OPTIMISING FILTRATION AT DUNGOG WTP

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ABSTRACT

Dungog WTP is a 90 ML/d direct filtration plant in the Lower Hunter region of NSW. This plant experiences significant variations in raw water quality on a seasonal basis as well as during elevated turbidity events caused by heavy rainfall. These variations in quality cause changes to coagulation conditions and filtration performance that can result in sub-optimal performance with regard to water quality, chemical dose rates and filter media condition. This makes optimisation of the process a difficult and challenging task for operational staff.

Each of the ten filters at Dungog WTP is fitted with a differential pressure (DP) cell measuring head loss across the media. One of the filters is equipped with three additional DP cells that monitor head loss at different points across the media profile. Actual and processed headloss data and trend charts were set up on the plant SCADA system to improve the ability to monitor and optimise filter performance.

This presentation describes how the improved monitoring was set up and how this information is now routinely used as an operational tool to optimise filter performance and minimise life-cycle costs.

1.0 INTRODUCTION

Dungog WTP was constructed in 1987 to treat water from Chichester Dam in the lower Hunter Region of NSW. The plant was designed to produce 90 ML/d of treated water through coagulation, filtration, chlorination and lime/carbon dioxde stabilisation.

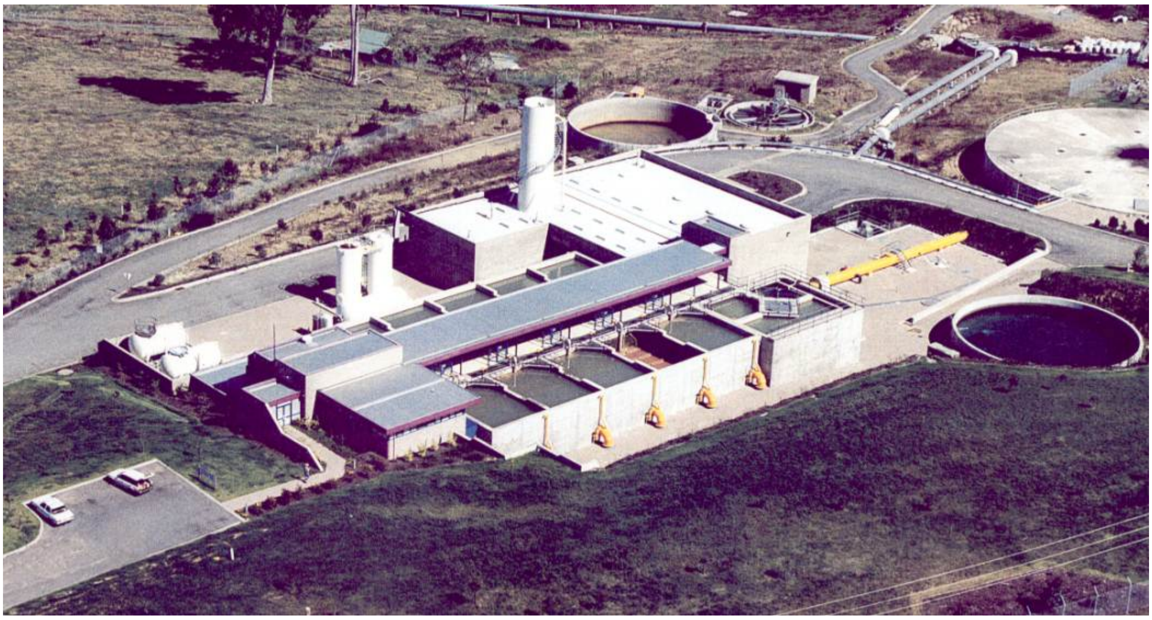

Figure 1: ***Aerial view of Dungog WTP***

Alum is dosed as the primary coagulant with a nonionic polyacrylamide polymer dosed as a filtration aid.

Raw water turbidity under 'normal' conditions is typically between 2 to 4 NTU, with a pH of 6.3 to 6.7 and alkalinity of approximately 15 mg/L as $CaCO_3$. The dam has a maximum depth of 37 m and has an approximate capacity of 20,000 ML. Historical rainfall events have resulted in flows over the spillway of over 25,000 ML per 24 hours, enough to replace the dam storage volume in about 20 hours. The potential for rapid turnover of the dam results in relatively rapid changes in raw water quality, causing alkalinity and pH to both drop. The flow of rain through the catchment into the dam also results in an increase in suspended solid matter and increasing turbidity, with values as high as 100 NTU being recorded at the offtake. These rainfall induced changes are referred to as 'turbidity events', and are characterised by a change in raw water quality that significantly impacts on the downstream treatment plant and requires an increased level of monitoring and control. In practice this occurs if the turbidity rises above 15 NTU, and in a typical year between 6 and 8 such 'turbidity events' are experienced at the plant. The design of the plant allows for treating variable raw water quality through adjusting chemical dose rates.

The filtration system consists of 10 dual media filters with 800 mm of filter coal and 400 mm of sand on a gravel support base. One of the ten filters at Dungog WTP (Filter 5) is equipped with 3 additional differential pressure (DP) monitoring cells. These instruments monitor pressure drop at different locations (heights) through the filter media and give a profile of head loss across the filter bed. The filter media configuration and location of the DP cells in the filter media is shown below in Figure 2.

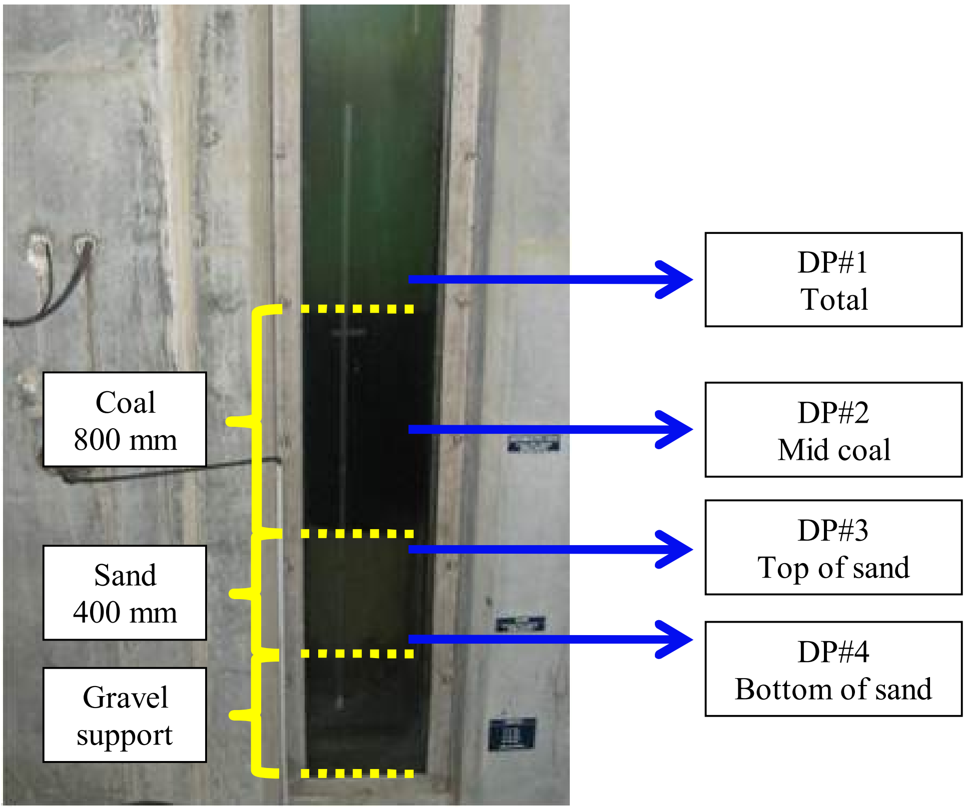

Figure 2: ***Filter 5 media configuration and DP cell tapping point locations***

The DP cells (red outline) and tapping points (yellow outline) are shown below in Figure 3. While the monitoring is only on one filter, the information provided is representative of all filters.

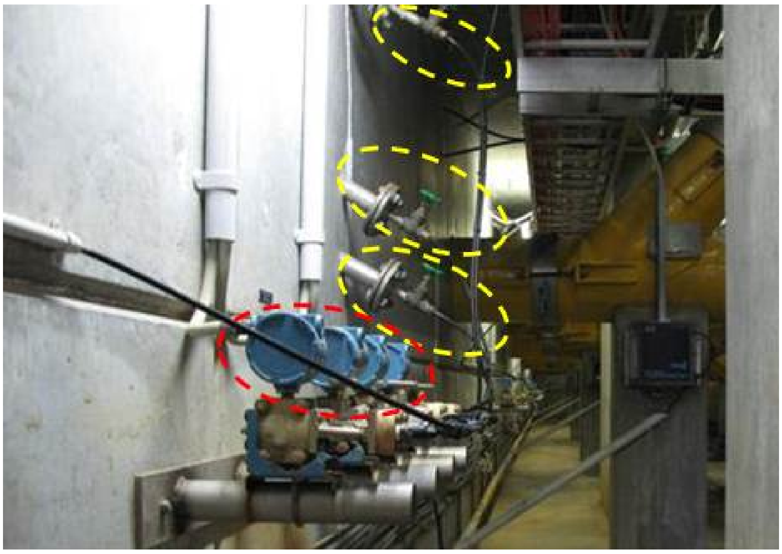

Figure 3: ***Bank of DP cells for Filter 5***

Filters are automatically triggered to backwash on the basis of run time, head loss or turbidity. The combination of a relatively small storage that can experience rapdily changing water quality and direct filtration (ie no clarification process) presents significant challenges to ensure that acceptable treated water quality is produced. During these events the coagulation and filtration processes experience rapid and significant changes and must be operated conservatively. When experiencing more normal conditions, in addition to maintaining acceptable water quality these processes are also optimised to minimise chemical cost, maximise efficiency (power and water) and sustain satisfactory media condition.

In addition to the direct DP data, additional monitoring has been set up using the difference and ratio between adjacent DP data points and all information is displayed on SCADA using standard trend charts. This additional monitoring allows for improved understanding of how filters are operating, and can be used as a tool after only a few hours into a filter operating cycle to predict:

- if a filter is likely to experience turbidity break through prior to reaching terminal headloss,
- if floc is not penetrating optimally into the media
- how long the filter might run before reaching terminal headloss and
- if changes are required to chemical dose rates.

The filter head loss profile monitoring has become an essential part of plant operation. The benefits include cost savings through reduced chemicals and power, increased plant efficiency, reduced filter mudballing (from excessive polymer dose) and increased understanding of the treatment process, all while achieving a high level of compliance with treated water quality targets.

2.0 DISCUSSION

A decision tree was previously used to determine the optimal configuration of the treatment plant. The decision tree included monitoring of floc size, head loss and temperature, and changes to paramteres such as alum and polymer dose rate, chemical injection points and flocculation tank residence time.

The decision tree (see Figure 4) was complex to administer, and situations would still arise where the plant was not performing optimally. **NOTE:** Sub-optimal performance of the coagulation and filtration processes was characterised by short filter run times, poor filter ripening, premature breakthrough and excessive filter mudballing. In approximately 2007 extensive mudball formation was observed in all filters at Dungog WTP. This followed a period of high chemical dose rates and unstable (but still acceptable) treated water quality.

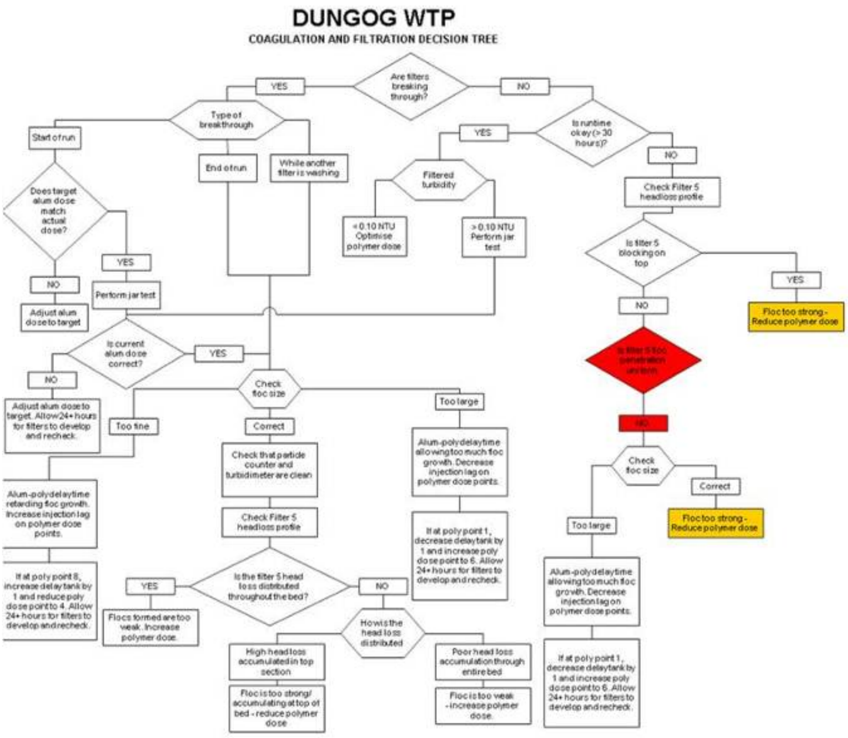

Figure 4: ***Dungog WTP Coagulation and Filtration Decision Tree***

In its initial configuration the plant SCADA only displayed the headloss at each point on SCADA. This allowed for simple interpretation, however it was not straightforward to compare headloss at different points. The standard SCADA trend over a filter run cycle (approx 36 hours) is shown in Figure 5. Evaluation of this trend at different times and under different situations showed that differences could be observed. This was confirmed through downloading data into a spreadsheet and performing some analysis.

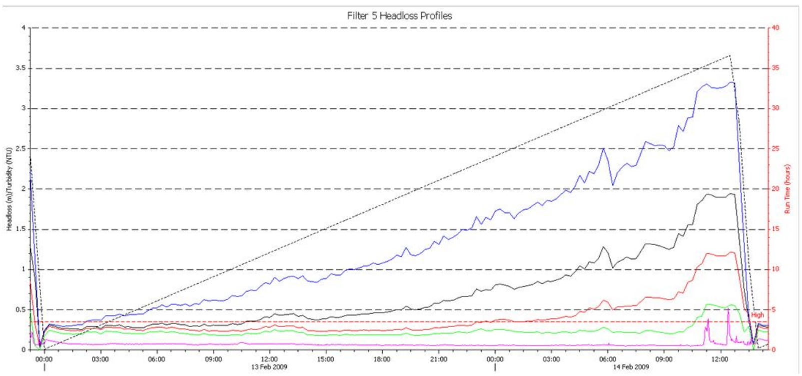

Figure 5: ***Standard SCADA trend for DP cell monitoring***

This analysis indicated that monitoring the difference in headloss between adjacent points, and the ratio of headloss at different points, gave a good indication of what was actually happening in the filter media between the respective points.
This included evidence of such occurrences as excessive headloss in the top layer (could

be caused by too much polymer) and early detection of increased headloss in the sand layer (ie that breakthrough is imminent).

Calculations were set up in the SCADA software and displayed on screen with standard trends for headloss, headloss difference and headloss ratio. These trends show for each layer if solids are being retained, if solids are being retained and when changes are about to happen eg breakthrough or rapid increase in headloss from blocking a layer of media. A SCADA screenshot is shown in Figure 6.

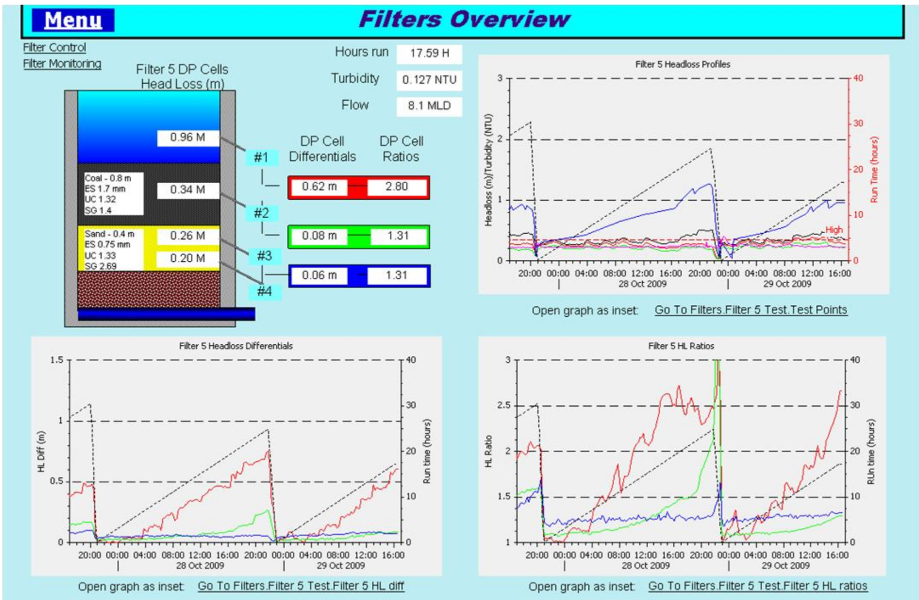

Figure 6: ***Standard SCADA trend for DP cell monitoring***

2.1 Optimised Filter Performance

Previous references to sub-optimal performance being characterised by short filter run times, poor filter ripening, premature breakthrough and excessive filter mudballing. In contrast, optimised filtration performance is characterised by:

- longest filter run times (terminal headloss just prior to floc penetration to sand layer),
- short filter ripening time with low ripening turbidity,
- filters backwashing before turbidity breakthrough occurs,
- no formation of filter mudballs,
- lowest possible alum and polymer dose rates to achieve acceptable filtered water quality and optimal production efficiency,
- low filtered water turbidity.

Changes to processes are typically made with an intended outcome in mind eg: increasing polymer dose with the objective of improving filtered water quality. Unfortunately if the intended outcome is not observed, the tendency is to make additional changes or larger changes, and this can be caused by not having sufficient accuracy in monitoring to assess effectiveness. Our analysis using the additional information SCADA monitoring page allowed the impact of changes from the decision tree to be monitored and assessed. This analysis showed that some of the changes made had a significant impact (eg alum and polymer dose rate), and some had virtually no impact (eg polymer delay time). Another important finding was that while raw water quality parameters may change (eg turbidity, temperature, algal levels), the required corrective action remained the same.
For example if a filter takes a long time to ripen with raw water turbidity of 2 NTU or 100

NTU the recommended change is the same. This meant that the performance of filters during different events could be characterised by the headloss profile trends and reacted to, rather than relying on 'typical dose rates' to predict how the current situation should be handled

The results of our analysis showed the the following major changes in understanding. Note that these changes may be specific to certain conditions, and are not recommended to adopt for all processes without the correct investigation and implementation.

<u>Table 1:</u> ***Changes in process understanding***

Previous Understanding	Current Understanding
• Floc size is critical and needs to be pinpoint – no smaller or bigger	• Floc strength is critical • Floc can be too small but not too big. • A large floc with the right amount of polymer can still penetrate into the media
• Delay time between alum and polymer dosing is significant	• No observable difference. Maximum delay time selected and maintained since.
• Flocculation tank residence time is important	• Floc size needs to be above a critical minimum, however it does not need to be controlled • With sufficent delay time, optimisation can be achieved via chemical dose rate adjustment only

3.0 CONCLUSION

Once the process changes were identified that did not have a significant impact, we were able to focus on those with a significant impact. This turned out to be the coagulant (alum) dose and the polymer dose. Previous work had already identified that a relationship between raw water turbidity and required chemical doses existed. This was able to be further refined resulting in a reduction in alum dose of approximately 5 mg/L or 25% under most oeprating conditions. Polymer doses were able to be optimised to favour solids being trapped in the coal layer which is expanded more during backwashing without overdosing. The previous issues with mudball formation have not returned and filters are normally producing treated water with turbidity of <0.15 NTU, while achieving run times of up to 48 hours.

The improved monitoring also allowed for refined procedures during periods of rapidly changing water quality, with the plant configuration able to be evaluted after only several hours of operation to determine if dose rates were sufficient. Fast and decisive responses are now able to be made with a greater degree of certainty.

4.0 ACKNOWLEDGEMENTS

The optimisation of filtration performance at Dungog WTP has evolved over more than 25 years and continues to be refined. It is the product of involvement of the water treatment operations team of Hunter Water Australia and Hunter Water Corporation. The authors would like to thank and acknowledge the input of the many staff over the years that have contributed their thoughts and ideas.