ACHIEVING ZERO EFFLUENT PHOSPHORUS – THE MEMBRANE TREATMENT SOLUTION

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INTRODUCTION

Achieving lower phosphorus level in wastewater effluent is an increasingly important issue for inland townships that discharge to sensitive river ways. Tighter limits for phosphorus (e.g. 0.1-0.5 mg-P/L) are becoming a norm for more wastewater treatment projects across the world. For new discharges to the Hawkesbury-Nepean Rivers in metropolitan Sydney, environmental regulators are starting to impose conditions such as “no additional phosphorous load” as the river system is known to be sensitive to phosphorous-induced algal bloom.

For the new inland township of Googong near Canberra / Queanbeyan, the new wastewater treatment plant needs to meet a tight phosphorus limit of 0.5 mg-P/L, as well as achieving a total dissolved solids (TDS) limit of 700 mg/L. As the township was designed with dedicated recycled water supply, the semi-closed water cycle suggests that the non-biodegradable nature of most dissolved solid compounds will accumulate and potentially lead to a breach in the effluent license conditions. This paper reports operational findings for the new Googong Water Recycling Plant, where new approaches were employed to achieve a combination of tight limits of phosphorus and total dissolved solids.

DESIGNS TO MINIMISE EFFLUENT PHOSPHORUS AND TDS

Conventional methods are available to achieve the effluent phosphorus limit of 0.5 mg-P/L, which include dosing of iron salts to bioreactor, followed by alum dosing prior to media filtration. This is a proven approach employed at most of Sydney Water’s inland wastewater treatment plants. Additions of iron salts and alum, however, introduce chloride or sulphate compounds, elevating TDS in the recycled water.

For Googong WRP, the conventional approach was modified to cater for the additional requirement to meet the effluent TDS limit. These include:

- Establishment of a water balance based TDS model to elucidate the amount of chemicals that could be added without breaching the TDS limit in a semi-closed water cycle.
- The use of membrane technologies to further remove phosphorous in the colloidal forms.
- Design the bioreactor to be operated in enhanced biological phosphorus removal (EBPR) mode to minimise addition of chemicals for the precipitation of phosphorous.
- A multi-point dosing approach to improve efficiency in chemical use for phosphorous removal.

PROJECT OUTCOMES

A TDS model was created to simulate dynamics of non-biodegradable compounds in the water cycle. This is shown in Figure 1. The background water balance model was based on 40-year of climatic data for the

Canberra region and water demand prediction for the proposed development mix of Googong. Key outcomes from the TDS model include:

- Elimination of machine washing as one of the end uses for recycled water.
- Direct plumbing of recycled water to household backyards for garden irrigation. This maximises the use of recycled water (and thus the associated TDS) onto land.
- Process decisions on the dosing of chemicals for the Water Recycling Plant. The WRP was designed with dosing of ferric and alum at three locations:
    - Dosage of ferric sulphate at the sewer main, prior to the inlet works
    - Dosage of ferric sulphate in the membrane bioreactor (MBR)
    - Dosage of alum prior to a set of ultrafiltration membrane trains

In 2016, the plant was successfully commissioned and underwent 90-day performance verification testing. The phosphorous levels in the wastewater feed, MBR filtrate and final effluent are shown in Figure 4. Commissioning and operation outcomes from the project demonstrated that phosphorus level as low as 0.01 mg-P/L could be achieved on a median basis.

In terms of chemical consumption, the total molar doses of ferric and alum is estimated to be around 1:1 when compared to the moles of phosphorous removed from the wastewater. The calculated molar dose is checked against measurement of sulphate increase across the WRP. This is significantly better than the molar ratios quoted in the literature (Metcalf & Eddy, 2003) for attainment of the very low phosphorus levels, where molar ratios up to 4.5:1 is quoted. Examination of the data suggests that the following are key contributing factors for the high chemical efficiency:

- Multi point dosing of chemical prior to a solid separation step, which facilitates different ways to optimise chemical dosage
- Tight pore sizes of the filtration membranes that remove colloidal phosphorous compounds
- Recycling of alum precipitates back to the bioreactor to facilitate a “secondary” precipitation of phosphorus with alum in the bioreactor

The high efficiency in chemical use is key to the achievement of low TDS in the effluent, which was measured to be less than 400 mg/L.

CONCLUSIONS

Overall the Googong project points to a new way to achieve lower effluent phosphorus with minimum use of chemicals. Lessons learnt from this project could be beneficial for other projects that face similar challenges to meet tight limits of phosphorus and TDS in the wastewater effluent.

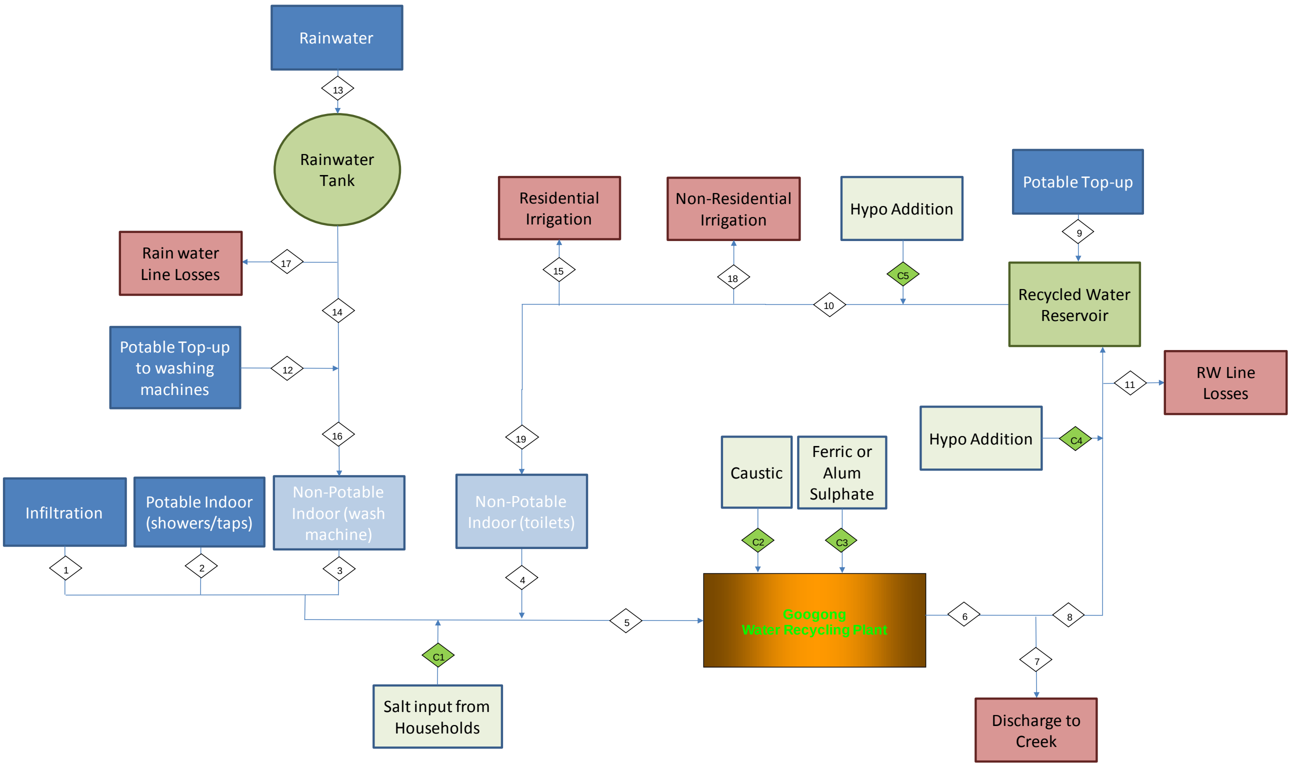

Figure 1: Schematic Diagram of Googong Township's water and TDS balance models

Figure 2: Membrane bioreactor at the Googong Water Recycling Plant

Figure 3: Tertiary filtration system at the Googong Water Recycling Plant

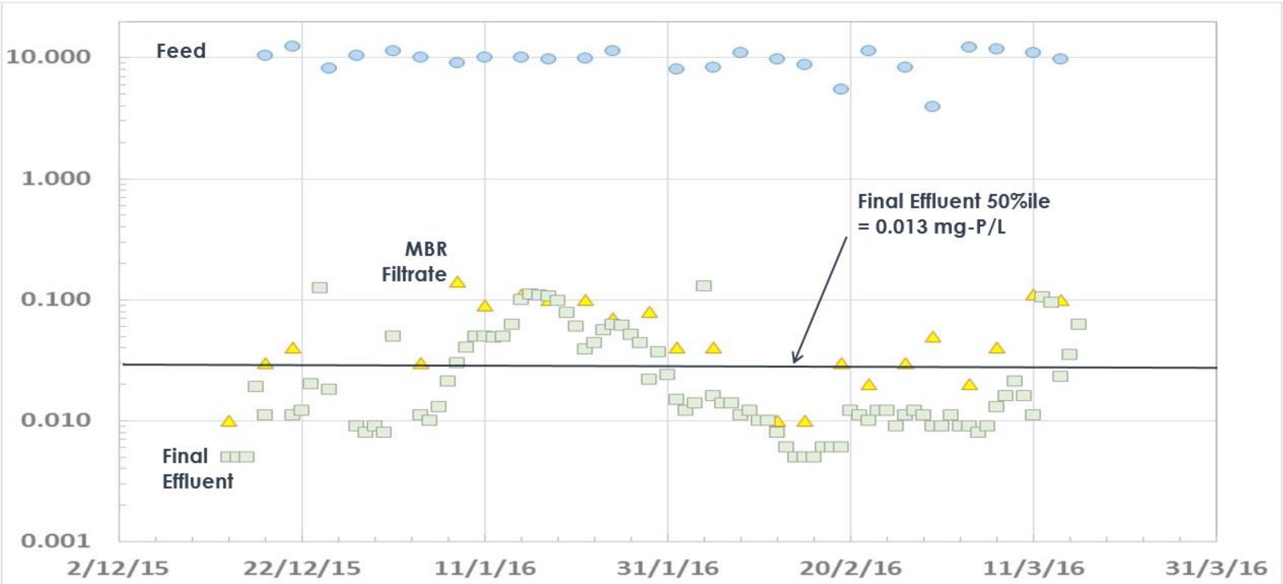

Figure 4: Phosphorous levels at different parts of Googong WRP