TRIMMING THE FAT

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ABSTRACT

Sarina Water Recycling Facility (SWRF) was commissioned in November 2014 and features a Membrane Bioreactor (MBR) using the five stage Bardenpho Process (8,000 EP). In November 2015 feedback control of the plant according to online permeate nutrient analysers was implemented. Aeration dissolved oxygen (DO) set points are automatically adjusted within a set range according to difference between permeate ammonia and the operator set target. The aluminium chlorohydrate (ACH) dose rate is adjusted over a long time period so that permeate orthophosphate is as close as possible to the target.

There is now much less need for the operations team to adjust dissolved oxygen (DO) set points. Plant total energy consumption has reduced by 6% since the trim was implemented on 17th November 2015 ($8,900 per year). Dosing of ACH to the bioreactor has decreased by 87%, saving $47,000 per year. Finally, sludge cartage decreased by 50 kg dry solids per day ($9,800 per year). The savings are significant for a plant with a load of approximately 3,800 EP (ultimate capacity of 8,000 EP).

1.0 INTRODUCTION

The secondary treatment process at SWRF is a 5 stage Bardenpho bioreactor (8,000 EP) with licence limits of 3 mg/L total nitrogen, 1 mg/L total phosphorous and 1 mg/L ammonia as nitrogen. There are three trains of Zeeweed 500D membranes (GE) that provide permeate for reuse and discharge to Plane Creek. Nutrients in the permeate are continuously monitored by wet chemistry analysers measuring orthophosphate, nitrite + nitrate and ammonia. Waste activated sludge (WAS) is thickened by a single centrifuge and sent to the aerobic digester so that solids can be stabilised and sludge removal costs reduced. The digested WAS is dewatered by the same centrifuge and removed in 13 m^3 skips.

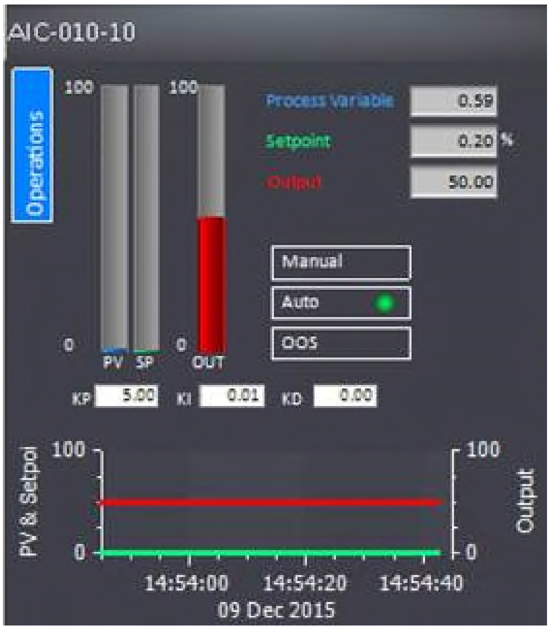
There is a high degree of process control (ClearSCADA) including DO aeration scheduling for our aerobic and swing zones. Target DO can be set for each hour. This is useful but it relies on the operations team to frequently review DO and permeate ammonia trends to adjust set points. There needs to be a safety factor to allow for the fact that only so much time can be spent fine tuning aeration. This results in greater blower power use.

Aluminium chlorohydrate (23.5 w/w%) is dosed as required for phosphorous removal, and the pH can be corrected if required with caustic. Gebbie (2001) concluded that in comparison to aluminium sulphate, ACH results in reduced chemical costs, reduced sludge generation and less pH reduction. ACH dosing is also controlled by SCADA. The ACH dose rate is flow-paced so that a set dose is provided. In its original form, wet weather events did not automatically trigger dose reduction, leading to high Alum consumption if the dose was not manually reduced. It was also difficult to keep phosphorous just below operational target because the ACH dose could only be adjusted during working hours.

In November 2015 “NH_3-Trim” and “Ortho-P Trim” control modes which rely on feedback from the permeate nutrient analysers were optimised to reduce operational costs.

2.0 DISCUSSION

The design included nutrient analysers to make it easier to adjust operation to achieve desired permeate quality. This created an opportunity to use the measurements for feedback control. In general, a benefit of feedback systems over feedforward systems (analysers in raw sewage or mixed liquor) is simpler installation and less maintenance (Reiger et al, 2014). NH_3-Trim scales the DO aeration schedule set points according to the difference between permeate ammonia and the operator set target. Ortho-P Trim adjusts ACH dose between set limits to minimise the difference between permeate orthophosphate and a set target (Figure 1).



<u>Figure 1:</u> ***Orthophosphate Trim Controller Faceplate (ClearSCADA*).**

For both modes the operator can select upper and lower bounds, the speed of control action, and the target set points, providing flexibility.

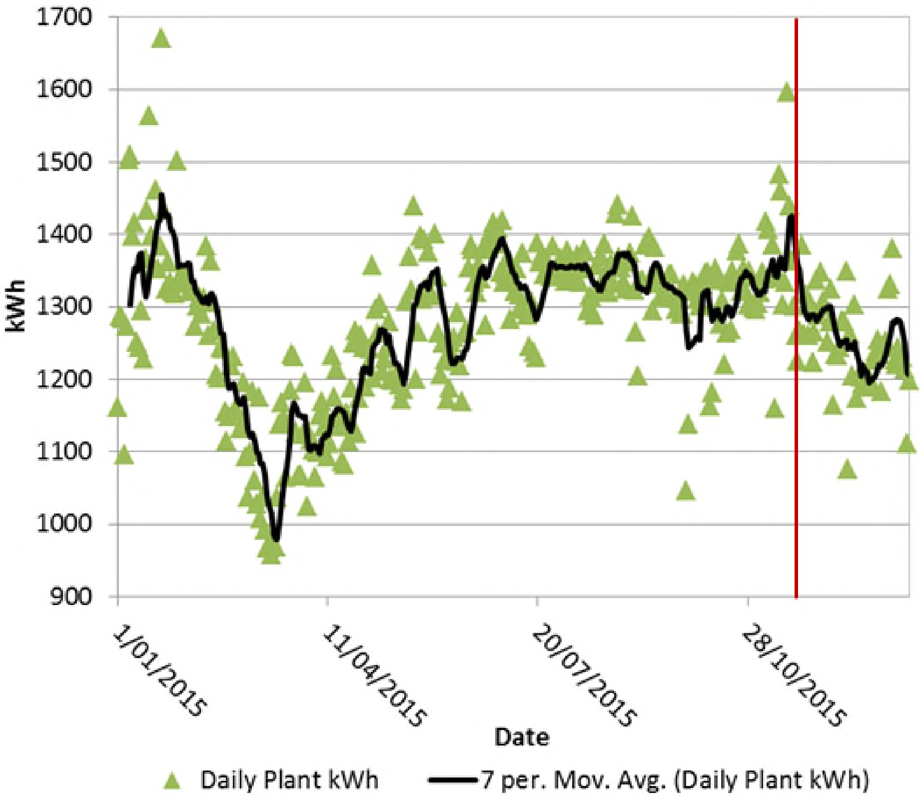
2.1 Ammonia Trim Control of Aeration

Each day operators look at the trends and adjust the scheduled DO set points. Because the pump station delivers large amounts of flow periodically, and there is no flow balance tank, loads are quite variable. When there is low load the blowers operate ON/OFF so that the bioreactor is not over aerated, adding more variability. When using DO set points alone some margin for error is included to account for this.

When in NH_3-Trim mode, 0.3 mg/L permeate ammonia-N is typically selected as the target. As ammonia increases above the target, DO set points are scaled upwards (limited to 30% increase). As ammonia decreases below the target, DO set points are scaled downwards (limited to 30% decrease). The scaling factor is controlled by a process instrumentation (PI) control loop that is tuned to make changes over long time periods.

Since NH3 trim mode was tested in 17th November 2015, daily composite ammonia has reached 0.8 mg/L at most, and never exceeded the 1.0 mg/L median limit. The DO set points require much less adjustment.

Plant total energy consumption has reduced by 6% (Figure 2) since the trim began (83 kWh per day, or $8900 per year). This would mostly be aeration, but also partly reduced sludge dewatering by the centrifuge due to the Ortho-P Trim.



<u>Figure 2:</u> ***Observed Reduction in Energy Consumption (Jan '15 to Jan '16). Line Indicates Date of Implementation.***

2.2 Orthophosphate Trim Control of ACH Dosing

The PI control loop for ACH dosing for the removal of phosphorus works on a similar principle. There is some biological phosphorous removal, but chemical dosing is normally needed to make up the difference because of a lack of carbon in the raw sewage.

In Ortho-P mode, the typical target is 0.4 mg/L. The PI controller increases the ACH dose in proportion to the difference between the target and the measured orthophosphate. There is an upper dose limit to prevent overdosing. When not using this mode there is no automatic recognition of wet weather flows, and if the dose was not manually reduce large quantities of ACH would be dosed unnecessarily. The system adapts to wet weather, purely by responding to dilution.

ACH dosing to the bioreactor reduced dramatically (Average of 82 L per day reduced to 11 L per day), saving $47,000 per year (Figure 3).

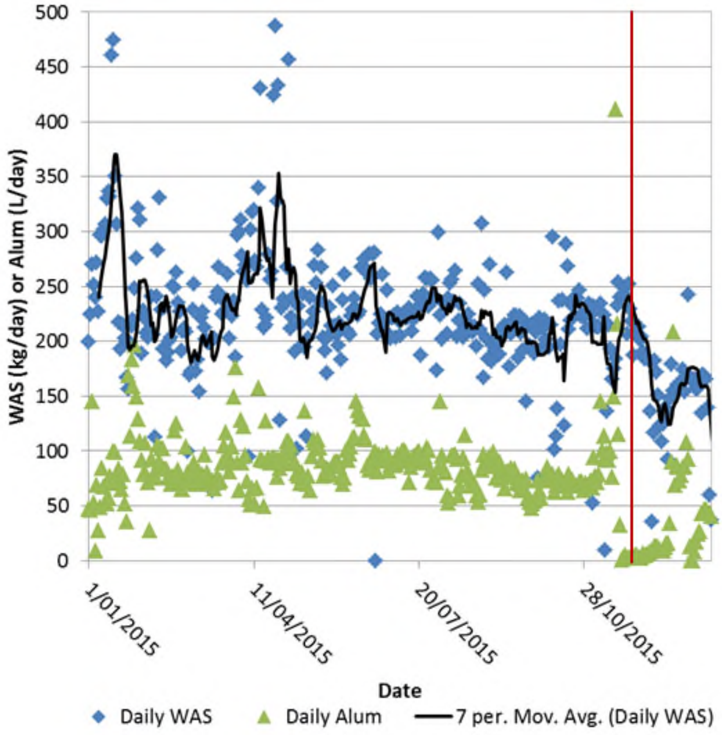


Figure 3: ***Reduction in ACH Consumption and Volume of Sludge Wasted (Jan '15 to Jan '16). Line indicates Date of Implementation.***

2.3 Reduced Sludge Costs

Mostly as a result of reduced ACH dosing, there has been a significant saving in dewatering and sludge cartage. Daily wasting has decreased by 50 kilogram dry solids per day while MLSS has remained steady (Figure 5), indicating reduced sludge generation and increasing sludge age. Sludge removal is expensive at a small site, sand this is calculated to save $12,500 per year (Figure 4).

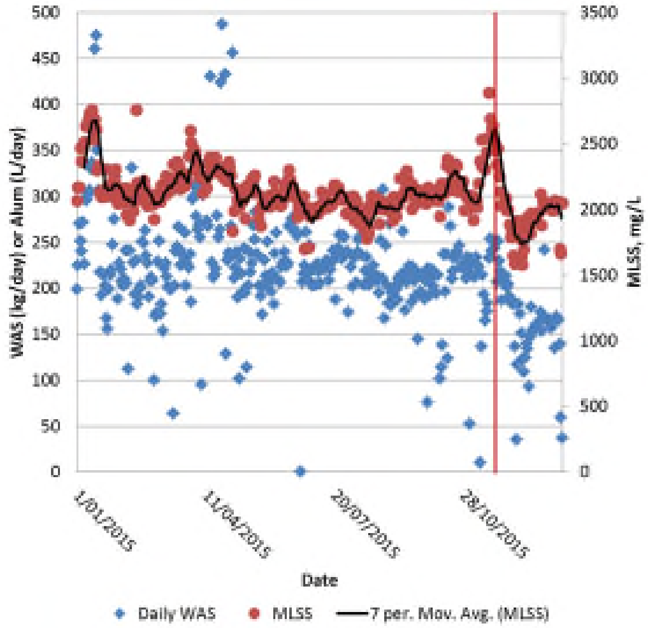


Figure 4: ***Daily Measured MLSS and Calculated Volume of Sludge Wasted. Line Indicates Date of Implementation.***

3.0 CONCLUSION

Because the control modes trim aeration and ACH dosing even when the plant is unattended it is possible to optimise nutrient removal and maximise operational cost savings. Since starting to use feedback control we have spent more time doing verification tests on our analysers, but this is a small price to pay for the great effluent results. The combined savings are significant for a plant of this size, particularly since they are achieved by use of feedback controllers that are simple compared to feedforward or predictive controllers.

It is important to review operational performance often so that reduced performance is seen early and quickly corrected. For example when low phosphorous targets were selected the controller wound up to the upper bound and remained there because increasing the dose no longer affected orthophosphate. In particular, if power is trending upward in a way that is not explained by catchment growth, then the NH_3 Trim controller and the ammonia analyser should be verified to be working.

4.0 ACKNOWLEDGEMENTS

Janice Wilson (Treatment Engineer, Mackay Regional Council) encouraged me to write the paper and assisted greatly with suggestions and feedback. Damien Sharland (Technical Director Water Facilities, Jacobs) has helped us tremendously with getting this control modes running and fine tuning the settings. Many thanks to Alex Wise (Process Engineer, Jacobs) for helping me submit the paper and for his assistance on operating SWRF.

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