14 August 2023

BECA HunterH2O Mangawhai WWTP Optimisation Summary Report

Liam and I first attended site on 1 August 2023 to kick off the initial's stages of optimisation of the plant. We have had a site presence from this time until the 11 August 2023 when Liam left site. We are continuing to work with the operators closely and further progress the plant optimisation.

Liam and I would like to make a special note regarding the excellent cooperation we received from especially Downer's operations staff Terry Roche and Aidan Van Rysewyk. From day one they were very welcoming and helpful. They also worked closely with us to assess the current plant status and are very focused on improving the performance of the plant they operate. We simply could not have achieved what we did on site without their help.

The broad aims of the optimisation were two-fold and included:

- Optimise the current configuration to maximise capacity both in the current non tourist and upcoming tourist period.
- Attempt to achieve an activated sludge culture with a higher population of polyphosphate accumulating organisms (PAO). PAOs are denser and assist in the operation of the planned inDense hydrocyclone system.

In a practical sense the focus areas for us to optimise the plant are the following:

1. **Optimise Sludge Age.** Lower the operational sludge age from the current ~ 30 days to 20 days. This ensures the sludge settles faster and improves capacity. A lower sludge age also reduces the power use slightly and lowers the risk of foaming. In the upcoming tourist period this may go much lower to 15 days.
2. **Optimise the selector and anaerobic zone operation.** The goal here is to target the optimal conditions to select for floc forming bacteria and against filamentous bacteria. The secondary goal is to make certain the anaerobic zone is anaerobic (minimal DO and nitrate). Anaerobic conditions are important to select for PAOs.
3. **Lower Dissolved Oxygen Levels (DO).** Lower DO levels are recommended to reduce the nitrate formation and ensure the anaerobic zone has a low enough nitrate load to become anaerobic. A lower DO (0.2 to 2 mg/L) then the historical values (~ 3 to 4 mg/L) will also reduce plant power use.

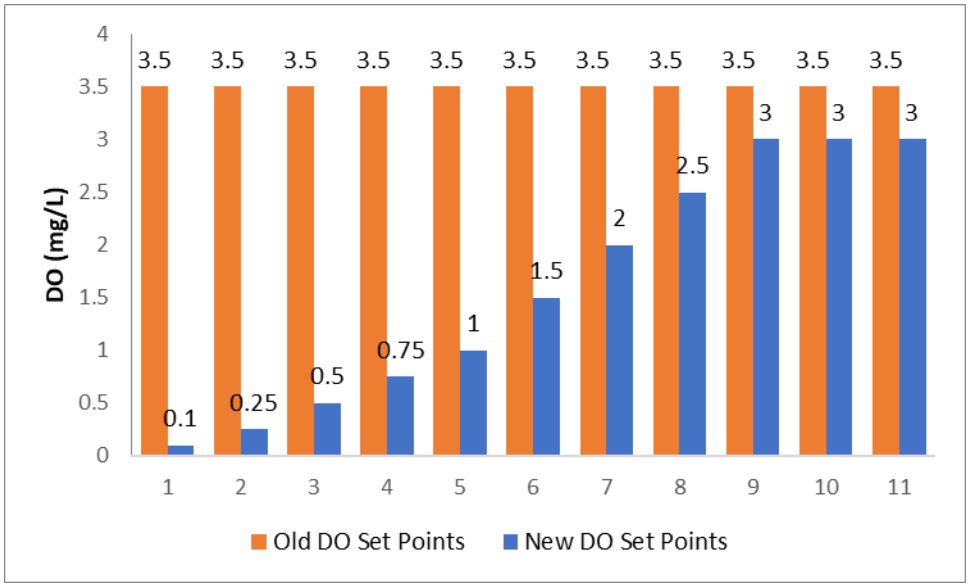
Up to this point we have had some success with items 1 and 3.

When we attended site, we measured the sludge was settling very slowly at 0.55 to 0.6 mg/L in both CASS reactors. To provide some context a good settling sludge with a DSVI around 120 ml/g will settle at 1.5 m/h at 4,000 mg/L. The slow settling rate was causing occasionally the sludge to be drawn into the decant during the peak flow part of the day. We believe the MLSS was high and above 5,000 mg/l when we attended site.

With the assistance of the operations team, we started to waste heavily for a few days to remove sludge from the plant by running the dewatering more often. The team managed to get the sludge

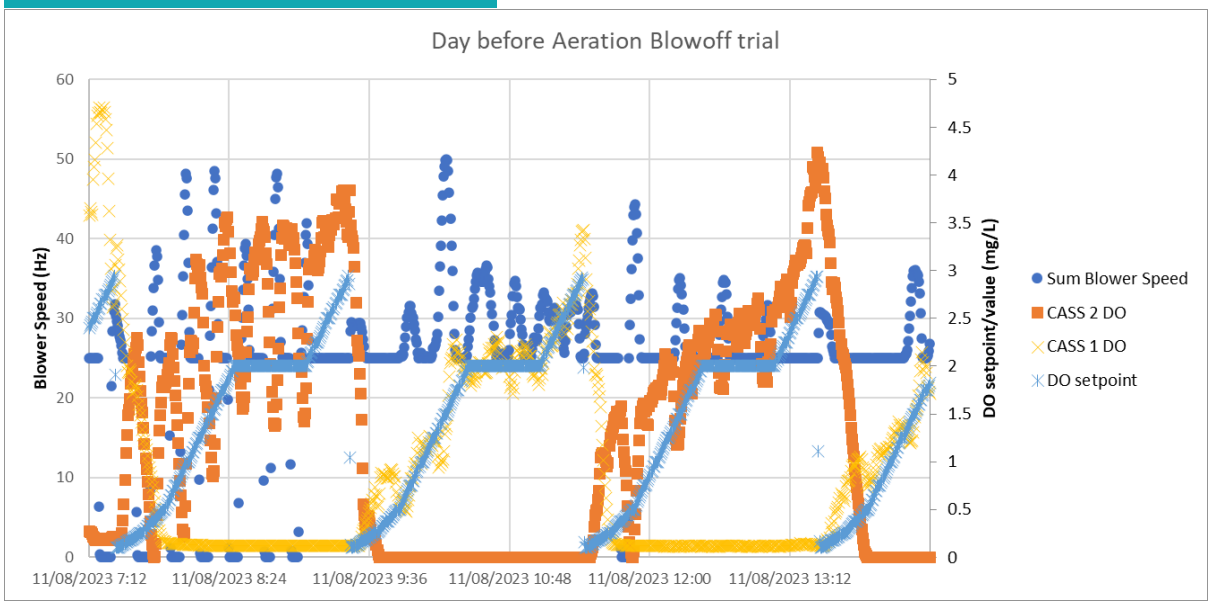
settling velocity to improve from ~ 0.6 to 1 to 1.1 m/h. After this time, we have not noticed sludge being drawn into the decant. We have since slowed the wasting rate to target a 20 days sludge age. This new sludge age setting is much lower than the original value of 30 days. Over a period of 2 sludge ages the sludge will turn over enough to hopefully select a less filamentous sludge. So some further improvements in the current settling rates may occur, even though the operational target sludge age is held constant.

On the first day we lowered the DO significantly and targeted a ramp up DO profile. The ramp up profile aims to provide very little DO initially to maximise the removal of nitrate. The DO is later gradually increased to allow for ammonia and phosphorus removal. The figure below shows the initial DO vales and our changes. The numbers 1 to 11 are equal spaced times over the CASS 120 min react phase (i.e. 11 min intervals)



The above change to DO has lowered the blower use and has had no negative impact. As of the 14/8/2023 the DO for periods 7 to 8 has been lowered to 2 mg/L. However, as we not below due to blower turndown issues we can't reach this value.

As part of the DO changes, we have identified and issue with blower turndown. In the graph below it shows the DO set point, actual DO and blower speed. You can see in the three cycles below despite one blower running at minimum speed the plant generally struggles to meet the target DO. Often it is rising in a non-controlled sense to 3.5 to 4 mg/L towards the end of the cycle. Some form of enhanced aeration turndown is likely required for operation during the non-tourist period. This could be shutting the blowers down in a controlled way, an aeration blow off or a smaller blower.



We have also identified an issue with how DO is controlled by the PLC system. It brings the assist blower in and does not adjust the duty blower down. This results in a larger (50%) increase in airflow which the PID controller struggles to address. We have a proposed fix for this issue we have discussed with McKay via Downer. We have a draft control change for this.

We have not been able to optimise the selector and anaerobic zone as we have not been able to control the flow. There appears a blockage in the pipelines which prevented us from sending a controlled flow to the selector and anaerobic zone. We have discussed with Downer a means to check the flow meter and clean the pipelines.

Other items we identified during the optimisation included:

- The aeration will shut off if DO is too high, however it takes too long (waits 10 minutes after DO is 1 mg/L above the set point) and is not effective. The operators cannot change it is PLC hard coded. We have a drafted an improved control loop to better shut down the blowers.
- Blower rotation seems disabled. It was there originally, however it now seems to not function. The reality of this is only one duty blower every operates.
- The decant weir rate may be able to be slowed further. It takes some time to reach the water level after the start of decant. The weir could be started earlier to ensure it reaches the water level to maximise the time it has to decant. This will slow the weir approach velocity and effectively lower the risk of decanting sludge.

In summary the optimisation of the plant has commenced with an initial 2-week period for us to identify the major issues. We are now working with the operations team to bed down improvements over time. The summary of key actions include:

- Sludge inventory has been adjusted to improve settling rate by 80% to lower the risk of decanting sludge.
- Sludge age is being maintained at a reduced value of 20 not 30 days to seek further settling improvements.
- Aeration has been optimised (DO lowered) to improved nutrient effluent quality.

- Monitoring undertaken shows the effluent quality improvement (nutrients) and the sludge blanket is no longer decanting sludge a peak times.

Further improvements are recommended and include:

- Investigation / unblocking the RAS lines. After this occurs further optimise the RAS system.
- Address the issues with poor aeration turndown by an enhanced control loop where blowers are shut down and rotated more often. If this is not fully effective a controlled aeration blow off or smaller blower can be installed.
- Improve the DO control loop to better manage how the assist blower cuts in to avoid control system hunting.
- Enhance the decant control to lower the rate to as slow as the cycle time will allow.