THERE'S A HOLE IN MY BIOREACTOR WALL

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ABSTRACT

In August 2012 an internal wall partially collapsed in one of the bioreactors at the Warragul WWTP. This paper details Gippsland Water's initial response to the issue, the planning stages to repair the wall and the execution of the subsequent works. The main difficulties Gippsland Water faced involved high groundwater levels, uncertainties in the extent of the damage and the plant's capacity to continue producing compliant treated effluent while halving the available bioreactor volume, allowing the bioreactor to be taken offline. The repairs were completed successfully and the plant was able to maintain compliance with the EPA licence for the duration of the works. Built upon the learnings from the original incident, preventative works were completed a year later on the second bioreactor to ensure it would not fail in the same way.

1.0 INTRODUCTION

The Warragul WWTP is a biological nutrient removal plant that is configured as a Biodenipho process. While the two bioreactors are located side-by-side, the process design control philosophy actually operates the bioreactors in series and each bioreactor alternates between and aerated and mixed state. The plant treats an average of 4 ML/d and discharges to an inland waterway and hence has tight nitrogen and phosphorus licence limits.

During a routine inspection on the morning of 3 August 2012, the Warragul WWTP operator discovered that a section of the internal wall in bioreactor 2 had disappeared, see Figure 1 and 2 below. Technical and management staff were notified immediately and an emergency onsite meeting was held to assess the situation.

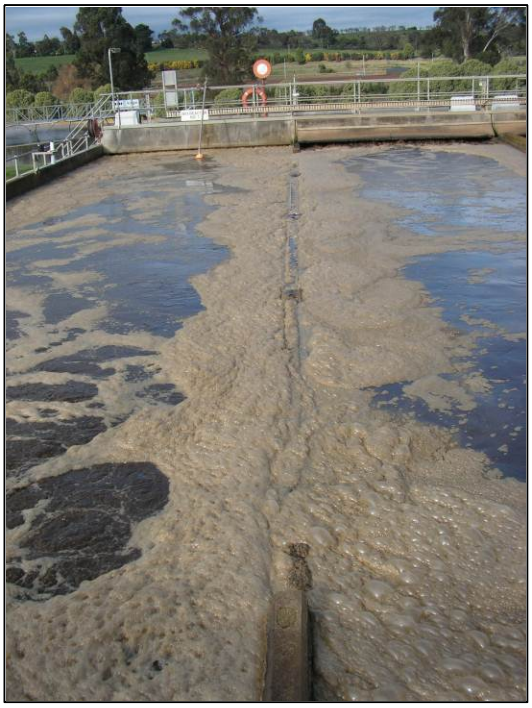

Figure 1: ***A comparison of the internal walls in bioreactor 1 (left) and bioreactor 2 (right)***

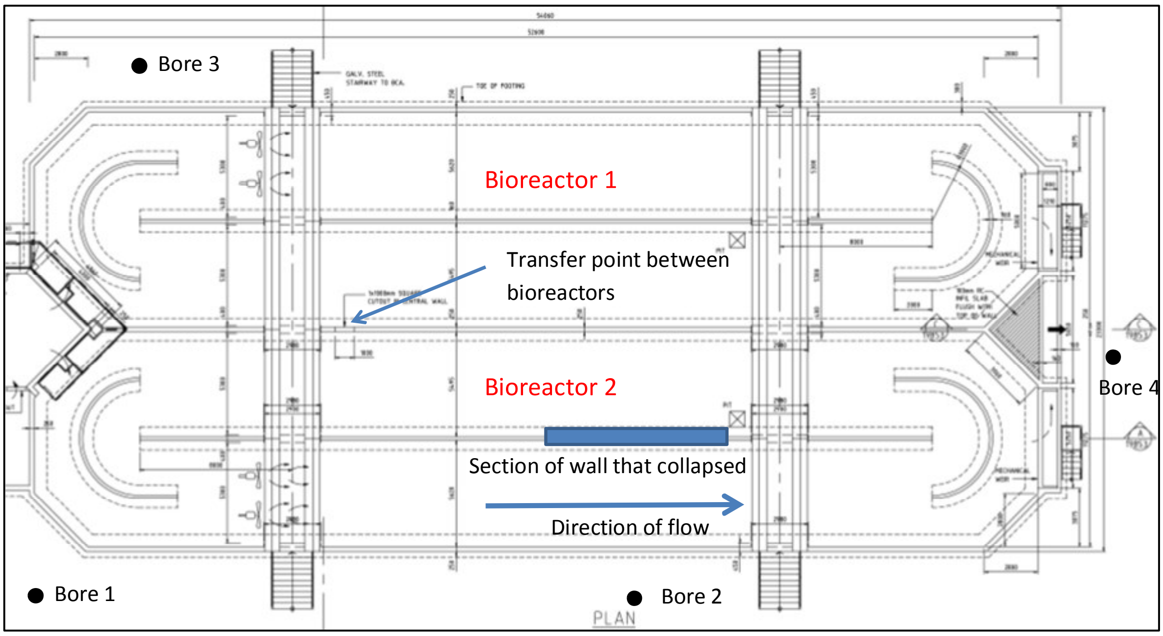

Figure 2: ***Diagram of Warragul WWTP bioreactors***

Many ideas were discussed about how this problem could be fixed, but the meeting raised more questions than it answered:

- How would the process be affected and would the quality of the effluent be compromised?
- The only visible failure was the wall, but had its collapse also damaged the floor of the bioreactor?
- What was the risk of the internal wall in bioreactor 1 failing in the same way?
- How much of the influent could be successfully treated using only 50% of the normal bioreactor capacity?
- Was it safe to drain bioreactor 2 or was there a chance of hydrostatic forces resulting from groundwater inflicting further damage?
- What was the level of groundwater in the area?
- Was it possible to isolate bioreactor 2 safely and reliably?

The initial plan was to move quickly and repair the bioreactor within three months of the failure. In the end, it took 10 months of investigations and planning to fully understand, discuss and solve the issues that presented themselves. The repair was carried out in May/June of 2013.

2.0 DISCUSSION

The Wastewater Treatment Group (WWTG) discussed all the issues that were raised in the initial and subsequent meetings and prioritised them according to their assessed risk. The first thing that was addressed was the plant operation and compliance with EPA licence limits.

2.1 Process Changes and Bioreactor 2 Isolation

Additional monitoring of the bioreactors and the final effluent showed that the process was coping reasonably well and the nitrogen and phosphorus removal had not been significantly impacted. It was apparent, however, that there had been a decrease in mixing efficiency as the collapsed section of the wall was allowing the flow to short circuit.

To counteract this, the existing control philosophy was modified to increase the amount of aeration, reducing the short circuiting that was occurring. The WWTG had previously attempted to drain bioreactor 1 in March 2012 to inspect the condition of the civil and mechanical assets. The attempt was cancelled with a metre of water still in the bioreactor due to non compliance with EPA licence limits. Once a debrief on the attempt was performed, it was discovered that the methodology used for treating the influent through one bioreactor was flawed. The resultant actions of the debrief were to monitor the plant effluent more frequently during an isolation and to increase the amount of aeration in the bioreactor still in service.

The new methodology was trialled through bioreactor 1 without draining bioreactor 2 and this was carried out twice for a week at a time, with the control of the plant further optimised at each attempt. Through these trials it was found that the inflow to the bioreactor in service needed to be limited to 30-50 L/s and the rest of the inflow sent to the onsite bypass storage lagoon. In addition, the aeration capacity was found to be limited and additional aeration would need to be temporarily installed to deal with the influent load and still meet compliance with EPA licence limits.

2.2 Integrity of Bioreactor 1

There was concern that the equivalent wall in bioreactor 1 could suffer the same fate as that in bioreactor 2. Further inspection revealed that the internal wall in bioreactor 1 was swaying slightly due to the constant flow path in the bioreactor. Steps were taken to mitigate this risk; braces were designed and installed to support the wall from above, eliminating the immediate need to drain this bioreactor as well. See Figure 3.

Figure 3: ***Installation of internal wall bracing in bioreactor 1***

2.3 Groundwater and Flotation Issues

The presence of groundwater was raised as a concern, but the extent to which it would impact the proceedings was, at first, an unknown. Contractors were engaged to drill bores around the perimeter of the bioreactors (see Figure 2 for the location of these).

These were completed within a week of the failure. The bores were then surveyed and continuously monitored. It was found that the groundwater level in this particular area was quite high and very sensitive to rainfall. The groundwater level was at its highest at the inlet end of the bioreactors (bores 1 and 3) but the level reduced towards the outlet (bore 4) such that the level here was always observed to be below the floor of the bioreactors.

It was important to understand the maximum allowable groundwater level to prevent the risk of floating the floor of the bioreactor while it was being drained. This was a particular concern as the bioreactor did not have any form of pressure relief in the floor. In the end, it was agreed that to drain the bioreactor safely, the groundwater needed to be at a level that was below the floor of the bioreactor.

The weather conditions improved as summer began and, by January 2013, the groundwater level had dropped low enough to allow the bioreactor to be drained safely. It was agreed that to reduce the future risk of flotation, pressure relief valves were to be installed in the floor of the bioreactor as part of the repair works.

2.4 Safe Isolation of Bioreactor 2

The bioreactor system includes a transfer point between the two reactors as seen in Figures 2 and 4. Being below the normal operating level of the bioreactors, any isolation of this point required a diving crew to guide a steel plate, suspended from a crane, into a frame in bioreactor 2. This was an expensive exercise and posed a number of risks, including the extent of isolation achieved when the water forces in the bioreactor 1 would act outwards on the plate. It was decided to install a penstock valve and this was achieved by a diving crew while the bioreactors were full. A gear box and spindle were also installed to allow the valve to be safely operated from the aerator bridge.

Figure 4: ***Photo of transfer point between bioreactors, taken during the attempted inspection on bioreactor 1 in March 2012***

2.5 Design of New Internal Wall in Bioreactor 2

In the months leading up to January 2013, there had been various options discussed and debated as to how to reinstate the collapsed internal wall. It was agreed that the six precast panels that made up the whole section of wall between the two aerator bridges needed to be replaced.
The main issue to resolve was whether the panels should be replaced with more precast

panels or whether it was better to pour a new concrete wall in situ. Ultimately, the precast panel option was deemed to be the most appropriate solution as it would reduce the duration of the outage required.

The new design comprised of six identical precast panels, mounted on stainless steel pins embedded in the bioreactor floor and braced back to the external wall above the water line.

2.6 Project Implementation

All of the above modifications, trials and monitoring were completed by the middle of April 2013 and, after 9 months of discussion and planning, it was time to schedule the outage and repair works. A start date of May 23 was agreed on and work continued on planning and finalising the last details of the repair works. To limit the total outage duration to two weeks, it was decided that working through weekends would be required.

Once the outage commenced, the following sequence of tasks was completed to enable the repair works to occur:

- Install three rental jet aerators into bioreactor 1
- Isolate bioreactor 2 and send all inflow through bioreactor 1. The final effluent was monitored frequently to ensure compliance with EPA licence limits
- Pump down bioreactor 2 by around 500mm to allow access to precast panels
- Lift out existing precast panels that were accessible from the surface (see Figure 5). Two cranes were used for this process.
- Pump down bioreactor 2 to 90% empty and lift out remaining precast panels
- Educt out and clean remainder of liquid and sludge in bioreactor 2
- Core holes in bioreactor floor and install pressure relief valves
- Embed stainless steel pins into bioreactor floor
- Lift in new precast panels and install top bracing to external wall

Figure 5: ***Photo of removal of existing precast panels***

While the bioreactor was empty the opportunity was taken to inspect the condition of all the associated civil and mechanical assets. It was found that the concrete joint seals in the bioreactor floor were in poor condition and the mixer guide rails were heavily corroded. Despite extending the outage duration, it was decided to replace the seals and new stainless steel mixer guide rails were able to be fabricated and installed without delay.
In spite of all the pre-project planning, there were still some issues that occurred during

the outage. A large storm event resulted in 45 mm of rainfall over two days halfway through the outage which slowed down the contractors and delayed the repair works by two days. This rainfall also resulted in increased inflows to the plant but, due to its dilute loading, the inflow pumped to bioreactor 1 was able to be increased up to 100 L/s while still meeting EPA licence limits. This also reduced the volume that was pumped to the bypass lagoon.

From a process point of view, the performance of bioreactor 1 was very good during the outage and all EPA licence parameters were maintained below the median limits most of the time. Figure 6 shows the nitrogen removal performance during the outage.

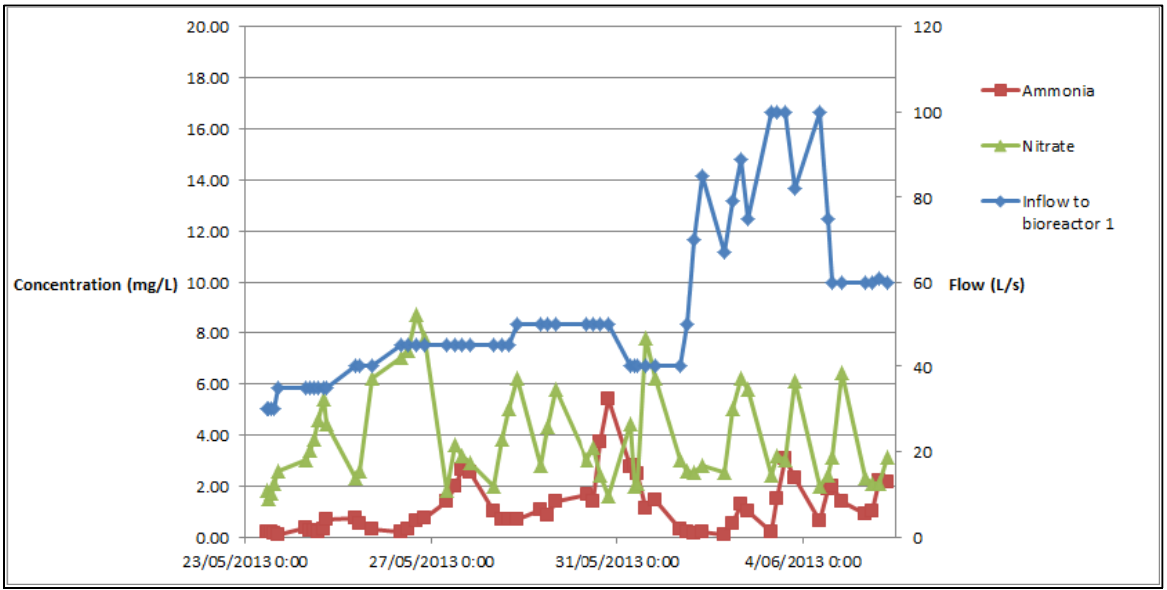

Figure 6: ***Trend of nitrogen removal performance and bioreactor 1 inflow during outage***

3.0 CONCLUSION

This project demonstrated that the 10 months of investigation and planning that led to the successful project completion was worthwhile and resulted in a relatively straight forward outage with minimal OHS and environmental risks. In particular, the trials that were performed to find the best methodology for operating on one bioreactor were invaluable in determining the optimum operational strategy for the plant.

In March 2014, the WWTG arranged an outage on bioreactor 1 to inspect the civil and mechanical assets. This outage went smoothly, owing to the lessons that were learned from the previous year, and the condition of the bioreactor was better than expected.

4.0 ACKNOWLEDGEMENTS

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