Minnesota Technical Assistance Program

Energy Efficiency Best Practices in Wastewater Treatment

North Branch wastewater treatment plant optimizes technology for exceptional performance

North Branch anoxic zone for biological phosphorus removal

North Branch WWTP highlights:

The plant is in the top 6% of plants in the U.S., in terms of energy efficiency

Electrical costs are $36K lower than average performing plants of similar size and load

The biggest energy savers are:
- automatic DO controls
- minimal aerating of biosolids
- identification of optimal equipment operating points.

MnTAP would like to thank Southern Minnesota Municipal Power Agency for their support in benchmarking the North Branch plant and other plants in their service area.

Energy is a significant part of wastewater treatment plant operating cost. Estimates suggest energy accounts for 25-40% of the operating budgets of most wastewater utilities, and energy has the greatest potential for reduction. The wastewater plant operated by the city of North Branch, Minn., performs in the top 6% nationally, in terms of energy efficiency, saving $36,000 a year compared to the average performing plant of similar size and load (based on an extrapolation of the Energy Star® benchmarking algorithm for wastewater plants).

The North Branch plant was built in 2004 and serves a population of 10,400. It has a mechanical activated sludge process of screening and grit removal for primary treatment, anaerobic and anoxic tanks for biological phosphorous removal, an oxidation ditch for secondary treatment, secondary clarifiers, and aerated biosolids stabilization prior to land spreading. It operates at 0.39 million gallons per day (MGD) and BOD load of 390 pound per day.

How Does North Branch Save All That Energy?

The North Branch plant started with energy efficient design features, made two important operational decisions, and currently aims for continuous small improvements.

Plant design

Automatic dissolved oxygen (DO) control, using newer luminescent DO sensing technology. DO control allows secondary aeration input to track the combined hydraulic and organic loads to prevent over aeration.

Variable frequency drives (VFDs) adjust equipment speeds to match loads on biosolids storage mixing blowers, return activated sludge (RAS) and waste activated sludge (WAS) pumps. VFDs provide plant operators flexibility and steadier operation, and they save energy compared to throttled flow or intermittent full speed operation. Pumps, blowers and mixer aerators are sized so they function efficiently at part-load; there is parallel equipment available to help carry higher loads.

Five elevation drops (about 7ft total) passively supplement aeration as wastewater moves through the plant. These drops, along with the 700 ft travel distance to disinfection, allow DO concentrations to increase above levels present in the oxidation ditches so effluent easily exceeds the discharge limit of 5 mg/l.

Plant design con't

Instrumentation: North Branch has a lot of instrumentation for its size. This instrumentation provides operators the information needed to understand plant processes and develop energy-efficient operating practices over time. Instruments include motor VFD hertz (speed) and amperage for high use pumps, biosolids blowers and aerator mixer; flow rates for biosolids blowers, RAS & WAS pumps and lift pumps, and run hours on important motors.

VFDs on lift station pumps. The city chose to upgrade lift pumps with VFDs, where more expensive but would allow them to run at a lower speed. Lift pumps are not on the plant's electric meter but they save the city $50K per year and are another example of the city reducing energy costs.

Operations

Maintain low DO concentrations in oxidation ditch. North Branch monitors several indicators — effluent BOD, beneficial bug counts, mixed liquor suspended solids (4,400), food to microorganism mass ratios (.015), solids retention time (51 hrs) — which show treatment at low DO concentrations of 1.0 to 1.2 mg/l remains adequate.

Allow biosolids to sit un-aerated for long periods. Operating at 50% of design, there is excess biosolids storage capacity. Waste activated sludge is added to each storage tank in turn to build levels, is aerated for 24 hours, then sits for a week without mixing, before decanting and starting the cycle over. Many plants continuously aerate biosolids. Plant staff look for 3% solids concentration and a fecal count under 2 million colony forming units before transferring to storage. They also monitor odors and look for other signs that biosolids may require more air but rarely find them.

Continous improvement and preventative maintenance

Identification of best operating points. Access to current and historical data helps plant operators understand problems and devise solutions. Staff have identified typical operating points as equipment benchmarks. Departure from these operating points may indicate a clog or a maintenance issue to attend to. This type of monitoring keeps problems from multiplying and allows quicker return to efficient operation and allows experimentation to find better operating points.

Collection system minimization of inflow and infiltration (I&I) keeps biological populations stable, decreasing the need to compensate for a variable biology with aeration. I&I has been minimized by disconnecting roof and sump drains, slip lining cracks in pipes, selectively lining sections of trunk and collector line, and replacing manhole covers that have holes to ones without.

North Branch WWTP Limits and Operating Data

Pollutant or Water Quality Parameter	Typical Influent Concentration (mg/l)	Effluent Limit - Monthly Averge (mg/l)	Typicla Effluent Concentration (mg/l)	Percent Removal
BOD	292	<25	3.0	99 %
Phosphorous	7.5	<1	0.35	95 %
Nitrogen (Ammonia)	Not measured	<7.6	0.13	N/A
Suspended Solids	265	<30	3.2	99 %
Effluent Dissolved Oxygen	Not measured	<5	7.5	N/A
Plant Loads	**Current Load**	**Design Capacity**		
Hydraulic Inflow	0.39 MGD	0.81 MGD		
BOD Inflow	390 lb/day	1,400 lb/day		