Nitrification Control at a WRRF with RTC-N

WRRF Pilots Ammonia-Based Aeration Control with Hach RTC-N to Optimize Nitrification

Problem

The diurnal ammonia loading fluctuates between 40.6 to 88.6 lbs/hr. To maximize nitrification, the DO concentration in the aeration basin trains is kept higher than necessary during most of the day in anticipation of increased load.

Solution

The plant installed the Hach® Real-Time Control System for Nitrification, at one of the plant's six aeration basin trains to measure ammonia and calculate the optimal DO setpoint in real-time. This would allow operators to gain insight into their process continuously instead of using discrete grab sample data points.

Benefits

Real-time nitrification measurment allows the facility to lower DO to achieve ammonia effluent values of zero during the lower load periods. Also, it's possible during high load periods to reduce inflow and maintain loading levels using existing equalization basins. This ensures compliance and opens the possibility for lower aeration energy costs.

Background

Inland Empire Utilities Agency is located in San Bernardino County in California. The wastewater service area is 242-square miles providing service to 875,000 residents. Top initiatives for the agency include: collecting, treating and disposing wastewater; supplying imported and recycled water; producing top quality compost, and maximizing renewable energy.

Currently, the agency's largest Water Resource Recovery Facility (WRRF) is Regional Water Recycling Plant No.1. This plant processes an average of 27 MGD, with daily peak flow of 40 MGD. At the WRRF, the liquid process consists of: headworks, grit removal, primary clarification, primary effluent equalization, biological nitrogen removal, secondary clarification, tertiary filtration, and hypochlorite disinfection.

The biological nitrogen removal process consists of six parallel plug flow aeration basin trains with secondary clarifiers. Its aeration basins are configured as an anoxic/oxic/anoxic/oxic (AOAO) system to maximize nitrification and denitrification.

One challenge the WRRF faces is operating near capacity and its struggles to maintain a TIN concentration less than 7 mg/L consistently during the year. Established by the California Regional Water Quality Control Board's Nation Pollutant Discharge Elimination System permit program, there is an agency-wide 12-month running average permit limit of 8 mg/L the agency continually meets. This program addresses water pollution by regulating point sources that discharge pollutants to waters of the United States. The WRRF targets complete nitrification of all NH_3-N (ammonia as nitrogen) in the aeration basin system; typically having an average daily effluent NH_3-N concentration of 0.1 mg/L.

Photo credit: IEUA.org

Controlling Ammonia Load

Operating near the plant's capacity causes issues with aeration and ammonia control. The WRRF uses variable frequency drives (VFD) for its blowers, but to attempt to maintain a 1.8 mg/L dissolved oxygen (DO) setpoint during peak ammmonia loading, two of the 700-horsepower blowers run at full power.

Operators typically recognize the plant is near capacity when they see suppressed DO concentrations across the aeration basins and increased bleach usage at the tertiary plant. When influent ammonia loading surpasses maximum capacity of the aeration basin system, the effluent is susceptible to approaching its target TIN limit.

To gain a better understanding of the effectiveness of the nitrification and denitrification process through the WRRF's aeration basin system, grab samples are taken and measured along the aeration basin train. A batch of process samples from a single aeration basin train can take up to three hours to measure. The lab results provide only a snapshot of the plant's treatment process, therefore it's nearly impossible to optimize the effectiveness and efficiency through the treatment process.

The aeration basin system is the second highest consumer of energy behind recycled water pumping distribution. Generally, a WRRF cannot effectively treat ammonia to permit limitations while optimizing the amount of energy expended to the aeration basin system with daily grab and composite sampling. Past attempts of ion selective electrodes for continuous monitoring of ammonia had been deemed inaccurate and required too much maintenance to justify a permanent installation.

"Recently, the general public water conservation efforts have improved drastically. Consequently, this means that the concentration of ammonia has increased over the past five years," said the agency staff. "The plants are struggling with treating the steady increase in ammonia loading. The agency is currently in the design phase to increase the capacity of two of the WRRFs over the next 10 to 15 years. Operations is in a tough spot to manage the ammonia with the limited tools at their disposal."

Solutions & Improvements

The plant's goals were to achieve continuous ammonia measurements throughout the day to truly understand its ammonia loading and airflow requirements. Second, the agency wanted to explore DO optimization strategies such as ammonia-based aeration control to decrease power consumption for its four 700-horsepower blowers.

To accomplish this, the WRRF installed the Hach Real-Time Control System for Nitrification (RTC-N) at one of the six trains. RTC-N at this facility is comprised of a Hach controller, influent and effluent ammonia analyzers, MLSS sensor, and an algorithm that computes optimal DO concentration based on a nitrification model. "I had no issues with the installation," said the agency staff. "I thought it was pretty much plug-and-play."

The model uses aeration basin influent and RAS flows, temperature, solids retention time, hydraulic retention time, compensated growth, decay rates of the nitrifying mass, and an operator-controlled effluent ammonia setpoint leaving the aeration basin.

If the plant can maintain the setpoint, the RTC-N will dial in the DO setpoint and optimize the nitrification process. Whereas traditional aeration strategy requires maintaining a constant DO set-point, RTC-N varies and optimizes DO concentrations to provide treatment that matches the actual ammonia loading. "We let Hach take control almost immediately," said the agency staff. "If there was a component failure, operators had the contingency that the RTC-N would go to a default DO setpoint or the operators could go back to manual control. So, there wasn't any hesitation from operators to put the system online."

Impact of Ammonia-Based Aeration Control

The plant used DO concentration from a parallel train as a control to compare RTC-N results over a six-month period. The two trains were identical in size and configuration; received the same influent flows; maintained the same population of microorganisms, and were independently controlled by actuated air valves. The only difference was the varying DO setpoint. Prior to the operation of the RTC-N module, the DO concentrations in the two basins were relatively equal (see Figure 1).

Figure 1: DO measurements from Train 6 and the control basin (Train 5) before RTC-N

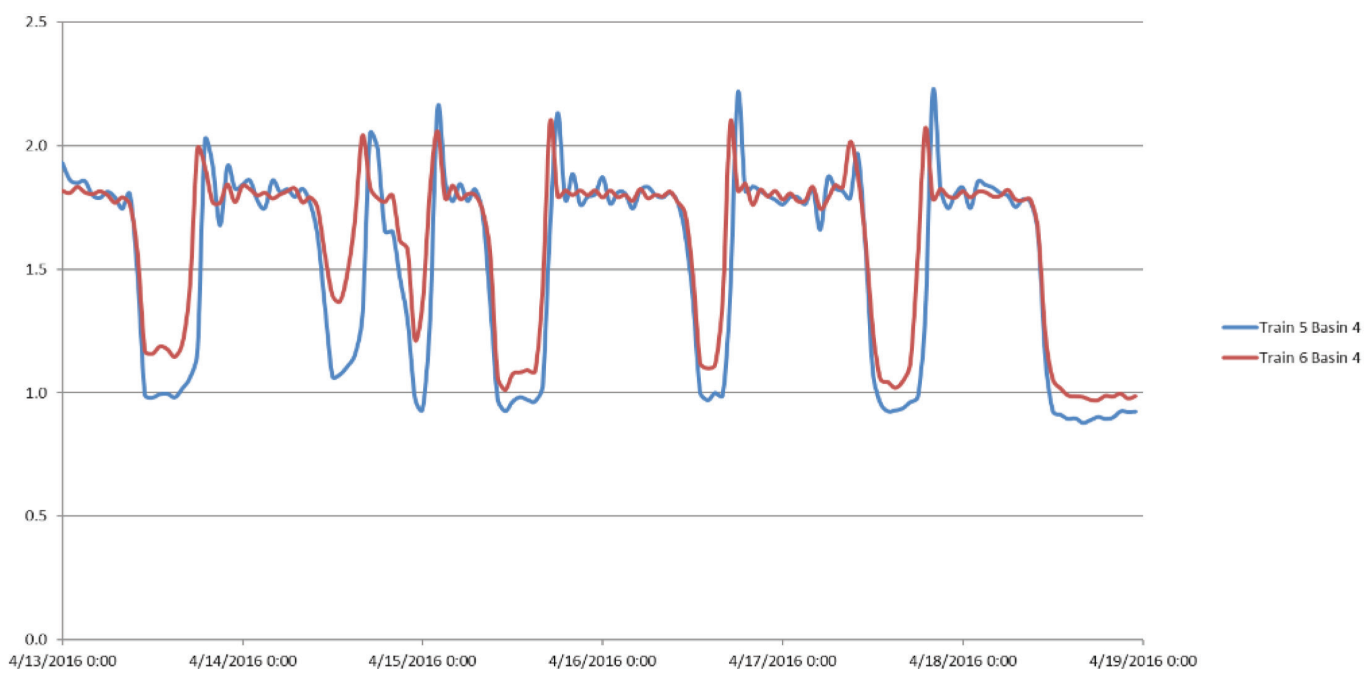


Figure 2: DO measurements from RTC-N (Train 6) and the control basin (Train 5)

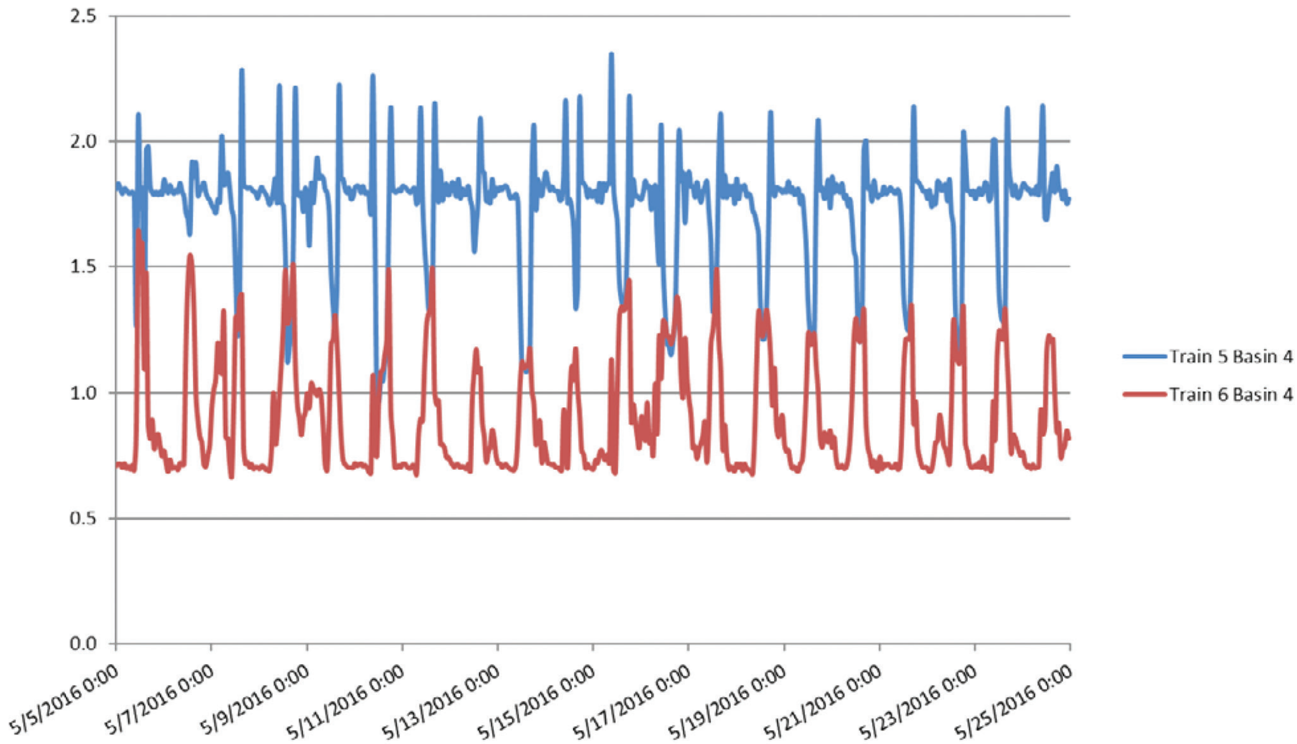
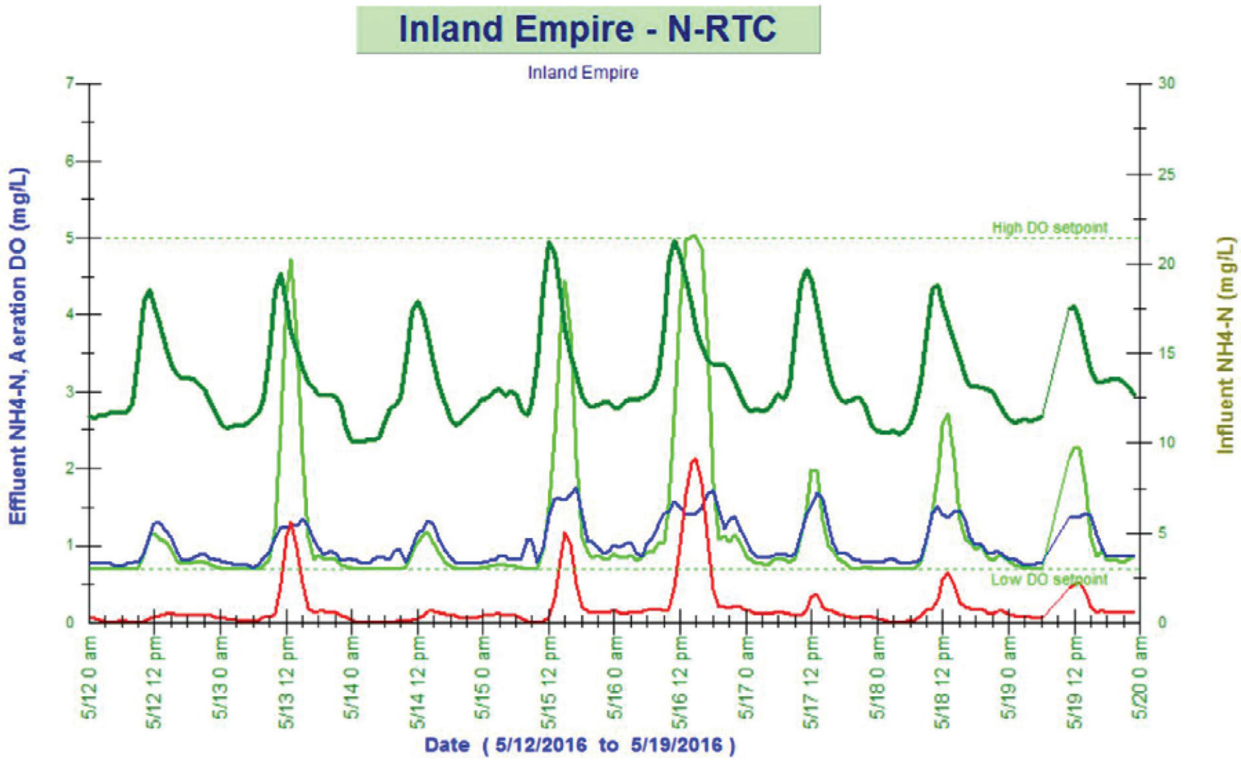


Figure 2 compares the DO concentrations between Train 6 being controlled by RTC-N (red line) and Train 5 (blue line), which is driven to the 1.8 mg/L DO setpoint. This figure illustrates the difference between traditional static setpoint DO control and ammonia-based aeration control using a variable DO concentration. To ensure compliance during the test period the effluent ammonia setpoint in the RTC-N was 0.1 mg/L NH_4-N. The RTC-N calculated significantly lower DO concentrations were needed for complete nitrification, while the other basin continued to run at a higher DO setpoint.

Through most of May, the data suggests that the aeration basin without RTC-N is over-aerating to meet the same desired ammonia effluent level. Assuming similar effluent ammonia values leaving the two trains and that lower DO values in train 6 equate to proportional lower energy costs, the RTC-N system could have reduced the necessary DO levels by 44%, which equates to a potential energy savings of 10.2% (per ATV 131[1]).

[1] The calculation for ATV 131; (DO conc - DO setpoint)/(9 - DO conc)
This results in percentages energy savings. This calculation comes from the German WWTP design manuals, ATV 131.

Figure 3: RTC-N DO and ammonia readings



Plant Optimization Reports

Figure 3 is an example of a RTC-N weekly report, which shows how continuous measurement gives the WRRF greater insight into its treatment process compared to isolated, discrete grab samples. The chart shows the peaks and valleys of influent and effluent ammonia, actual DO and the suggested DO setpoint. One interesting point this chart illustrates is how effluent ammonia peaks are tied to when two blowers are at full output (see red spikes on May 13, 15, 16, respectively). On those days the RTC-N is asking for more DO than the plant can deliver (note the light green line vs the blue line) and the effluent ammonia breaks through. Typically these ammonia peaks start shortly before noon and end around 5 p.m. with an average peak value of 1 mg/L.

Without continuous analysis, it's impossible to predict when the ammonia is going to break through the process. Knowing when a spike of ammonia is heading towards the influent of the tertiary treatment plant can also helps operators understand the impact on disinfection, so they can respond appropriately.

Conclusion

With the flexibility to utilize an equalization basin, RTC-N's ammonia data will help control flow to achieve a steadier state of ammonia loading. At the WRRF, RTC-N has a high impact on the one train it is installed on by measuring ammonia in real time, giving the WRRF the insight to fully understand the dynamic loads and optimizing the nitrification process. Based on the results of the pilot train, if the plant chooses to optimize all six trains using RTC-N it's possible that the plant could power down at least one blower during lower ammonia loading. This usually happens between 10 p.m. and 6 a.m. with average ammonia values of around 11 mg/L. This would yield energy savings while maintaining the plant's permit limits.

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