

Full-Scale Testing Postpones Total Nitrogen Reduction Expansion

Don Esping, Mark Allenwood, Dave Green

Problem

The City of Rochester New Hampshire received notice that its next National Pollutant Discharge Elimination System permit will contain seasonal summer total nitrogen (TN) discharge requirements of 8 to 10 mg/L. To reduce TN discharges to the anticipated discharge levels, the City must either expand its plant at the cost of millions of dollars or potentially operate in a low dissolved oxygen (DO)/simultaneous nitrification denitrification (SND) mode.

Objective

Conduct full-scale demonstration testing of SND operations to define treatment performance, operating parameters, carbon requirements, sludge quality impacts and potential facility needs. Evaluate full-scale testing results along with subsequent process modeling to determine if the existing facility can achieve the target effluent TN discharges without a plant expansion.

Methodology

Full-scale demonstration testing was conducted from January through November 2015 to evaluate treatment performance under full aerated and SND modes and develop operating parameters to achieve the lowest TN discharges. A BioWinTM process model was then calibrated to the test results and used to evaluate the effectiveness of SND operations and whether SND could be optimized to meet the target effluent TN discharges requirements.

Existing System

The Rochester wastewater treatment plant (WWTP) treats an average flow of roughly 3 mgd using an earthen basin air activated sludge system as shown in Figure 1. Each aerated basin has three small anoxic selector zones for sludge quality control and a large non-baffled aerated basin with three fine pore aeration grids or zones.

In the City's first attempt to operate in a SND mode, the City installed one floating mechanical mixer in each of its aerated activated sludge zones to assist in maintaining mixed liquor solids (MLSS) in suspension at low airflow rates. Testing showed the mechanical mixers could not fully maintain the MLSS in suspension even with the aeration grid airflow set at the minimum diffuser airflow, hence a modified SND operating strategy was developed in which the Zone B mixer was moved to Zone A to provide additional mixing, Zone B was fully aerated with DO levels of 2 mg/L, and Zone C was unchanged.

The City has several additional challenges which make TN reduction difficult. First, the influent soluble COD to ammonia ratio is roughly 2. Second, the City receives high nitrate loadings from a landfill leachate treatment system which contributes up to 7 mg N/L of nitrate to the City influent further decreasing the carbon to nitrogen ratio for TN reduction. To counter the low carbon content, the City proactively found a source of readily biodegradable carbon from a local food processing industry. The hauled waste increased the plants influent COD loading by an

average of 20 percent, however the plant has limited capabilities to accept and meter the hauled waste flows.

Full-Scale Testing

Full-scale testing was conducted between May 1 and November 31, 2015 with the modified SND operating strategy. Figure 2 shows the daily and monthly effluent TN discharges. Baseline operations with the basin fully aerated are shown from February and March with monthly effluent TN discharges of 16 mgN/L (45% TN reduction). November SND operations with reduced operating DOs in Zone A and C and no mixed liquor recycle (MLR) decreased monthly TN discharges to 10 mgN/L (70 to 75% TN reduction). Further effluent TN reduction to 8 mgN/L or less (75 to 80% TN reduction) was observed during July through August when the MLR pumps were operating at 100% of the influent flow.

Full-scale testing showed no negative sludge quality impacts from SND operations, but MLSS variability to the secondary clarifiers increased dramatically during the test period. (Figure 3). The variability in MLSS resulted from insufficient mixing in Zone C even after intermittent aeration was implemented to help keep solids in suspension.

Data showing the modified SND control strategy reduced aeration airflows by 25 percent and supplemental alkalinity addition by 40 percent will be presented. Two additional years of seasonal operating data under SND operations were subsequently completed in 2016 and 2017 and will also be presented along with the impact of diffuser failure/replacement (increased DOs) on plant performance and lessons learned.

Nitrogen Reduction Optimization

During testing, the plant received hauled food processing waste rich in carbon three to five days per week. (Figure 4) The plant has capability to accept one 4,500-gallon tanker of hauled waste a day which can be metered to the aeration basin influent over 6 to 8 hours. Any additional hauled waste loads were fed directly to the aeration basins over 15 minutes. In addition, the plant operated based upon MLSS control which proved difficult given the varying MLSS concentrations resulting in reported solids retention times (SRT) ranging from 15 to 45 days.

To evaluate the impact of these two operating condition on plant performance, a BioWin model was calibrated to the plant effluent TN discharges (Figure 2) and then used to evaluate whether changes to plant operations or other plant improvements could further reduce TN discharges.

Process modeling showed changing from baseline operations with an anoxic selector to the modified SND operations reduces monthly effluent TN discharges by 8 and 4 mgN/L under summer and winter conditions respectively. (Figure 5) Surprisingly, implementing SRT control to reduce the wide swings in SRT variability does not reduce monthly TN discharges. Similarly, equalizing hauled food processing waste to provide a continuous supply of readily biodegradable substrate throughout the week did not reduce the predicted monthly TN discharge. However, the predicted effluent TN variability does decrease with industrial waste equalization combined with SRT control.

Operating the plants MLR pumps at 100% of the influent flow (100% capacity) can provide additional TN reduction of roughly 1.5 to 2 mgN/L as seen in the test period. Modeling shows

further increasing the MLR recycle ratio to 200% and 300% of the influent flow could further decrease TN discharges by 0.5 and 1.0 mgN/L respectively; however, at significant capital costs and higher operating costs. Further TN reduction improvements such as modifying the plant to a 4-stage BNR system by converting half of Zone C into an anoxic zone and step feeding half the hauled food processing waste to this zone will be presented.

This paper will also present the impacts of changing to methanol as the carbon source which would increase chemical usage and fail to achieve the same level of TN reduction due to the low wastewater temperatures of 6 degrees C in winter.

Ultimately, full-scale testing and subsequent process modeling shows the combination of hauled food processing wastes for carbon supplementation, modified SND operations, and operating the plants MLR can achieve the target summer effluent TN discharges thus delaying large capital improvements.



Figure 1. Rochester WWTP Aerial View.

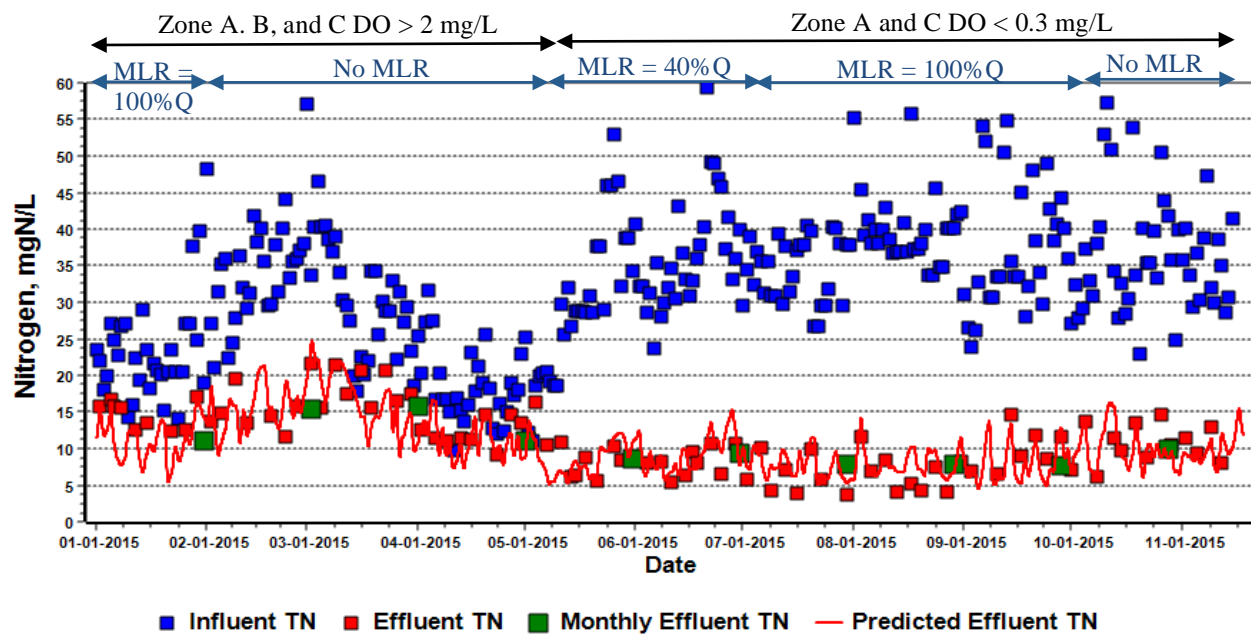


Figure 2. Rochester WWTP Nitrogen Reduction Testing Results.

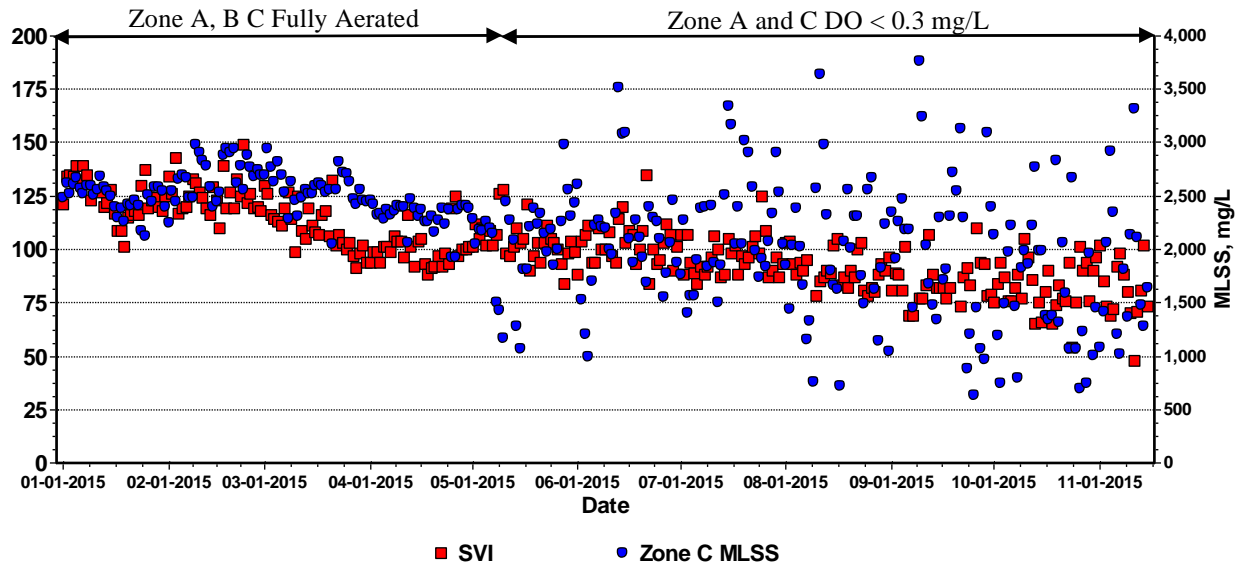


Figure 3. Rochester WWTP Nitrogen Reduction Testing Sludge Quality.

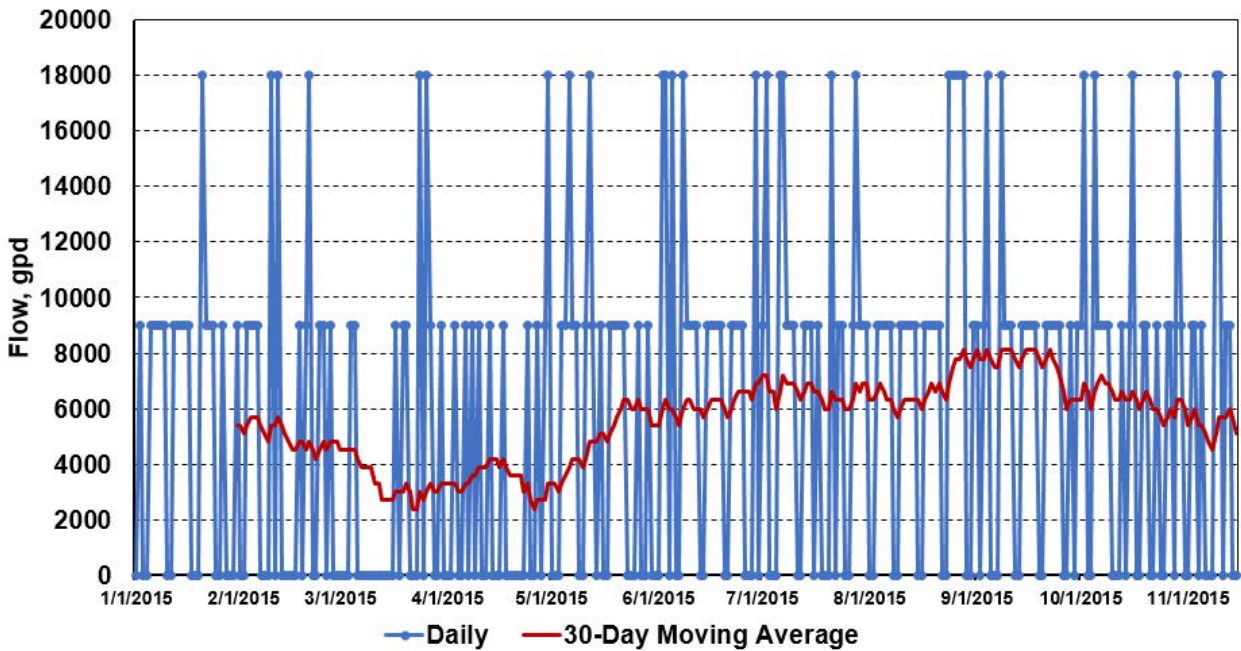


Figure 4. Rochester WWTP Nitrogen Reduction Hauled Waste.

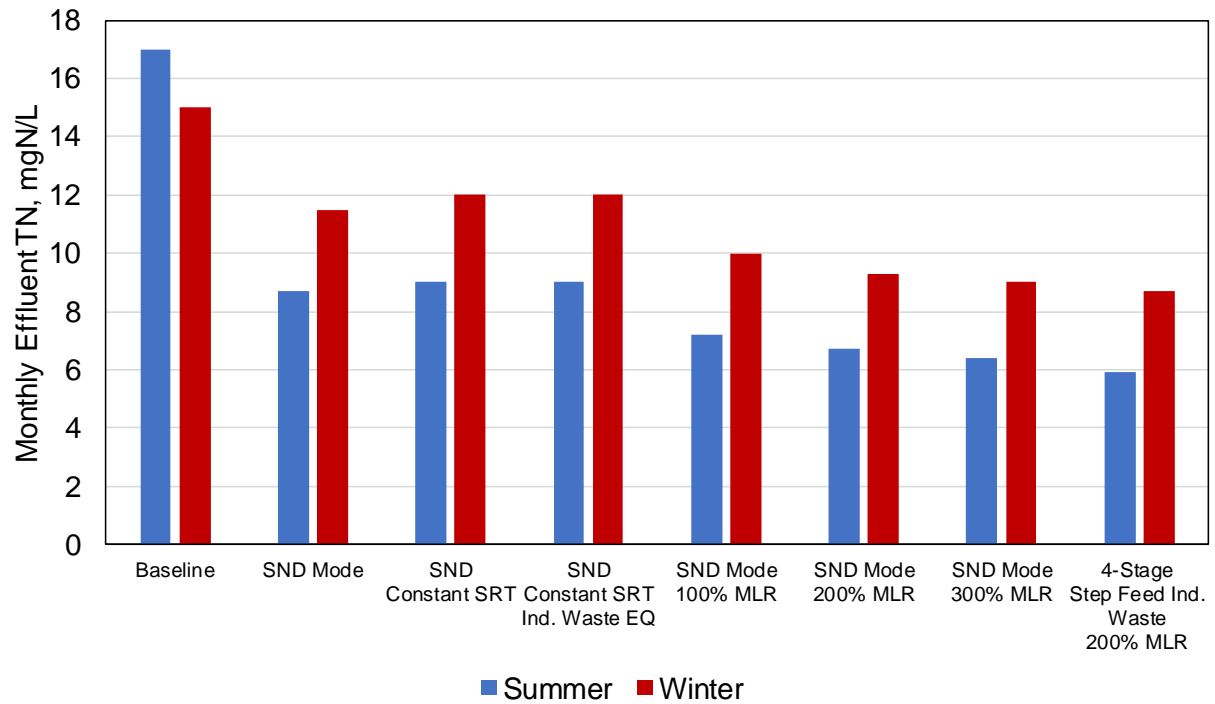


Figure 5. Rochester WWTP Nitrogen Reduction Optimization.