Rochester Water Reclamation Plant Rochester, Minnesota

GENERAL BACKGROUND

The Rochester Water Reclamation Plant (WRP) serves a population of approximately 110,000 including residential, commercial, and industrial customers treating an average daily flow of 14 million gallons per day (MGD). The WRP has 31 staff members that are responsible for the operation and maintenance of the water reclamation plant and four remote lift stations. The plant is staffed 24 hours per day, seven days per week, 365 days a year. The Rochester Water Reclamation Department currently operates and maintains four lift stations within the city. The collection system is maintained by another division of the city.

Aerial view

Fine screens

Primary clarifier

Headworks:

Influent enters the plant via an 84-inch gravity sewer where it flows through trash racks to collect large debris. Five centrifugal pumps lift the flow 65 feet to the headworks and from here on, the liquid stream flows entirely by gravity through the entire plant. Six millimeter fine screens remove any debris before a vortex grit drops out the heavier grit. From here, the flow is directed to either the High Purity Oxygen (HPO) Plant, the Aeration Basin Complex (ABC) Plant, or the equalization basin. The equalization basin is considered part of headworks and is a storage tank that allows flow to be stored during high flow periods and released during low flows. A more steady flow reduces strain on the different processes at the plant.

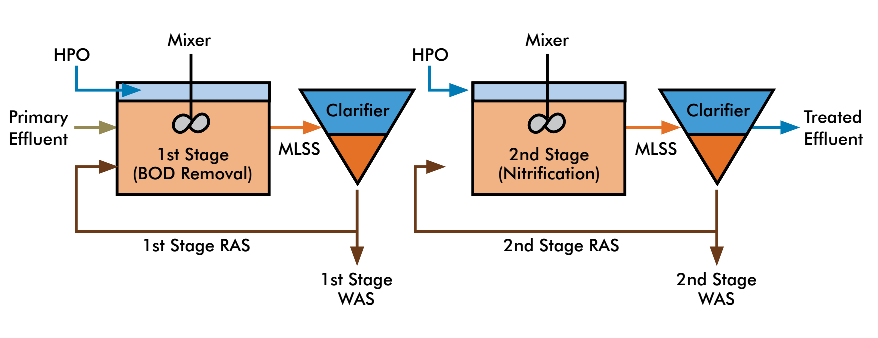

Figure 2: HPO activated sludge

HPO Plant:

The HPO plant divides the activated sludge concept into two stages. The first stage is made up of two trains that operate in parallel with each train using three 40 hp mixers that mix and aerate the MLSS. The first stage achieves approximately 95% removal of the biochemical oxygen

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demand (BOD), or organic material. This stage has a solid retention time of less than two days. Solids retention time is a measure of how long a typical microorganism is in the system.

The second stage of the HPO plant is made up of three trains operated in parallel, each containing three 30 hp mixers that mix and aerate the MLSS. This stage is responsible for nitrification or the conversion of ammonia to nitrate. The second stage has a typical sludge age of 60 days and removes approximately 99% of ammonia. Figure 2 shows the HPO process schematic.

Oxygen is supplied to the HPO aeration tanks by a 20 ton per day cryogenic oxygen plant that produces high purity oxygen. High purity oxygen provides increased oxygen transfer efficiency because the feed air is 95% oxygen compared to conventional aeration which is only 21% oxygen. The aeration tanks are covered and the high purity oxygen is confined to the layer between the liquid and tank cover. Mixers agitate the liquid to encourage oxygen transfer from the confined air space to the liquid.

ABC Plant:

The ABC Plant is a conventional air activated sludge plant and consists of two parallel aeration basins. The basin is divided into four different zones. Zone 1 is where primary effluent and RAS is combined to form the MLSS. Zone 1 is unaerated and can be operated as an anaerobic (no oxygen available) zone or as an anoxic (oxygen available in the form of nitrate) zone. Zone 1 also can receive an internal recycle stream from Zone 4 if an anoxic environment is desired. A mixer is used to keep Zone 1 mixed.

Zone 2 is a swing zone and can be operated in an anaerobic, anoxic, or aerobic mode. If operated in anoxic or anaerobic, a mixer will be used to ensure a homogenous environment. If operated aerobically, fine bubble diffusers will deliver air for oxygen transfer and mixing. The internal recycle from Zone 4 can also be directed to this zone to create the anoxic environment.

Zone 3 and 4 are always aerobic. Fine bubble diffusers are used to deliver oxygen and create a well-mixed environment. MLSS from Zone 4 can be internal recycled to create anoxic environments in Zone 1 or Zone 2. Figure 3 shows a general layout of the ABC activated sludge system.

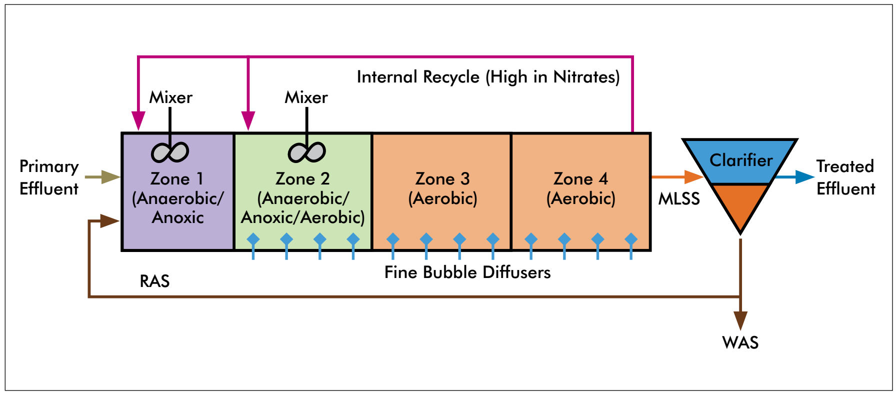

Figure 3: ABC activated sludge

Air is supplied by one of three blowers that deliver conventional air (21% oxygen) to the zones that are operating in aerobic mode. A solids retention time of approximately 15 days allow for BOD removal and nitrification with respective removal rates of 98% and 99%. Different ABC operation modes and the corresponding effects on pollutant removal is discussed further in the ABC Configuration paragraph.

The Rochester Water Reclamation Plant uses several advanced treatment technologies including biological nutrient removal. Both plants perform nitrification and the ABC plant has the ability for denitrification (or the conversion of nitrates to nitrogen gas) and biological phosphorous removal.

ABC CONFIGURATIONS

AO Process (Anaerobic/Aerobic):

Zone 1 and potential Zone 2 are operated anaerobically to encourage growth of phosphorous accumulating organisms (PAOs) while Zones 3 and 4 are aerobic. The aerobic portions of the tank remove BOD and nitrify any ammonia. This mode may also be considered conventional activated sludge with nitrification if no PAOs accumulate. Even if PAOs are not present, Zone 1 (anaerobic) can be used as a selector to limit growth of filamentous bacteria which can result in poor settling sludge in the clarifiers.

A2O Process (Anaerobic/Anoxic/Aerobic):

Zone 1 is anaerobic and will encourage growth of PAOs, Zone 2 is anoxic using the internal recycle to send nitrates here for denitrification or conversion of nitrates to nitrogen gas, Zones 3 and 4 are used for BOD removal and nitrification.

MLE (Modified Ludzack Ettinger):

Zone 1 and possible Zone 2 is anoxic and will denitrify nitrates that are from the internal recycle. Zone 2 is either aerobic or anoxic depending on the level of denitrification desired. The aerobic zones (Zones 3, 4, and possible 2) will be used for BOD removal and nitrification.

Chemical for Phosphorous Removal:

Both the HPO plant and ABC plants inject ferric chloride into the primary clarifiers to assist in precipitation of phosphorous. Both plants also inject alum into the final clarifier to precipitate any remaining phosphorous. An anionic polymer is combined with the alum to improve settling characteristics of the sludge.

Chlorination/Dechlorination:

Flow from both the HPO plant and ABC plant are combined prior to chlorination. Chlorine gas is added to the process flow between April and October and is allowed several hours of contact time. Sodium bisulfite is used to neutralize any residual chlorine to prevent any negative impacts to downstream aquatic life.

Solids Handling:

Waste activated sludge from both stages in the HPO plant and the ABC plant are thickened on the gravity belt thickeners (GBTs) prior to being combined with primary sludge in the blend tank. Blended sludge is anaerobically digested in a single stage digester with a detention time of approximately 30 days that produces a methane rich gas byproduct. The digested sludge is thickened using GBTs to reduce the volume before being stored and ultimately being land applied seasonally.

Cryo plant

ABC diffusers

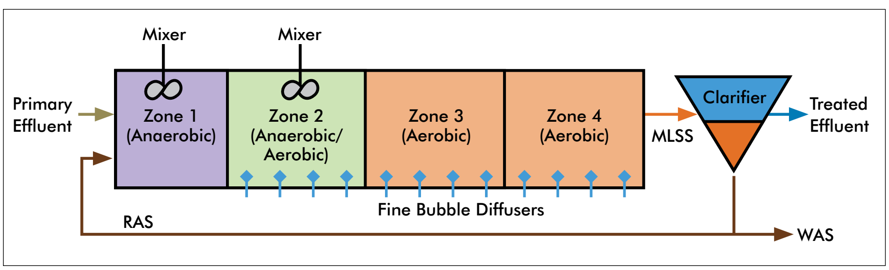

Figure 4

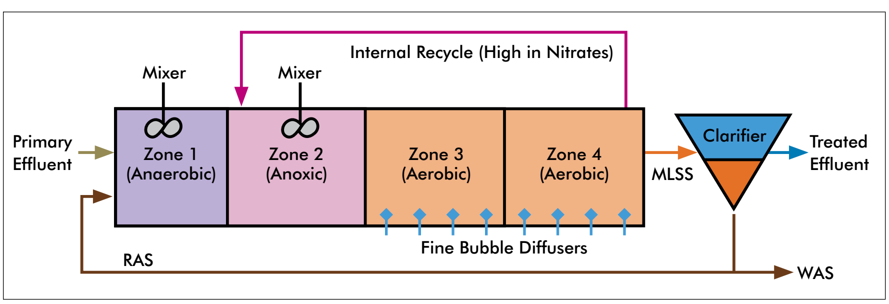

Figure 5

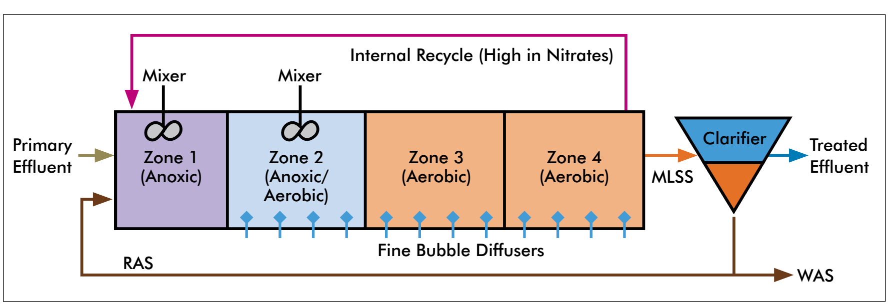

Figure 6

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Each year approximately 12,000,000 gallons of 6% Class B biosolids, or 3000 dry tons, are produced and land applied. Figure 4 shows the solids process schematics and approximate percentage solids between processes.

The Water Reclamation Plant has a multifaceted energy management system. There are three heating/cooling loops throughout the plant that are used to recover heat from various processes which can be reused in heating other process such as the anaerobic digesters or plant facilities. Methane gas produced in the anaerobic digesters is either used directly in boilers for building and process heat or is used in two one-megawatt engine generators that are used to produce electricity for use in the plant. Heat is collected off of the engine and also off the engine exhaust to be used throughout the plant. Collection and use of methane gas saves approximately $600,000 annually in electrical and heating costs.

Energy Efficiency:

The Rochester Water Reclamation Plant has been successfully operating a combined heat and power (CHP) system since 1982. Initially there were two generators rated at 400 kW each, however, they were upgraded to 1000 kW in 2002 and 2008. The generators are Waukesha turbo-charged lean burn engines and have the capability to run off methane (byproduct of anaerobic digestion) or natural gas. Heat is recovered from the engine jacket and exhaust gases in the form of hot water (180°F–190°F) that is used to distribute heat to the anaerobic digesters and

ABC plant

Chlorine contact

Digesters

GBT

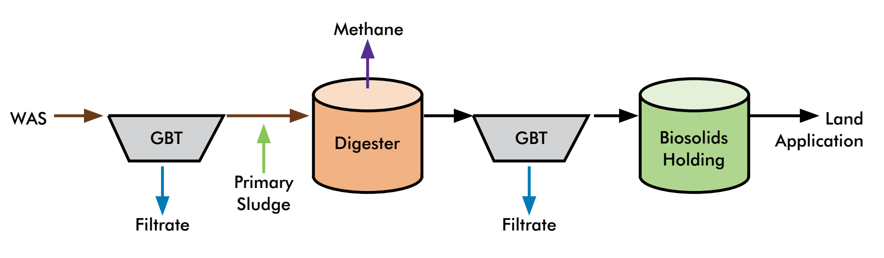

Figure 7

Land Application

Generator

Heat recovery

seasonal heating of the plant. The engine jacket water system is capable of approximately 2.5 MMBtu/h/engine and the exhaust gas system is designed to recover approximately 2 MMBTu/h/engine.

Two anaerobic digesters produce approximately 375,000 cu ft/day of biogas that contains approximately 66% methane. This allows WRP to typically run the generators between 500-800 kw depending on the season and temperature. The amount of heat recovered is sufficient to provide complete process and facility heating for most of the year (outdoor temperatures as low as 40 degrees). The methane also can also be used in boilers in cold weather and this allows the plant to buy a minimal amount of natural gas, typically only required when temperatures drop below -10°F. The combined heat and power system typically saves around $300,000 annually in heat and electrical costs.

In 2007, construction was completed on a secondary treatment plant to the Rochester Water Reclamation Plant that increased the overall plant capacity by 4.8 MGD. A new circular primary clarifier was added with a dome for odor control. While ventilation was accounted for, supply air was taken directly from the ambient atmosphere. During the cold weather months the cold air reacted with the warm moist air from the process liquid creating a microclimate within the dome that resulted in fog, condensation, and even precipitation. This atmosphere created an environment that resulted in rapid deterioration of the metal components in the primary clarifier.

To resolve this issue a hydronic heating system that uses thermal energy taken from final clarifier effluent is used to heat supply air into the primary clarifier during the cold winter months. This effectively stopped the microclimate reaction and mitigated the deterioration of the metal components. Simply installing a heater or using the existing hot water loop would have resolved the issue as well but would have driven up capital and operating costs. The system operates with a coefficient of performance of approximately 5.2. This means that for every unit of energy that is input to the system, 5.2 units are output. The difference in energy is heat that is recovered from the effluent water. This results in operating cost savings of approximately 20%-50% vs. using natural gas. CS

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