A NEW MEMBRANE FILTRATION PLANT FOR GIRGARRE

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ABSTRACT

In response to its obligations under the SDWA and ADWG, Goulburn Valley Water (GVW) adopted specific turbidity targets for potable water and carried out a risk assessment of water supplies to the communities within its service area. Six small towns utilising only settling dams and disinfection prior to customer supply were identified as having water quality risks. GVW determined that membrane filtration was the appropriate treatment option to minimise those risks. A project was initiated to select the membrane filtration process that would be most suitable for all six small towns and to construct the initial membrane filtration plant at Girgarre. Girgarre is a small town ~40 km west of Shepparton with raw water supplied from the Goulburn Murray Water channel system. This paper describes the process undertaken by the team comprising GVW, the consulting engineer, Parsons Brinckerhoff Australia (PB) and the contractor, Haulton Water Services (HWS) to successfully complete this important project. The key issues covered include the drivers for the project, a review of the various membrane filtration technologies, the selection process used to determine which treatment process to use and a report on the on-going performance of the plant.

KEY WORDS

Membrane filtration, Potable water, Turbidity

1.0 INTRODUCTION

GVW carried out a review of their various potable water supply systems and identified six small towns having clarification and disinfection as the only treatment prior to customer supply. The ultimate supply water in all cases is channel water and without effective filtration these water supply systems are at risk from turbidity and microbiological contamination during channel changeover and heavy rain events. In particular, the water supply systems are at risk from contamination by Cryptosporidium, an obligate parasite producing oocysts.

In recognition of all of these factors GVW decided that appropriate filtration processes were required for the six small towns and adopted filtered water turbidity targets of 0.5 NTU for 95% of the time, with an allowable maximum of 1.0 NTU. Furthermore, GVW decided that membrane filtration was the most appropriate filtration process and that the first membrane filtration plant would be installed at Girgarre. Once the membrane filtration process and equipment is proven at Girgarre, then it is intended to install similar plants in each of the remaining five small towns.

GVW carried out a review of potable water demand at Girgarre and established that the new membrane filtration plant should have a daily filtered water production of 400 m^3. Plants of this size are most cost effectively supplied by specialist vendors as a factory tested, skid mounted, packaged plant.

Girgarre is a small town 40 km west of Shepparton, Vic with its potable water supply being sourced from the nearby channel. Prior to March 2009 potable water supply to the town was treated via coagulant dosing ahead of a sedimentation dam, followed by pH correction and disinfection via chlorination.

GVW also carried out a comprehensive review of clearwater storage capacity for many of their potable water supply systems and it was determined that Girgarre required an additional 90 m^3 to meet the new minimum storage capacity guidelines. It was decided to carry out the clearwater storage tank augmentation program concurrently with the installation of the new membrane filtration plant and combine the work in a single tender.

1.1 Procurement Process

A two stage procurement process was used for this project.

1. Engage a suitably qualified engineering consultant to collaborate with GVW to determine the scope of works and produce detailed design sufficient to prepare a tender document based upon a D&C contract to AS 4300. The consultant would then assist GVW to assess the tenders and provide specialist technical advice as needed during construction and commissioning. The consultant's brief was issued in late September 2007 and PB was subsequently awarded the engagement in November 2007.

2. Issue a tender document, then assess the submitted tenders and select a preferred contractor to design, supply, install and commission the works. The tender document was publicly advertised in mid May 2008 with a closing date a month later. Following a comprehensive assessment process, Haulton Water Systems was awarded the D&C contract in mid August 2008.

2.0 DISCUSSION

2.1 Membrane filtration

Potable water systems have been treated by membrane filtration in Victoria for more than two decades. The experience gained by equipment suppliers and operators over this period has allowed designers to develop reliable and well designed second and third generation systems.

Membrane filtration typically utilises hollow fibre membranes (i.d. range 0.5 to 1.2 mm) with two generic flow paths, (1) outside-in, and (2) inside-out. Nominal pore size for modern membrane filtration hollow fibres is <0.04 µm, which places them in the ultrafiltration size range. Older technology was more correctly categorised as microfiltration and utilised hollow fibres with a nominal pore size of 0.2 µm or greater. It is worth noting that a Cryptosporidium oocyst is >3 µm, which is more than an order of magnitude larger than any of the membrane pore sizes. Therefore, membrane filtration provides an effective barrier to protozoa in addition to removing turbidity that can shield protozoa from the effects of disinfection chemicals.

In Victoria the original membrane filtration plants often used polypropylene membranes, which are not resistant to oxidants such as chlorine. Current membrane materials, however, are typically fabricated from chlorine resistant polyvinylidene fluoride (PVDF) or polyethersulfone (PES).

Figure 1: ***Typical hollow fibre filtration membranes (courtesy of Memcor)***

2.2 Process Selection

The tender document was not particularly proscriptive regarding the membrane filtration process and as a consequence it was anticipated that a range of different processes might be proposed. This turned out to be the case with six different processes being offered based on both outside-in and inside-out technologies.

Compliant tender responses were received from thirteen separate contractors. The tenders were initially ranked on the basis of the offered lump sum price and since the highest priced five tenders offered no advantage over the remaining eight, these five highest priced tenders were no longer considered.

A multicriteria assessment procedure was then used to compare the remaining eight responses. A key aspect of the multicriteria analysis was a whole-of-life cost determination for each offer using a discounted cash flow analysis approach. This analysis involved the calculation of the net present value of the operating costs over 20 years for each offer. Four primary criteria were used in the assessment, (1) price, (2) suitability of design, (3) track record in delivery of membrane water treatment plants in Australia, and (4) service support in the region.

Sub criteria within the primary criteria were then allocated a factor, with the sum of the factors being 100. For each sub-criterion the respondents were ranked from best to worst and assigned an appropriate relative score. Linear interpolation was used to determine the intermediate scores for the lump sum prices and the operating cost net present values. Two sub-criteria required Yes/No answers and these were scored either 10 or 1. The individual scores multiplied by the factors were summed to give a total score. The total scores were then reduced by a factor of 0.7 if it was deemed that the offer contained a serious departure to the technical requirements of the project. The result was the grand total score between 26 and 100 for each respondent.

Important features of the various systems that were considered as part of the assessment process are listed below.

- A requirement for regular (at least daily) chemically enhanced backwashes. As there is no access to a Trade Waste sewer at Girgarre, all chemical wastes must be captured, stored and ultimately trucked off-site by a specialist waste removal contractor. Therefore, any process producing chemical waste on a daily basis is not favoured compared to a process that only requires a chemical clean-in-place (CIP) once every month or so.

- An automated membrane integrity test based on a pressure decay measurement. Industry studies have conclusively shown that the most reliable means of detecting broken membrane fibres and consequent unfiltered water bypass is a pressure decay test carried out daily. On-line turbidity measurement has been shown to be too insensitive to be relied upon. The un-manned nature of the Girgarre plant mandates that a reliable automated test be carried out on a daily basis to confirm the integrity of the membrane filtration plant.

- Oxidant resistant membranes. Modern polymeric filtration membranes are typically manufactured from PDVF or PES and are resistant to oxidants, such as free chlorine. Older style membranes were often manufactured from polypropylene, which is not oxidant resistant and typically has significantly larger nominal pore sizes. Polypropylene membranes were marked down in the multicriteria assessment procedure.

The final result of the assessment process was the selection of the Memcor low pressure, outside-in process, specifically the XP 18L10V unit. This system is a fully automated unit holding 18 membrane modules and having a flux of 47 L/h.m² at design flow.

2.3 Construction and Commissioning

Plant construction commenced in September 2008 and proceeded without incident over five months, which included the Christmas period. The plant was commissioned in late February 2009 and proof of performance testing was carried out successfully between 25 February and 5 March 2009.

The Memcor XP 18L10V membrane filtration unit is shown in Figure 2.

<u>Figure 2:</u> ***Girgarre membrane filtration unit***

2.4 Plant Performance

The plant has operated smoothly and without incident since commissioning in March 2009 consistently producing low turbidity treated water. A chart showing some key plant operational data is provided below in Figure 3. Fouling on the membranes is indicated by trans-membrane pressure (TMP) and fouling resistance. The chart shows that TMP increased from the new membrane value of ~15 kPa to ~28 kPa over a period of two months. This is a very acceptable operational TMP. Routine monthly clean-in-place (CIP) chemical cleaning using sodium hypochlorite is maintaining the TMP in a range between 20 and 30 kPa.

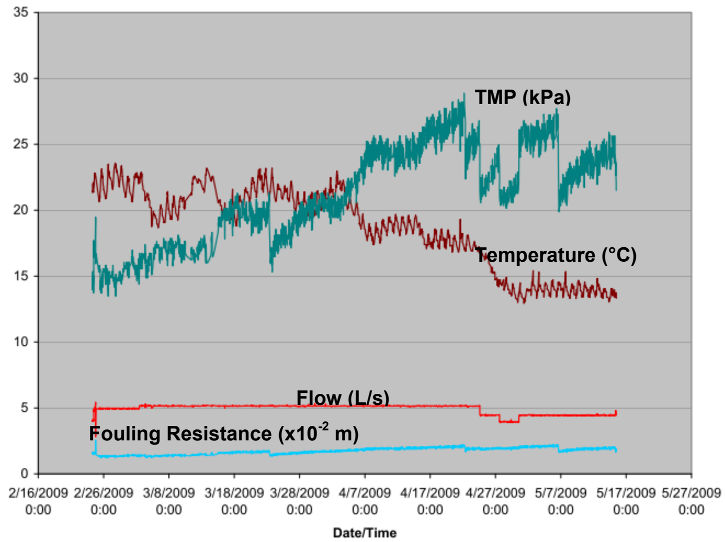

Figure 3: ***Girgarre membrane filtration unit***

The build-up of particulate material on the membrane fibres requires removal via regular backwashing and the Girgarre plant is set to carry out an automatic backwash every 25 min. Downtime during backwashing is ~2.5 min, so on-line plant availability is 2.5/27.5 = 91%. Overall water recovery by the membrane filtration unit is ~95%. However, the Girgarre plant backwash wastewater is returned to the far end of the sedimentation dam, so there is no water loss from the overall system and recovery is effectively 100%. Particulate material filtered out by the membranes will settle out in the sedimentation dam.

An important advantage of the system is that operation does not require the routine use of chemicals, which allows the recovery of backwash wastewater. The only chemical treatment is the monthly CIP and the wastewater from this process is collected in a storage tank for subsequent disposal off-site.

3.0 CONCLUSIONS

Raw water is supplied to the membrane filtration plant direct from the channel via the sedimentation dam without coagulant dosing and has a turbidity of ~30 NTU. The new membrane filtration plant has been treating this water without incident since commissioning in March 2009 producing high quality treated water with turbidity typically <0.1 NTU. Prior to the advent of the new plant, treated water turbidity averaged 2 NTU. In the past Girgarre would average five water quality non-conformances per month, but since the commissioning of the membrane filtration plant this figure has dropped to zero.

The ability to operate the membrane filtration plant without coagulant dosing has the significant benefits of simplifying plant operation and reducing the potential for over or under dosing alum and the pH adjustment chemical, which is needed to counter the acidity of the alum.

This project has been a success on a number of levels for GVW, coming in on time and budget, having a smooth handover from Major Projects to Operations and performing as designed from day one. The success of this project means that the program to install similar plants in five more small towns can now be confidently progressed.

4.0 ACKNOWLEDGEMENTS

The authors would like to thank the operations staff of GVW for their enthusiasm for the project and their ability to accept and meet the challenge of running a new and sophisticated water treatment plant.