MATAMATA TERTIARY MEMBRANE PLANT UPGRADE

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ABSTRACT

Matamata-Piako District Council manages the Wastewater in the district through state-of-the-art treatment plants, to ensure wastewater is collected, treated and disposed of appropriately for the health and wellbeing of the community. The provision of reliable wastewater treatment is a fundamental service for the community. Council wanted to ensure they could deliver that service during wet weather periods, with minimal impact to the environment. The council faced the challenge of operating an ageing tertiary membrane treatment plant at its Matamata Wastewater Treatment Facility. Before the upgrade, the plant was at risk of not being able to meet capacity during peak wet weather events, which resulted in occasional overflows to the nearby environment. The plant built 8 years ago, was operating with reused ZeeWeed500c membranes from the Tuakau Water Treatment Plant. The council was looking for a solution that not only replaced the old membranes but ensured they could reliably meet increasing capacity requirements and futureproof the plant for additional growth. The solution also had to be cost-effective for the ratepayers.

This paper outlines, how Matamata-Piako District Council, in collaboration with SUEZ Australia & New Zealand (SUEZ), planned and executed the membrane plant upgrade. The paper also describes the engineering challenges faced, and plant optimisation and automation implemented as part of the project.

With the installation of the new ZeeWeed500d membranes (within the same footprint) and the implemented plant optimisations, the upgrade doubled the plant capacity, and reduced power consumption and operational labor requirement. It also provided the council with an overall more reliable and higher performing plant eliminating environmental discharge risk to the nearby river.

KEYWORDS

Upgrade, Membrane, Tertiary

PRESENTER PROFILE

Sean Pathmanathan is the operation Manager for MPDC. He has 8 years wastewater Treatment and Process Control Experience and 13 Years as Water Laboratory Manager for Downer NZ. Sean has a Master's Degree in Chemistry and Post Graduate Dip in Management. Sean has vast experience in Analysis and Process optimision.

Nadine Oschmann is Lead Process Engineer for SUEZ's Water Technologies and Solutions division. She has fifteen years' water and wastewater treatment experience as a process engineer. Nadine has worked on various projects including wastewater, industrial water and recycled water treatment plants. Nadine has extensive experience in Membrane based technologies.

Nalin Vithanage is the Design Manager for SUEZ's Water Technologies and Solutions division. Nalin possesses twenty years' project engineering and design management experience in the water industry. Nalin provides Engineering support by leading the design management and contributed to more than sixty industrial, municipal wastewater and water projects.

1 INTRODUCTION

Matamata-Piako District Council (MPDC) manages the wastewater in the district through state-of-the-art treatment plants, to ensure wastewater is collected, treated and disposed of appropriately for the health and wellbeing of the community. In 2009 MPDC purchased second-hand membranes and built the tertiary treatment plant. At that time the membrane modules were five years old and had an expectation to operate for a further two years before requiring replacement with equivalent SUEZ membranes. The membranes have exceeded life expectations and were only showing signs of reduced performance and high failure risk in 2016. By then the membranes were in service for 12 years, which is generally well over 8-year UF membrane life expectancy.

Faced with the challenge of operating an ageing tertiary membrane treatment plant the Matamata Wastewater Treatment Facility (shown in Figure 1) was at risk of not being able to meet capacity during peak wet weather events, which resulted in occasional overflows to the nearby environment. Additionally, the membrane plant was not designed by SUEZ and required a high level of manual intervention and operator presence on site. MPDC saw an opportunity to engage SUEZ for the membrane replacement and work collaboratively to improve membrane operation, fully automate the plant and upgrade the chemical dosing system.

Figure 1: Matamata Wastewater Treatment Facility

This project delivery model was new to council, who would have normally engaged a design consultant. The council engaged SUEZ directly for supply and installation of the new membranes, engineering and management of local subcontractors. This model of delivery allowed MPDC to spend money on the actual upgrade rather than consulting services. The design was undertaken cooperatively between Council and SUEZ engineers and the equipment sourcing was split on a best for project basis, which allowed council to source some items locally. The fabricated stainless-steel items for the cassettes, supply-installation and commissioning of the chemical dosing systems and the PLC coding services were therefore sourced via local contractors. Use of local contractors ensured availability of long term maintenance services directly to the council, while SUEZ provided review, engineering and project management services. Any issues discovered during the design phase were resolved very amicably between MPDC and SUEZ with always the best project outcome in mind.

2 MEMBRANE PLANT UPGRADE CASE STUDY

The council was looking for a solution that not only replaced the old membranes but ensured they could reliably meet increasing capacity requirements and futureproof the plant for additional growth and reduce operator attendance on site. The solution also had to be cost-effective for the ratepayers and within the budget allocation of the council. The scope of the membrane plant upgrade included:

1. Upgrade the membranes to achieve increased flow rates,
2. Upgrade the old chemical dosing facility to reduce operator attendance requirements and to comply with the ANZ HAZCHEM requirements,
3. Increase Plant automation to decrease operational expenditure.

The project was awarded in September 2016 and the upgraded plant was commissioned in May 2017. The council engaged SUEZ directly to do the membrane supply, engineering and integration of the project.

The objectives of the membrane plant upgrade were:

- Reduce health and safety risks,
- Maintain compliance with consent conditions,
- Replace failing membrane modules,
- Increase plant automation,
- Achieve operational savings,
- Increase plant treatment capacity,
- Future proof the plant.

2.1 MEMBRANE REPLACEMENT

The first part of the upgrade was the replacement of the aging membrane modules. The original membranes installed in the Matamata Wastewater Treatment Facility were SUEZ ZeeWeed500c membranes, which were aquired as second hand membranes from the Waikato Water Treatment Plant. The membranes were approximately 5 years old at the time of installation in 2009. The ZW500c membranes are a discontinued product. The council was looking for a replacement and SUEZ recommended the next generation ZW500d membranes which are available in similar configuration to the 500c membrane cassettes. Figure 2 shows the ZeeWeed membranes module evolution.

Figure 2: ZeeWeed Membrane Evolution

The Tertiary Membrane system is fed from the oxidation pond system of the Matamata Wastewater Treatment Plant. Replacing the old membranes with the new ZW500d membranes required minimal changes to the existing plant. Advantages of the ZW500d membranes are:

- Increased membrane area,
- Improved membrane chemistry,
- Higher operating fluxes,
- Better aeration technology,
- Easier module removal for repairs.

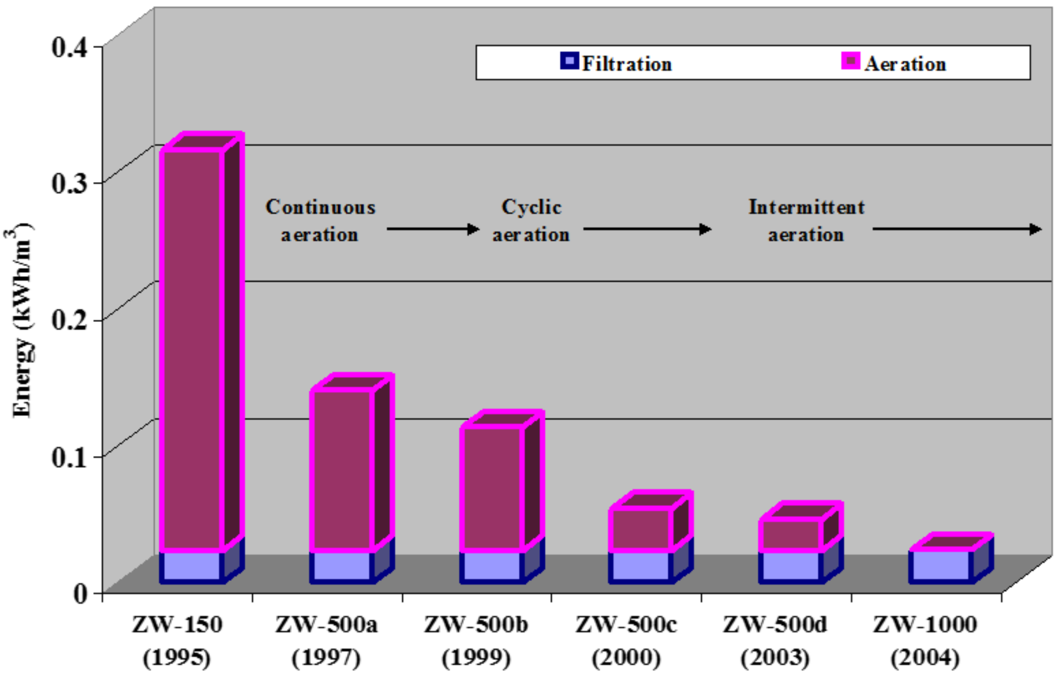
Table 1 shows the membrane plant confuguration pre and post upgrade. The new membranes with their increased surface area and improved fluxes achieved more than double the design capacity. The old plant capacity was only 2500m3/day, the upgraded Plant can treat a peak flow of 6000m3/day. This will allow MPDC to operate the plant at peak flows to lower the pond levels quickly before a storm event to free up buffer storage capacity in the pond. The increased capacity will also add redundancy for any required maintenance and has future proofed the plant for additional population growths in the area. The capacity increase was achieved within the existing plant footprint without any additional infrastructure.

Table 1: Pre- and Post- Upgrade Membrane Plant Configuration

Description	Pre-upgrade	Post-upgrade
No. Trains	4	4
No. of Cassettes per Train	3	3
Membrane Type	ZW500c 26M cassettes	ZW500D 20M cassettes
Total numbers of installed modules per Cassette	26/26	20/20
Surface area per module (m^2)	23.2	40.8
Total membrane Area per plant (m^2)	1,809	2,448
Membrane Chemistry	PVDF-1 (SMC)	PVDF-2 (CP5)
Primary Op. Mode	Feed and Bleed	Deposition
Aeration mode	Continuous	During backwash only

In addition to the higher surface area of the ZW500d membrane, change of operating mode to Deposition mode with Backwash Aeration allows for improved intermitant aeration technology, which has reduced the power consumption of the plant. Figure 3 shows the reduction of aeration power over the membrane product evolution.

Figure 3: Aeration Energy Reduction Over the ZeeWeed Membrane Evolution



2.2 CHEMICAL DOSING UPGRADE

The second part of the upgrade was the upgrade of the chemical dosing system. The existing system was very manual and prone to frequent breakdowns due to old age. The existing system could not deliver the higher instantaneous flow rates required for the increased membrane area. The chemical unloading process was very manual and required operator attendance and there was no instrumentation to fault find.

The upgraded chemical dosing system was designed with increased chemical storage and is fully compliant with the NZ standards for hazardous chemical storage. The new system is fully automated with pump operation visible through PLC and SCADA. The chemical unloading facility has been designed externally to the plant building and is fully automated, this allows for filling of the storage tanks by the chemical supplier without entering the plant house and without operator involvement. The fully automated filling system eliminated the health and safety risk on site due to manual handling of chemicals and exposure to highly concentrated Sodium Hypochlorite and Citric Acid. Figure 3 shows the external filling station and figure 4 shows the upgraded chemical dosing and storage facility.

Figure 3: Chemical Loading Station

Figure 4: Chemical Dosing System

Prior to the upgrade the Matamata plant required operator attendance seven days per week. After the upgrade of the chemical storage system and increased automation of the plant operator attendance was only required three days per week, with no attendance required on weekends. The estimated labor cost savings are presented in Table 2.

Table 2: Yearly Labor Cost Savings

Description	**Cost (NZD)**
Yearly labor cost based on 7-day visits	163,531.00
Yearly labor cost based on 3-day visit	98,118.00
Yearly savings	**65,413.00**

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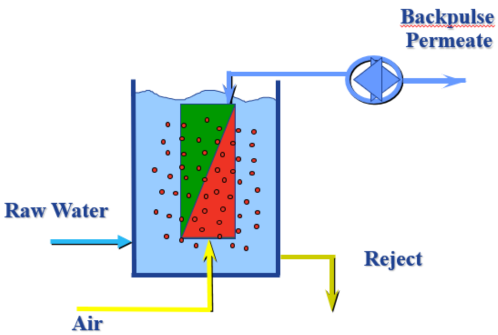
2.3 CONTOLS AND OPERATIONAL IMPROVEMENTS

As part of the upgrade the control philosophy of the membrane plant was reviewed, and the plant operation modes were changed to improve plant operation and power consumption. In addition, the control system was upgraded to include automated demand forecasting based on pond level, rather than operator input and improve trending and troubleshooting capability.

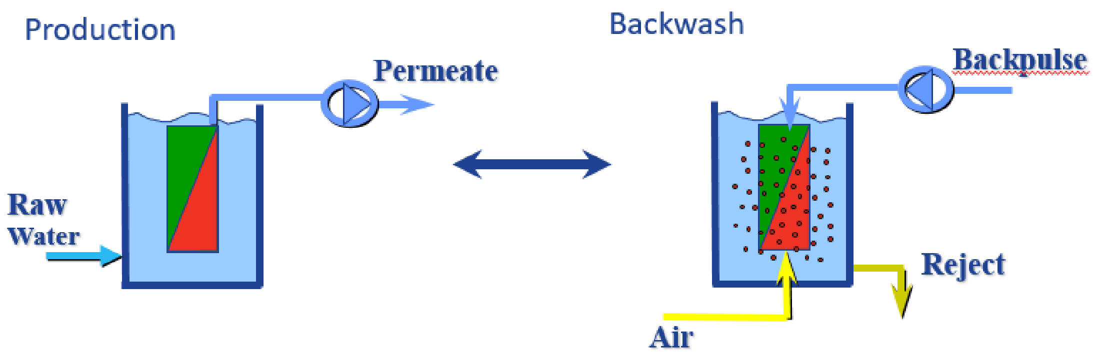
The existing plant was designed to operate in "Feed and Bleed" mode. In this mode the membrane tanks are fed, and a concentrated reject stream approximately 10% of the feed is bled off continuously to achieve the design recovery. The membranes are periodically backpulsed. In this mode the membranes are continuously aerated during production to reduce the membrane fouling. Figure 5 shows a schematic of the feed and bleed mode.

Figure 5: Feed and Bleed Mode of Operation



The ZW500d membranes allow for operation in "Deposition Mode" schematic shown in Figure 6. In Deposition Mode, the membrane trains alternate between Production and Backwash. In Production, the membrane tank is fed and the permeate is withdrawn through the membranes. No aeration occurs during Production. Periodically Production is stopped, membranes are backpulsed and the concentrated reject is drained from the tank. In this mode the trains are only aerated in Backwash. This results in a significant aeration energy reduction compared to feed and bleed mode of operation.

Figure 6: Deposition Mode of Operation



Deposition Mode is the most cost-effective operation mode. However, it requires fast tank drains and refills to minimize downtime. The existing plant infrastructure didn't allow for fast fills and drains. Originally it was intended to reduce the drain time by upsizing the pipes. However, during the detail design stage, the mechanical contractor advised the council that upgrading this infrastructure was too expensive and would have required complete plant shutdown for a few weeks. As the plant needed to be operated during the upgrade and considering the cost of upgrading the drains, it was decided not to carry out this work.

During commissioning it was soon realized that it was difficult to operate the plant at peak capacity. SUEZ in conjunction with MPDC trialed following strategies;

1. To operate the plant in partial tank drain with intermittent aeration and backpulses,

2. To provide flexible modes of operation with ability to switch over to Feed and Bleed mode during peak period.

After the trials, SUEZ and MPDC developed a control philosophy, where the plant would operate in Deposition mode during average flow conditions, when the plant had sufficient spare capacity to cater for the extended downtimes. The plant switches to feed and bleed mode during peak flow events, when extended downtimes would have impacted capacity. This resulted in a fully automated flexible system, which could operate with reduced power demand for most of the year during average flow condition, while still being able to meet peak flow capacities during wet weather events. Currently the plant operates in Deposition mode for about 95% of the year and only switches to feed and bleed mode during peak flow events. Furthermore, the plant is now operating on automated demand forecast based on pond levels, rather than manual operator demand input and has improved trending and troubleshooting capability, which greatly helped in reducing operator attendance requirements on site. The estimated labor cost savings have been presented in Table 2 above and the estimated power savings are presented in Table 3 below.

Table 3: Yearly Power Cost Savings

Description	**Power Savings**
Average monthly Power consumption pre-upgrade(kWh/month)	63,442
Average monthly Power consumption post-upgrade(kWh/month)	60,184
Average monthly Power savings(kWh/month)	3,257
Average yearly Power savings(kWh/year)	**39,090**
Average yearly Power cost savings	**NZD 5082**

The power savings are based on the average power usage for the 11 months prior to the upgrade and on the same period post upgrade. The savings have been calculated based on an average of $0.13 per kWh.

3 CONCLUSIONS

With the installation of the new ZeeWeed500d membranes (within the same footprint) and the implemented plant optimisations, the upgrade doubled the plant capacity, and reduced power consumption and operational labor requirement. It also provided the council with an overall more reliable and higher performing plant eliminating environmental discharge risk to the nearby creek. It is expected that the operational time savings from the automaton of the plant and the power savings expected from improved operating regimes will offset the costs for the membrane replacement within nine to ten years.

The council's decision to engage the membrane supplier directly eliminated the risk of handover of a plant which could not meet peak capacities due to the undersized drain lines. In this delivery arrangement council and SUEZ could work together to find the optimised solution within the project budget.

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The project was a great success and Matamata-Piako District Council and SUEZ Australia & New Zealand are looking forward to working together in the future.