SUGARLOAF PIPELINE: PREPARING THE WINNEKE TREATMENT PLANT FOR AN INCREASE IN CAPACITY

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ABSTRACT

Melbourne Water's Winneke Water Treatment plant currently treats approximately 100GL of water per year. The implementation of a pipeline to supply water from the Goulburn River to the Sugarloaf Reservoir is expected to deliver an extra 75GL per year and increase Winneke treatment requirements. In order for the plant to handle larger volume of water, significant upgrades to the existing treatment system will be required. Melbourne Water undertook an extensive study of plant operations to determine the most appropriate upgrade strategy. To this end, a monitoring program was conducted over a two-month period in which alkalinity, colour, pH, temperature and turbidity of the water were tested. The monitoring results confirmed concerns raised by the operators regarding inefficient plant processes, including chemical dosing and hydraulic configuration. This program provided further justification for the need of several capital upgrades.

KEY WORDS

Chemical Dosing, Monitoring, Water Treatment Plant, Winneke, Upgrade

1.0 INTRODUCTION

The Sugarloaf Reservoir and the Winneke Water Treatment Plant (Winneke) are located 32 km north-east of Melbourne, near Christmas Hills. The Sugarloaf Reservoir is the fourth largest reservoir in Melbourne's water supply system, with a capacity of 96GL. Winneke currently treats approximately 25% of the drinking water for the Melbourne region. The plant feed water originates from the Yarra River (55GL/year average) and the Maroondah Reservoir via the Maroondah Aqueduct (45GL/year average).

The growth in Melbourne's population and climate change concerns prompted the government to look at alternative sources of potable water for Victoria. As part of the Victorian Government's Water Plan, 75GL of water will be sent to Melbourne via the Sugarloaf pipeline (DSE, 2007). Once the pipeline is connected, Winneke's total output will increase to 40% of Melbourne's potable water supply. In order to determine the ability of the system to handle the additional inflow, an investigation of existing infrastructure was undertaken. This report is particularly concerned with a monitoring program conducted at Winneke to inform a series of capital upgrades.

1.1 Winneke Water Treatment Plant Process Overview

The Winneke water treatment process is shown in Figure 1. It consists of coagulation, clarification, filtration, chlorination and fluoridation. Untreated water is pumped from the Sugarloaf Reservoir to the Winneke inlet structure where lime and alum (aluminium sulphate) is added. The water is then sent to one of five sludge blanket clarifiers and polyelectrolyte injected to aid flocculation and sedimentation processes.

The water is then passed through 14 sand filters prior to being dosed with chlorine, lime and fluoride. The treated water flows into the clear water reservoir and is transferred to the Winneke-Preston pipeline for distribution to the Greater Melbourne area.

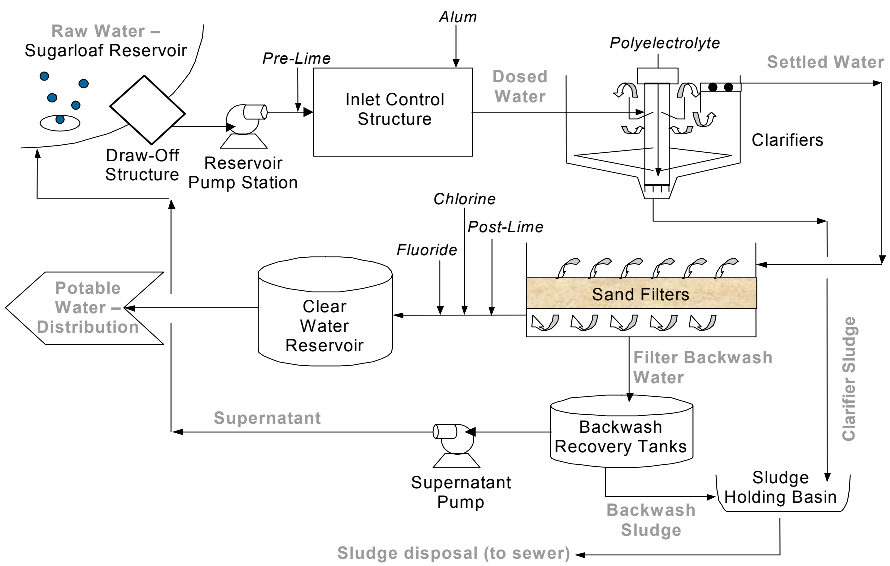

Figure 1: ***Winneke Process Flow Diagram*** (adapted from MWC, 2006)

2.0 MONITORING PROGRAM

As part of the Winneke Treatment Plant Process Reliability Upgrade Plan, previous reports on plant performance were reviewed and operators were consulted. It was found that not all pertinent data required to understand plant performance was automatically logged by the plant's SCADA system. To obtain the necessary information, a monitoring program was designed with a focus on three key issues:

- Inappropriate flow split at the Inlet Control Structure (ICS)
- Unsuitable chemical dosing
- Stratification within clarifiers

2.1 Inlet Control Structure

Figure 2 is a schematic of the ICS showing the pre-lime and alum dosing points. The ICS comprises of two separate channels, the first channel supplies water to clarifiers 1-4 (C1-4) while the second provides water to clarifier 5 (C5). C5 was built as part of an upgrade to the Winneke Treatment Plant completed late 2006.

The flow between the two channels of the ICS is deliberately uneven and is controlled by drop boards on the outlet of the ICS. C5 is only designed to receive one fifth of the plant flow, however the operators believe that the current hydraulic configuration results in C5 receiving more flow than desired (SKM & MWC, 2008a).

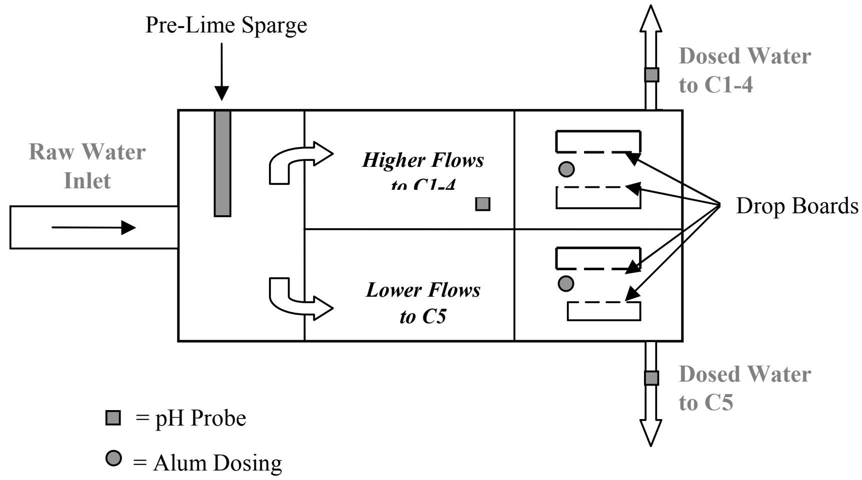

Figure 2: ***Schematic Representation of the Inlet Control Structure***

2.2 Pre-Lime Dosing

Pre-Lime dosing is important at Winneke due to the soft nature of the Sugarloaf raw water source. The typical alkalinity of the raw water is 12mg/l. The alkalinity of water in the plant must be sufficient to buffer the pH changes that result from the dosing of alum (which consumes alkalinity) and to ensure that some residual alkalinity remains post alum dose (typically 5mg/l). The buffering effects of the raw water alkalinity are also required to ensure coagulation occurs within an optimal specific pH range of 5.6 to 6.6 (MWC, 2006). For this reason, lime is added to raise the alkalinity of the raw water to meet the operational requirements of the plant.

The upgrade of the plant completed in 2006 saw the addition of a fifth clarifier. However the work did not involve modification of the lime sparging system or the installation of a pH meter on the C5 side of the ICS. Since the upgrade, operators have suspected that there was insufficient mixing of lime between the two sides of the ICS. The inadequate mixing and the uneven flow rate are believed to result in the bulk of the lime moving towards the side with greatest flow (C1-4 side). In order to quantify the actual lime dosing discrepancy between the two channels, pH tests were performed on the pH adjusted raw water (water dosed with lime) on both sides of the ICS. Samples were collected twice daily, in the morning and early afternoon.

2.3 Alum Dosing

Alum is dosed based on the quality and quantity of the raw water. Raw water was characterised by twice daily measurements of colour, turbidity and alkalinity. Alum dosing is undertaken in order to facilitate coagulation in the clarifiers. Dosing occurs at the point where pH adjusted raw water spills over weirs located on either side of the ICS channels. The hydraulic drop over the weirs creates turbulence which is used to provide rapid mixing of alum prior to water entering the clarifiers (SKM & MWC, 2008a). Two primary issues have been identified with the alum dose: firstly, the possible difference in pH between water going to C1-4 and C5 (due to unequal lime distribution); and secondly, the alum dosing is based on the assumed one fifth flow split to C5. In undesirable circumstances, when lime dosing is incorrect, the alum dose is adjusted to correct the pH of the dosed water distributed to the clarifiers. To address the concern raised around alum, the alkalinity and pH of the dosed water going to C1-4 was compared to that going to C5.

2.4 Clarifiers

There are currently five clarifiers at Winneke, four of which have a square design (C1-4) and the other (C5) has a circular design. Although all five have the same surface area and volume, the operational behaviour of each clarifier is different. In order to determine the ability of the clarifiers to handle higher flows, the apparent correlation between the turbidity of the settled water (water leaving the clarifiers) with air temperature was examined. The settled water temperature and turbidity were measured every hour from 8am to 3pm.

3.0 RESULTS AND DISCUSSION

3.1 Flow Split and Chemical Dosing

Figure 3 shows the results of the sampling performed on the pre-lime dosed water.

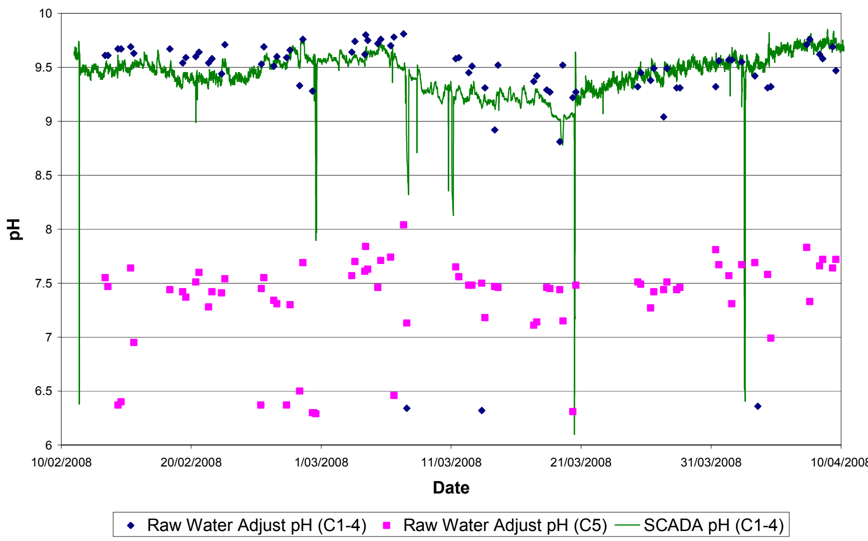

Figure 3*:* ***pH Comparison at the Inlet Control Structure***

The average raw water pH over the course of the sampling program was 7.0 ± 0.2. Figure 3 indicates that after lime dosing, the pH of C1-4 was raised to 9.5 ± 0.2 while that of C5 was raised to 7.5 ± 0.2, with some individual samples falling below 6.5. This suggests that the bulk of the lime remains on the C1-4 side of the ICS and therefore supports the initial concerns raised by the operators (as outlined in section 4.2).

Although the pH of the C1-4 side in available online through SCADA, testing was carried out to confirm the results recorded by the online instrument. Figure 3 shows that the sample data matches the values stored on SCADA.

Figure 4 indicates that there is a large difference between alum dosing on the two sides of the ICS. The discrepancy compares closely with Figure 3, with the highest alum dose being sent to the side of the inlet with the highest pH. Ultimately, this also balances to provide each side with approximately equal residual alkalinity after alum dosing. The discrepancy in lime mixing results in more alum being used than should otherwise be necessary. The problem of inadequate mixing is further exacerbated at higher plant flow rates which will therefore pose further problems when Winneke increase its treatment capacity (SKM & MWC, 2008a). This suggests that an upgrade to the chemical dosing system is required.

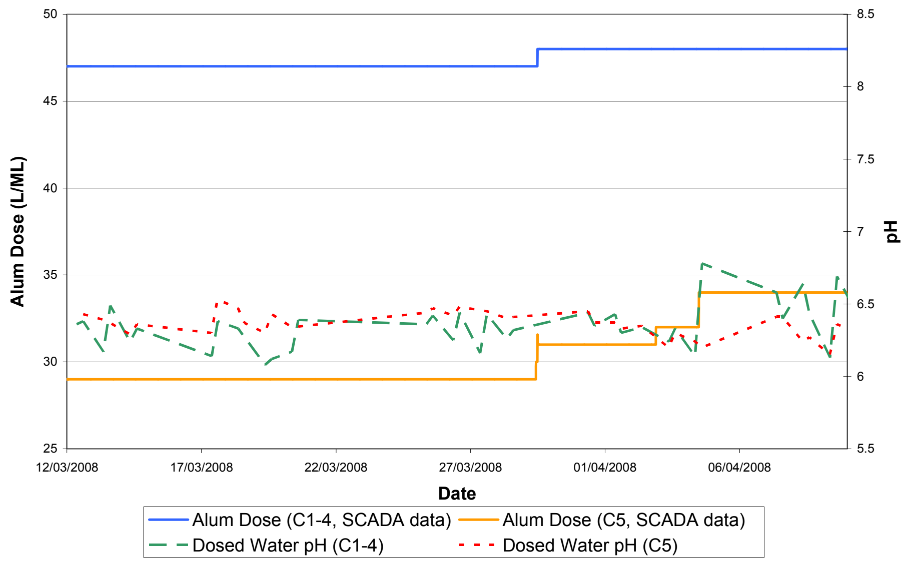

Figure 4: ***Discrepancy in Alum dose on the two sides of the inlet control structure***

To address the issues raised by the monitoring program a design has been completed to move the lime sparge further upstream from the ICS and to install a static mixer. This will allow for even mixing of lime prior to the water entering the ICS.

Similarly, the alum dosing issue was addressed by replacing the existing drop boards with actuated weirs. This will provide operators with greater control over the flow split between C1-4 and C5. In addition, flow meters will be installed at the inlet of each clarifier to assist with accurate alum and polyelectrolyte dosing (SKM & MWC, 2008b).

3.2 Clarifiers and Water Turbidity

Figure 5 shows the daily variation in settled water turbidity and the air temperature as recorded by the Coldstream Automated Weather Station (AWS) (Bureau of Meteorology, 2008). The figure indicates that higher turbidity levels are found following a decrease in ambient temperature. This was attributed to convection, whereby small particles move with a fluid. Indeed, cooler ambient temperatures gradually decrease the surface water temperature in the clarifiers, causing the surface water to sink to the base of the clarifier. This forces warmer water from the bottom of the clarifier to rise to the surface, bringing fine solids to the surface and therefore causing a rise in turbidity.

Figure 5 also indicates there is a constant difference between the turbidity levels of settled water leaving C1-4 and C5. This was attributed to the difference in shape of the clarifiers and potentially to the imbalance in chemical dosing and the uneven flow spit. The monitoring program further revealed that each clarifier behaves independently, producing different settled water turbidity readings (results not presented in this paper). The differences between the clarifiers appeared to be related to the polyelectrolyte dosing and de-sludge rates.

The sampling program demonstrated the difficulty of the clarifiers to provide constant turbidity and therefore a consistent feed to the filters. The results of this study initiated an upgrade of the clarifier monitoring system. Turbidity meters will be installed on each clarifier to assist operators in effectively managing the plant, particularly at higher flow rates.

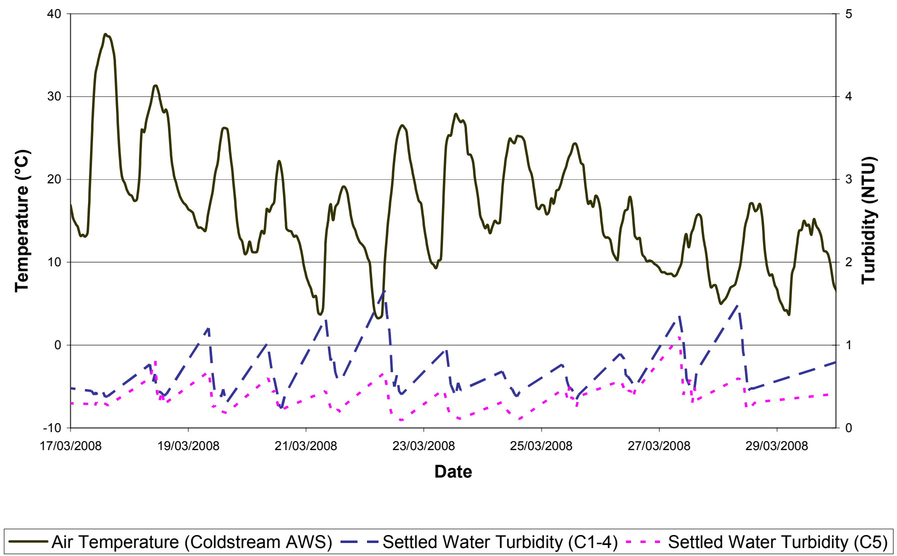

Figure 5: ***Comparison of Settled Water Turbidity and Air Temperature***

4.0 CONCLUSION

The monitoring program identified two main problems in regards to Winneke plant efficiency: the inadequate chemical dosing and daily variations in settled water turbidity. The inappropriate chemical dosing was attributed to both insufficient mixing time for lime and insufficient flow control to the clarifiers; while the variation in turbidity was shown to relate to the variation in air temperature around the clarifiers.

5.0 ACKNOWLEDGEMENTS

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