BIOLOGICAL PHOSPHORUS REMOVAL AT THE GIPPSLAND WATER FACTORY

Paper Presented by:

Ryan Snell & Adrian Harper

Authors:

Ryan Snell, *Systems & Performance Technologist,*
Adrian Harper, *Senior GWF Engineer,*

Gippsland Water

81st Annual WIOA Victorian Water Industry Operations Conference and Exhibition
Bendigo Exhibition Centre
5 to 6 September, 2018

BIOLOGICAL PHOSPHORUS REMOVAL AT THE GIPPSLAND WATER FACTORY

Ryan Snell, *Systems and Performance Technologist,* Gippsland Water
Adrian Harper, *Senior GWF Engineer*, Gippsland Water

ADDENDUM – August 2019
In the period since this paper was written, the operation of the GWF domestic MBR has been altered such that the conclusions drawn are not entirely valid. In December 2018 the intermittent recirculation was changed to be a constant recirculation and since then the biological phosphorus removal has still been excellent. The reason for changing to a constant recirculation was to help with dissolved oxygen control, flow control and level control.

Further investigation is required to determine how anaerobic conditions are still being achieved in zone 1 to allow the biological phosphorus removal to occur.

ABSTRACT

The Gippsland Water Factory is a Membrane Bioreactor (MBR) site that treats ~12 ML/d of domestic influent. It was designed for biological nitrogen removal and chemical phosphorus removal but has been modified to effectively and efficiently remove phosphorus biologically to consistently achieve phosphorus effluent targets. This paper outlines a simple modification that was implemented and also the other factors influencing biological phosphorus removal.

1.0 INTRODUCTION

The Gippsland Water Factory (GWF) processes approximately ~35 ML/d of industrial and domestic wastewater on separate treatment trains. The domestic system treats ~12 ML/d of residential domestic and some small industrial wastewater. The system was designed for biological nitrogen removal and chemical phosphorus removal using a four stage Bardenpho configuration (Figure 1).

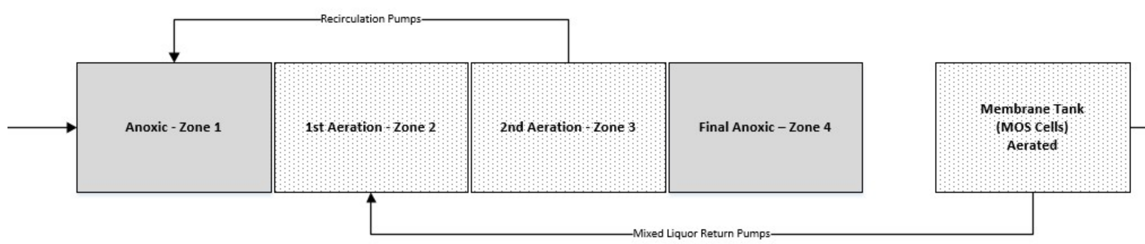

Figure 1. GWF Configuration - four stage Bardenpho

The main treatment processes for the domestic system includes 5mm band screens, grit removal, primary clarifier and then 1.5mm prefilters followed by a Membrane Bioreactor (MBR). Domestic filtrate can either be discharged from site or sent through reverse osmosis and final chlorination to produce ~8 ML/d of recycled water to Class A standard.

Since commissioning of the treatment plant in 2011 phosphorus removal was achieved by Enhanced Biological Phosphorus Removal (EBPR) with no chemical dosing recorded. However, EBPR was inconsistent and meant that the production of recycled water was not always possible due to feed water quality limits on the reverse osmosis membranes (Figure 2).

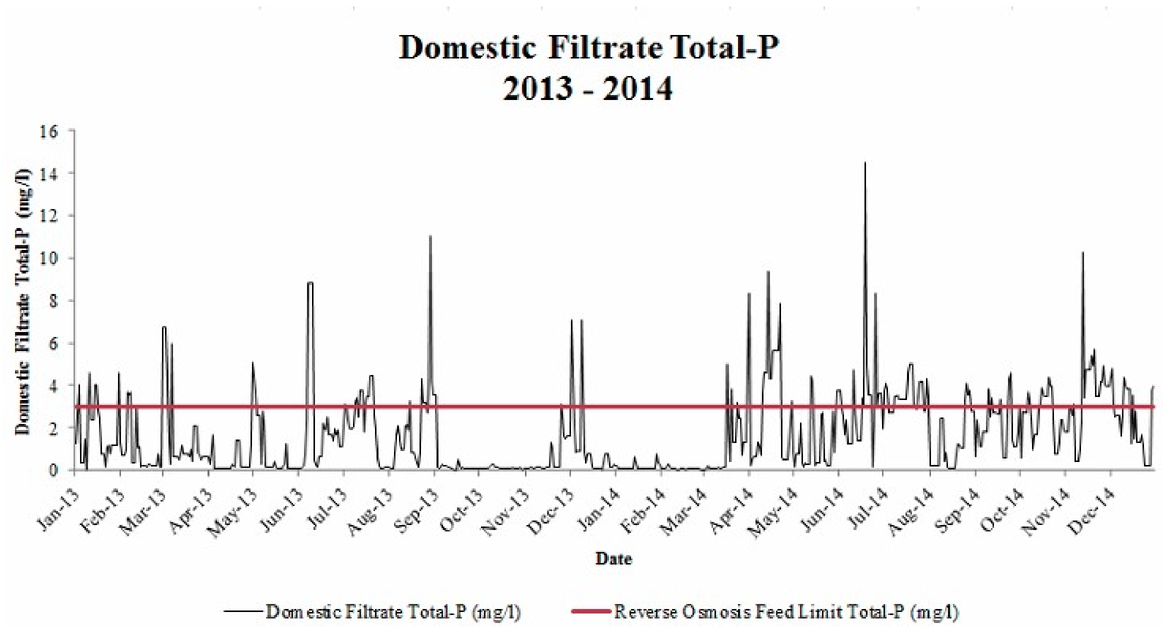

Figure 2. GWF Domestic Filtrate Total-P (mg/l) between 2013 and 2014

The GWF engaged a consultant to assist in quantifying the effectiveness of EBPR on-site and to identify feasible phosphorous control mechanisms so that more consistent and easily manageable EBPR could be achieved. The study found that there was sufficient carbon for biological phosphorus removal but it was suspected that re-release of phosphorus was occurring in the final anoxic zone. Three recommendations were proposed to address these findings:

- alter the MBR feed pipework from the front of the first anoxic zone to the midpoint of the zone;
- reduced internal recycled flow rate from the aerobic zone back to the first anoxic zone; and
- optimise Volatile Fatty Acids (VFA) generation in the activated primary clarifier (pre MBR).

2.0 DISCUSSION

2.1 Intermittent Recirculation

The GWF Operations Team decided to focus on reducing internal recycled flow rate and promote some more anaerobic activity in the first anoxic zone. Initially the internal recycle flow was reduced by decreasing the set point on the variable speed controller for the recirculation pumps. While this reduced the power use, it was not found to be effective in improving the biological phosphorus removal.

The GWF Operations Team then identified an alternative option to modify the existing internal recycle to operate intermittently. The change aimed at creating a swing anaerobic and anoxic zone at the front of the MBR using existing equipment and a simple PLC control modification. This option did not require any further capital investment and a trial for intermittent internal recirculation was commenced on 13 August 2015.

The recirculation pumps were initially set to alternate between 45 minutes on and 20 minutes off. This effectively converted the bioreactor to be alternating between a four stage and five stage Bardenpho configuration (Figure 3). Since the change the recirculation pump on time has been increased to alternate 50 minutes on and 10 minutes off to maintain nitrogen removal. There has been no impact on phosphorus removal due to this change.

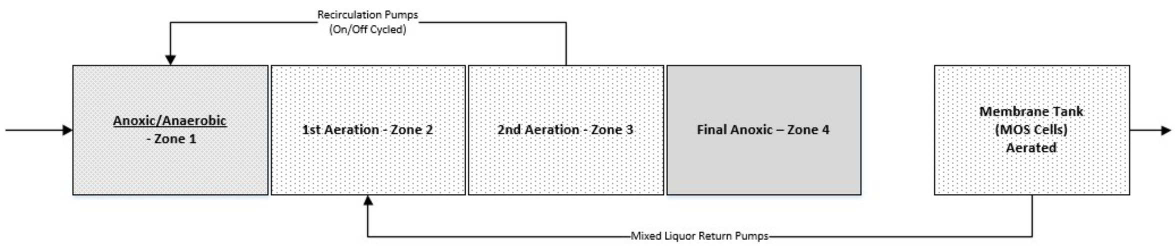

Figure 3. GWF Configuration - five stage Bardenpho

2.2 Benefits

Since the modification was made, the intermittent recycle has proven to be effective in achieving an increase in phosphorus release at the end of the first zone and consistently reducing phosphorus in the filtrate (Table 1).

Table 1. Phosphorus release and removal in domestic treatment system pre and post intermittent recirculation

	Pre-intermittent recirculation 1 January 2013 – 12 August 2015	Post intermittent recirculation 13 August 2013 – 31 March 2018
Domestic Reactor 1 average Ortho-P end of zone 1	8.66 mg/l	12.98 mg/l
Domestic Reactor 2 average Ortho-P end of zone 1	6.92 mg/l	11.07 mg/l
Domestic Filtrate average Total-P	1.65 mg/l	0.45 mg/l

See Figure 4 for a trend of the phosphorus in the filtrate from 2013 to 2018 which shows the consistently low filtrate concentration after the intermittent recirculation was implemented with a few short term periods where loss of biological P removal occurred. Since the filtrate Total-P has consistently decreased to below 0.5 mg/L the availability to operate the reverse osmosis unit has improved.

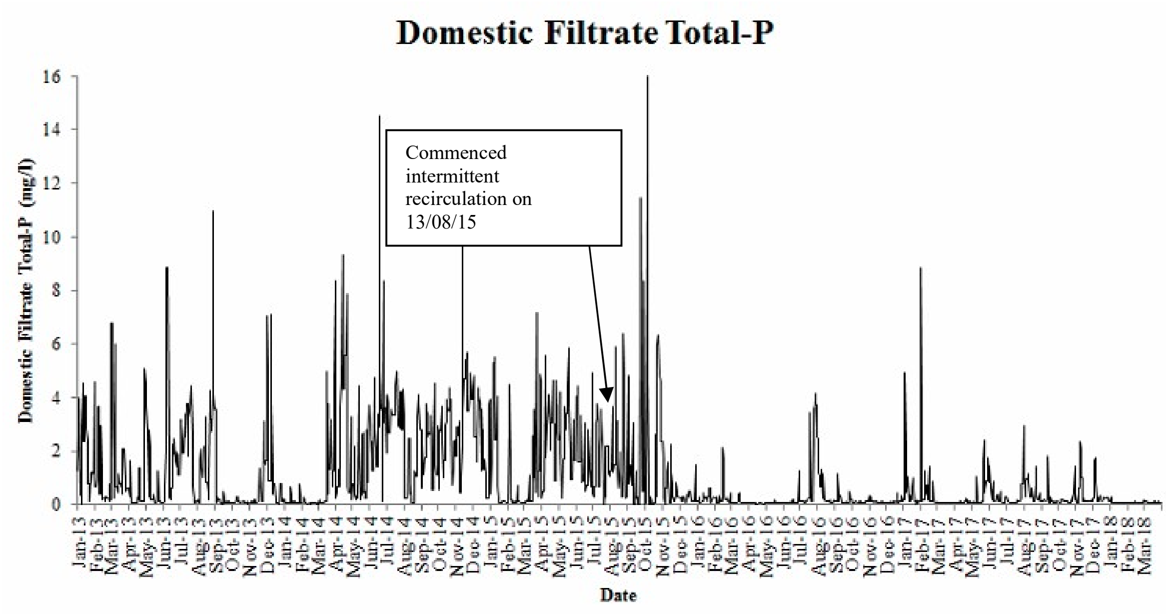

Figure 4. GWF Domestic Filtrate Total-P (mg/l) since operation

Another advantage of changing to the intermittent recycle was the opportunity to save on the energy use of the recirculation pumps. Calculating the power use of these duty/standby pumps has demonstrated an average daily saving of approximately 24-44 kW total between the two bioreactors depending on the recirculation pump on and off time ratio.

On the industrial treatment system historically there had been a requirement for phosphoric acid dosing to offset the lack of nutrients in the industrial influent. Since changing to the intermittent recirculation on the domestic treatment system the domestic WAS has been higher in phosphorus. This WAS stream is pumped to the anaerobic reactors, where the effluent feeds the industrial MBR, and has significantly reduced the requirement to add phosphoric acid, see Figure 5 for daily phosphoric acid use.

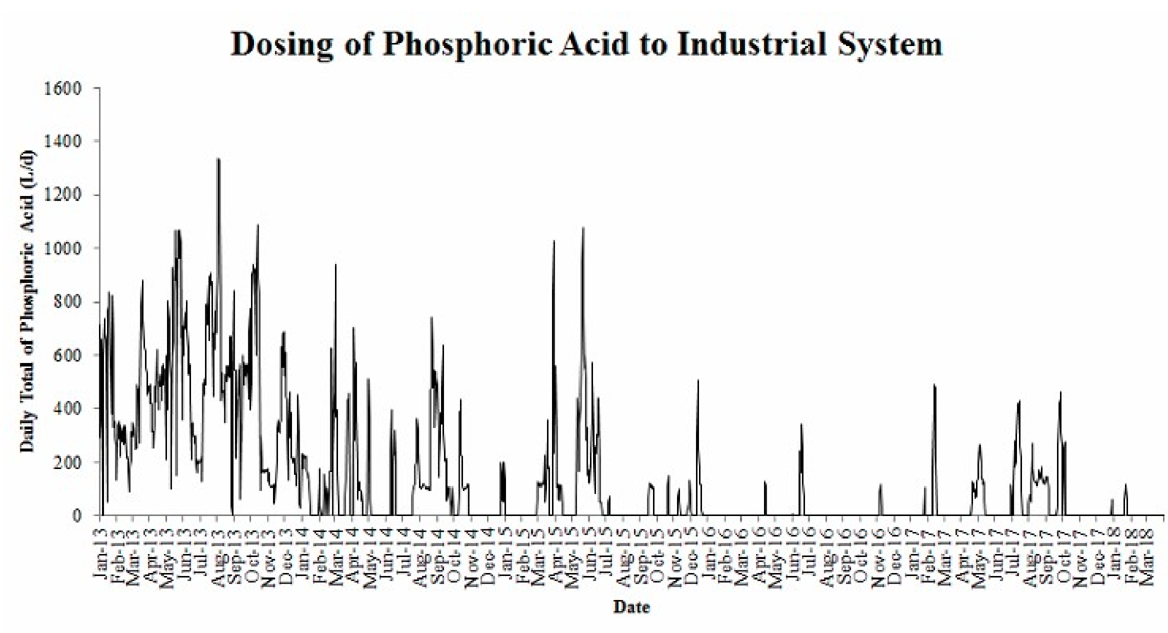

Figure 5. Reduction in Phosphoric Acid dosing to Industrial System since 2013

The excellent biological phosphorus removal at the GWF has offset the significant cost of chemical phosphorus removal. Other well performing Gippsland Water activated sludge waste water treatment plants (WWTPs) with chemical phosphorus removal typically dose between 50-100 ppm of iron salts which if in place at the GWF would cost ~$500-1,000 per day. On top of this, pH correction is required to offset the acidity of the iron salts and at a typical sodium hydroxide dose of between 50-100 ppm, the GWF is saving ~$250-500 per day.

2.3 Loss of Phosphorus Control

Since the implementation of the intermittent recirculation there have been times where the domestic filtrate phosphorus levels have increased. The loss of phosphorus control on most occasions is associated with a significant increase in inflow to the domestic MBR due to wet weather events.

2.4 MBR feed characteristics

When reviewing the domestic MBR feed characteristics there is an increase in the COD:Ortho-P ratio starting in May 2015 (Figure 6). The ratio increase is due to a reduction in Ortho-P concentration in the influent waste water that has continued to occur to date. The Ortho-P concentration in the feed to the domestic MBRs is quite low when compared with other Gippsland Water WWTPs.

Due to the large catchment size of the GWF (9 towns and multiple small industries) it is hard to pin down the main reason for the reduction of Ortho-P. The increase in COD:Ortho-P ratio may have also contributed to the consistent biological phosphorus removal.

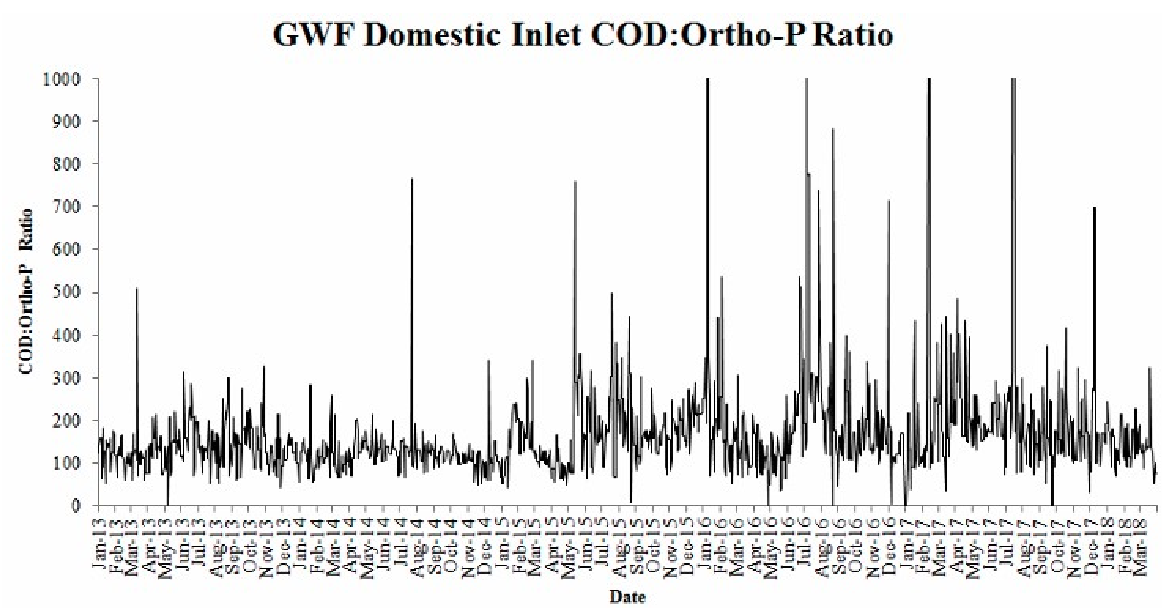

Figure 6. Increase in GWF Domestic Inlet COD:Ortho-P Ratio in May 2015

2.5 Further Investigation

An unintended consequence of the intermittent recirculation is swings in dissolved oxygen through the domestic MBR aeration zones. The swings in dissolved oxygen have no impact on the treatment capability of the domestic MBR and average levels of dissolved oxygen over a 24 hr period meet the required set point (Aeration Zone 1 = 1 ppm; Aeration Zone 2 = 0.5 ppm).

However, due to the specific process blower control at the GWF this swing in dissolved oxygen can cause blowers to stop and start frequently during low process air demand periods. Investigation into the cause of swings in dissolved oxygen and an improved blower control process logical control would be beneficial.

3.0 CONCLUSION

The GWF has been able to achieve consistent biological phosphorus removal by implementing an intermittent recycle in the bioreactor. The solution demonstrated savings in energy and was inexpensive to implement. It has also had additional benefits with regards to offsetting nutrient dosing to the industrial treatment system.

4.0 ACKNOWLEDGEMENTS

We would like to thank both Mick Cook (GWF Senior Operator) and Dale Yeates (Wastewater Engineer) for their efforts in investigating the problem and implementing the solution. This work was carried out before the authors worked at the GWF.