing capacity of 315 tons per day, it is one of the largest fluidized-bed sewage sludge incinerator facilities in North America. The SMB became operational in 2004 and 2005 replacing a series of multiple hearth incinerators.

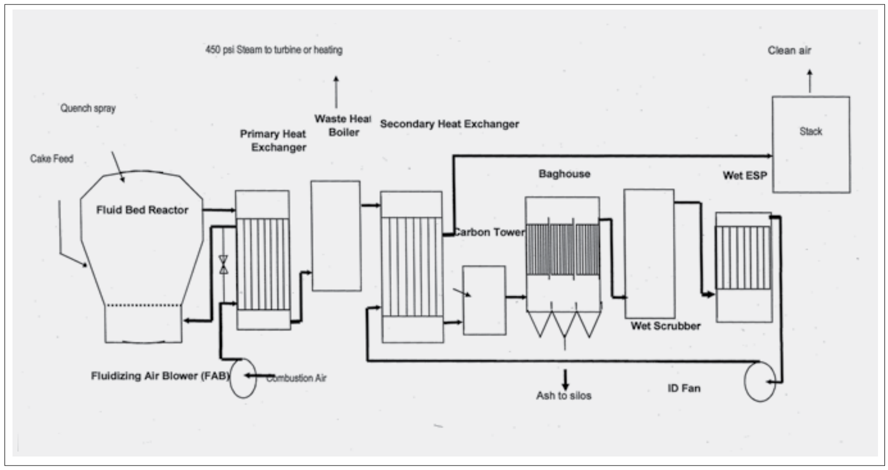
Incineration of biosolids begins when dewatered cake is pumped from the centrifuges to the plant's fluidized bed reactors (FBRs). Air is sent upward through a bed of sand, fluidizing the solid sand particles and creating a homogeneous combustion zone. Water in the sludge is vaporized rapidly and the solids undergo combustion. Ash created in the burning process is carried out of the incinerator by the exit gas and into the air pollution control train.

These two are the operator trainee class of 2012 and 2013. We have a 6-month training program for new operators that includes instructor led, online, self, and on the job training. Since 2007 we have graduated approximately 80 trainees.

Air Pollution Control
According to a 2011 US EPA sewage sludge incineration emissions survey, the Metro Plant FBRs have one of the lowest levels of pollutant emissions in the country. Four types of pollution control equipment make this possible.

Powdered activated carbon is injected into the incinerator flue gas to absorb mercury and volatile organic compounds. After the mercury is adsorbed by the carbon, the carbon/mercury particles are removed by the downstream pollution control equipment.

Each FBR has three ash baghouses, each baghouse containing over 800 individual woven, fiberglass bags. Flue gas contacts the tubular bags, and the particulates are captured on the bags while the clean flue gas passes through the fabric and up the bags. A pulse jet reverse flow cleaning system uses pressurized air to remove the ash from the bags approximately every one to two hours. Ash collects in a hopper at the base of the baghouse and is transported to the ash silos.



Air pollution control train – fluid bed incineration.

Within the wet scrubber, there is essentially a series of smaller systems that allow for contact between the flue gas and a scrubbing liquid (water). Its purpose is to remove moisture by cooling the gas, remove SO_2 and other acid gases by adding caustic, and remove fine particulate through ring jets that increase the velocity of the gas in their throats. The ash particles become encapsulated in the water droplets and collect in the bottom of the scrubber where the flow can be directed to the primary clarifier effluent. The flue gas passes through the top of the scrubber and continues through the process.

The last of the air pollution control devices, the Wet Electrostatic Precipitator (WESP) uses electrostatic forces to collect particles. Gas is sent through positively charged collection tubes that have negatively charged electrodes in the center. Particulates in the gas become negatively charged as they pass through the ionized field. Once they possess a negative charge, the particles become attracted to the positively charged collection tubes. The electrodes are cleaned periodically by washing them down with water to remove the particulates.

Energy Recovery

A Primary Heat Exchanger transfers heat from the hot flue gas exiting the FBR to the combustion air being provided to fluidize sand in the FBR.

Following heat exchanger, a waste heat boiler takes the excess heat in the flue gas and uses it to boil a combination of demineralized city water and recycled plant water. The water is vaporized to steam which is used to heat the plant or to generate electricity in a steam turbine.

The SMB can generate electricity from steam in one or both of our steam turbines. The larger turbine generates up to 4.5 MW of electricity during the summer time when plant heating is not required. The smaller turbine recovers energy while reducing the steam pressure. It normally runs during the winter, producing up to 0.8 MW of electricity.

Following the waste heat boiler, a secondary heat exchanger reheats the stack gases to prevent a vapor plume, while further cooling the flue gas before entering the carbon tower.

Performance

The Metro plant is regulated by multiple permits covering areas of stormwater, NPDES, Title V Air Permitting, hazardous waste and a new system-wide total phosphorous permit that combines the mass of phosphorous from five MCES plants. There have been no permit exceedances for the past six years and the most recent MPCA audits have found the plant fully compliant.

Effluent quality is exceptional, typically < 5 mg/l TSS, < 5 mg/l BOD, < 0.4 mg/l total phosphorous, and < 3 ug/l mercury. Emissions from the FBRs consistently meet all the requirements of the Title V permit as well as the new US EPA Sewage Sludge Incineration rules.

Of special significance, phosphorus discharge from the Metro Plant to the Mississippi River has been reduced 92% since 1975; total metals have been reduced by 90% since 1980; and influent mercury concentrations have decreased 55% since 2003 with the inception of the dental mercury reduction program.

SUMMARY

Water quality in the Mississippi River is better than it has been in the past 100 years, and much of the improvement is due to the performance of the Metropolitan Wastewater Treatment Plant. The river today supports a world-class catch and release fisheries program, is the center point of the Mississippi National River and Recreational Area, and has stimulated economic development across the region.

This would not be possible if not for the hard work of a highly skilled and dedicated staff who take great pride in their role regarding environmental protection. CS