PRACTICAL ISSUES INVOLVED IN COMMISSIONING OF A MEMBRANE BIOREACTOR WASTEWATER TREATMENT PLANT

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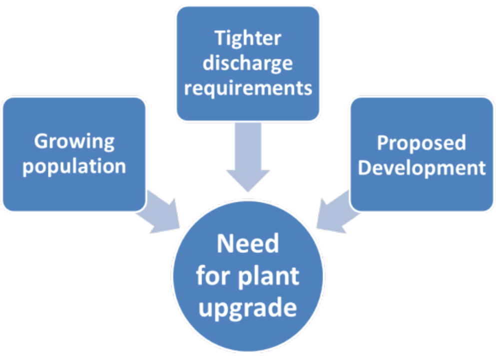
ABSTRACT

Paxton wastewater treatment plant (WWTP) is a 1000 kL/day capacity facility situated in the Hunter Valley of NSW, Australia. A growing population as well as tighter discharge requirements for the sensitive discharge environment resulted in the need for a plant upgrade. The upgrade was delivered via an Alliance contract, with Hunter Water Australia, as the contacted operator, liaising closely with the Alliance team. This paper outlines practical issues involved in the brownfield upgrade and commissioning of the membrane bioreactor process adopted for the upgrade, as well as the problems encountered and the changes made in order to resolve them. Performance results for the upgraded plant are also presented.

1.0 INTRODUCTION

Paxton WWTP was built in 1993 and originally served as a dormitory town for the local mining and forestry industries. The plant had no inlet works and consisted of an intermittently decanted extended aeration (IDEA) activated sludge process which discharged into a catch pond and maturation pond prior to discharge to Congewai creek via two artificial wetland cells. A portion of the effluent was also discharged into a two hectare woodlot area.

The government had made the commitment to sewer two local townships and a growing population and proposed development in the area combined with stricter discharge requirements meant that an upgrade of Paxton WWTW was needed.



1.1 Process Selection

During the selection process a number of options were considered. These included decommissioning the treatment plant and transferring effluent to a nearby WWTW. Once it was decided not to decommission Paxton WWTW, a 5 stage Bardenpho process was considered due to the low total nitrogen discharge requirements. After the Alliance delivery method was chosen, the cost for this process exceeded the allowed budget. Other process options were then considered and it was found that a membrane bioreactor (MBR) process combined with chemical phosphorous removal was the most cost effective option.

1.2 Alliance Delivery Model

An alliance is a contract that involves a collective responsibility for risk, performance and outcome (gain-sharing / pain-sharing) and avoids a blame culture. The alliance involved a designer, constructer and the owner/operator. The factors that favoured the alliance were the major program of capital works, short delivery timeframe, desire to have owner/operator input to design, design flexibility, legacy documents and learning from experiences on each upgrade. These factors are shown in the below diagram.

The process of selecting the members of the alliance involved expressions of interest, consortia listed, long workshops with each consortium to assess the capability and team-fit which was facilitated by independent expert.

The alliance delivery method involves the development of a Total Outturn Cost which is based on the initial/concept design of the plant. The delivery method involves all stakeholders including the owner, assets, planning, infrastructure delivery, operator and maintenance. After the TOC is complete the detailed design is then completed followed by construction and commissioning.

In order to ensure that the alliance is operating effectively, there are a number of overseers. The project leadership team oversees the operation of the project directly. The APMT oversees the PLT for each project, and the ALG oversees the work of the APMT. This ensures that each group is operating effectively, and it also gives the opportunity for unresolved issues to be escalated to a higher level for discussion and decision making.

1.3 Issues

The following tables describe some significant issues involved in the design, construction and commissioning of the Paxton membrane bioreactor WWTW.

Area	Problem(s) / Issue(s)	Response / Solution	Lesson
Screens (1mm rotary drum screen)	Gap in the side of the screen Holes in the bottom seal Fouling	Installed new seals Hose installed to initially plug hole prior to permanent solution Control set points adjusted (e.g. water flush time, duration/frequency)	It is crucial to verify in pre-commissioning tests that there is no bypassing of the screens
Strainers (1.5mm in line y-strainers)	Hair material fouling meant that frequent manual cleaning of the strainers was required (more than once per hour)	Replaced with 6mm strainers however rapid fouling still persisted. Strainers were removed by constructor against designer's advice but with endorsement from membrane supplier. Operator advocating auto-cleaning strainers due to the high consequence and cost of membrane damage	Hair will pass through the screens which could potentially cause fouling and damage to the membranes. Strainers can remove this hair however will require frequent cleaning making auto-cleaning strainers essential.
Bioreactor Aeration	Blowers were sized for 2030 plant load meant that limited turndown was possible. Over-aeration resulted in nitrate spikes which affected total nitrogen discharge concentrations	Dissolved oxygen set points reduced until nitrate levels dropped. Recirculation rates reduced. Daily sampling required to ensure that discharge requirements were met.	It is crucial to design blowers with sufficient turndown for the current plant operation. Staged blower installation should be considered.
Chemical Dosing-Phosphorous removal	Phosphorous removal dosing was not optimised by the designer's operator resulting in phosphorous spikes above the discharge limit.	Increased alum dosing for phosphorous removal. Daily sampling to monitor phosphorous levels.	It is crucial that as an operator you keep a close watch on the process performance and add input as needed. As an operator you will be ultimately responsible for licence compliance. Internal operational expertise is an important in order to overview the contractor design and operation.

Description	Problem(s)	Solution	Lesson

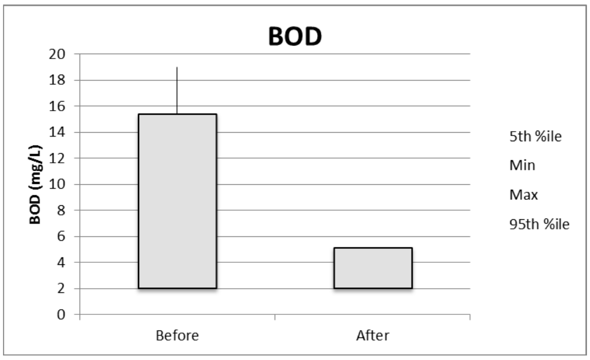
Chemical Dosing-pH correction	pH feedback control faulty resulting in overdose of chemical leading to a high pH on the effluent.	Raise the issue with the constructor as a defect. Run the pH correction dosing in manual until the issue is fixed to maintain effluent pH limits.	It is crucial that as an operator you keep a close watch on the process performance and add input as needed. As an operator you will be ultimately responsible for licence compliance. Internal operational expertise is an important in order to overview the contractor design and operation.
Layout for Maintenance	Removal of blowers/pumps for maintenance/overhaul is impaired by layout.	Install appropriate lifting devices to ensure the safety and useability of equipment removal.	During design it is critical that you think about the removal of equipment so that you can safely remove equipment for maintenance and breakdowns. Internal operational expertise is an important in order to overview the contractor design and operation.
Discharge arrangement through wetland cells	During the construction phase, 1 of the 2 wetland cells was offline. This meant that all of the flow through the plant was discharge through one cell resulting in hydraulic overloading and overflow from the wetland cell.	Continually monitor the flow pumped through the wetland cells so as to not exceed the hydraulic limitation of the cells.	Make sure you monitor the discharge of the effluent so ensure that it is within licence requirements. Internal operational expertise is an important in order to overview the contractor operation.
Woodlot Irrigation	Temporary irrigation system set up by the constructor resulted in an overflow from the utilisation area.	Stop irrigation of the woodlot.	Make sure to monitor the reuse of all effluent. Internal operational expertise is an important in order to overview the contractor operation.
After hours response	SCADA communications were not finished prior to commissioning. Limited capability for the designer to respond (reliant on one operator 24/7). Limited capability for equipment maintenance.	Delayed commissioning until the communications issue was resolved. Modified callout list to include more backup. Reviewed response by contractor and involved our own maintenance crew in some circumstances.	Don't assume that the contractor will have adequate systems in place for after-hours emergency response. Internal operational expertise is an important in order to overview the contractor design and operation.

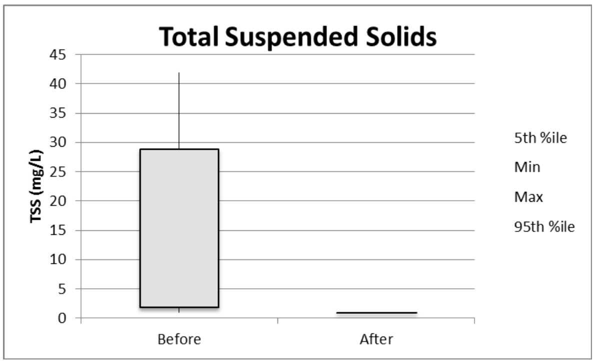
Description	**Problem(s)**	**Solution**	**Lesson**

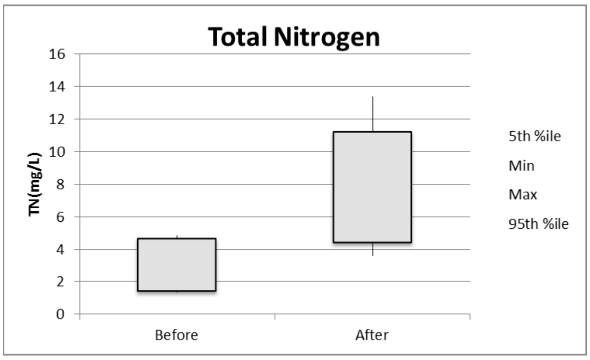
Training	Training planned however did not progress. Training from designer particularly difficult and contractor did not possess sufficient expertise. Training for maintenance personnel late which meant that in an emergency event requiring response, these people could not be utilised as they had not been trained appropriately.	Commissioning initially halted until critical training conducted. Constructive feedback given on quality of training provided. Training timeliness was escalated from the PLT level to the APMT level in order to get some progress on the issue.	Speak up and provide feedback on the quality and timeliness of the training. Halt commissioning/handover if training not complete. Ensure contract documentation details hold-point requirements for commissioning (eg training, procedures, equipment testing
Alliance delivery model	The alliance delivery model put a huge drain on operational resources during the design, construction and commissioning phases. Characters difficult at times (by disagreeing you are seen as not a team player).	Operations team initially restructured to provide the extra support required. A single operational liaison was appointed to each site. Standing strong on the issues that are important to the operator to ensure our needs were met and referred issues to the APMT where required.	Alliances can result in a drain on operational resources. Contractors will behave like contractors regardless of the delivery method and it is crucial to raise concerns appropriately. Document everything- don't assume verbal agreements will be honoured. Elevate issues to next level in organisation and be persistent

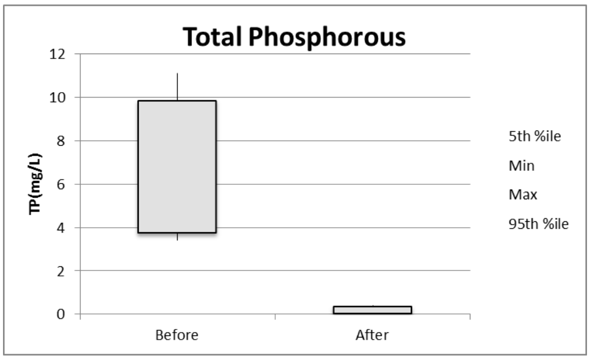
2.0 PLANT PERFORMANCE DATA - BEFORE AND AFTER

Plant performance data for major analytes from both before and after the upgrade is illustrated in the figures below.









It can be seen that there has been a significant decrease in the total suspended solids, biological oxygen demmand and total phosphorous. This is because the membranes provide a physical barrier as opposed to gravity clarification, and also a more robust process for supplying aeration.

Total nitrogen levels have increased. This could be due to the capacity of the blowers making turn-down difficult, however it does show that the previous process removed nitrogen very sucessfully. Contributing factors are likely to be the wetland cells which provide an excellent treatment for nitrogen removal by through plant and microorganism uptake.

3.0 CONCLUSIONS

The alliance delivery method has pros/cons. Controls can be put in place to maximise pros and minimise risks. Membrane bioreactor treatment provides a reliable and high quality effluent in terms of suspended solids, biological oxygen demand and phosphorous. Design inefficiencies have limited the degree of nitrogen removal possible. Wetlands can provide a cheap and low energy form of nitrogen removal. A complex plant in a remote location has increased the reliance on good telemetry communications, power supply and equipment reliability. Overall, operators have an important role to play in plant upgrades, at both the design, construction and commissioning.