AFTER THE VICTORIAN FLOODS: IMPACTS OF RAW WATER QUALITY CHANGES ON MICROFILTRATION PLANTS

Paper Presented by:

Dr Kathy Northcott

Author:

Dr Kathy Northcott, *Process Operations Engineer,*

Veolia Water Australia

75th Annual Water Industry Engineers and Operators' Conference
Bendigo Exhibition Centre
4 to 6 September, 2012

AFTER THE VICTORIAN FLOODS: IMPACTS OF RAW WATER QUALITY CHANGES ON MICROFILTRATION PLANTS

Dr Kathy Northcott, *Process Operations Engineer,* Veolia Water Australia

ABSTRACT

Bendigo and Castlemaine water treatment plants (WTPs) are designed, constructed and operated by Veolia Water Australia (Veolia) under a 25 year "BOOT" contract. Veolia operates these WTPs' on behalf of Coliban Water, under strict water quality licensing conditions. After almost 13 years of drought, Central Victoria experienced a period of extremely high rainfall from mid 2010. Storages filled from record low levels to 100% full in a matter of months. The raw water quality changes resulting from these high rainfall events were dramatic, with increased colour, turbidity, dissolved organic carbon (DOC) and elevated iron and manganese concentrations.

At around the same time as these extreme rain events occurred, the Veolia Bendigo operations team was involved with the change-out and upgrade of the entire membrane inventory across the three sites. The raw water quality changes, coupled with a new type of membrane and new chemical cleaning systems, posed challenges for the team to understand the most effective means of managing the raw water quality and maintaining membrane performance.

This paper will describe the impact of the changed raw water quality on the newly installed membranes, and compare and contrast the performance of PP membranes and PVdF membranes under these water quality conditions.

1.0 INTRODUCTION

After almost 13 years of drought conditions, Central Victoria experienced a period of extremely high rainfall from mid 2010, culminating in a major flood event in January 2011. The massive influx of stormwater resulted in the water quality in the catchments changing rapidly, with increased colour, dissolved organic carbon (DOC) and elevated iron and manganese concentrations.

1.1 Rain Events and Raw Water Quality Changes

Figures 1 to 3 show the changing raw water quality profiles for Sandhurst and McCay reservoirs for a seven month period between the beginning of August 2010 and the end of February 2011. Sandhurst reservoir supplies the Bendigo WTP, whilst McCay supplies Castlemaine WTP. This time period includes the major rainfall events that had the most significant impact on storage levels in the Coliban Water catchment area.

True colour results over this period increased from around 10-30 HU to over 200 HU at Bendigo WTP. DOC results in raw water increased from around 4 mg/L to over 11 mg/L at Castlemaine WTP and over 10 mg/L at Bendigo WTP. Iron and manganese results also trended upwards, iron concentrations increasing from around 0.2 mg/L to approximately 0.6 mg/L and manganese results increasing at both WTPs from around 0.01mg/L to 0.02-0.03 mg/L.

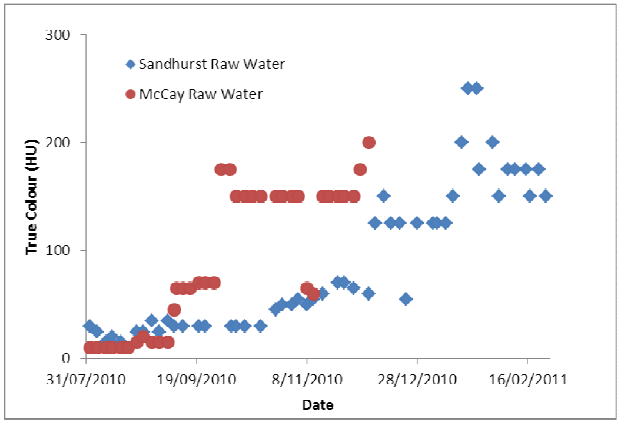


Figure 1: *True Colour in Raw Water at Sandhurst and McCay Reservoirs (Aug 2010 to Feb 2011)*

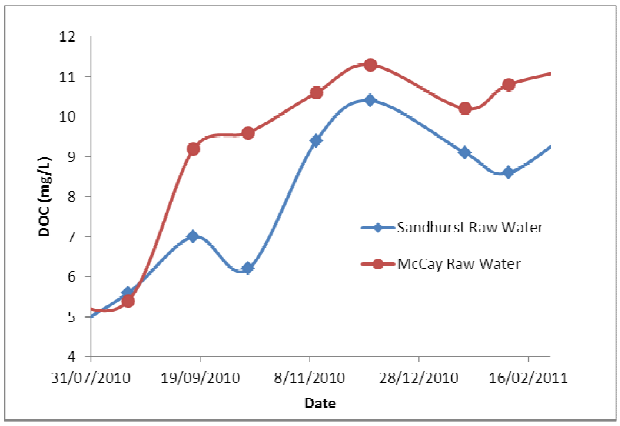
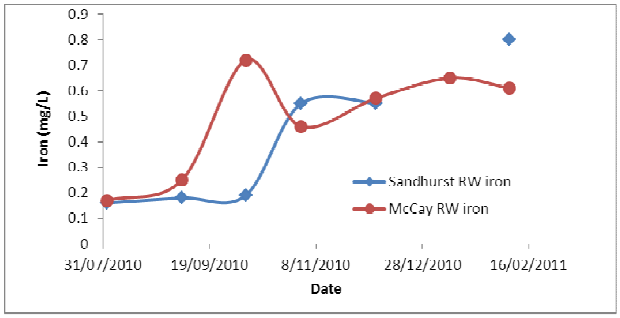


Figure 2: *DOC in Raw Water at Sandhurst and McCay Reservoirs (Aug 2010 to Feb 2011)*



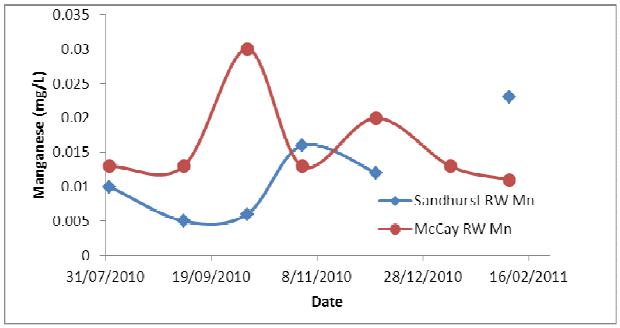


Figure 3a & 3b: *Iron and Manganese (mg/l) results in raw water for Bendigo (Sandhurst) and Castlemaine (McCay) WTPs*

1.2 Membrane Upgrades and Change-outs

Coinciding with the rain events and the raw water quality changes, membrane change-outs and upgrades were being conducted. At Bendigo the entire membrane inventory was being upgraded to a PVdF system:

- **Membranes** – Replacement of the existing polypropylene (PP) membranes with new polyvinylidene fluoride (PVdF) membranes.
- **Membrane Ancillaries** - Changes to the Clean In Place (CIP) system:
- Changes to the acid CIP system for better cleaning of iron and manganese from membranes
- Switch from sodium hydroxide to sodium hypochlorite CIP system. Hypochlorite is more effective for removing colour and DOC from membranes.
- Installation of sodium metabisulphite (SMBS) for dechlorination
- A new ventilation system with dedicated extraction and covers for channels and neutralisation pits.

The Castlemaine WTP had a direct change out of new PP membranes, with no changes to the CIP system required.

The membrane conversion occurred during summer (high flow demand) on a fully operational treatment plant. Hence there were potential risks to production (quantity) and to treatment effectiveness (quality). A complete process risk review was conducted, a process risk management plan was developed and communicated to operators, project team, clients and contractors.

At Bendigo, the membrane system was successfully upgraded with no impact to production or water quality. The first few months after upgrade and change out to the new membranes found that:

- The membranes had a higher resistance to fouling and longer run times between cleaning cycles.
- The CIP cleaning systems were found to be effective at keeping the membranes clean.
- All control system programming changes successfully implemented.
- The new ventilation system at Bendigo was effective in removing all cleaning chemical fumes.

2.0 DISCUSSION

2.1 Impacts of Raw Water Quality Changes on Microfiltration Process

The raw water parameters, iron, manganese, DOC and colour, in Sandhurst and McCay reservoirs have remained elevated for the past eighteen months after the January 2011 flood event. As a result, over this period there has been a measureable impact to microfiltration membrane performance.

The impact has been particularly significant at Castlemaine WTP. Figure 4 and 5 shows the membrane permeability and resistance for one of the Castlemaine WTP membrane skids in the months after the January 2011 floods. Typically, due to the presence of significant levels of fouling compounds in the raw water, permeability decreased and membrane resistance increased with time.

For the Bendigo system, by comparison, it is more difficult to determine if the PVDF membranes are fouling using resistance trend data, as the resistance ranges are on a much smaller span compared to what we see on PP membranes. For the PP membranes at Castlemaine we can see sharp increases on the trend data and see clearly that our membranes are fouling. For the PVdF membranes at Bendigo the resistance trends don't change a great deal, but it doesn't necessarily reflect how fouled the membranes can actually be until we physically remove them and inspect.

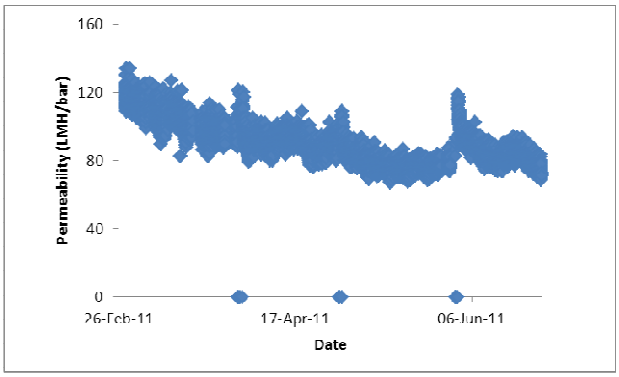


Figure 4: ***Membrane permeability for Castlemaine WTP skid 2***

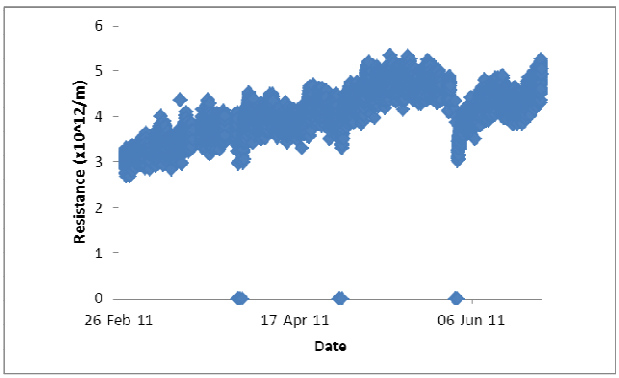


Figure 5: ***Membrane resistance for Castlemaine WTP skid 2***

2.2 Membrane Maintenance

For Bendigo and Castlemaine all membrane maintenance activities are recorded in an in-house database called the membrane "Module-Map". This database contains information on the frequency of membrane inspections, membrane pinning and patching, membrane replacement, dry membranes and damage to membranes. The database can also be used to generate reports to investigate trends in maintenance and membrane performance.

Table 1 provides a comparison in the membrane maintenance requirements for the PVdF membranes at Bendigo compared to the PP membranes at Castlemaine for the first eighteen months of operation (January 2011 to June 2012). Membranes are chosen to be inspected on the basis of leak testing. At Bendigo, the leak test is a visual inspection for air bubbles leaking from membranes. For Castlemaine, the leak test is a sonic test to listen for the sound of air passing across the membrane fibres. It is apparent that there is a higher maintenance requirement for the PVdF membranes compared to the PP membranes, with an average of 29% of membranes inspected per cell at Bendigo compared to 6% of membranes per skid at Castlemaine.

This is also reflected by the average number of modules per cell that require pinning during inspections. Our experience regarding the increased inspections and pinning for the PVdF membranes over PP is typical of that found by other treatment facilities that have moved across to the newer membrane material.

Table 1: ***Membrane inspection and pinning data for Bendigo and Castlemaine for first 18 months operation***

Site	Bendigo	Castlemaine
No. cells/skids	8	7
Modules per cell/skid	576	90
Average modules inspected	169	5
Percentage inspected	29%	6%
Average modules pinned	121	4
Percentage pinned	21%	4%

2.3 Membrane Autopsy

During routine membrane inspections the operators identified an issue with extensive fouling building up in the core of the membrane bundles. This appeared to be a particular problem at Castlemaine. It was decided to send a number membrane modules from Bendigo and Castlemaine away for a complete membrane autopsy, to determine the extent and characteristics of fouling on the 18 month old membranes. Membranes were sent to Membrane Futures, a specialist membrane autopsy laboratory in Queensland. The modules sent away for autopsy included membranes immediately before and after CIP.

At Bendigo it was found that:

- Membranes were caked with aluminium silicate (clay) with high presence of iron.
- Overall the fouling was found to be a mix of organic and inorganic components.
- The aluminium silicate had not penetrated the fibres, so it may be reversible.
- CIP cleaning changes the nature of the fouling in the core (colour and texture) and both inorganic and organic fouling is significantly reduced during CIP cleaning.
- The cleaning was found to be very effective at removing iron fouling, but less effective at removing aluminium silicate fouling

At Castlemaine it was found that:

- Membranes were caked with aluminium silicate (clay) with high presence of iron.
- The fouling was found to be predominantly inorganic with only around one third organics.
- The aluminium silicate has penetrated the fibres, so it may not be reversible.
- CIP cleaning changes the nature of the fouling in the core (colour and texture).
- Cleaning was found to be very effective at removing iron fouling but not effective at removing aluminium fouling.
- There was more silicate removal during cleaning than aluminium removal. Hence the indication is there is a second source of aluminium fouling not related to clays.

2.4 Membrane Management Review and Optimisation

A number of management strategies were implemented and are ongoing to counteract the fouling potential of the raw water quality:

- Increased backwash frequencies.
- Changes to backwashing set points.
- Review CIP effectiveness of CIP cleans, adjust chemical dose and chemicals used accordingly.
- Implement extended chemical soaks to assist in removal of foulants.

3.0 CONCLUSION

After almost 13 years of drought, Central Victoria experienced a period of extremely high rainfall from mid 2010, resulting in increased colour, dissolved organic carbon (DOC) and elevated iron and manganese concentrations.

At around the same time as these extreme rain events, the Veolia Bendigo operations team was involved with the change-out and upgrade of the entire membrane inventory at Bendigo and Castlemaine WTPs. The raw water quality changes, coupled with a new type of membrane and new chemical cleaning systems, posed challenges for the team to maintain membrane performance.

There was a measureable impact to microfiltration membrane performance in the months after the January 2011 flooding event. The impact was particularly significant at Castlemaine WTP, which continues to operate with the PP membranes. In general it was found that membrane permeability decreased and membrane resistance increased as a result of increased fouling.

Membrane autopsies found that membranes were caked with aluminium silicate (clay) with high presence of iron. Overall the fouling was found to be a mix of organic and inorganic components. The aluminium silicate fouling appears to be reversible at Bendigo but not at Castlemaine. CIP cleaning was found to be very effective at removing iron fouling, but less effective at removing aluminium silicate fouling. At Castlemaine there was more silicate removal during cleaning than aluminium removal. Hence the indication is there is a second source of aluminium fouling not related to clays.

In contrast to the fouling potential of PP compared to PVdF, the inspection and pinning requirements appear to be less. Over the first 18 months operation almost 30% of membranes needed to be inspected at Bendigo compared to 6% of membranes at Castlemaine.

4.0 ACKNOWLEDGEMENTS

The authors would like to acknowledge the support of the Veolia Bendigo Operations team, as well as Coliban Water.