WATER WORKS

OFFICIAL JOURNAL OF THE WATER INDUSTRY OPERATORS ASSOCIATION

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Contributions Wanted

WaterWorks welcomes the submission of articles relating to any operations area associated with the water industry. Articles can include brief accounts of one-off experiences or longer articles describing detailed studies or events. These can be emailed to a member of the editorial committee or mailed to the above address in handwritten, typed or printed form. Longer articles may need to be copied to CD and mailed.

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TOWARDS A NEW OPERATIONS ENVIRONMENT

George Wall and Peter Mosse

Water quality incidents continue to happen both here in Australia and in other developed countries of the world. Galway (Ireland) 2007, Nokia (Finland) 2007, South East Queensland (2007), Pitsford (UK) 2008, Cairns/Port Douglas (2008), Brisbane (2009) are all testament to what can happen. To date Australia has been spared a significant event involving pathogens and widespread illness in the receiving community. The question has to be posed however "Are we doing all we can in the operations area to avoid such an event?"

Readers may recall the Editorial from our December 2007 edition of *WaterWorks* entitled "The Australian Water Industry, The Other Crisis". In this article, a number of operational and training deficiencies were identified along with a list of actions required to reduce the risks associated with these deficiencies. The article can be downloaded from the WIOA website at http://www.wioa.org.au/publications/waterworks.htm

The issues facing water industry operations are many and varied, however the majority can be summarised under the headings of training and development, certification and qualifications, and implementation.

Training and Development

The training system for water industry personnel Australia wide is in urgent need of overhaul. WIOA has conducted open forums on training issues at a number of recent events and the consistent theme emerging is that of considerable problems with training.

In addition to all the issues raised in 2007, it has been reported that either the trainers and courses are not available or the quality of what is being delivered varies significantly from State to State (and within States) with some courses labelled "a total waste of time".

Generally, the key operational expertise is embedded in water utilities rather than with educational institutions and as a result, some Registered Training Organisations (RTO's) haven't been able to engage assessors and trainers with the required depth and breadth of knowledge and expertise. Some RTO's have not been able to develop quality resource material and E-learning is not working for the delivery of the more technical requirements of Certificate III or higher units.

In the absence of enforceable minimum standards for operator competencies on a National basis, there is no real driver for enterprises to undertake training. The thin market and limited demand for water industry training is not encouraging RTO's to deliver training across all segments of the Water Training Package. This is effectively leaving large groups of operational staff in some States un-serviced.

On the positive side, Government Skills Australia (GSA) has been active in the review and continuous improvement of the Water Training Package and in conjunction with WIOA has undertaken a significant revamp of the water and wastewater treatment technical units at Certificate IV level. This will now allow a "Technical" or "Management" qualification at this level.

GSA is also well advanced with a project funded by the National Water Commission to develop learning resources for all units in the Water Training Package from Certificate II to Certificate IV level. This project will deliver a standardised set of learning resources that can be made available to RTO's. The downside of this project however, is that it may also increase the risk of RTO's without appropriate or experienced trainers being able to purchase the resources and enter the training market.

OUR COVER

Jim Wheelhouse and John Basile from Goulburn-Murray Water servicing the temporary pumps set up to supply additional irrigation water from the Waranga Basin in northern Victoria.

Operator Certification and Qualifications

At present, there are no mandated minimum standards for the operation of water or wastewater treatment plants and there is no formal requirement for certification of operators. More importantly though, there is no requirement for water businesses to match training with the operational requirements of the system being operated. In addition, there is no requirement for formal external reporting of critical control point performance.

WIOA has been actively working with the Department of Human Services (Victoria), as the drinking water regulator in that State, and the Victorian Water Industry Association (VicWater) to develop a Code of Practice for Water Treatment Competencies. This draft Code includes a requirement for operator competency to match the public health risk associated with a water supply system. Minimum levels of operator qualifications and experience will be linked to the water supply pathogen risk and the process capability of the treatment plant. A system with a high risk requires a technically advanced plant plus higher operational skills and experience than a water supply with a lower risk.

The Code of Practice will also include a requirement that operators in charge of high risk systems and technically advanced plants be certified under an operator certification to be developed and administered by WIOA. The operator certification is designed to encourage the ongoing training and skill development of operators.

The implementation of the Code of Practice in Victoria is being undertaken as a pilot for National Health and Medical Research Council (NHMRC). Successful implementation is likely to lead to NHMRC support for the development of a competency framework for all States.

In addition to the NHMRC program, WIOA has held meetings and discussions with numerous organisations throughout 2008 and 2009 about the merits of expanding the Code concept so that it can be adopted in every Australian State. There are also discussions under way in an effort to develop a similar Code to cover wastewater operations as well.

The Code is an excellent start along the reform process, however, there are a number of areas that are not being addressed under the Code. For example, although the Code aims to match the level of operator training with the public health risk of the water supply system, there is nothing in the Code to ensure that the training is of an appropriate level or that the skills learnt during training are in fact being implemented in the workplace.

Implementation and Reporting

Some water business operations and HR departments believe "training" to be the solution to all problems. There is indeed some truth in this, however, if the newly acquired skills are not implemented the value of the training is negligible for the individual, the utility and the industry. While training attendance is closely monitored, the implementation of skills learnt in undertaking the training is not monitored. This, combined with increased demands on the time of operators, often results in the new skills and knowledge not being implemented and the appropriate and necessary level of operational performance not being attained.

While there is often a formal requirement for OHS training to be undertaken annually, there is no recognition of the need for ongoing formal refresher training relating to the key operational competencies and there is also no recognition of "duration of competency" once training is completed. There is also a tendency for many organisations to train "on the job" in a work environment with reduced overall staff numbers and capacity to safely achieve this.

Formal reporting to an external Regulator is required to provide an external overview of the integrity of the two key barriers for the control of pathogens in conventional water treatment, media filtration and disinfection. Chlorine disinfection (practiced at the vast majority of Australian plants) is only effective against bacteria and most viruses. Media filtration is the only barrier to protozoan pathogens. Having a zero *E.coli* is no longer suitable as a stand alone indicator. Reporting needs to be able to demonstrate that these barriers are consistently applied.

Career Issues

All the issues noted above are coming into play at a time when we have a rapidly ageing water industry workforce and imminent retirements will significantly reduce the industry's pool of operational "experience". This has the potential to leave inappropriately qualified or inadequately trained staff to operate some systems placing those systems at increased risk of a water quality incident

Many utilities are experiencing rapid turnover of staff in operations and there is a distinct lack of career structure for operators. Water industry operations is not seen as a career path for secondary or tertiary graduates.

Formation of a Technical Reference Group

A number of organisations address some aspects of water industry operations at State/Territory and National levels. However until now no single body has attempted to identify, collate and concretely address all issues facing operations in a coordinated way.

As a first step in the process, GSA has recently established an Operations Technical Reference Group to review the current status of training and issues related to skills for the operations side of the industry and to discuss all the issues noted above. The Group includes GSA staff, GSA Water Industry Advisory Committee representatives, RTO's and a number of operations experts derived from the water industry currently employed in management, operational and policy development roles.

The main purpose of the Group will be to meet and identify all the operational issues, undertake a review of what work is being undertaken by various organisations, undertake a gap analysis identifying items not currently being addressed, prioritise issues and suggest and facilitate implementation of appropriate mechanisms for their resolution.

Clearly, resolution of some of the issues described above will fall well outside the influence of GSA or WIOA alone, and will require higher level political and financial support if they are to be adequately addressed.

Recommendations arising from the Operations Technical Reference Group will be forwarded to the Water Industry Skills Task Force for further discussion and action. This Task Force comprises representatives from the water industry, government sector and education sector. Its role is to promote and oversee a nationally coordinated effort to address the skills shortage.

We look forward to reporting on the outcomes of this very important initiative in the future.

AFTER THE BLACK SATURDAY FIRE STORM!

Bruce Anderson

Goulburn Valley Water faced a significant operational challenge responding to the devastating bushfires in its region on Black Saturday 7th February. The fires impacted on a number of towns serviced by the Corporation including Kilmore, Broadford, Wandong, Heathcote Junction, Buxton and Marysville.

Following an early morning inspection of damage from the Kilmore East fire an emergency response team was convened on the Sunday morning and Goulburn Valley Water's Crisis and Incident Management Plan was invoked. The initial response concentrated on fire damage and loss of power to a number of sites in our south-west and south-east districts.

In the south-west district the fires destroyed the control building at the Kilmore Water Treatment Plant which contained all electrical switchboards, control systems and chemical dosing components.

Fortunately the Kilmore system incorporates large treated water storages that held around five days supply. Stage 4 water restrictions were introduced immediately and a supplementary pumped supply from Wallan was recommissioned by Sunday night. Early on Sunday afternoon a small GVW project team inspected the water treatment plant and developed a strategy to install temporary facilities to produce water within five days. A key component was the building of electrical switchboards and control systems in a shipping container.

After a late night planning session a container was delivered on Monday morning and building of the replacement system commenced immediately. The container was originally sited at our Shepparton depot, and then relocated to the Kilmore site on Wednesday.

In conjunction with work on the container, other contractors and staff were doing on-site electrical cabling and installing chemical dosing systems.

Repairs were a round the clock effort utilizing our four electrical/instrument staff and a small number of operators and contractors. The production of water recommenced on Friday, with the plant restored to fully automated operation with SCADA interface on Saturday. It was a great effort, and all involved were deservedly very proud of their achievement.

The fires also involved a loss of power to a number of sites in the south-west district including Broadford, Waterford Park and Wandong. Temporary diesel generators to enable water and wastewater systems to operate were installed on the Sunday after 'Black Saturday'.

Overall, little or no interruption to services were experienced by our customers in the south-west district.

Melted instrument controller which, miraculously, was still functioning even though everything it had been connected to had been destroyed.

The challenge in our south-east district was a task of another dimension, as in Marysville nearly every building was destroyed, and Buxton, which is supplied by a pipeline from Marysville, was without water.

Access to these towns was not permitted until Monday morning, when Goulburn Valley employees, police and a small handful of remaining residents were the only people working in a scene from hell.

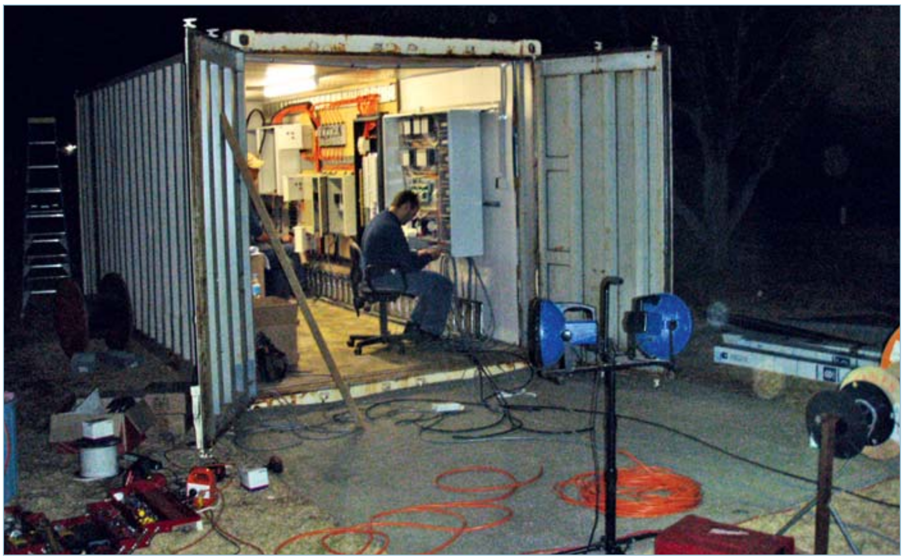
The priority was to turn off fire and water services that had been left running when the fire storm hit the town, and to isolate damaged services. The wastewater system was also operated using mobile generators to prevent overflows to the Steavenson River.

While progress was slow because of damage to buildings, supply was restored to most of Marysville late Monday and to Buxton on Tuesday. Disinfection plants were also recommissioned, but a 'boil water' notice remained in place until a reliable power supply was installed.

The major impact to water and wastewater infrastructure at Marysville was severe damage to the water supply pipeline to the town's reservoir, and the loss of the spray irrigation system at the wastewater treatment plant. To compensate for the loss of the water supply pipeline, a temporary diesel powered pumping system was installed while the pipeline was replaced. This work was completed by Easter, with a total of 2150 metres of new 200mm diameter ductile iron pipe having been sourced and installed by a contractor. It was a new experience to receive immediate approval to install this pipeline without the normal lengthy approval processes, and we received great cooperation from all Government agencies. An 80mm diameter polyethylene pipe was also installed in the same trench to allow for the future servicing of facilities at the nearby Cumberland Falls.

Our operational response is not over yet as we still face the challenge of the potential for runoff from fire affected areas impacting on our water treatment plants. A number of catchments in our region have extensive fire damage so if there is a heavy rainfall event ash and debris from the fires could be washed into the waterways that we draw our water from for drinking water supplies. Fortunately, this has yet to occur.

Goulburn Valley Water is very proud of the way its field staff responded to the



New switchboards being wired.

emergency. In some cases employee houses were under threat of the continuing fires, but they continued to work long hours and to provide excellent service to our customers. It was a great effort by everyone involved.

The response from our staff, contractors and other water businesses was outstanding, and demonstrated the ability of Australians to respond quickly and positively to any real crisis. A big thanks to all involved.

The Author

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REACTIVE SOIL REMINDER - OUT OF SIGHT, OUT ...

Paul Trentini

There is a tremendous lack of awareness of the meaning of "reactive soils". People tend to think that this term identifies contaminated areas or areas that have some chemical toxicity. Although that may be true in some places, reactive soils are soils that react to water by changing volume with changes in moisture content. Expansion or contraction in 3D! Whilst this shrinking and swelling only applies to clay soils, sands can also be problematic and move by a variety of mechanisms including differential consolidation and in some areas they are just soft and collapsible. Problematic clays and sands are found in abundance in most populated areas of Australia.

Our recent drought has highlighted significant soil movement due to a drying. The associated problems are far reaching with serious consequences. One area of concern is in drainage systems.

All modern drainage systems are connected and glued and do not allow for any mechanical movement. However, when soil movement exceeds even 25-30 mm, and this is not unusual, the junctions that connect the pipes, the diversion points, simply crack and fluids then seep into the sub-soil. This action is due to the simple understanding that a standard slab, 20 square brick house with a tile roof has a downward pressure footprint of approx 20kpa/m^2. In contrast, normal reactive soils may have an upward pressure of approx 4-600kpa/m^2. No contest!

This action is unrelenting and very, very slow and very, very quiet. This action is treacherous, not only from the waste and health point of view, but from the reaction it will cause if the seepage occurs near some structural supports or under concrete slabs or their edges. It simply creates unwanted heave (far in excess than that allowed for by the design engineer). The result: cracks appear in the floor and walls. They have no choice; the force is against them.

If the problem of reactive soils isn't enough, we have a new development, Sodic soils. These soils are found in over 30% of Australia's populated areas. The effect of this nasty soil on buildings is so different and new, it has yet to receive official recognition. The problem arises when these soils, having a higher content of sodium and magnesium, receive reasonably unadulterated water. Not rain water (which is mineralized as it passes through the top soil) but rather any relatively soft water that manages to reach the sub-soil as in from leaky pipes. The interaction of this water with the sodic soils produces soil BREAKDOWN and creates a tunnelling effect resulting in unexpected soil collapse. The collapse can be small diameter to metres in diameter, in whatever directions these soils lay and over long, mostly underground distances. It tends to leave a sand residue. Not good where construction has been made based on solid ground. Again, hidden, quiet and destructive.

This information is not provided to produce any sort of fear. The opposite. Forewarned is forearmed. Have a soil engineer do a thorough soil test in the relevant area. Understand the requirement and protect your drains. You may require expansion joints. These have been available for around 20 years but haven't always been installed where they were needed. If drainage systems are installed in reactive soils without appropriate flexible connections, pipe system failure will occur. The onus is on the pipe system installer, generally the plumber as well as the builder, and not just for the 7 year guarantee period to make appropriate allowance for the effects of reactive soils. Note also that the use of "corrugated PVC pipe" as flexible joiners does not constitute an articulated joint as these fittings do not allow sufficient flexibility and in Queensland, the Building Services Authority cautions against their use.

The Author

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LONG TERM FILTER MONITORING AND SAFE DRINKING WATER - DATA FROM TWO AUSTRALIAN WATER UTILITIES

Peter Mosse

Analysis of waterborne disease outbreaks in the developed world (e.g. Hrudey and Hrudey 2004) has implicated the protozoan pathogens *Cryptosporidium* and *Giardia* as major agents in the cause of waterborne disease.

Risebro *et al* (2007) analysed as many waterborne disease events as they could from the literature. For the 61 events analysed, the number of causative events identified varied between 1 and 10. Of these 61 events, only 13 were deemed due to a single cause. 34 of 61 were due to the juxtaposition of two events, notably source water contamination and treatment system failures occurring together. 23 of 61 were due to contamination of drinking water with protozoa where there had been a failure of treatment. 90% of the identified failures of treatment were filter failures, many of which were chronic failures. The role of protozoa and the link with filter performance was clearly established.

Since these protozoa are resistant to chlorine at the levels commonly used in the water industry the only barrier to prevent them reaching the consumer are the media filters employed at conventional water treatment plants (WTPs). To achieve even quite low levels of removal (Log 2 or 99% removal) requires the filters to be optimised and run very well, 100% of the time. Such removal requires consistent achievement of 0.1 NTU from all filters at all times and the absolute minimisation of the filter ripening period. Any increase in turbidity represents a loss of control and possible risk of exposure of consumers to increased risk of infection.

Filters, well run filters, are therefore an absolute requirement for the vast majority of surface water WTPs. The old reliance on 0 *E.coli* representing safe drinking water is no longer tenable. In the presence of poorly operating filters but adequate disinfection, *E.coli* would be removed but *Cryptosporidium* and *Giardia* would not, leaving the consumer at risk of exposure to these pathogens. Irrespective of this shortcoming, *E.coli* is still the best indicator of faecal contamination of drinking water but the limitations of this monitoring must be understood by all with responsibility for the production and distribution of drinking water.

The foregoing then begs the question how best to monitor filter performance and indeed WTP performance to ensure maximum removal of *Cryptosporidium* and *Giardia*.

The Water Treatment Alliance (WTA) offers a methodology for the optimisation of WTP performance as well as an excellent data analysis process. The graphs produced allow long term monitoring of individual filter performance and are sensitive enough to detect subtle differences between filters and between plants and also over periods of time of several years or more. Short term monitoring of the type currently employed at WTPs is not good enough to ensure safe drinking water particularly where the raw water is subject to variation or where there is significant protozoan challenge on the WTP.

The WTA is a self-improvement program for the operation of WTPs. One of the first steps in the WTA process is the collection of 12 months baseline turbidity data for raw water, settled or floated water and for individual filters. This data forms a baseline for monitoring the performance of WTPs over the long term and for bench marking with other WTPs.

While there are a significant number of WTA members in Australia, very few have fully embraced the process and even fewer have submitted data. However we now have two substantial data sets from two large Australian water utilities. One set of data covers two plants for a period of 5 years. It covers a period of some effort to improve the operation of the plants. The success of this is supported by the long term monitoring data. The other data set documents the performance of several WTPs over a one year period.

In the following report the utilities are referred to anonymously as Utility 1 and Utility 2. The data is however real and the results are real.

Presentation of Data

The results of the data analyses are presented in three ways. The first is a simple time series, the second a cumulative frequency distribution of the data and the third presentation is a numerical histogram. The alternative presentations allow very clear conclusions to be reached as to the performance of the WTPs and therefore the safety of water supplied to the consumers.

The simple time series allows identification of variations throughout the year. The cumulative frequency distribution graphs allow determination of the percentage of data that falls below a certain turbidity, in particular 0.1 NTU that is the bench mark for the performance of media filters. The cumulative frequency distribution graphs include curves for the performance of all plants registered with the US Partnership for Safe Water (PfSW). These are included to allow comparison with a large number of plants that have participated in the US program for some considerable time. A simple way to interpret the cumulative frequency distribution graphs is that if the line for a filter is above those for the US plants, then the filter is producing water with a higher turbidity than the maximum monthly values recorded by all the US plants. If the line for a filter is between the maximum and 95%ile plots for the US plants then the filter is producing water with a turbidity lower than the maximum monthly values recorded by the US plants but higher than the monthly 95%ile values. If the line is below the 95%ile line for the US plants then the filter is producing water with a turbidity lower than both the maximum monthly and 95%ile monthly values and can be considered to be performing more efficiently. Clearly the lower the line the better the performance of the filters.

The numerical histogram provides an alternative view of the WTP performance over time and in particular highlights poor performance, and the extent of that poor performance.

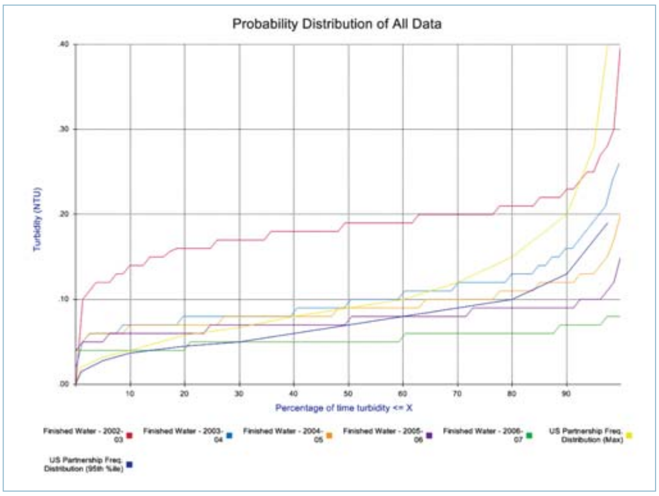

Figure 1. Cumulative probability curves for Utility 1 Plant 1 for the period 2002 to 2007.

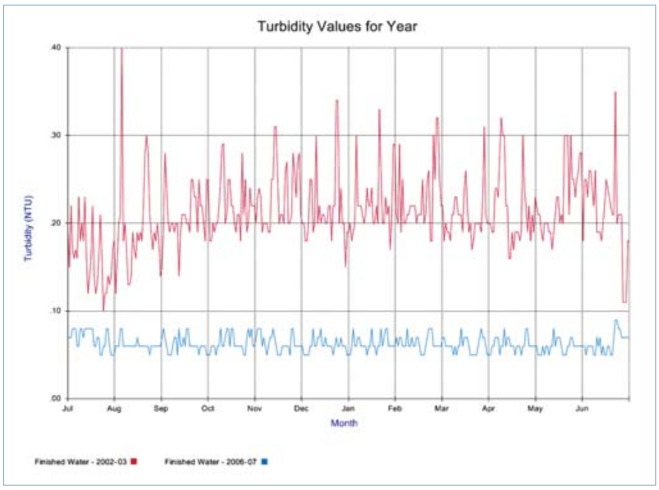

Figure 2. Simple time series plots for Utility 1 Plant 1 for the years 2002-2003 and 2006-2007.

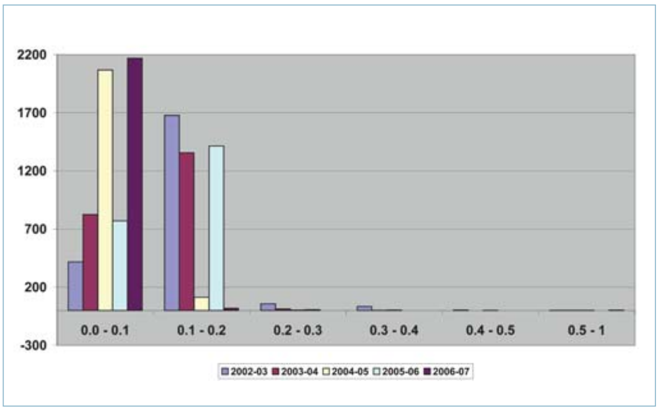

Figure 3. Histogram plots for Utility 1 Plant 1 for the years 2002 to 2007. The x axis is turbidity, the y axis the number of data points in the given turbidity range.

Water Utility One

This data set covers the 5 years 2003 to 2008 for two WTPs. Figure 1 shows the cumulative performance plots for one of the plants.

The line for 2003 is well above that for the PfSW plants and indicates poor performance and generally unsafe drinking water. There is then a progressive improvement in the quality of the water over the next 4 years with the data for 2006-2007 well below the US PfSW lines. This shows clearly the benefit of the improvement program implemented by that utility. Figure 2 shows the simple time plots of the turbidity for the two years. Clearly performance in 2006-2007 is far better than that in 2003.

Figure 3 shows the same data as that presented in Figure 1 as a histogram. In the same way as Figure 1 allows easy comparison of several years of data, Figure 3 allows this also. With improvement in water quality the bars will move progressively to the left and this is apparent with the data for Plant 1 Utility 1.

Closer inspection of Figure 3 reveals a discontinuity in the trend towards increasing improvement in water quality. The bar representing data for 2005-2006moves back to the right, clear indication of poorer quality water.

Clearly Plant 1 Utility 1 started off in 2003 producing water of relatively poor quality. With the implementation of a formal HACCP program and incorporation of the broad principles of the WTA, there was a clear improvement to the situation in 2007. The drop in performance in 2005-06 and the dramatic improvement in 2006-07 is clearly apparent in Figure 3. The drop in performance was due to experimenting with different polymers during a period whilst the plant was experiencing shortened filter runs due to excessive head loss after a change in raw water quality. Traditionally non-ionic polymer had performed best and did so during this period with regard to turbidity however at the expense of shortened filter runs due to high head loss. Cationic polymer improved the filter head loss performance but resulted in poorer turbidity in the filtered water. The utility in question decided to put up with the shorter filter runs and keep the turbidity as low as possible (<0.1NTU) until the raw water characteristics improved as occurred around February 2006.

Figure 4. The state of the filters in 2003 in Plant 1 Utility 1.

The three types of graphs combine to provide a powerful and clear reporting tool. Just to complete the picture of this period at Utility 1, Figure 4 shows the state of the filters at Plant 1 in 2003 where a thick layer of mud covered most of the surface of the sand filters and filter performance was at best marginal.

Water Utility Two

This data set includes data from 5 WTPs for the year 2006/2007.

Plant 1

Figure 5 shows the cumulative frequency distribution for all the filters at Plant 1. All the curves are below the curves for the maximum and 95th percentile performance of the US plants participating in the PfSW program and indicate very good performance. However, closer examination of the curves show that filter 4 performed the worst while filter 6 performed the best of the six filters. Filters 2, 3 and 5 were very similar in performance and only slightly worse than filter 6.

Plant 2

Turbidity data for the raw water supplying Plant 2 shows a significant period of elevated turbidity from October to January (Figure 6).

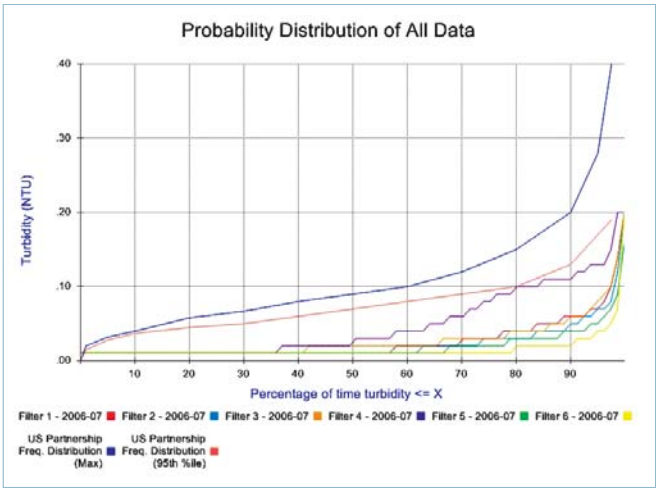

Figure 5. Cumulative frequency distribution of turbidity data for filters 1 to 6 at Plant 1 (Utility 2).

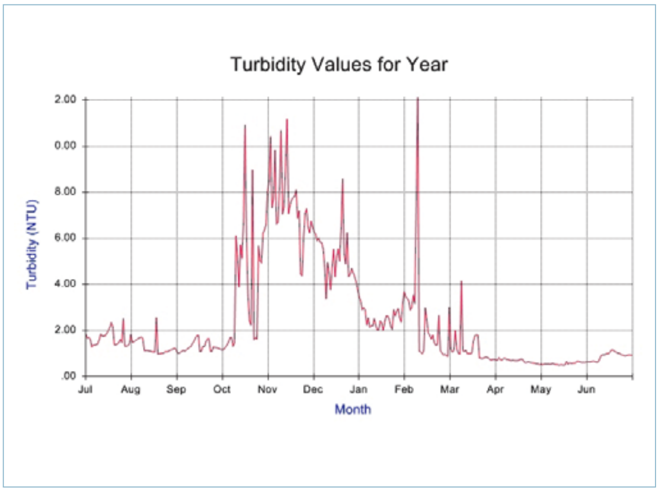

Figure 6. Times series turbidity data for the raw water supplying Plant 2 (Utility 2).

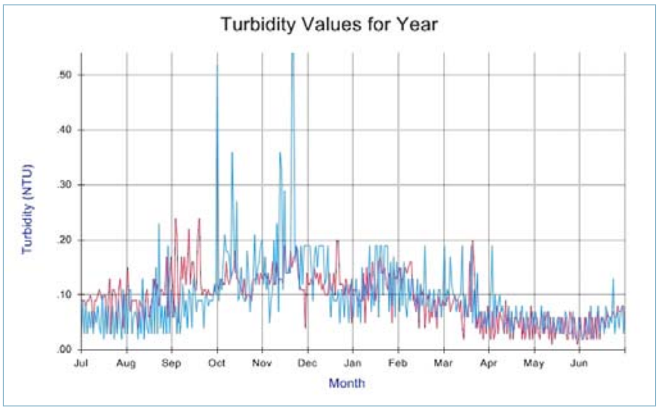

Figure 7. Time series data for two of the filters at Plant 2 (Utility 2).

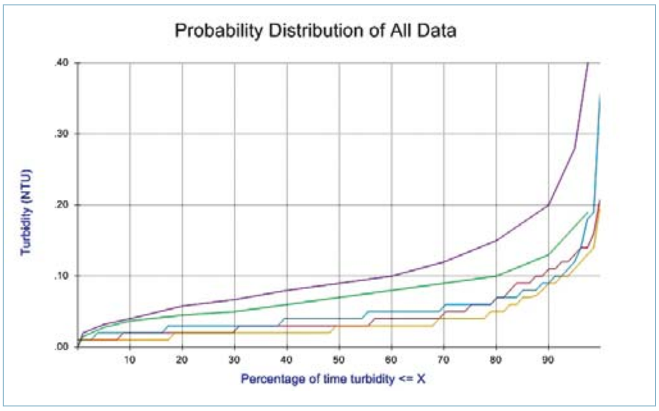

Figure 8. Cumulative frequency distributions for filters 1,2 and 6 at Plant 2 (Utility 2).

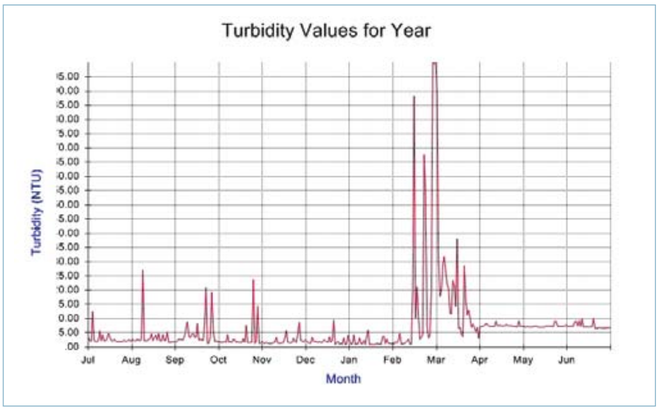

Figure 9. Times series turbidity data for the raw water supplying Plant 3 (Utility 2).

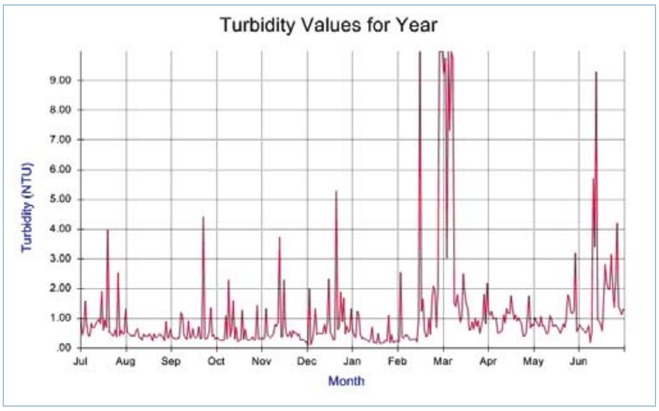

Figure 10. Times series turbidity data for settled water at Plant 3 (Utility 2).

This variation in the raw water turbidity is reflected in the performance of the filters (Figure 7). While the increase is small, it does indicate that under conditions of increased raw water turbidity there is a rise in filtered water turbidity and since the raw water turbidity is still quite low (<10NTU) there may be an opportunity to improve the operation of the plant to prevent this rise.

Analysis of the cumulative frequency distribution graphs for filters 1, 2 and 6 (Figure 8) shows very good performance despite the slight increase in filtered water turbidity seen in Figure 7.

Plant 3

Figure 9 shows the time series data for the raw water supplying Plant 3 Utility 2. The trend shows a period of elevated turbidity in excess of 90 NTU for the period February to March. This increase in turbidity is reflected in the settled water turbidity data for the same period (Figure 10). The settled water also shows some increase in June 2007 that was not present in the raw water. Plant records may give some insight into the cause of the fluctuations in the settled water turbidity in June. This might provide an opportunity to establish better control of the settling in the future.

Importantly however, the increases in turbidity in the raw or settled water are not reflected in the filtered water turbidity which remains consistently low during the period of elevated raw and settled water turbidity (Figure 11). This indicates the filters are performing very well despite these periods of increased load.

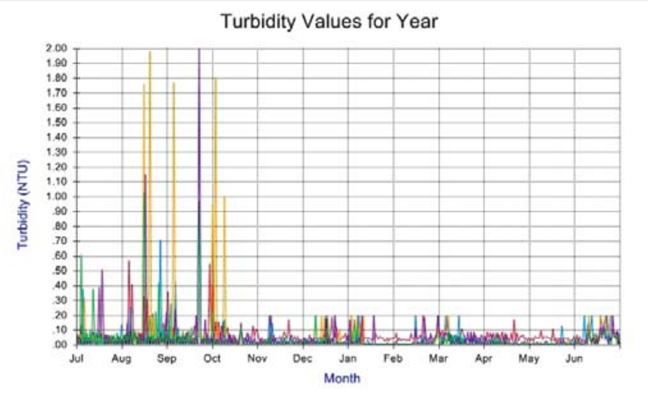

Figure 11. Time series turbidity data for filters 1 to 5 at Plant 3 (Utility 2). Note the greater variability in data from July to October 2006. This could be due to poorer performance of the turbidity meters.

Comparison of Plant 2 (Utility 2) and Plant 3 (Utility 2) shows significant differences in the performance of the plants in the face of increased raw water turbidity. While the actual increase in raw water turbidity for plant 3 is greater than that for plant 2, plant 3 filters show no apparent deviation or increase whereas the filters in Plant 2 do not seem to cope as well even with only a small rise in raw water turbidity.

Table 1 shows the turbidity data presented in an alternative way as a numerical histogram. This allows closer examination of the occurrence of the higher turbidity values and closer scrutiny of those filters or plants that may be contributing water less safe than others. While this could be presented graphically in the form of a conventional histogram it is easier to see the differences in a tabular form because the scale that would be necessary on a graph would hide the values at the higher turbidity ranges. Plants 1 and 4 produce consistently excellent quality water. While the water produced by the Plants 2 and 3 is also very good as shown in Figures 6 and 8, further investigation could be undertaken to understand the occurrence of the higher turbidity values and put in place corrective measures to control these deviations.

Settled water data for Plant 3 is also included to show the bimodal distribution of data. Investigation of the operation of the "settler" may provide an explanation and the operation of the settler further improved.

Table 1. Spike count data for the Utility 2 WTPs.

Utility 2 Plants	0-0.1	0.1-0.2	0.2-0.3	0.3-0.4	0.4-0.5	>0.5
Plant 4 F2	2164	25		1		
Plant 4 F3	2172	17			1	
Plant 4 F4	2143	43	2		2	
Plant 4 F5	2146	42	1	1		
Plant 4 F6	2133	56			1	
Plant 4 F7	2166	22	0	1	1	
Plant 4 F8	2179	9	1	0	1	
Plant 4 F 9	2178	11	1			
Plant 1 F1	2140	50				
Plant 1 F2	2154	36				
Plant 1 F3	2138	52				
Plant 1 F4	1837	353				
Plant 1 F4	2173	17				
Plant 1 F5	2179	11				
Plant 2 F1	1956	229	5			
Plant 2 F2	2032	146	6	3	0	3
Plant 2 F4	1924	177	16	9	2	62
Plant 2 F5	2048	114	4	0	5	19
Plant 2 F6	2053	137				
Plant 3 F1	2144	37	1	3	2	3
Plant 3 F2	2152	32	2	1	1	2
Plant 3 F4	2163	21	2	1	0	3
Plant 3 F5	2173	9	3	1	1	3
Plant 3 Settled Water	**27**	**222**	**495**	**450**	**275**	**721**

Conclusions

The WTA provides a structured way to assess the current operational characteristics of a WTP and provides a mechanism whereby the deficiencies of a plant can be identified. Once identified, the process provides a mechanism to identify ways to overcome the deficiencies, prioritise work necessary to improve the operation of the plant and to monitor that improvement. The steps are exactly analogous to those described in the Framework for the Management of Drinking Water Quality (ADWG 2004) where hazards and preventive measures are identified and the preventive measures assessed as to whether they are sufficient to reduce or eliminate the hazard. If they are not, alternative measures or modified measures are identified, prioritised and implemented. The WTA also provides best practice targets for WTP operation. For example, best practice operation of media filters should result in water with a turbidity of <0.1 NTU at all times except for a ripening period with a maximum turbidity of <0.3 NTU for no longer than 15 minutes.

The data really shows the power of the long term monitoring of filter function as opposed to the more normal short term monitoring in Australia. Without monitoring of this type so common in financial and other water industry reporting functions it is reasonable to say that water utilities cannot be really sure of the safety of the water they provide.

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TARCUTTA TALES OF MANGANESE AND IRON

Peter Outtrim, Awarded Best Paper at the WIOA NSW Operators Conference, Tamworth, 2009

Background

Tarcutta is a small village with a population of around 350 located on the Hume Highway approximately 400 km's south of Sydney. The village is supplied with "potable" water from two bores both of which contain high levels of soluble iron and manganese.

The original Tarcutta Water Treatment Plant (WTP) was built in 1949 and apart from some minor upgrades had essentially remained unchanged. The plant is visited three times per week by an operator to undertake routine tasks that includes backwashing of the filters.

Plant capacity is 6 L/s maximum output and backwash water consumes around 120 kL per week. Backwash water is discharged to the table drain in front of the plant and then into Tarcutta creek.

One bore is located within the treatment plant yard with the other being several hundred metres south beside the creek. Iron levels entering the treatment plant range from around 15 mg/L to 25 mg/L and manganese levels are stable at 0.5 to 0.6 mg/L.

Prior to the upgrade, treatment included aeration followed by contact time and then sand filtration. The village water had not previously been chlorinated and the residents were generally very happy with the unchlorinated supply. Figure 1 shows a picture of the plant prior to commencing any work.

The main reasons for undertaking the upgrade were to:

Figure 1. Tarcutta Water treatment plant as it was.

- Commence disinfection.
- Remove manganese.
- Decommission the old inefficient filters and aeration towers.
- Replace ageing infrastructure.
- Discharge wastewater to a more suitable site.
- Reduce iron solids loading on the existing filters.

The initial stage of the project commenced early in 2005 and involved filling a 200 litre drum with bore water and adding varying amounts of hypo to see what type of reaction we got. At around 10mg/l hypo dose an iron based floc formed in the bucket. Jar testing was then commenced and after some fiddling we established a regime that seemed to work. So in theory it seemed simple, kill two birds with one stone, oxidation of all iron and manganese with hypo followed by clarification, filtration and then maintain enough residual for disinfection purposes.

Pilot Trial No 1

A Candy Tank (clarifier) was sourced from a decommissioned plant and placed on site and a 2 L/s flow diverted through it. The process train was aeration, sodium hypochlorite dosing, flash mix, clarification and filtration.

Unfortunately the iron floc refused to settle even after trying various set ups which included the addition of polymer as well as lowering flow rates. Chlorine doses were also altered to attempt to maintain a

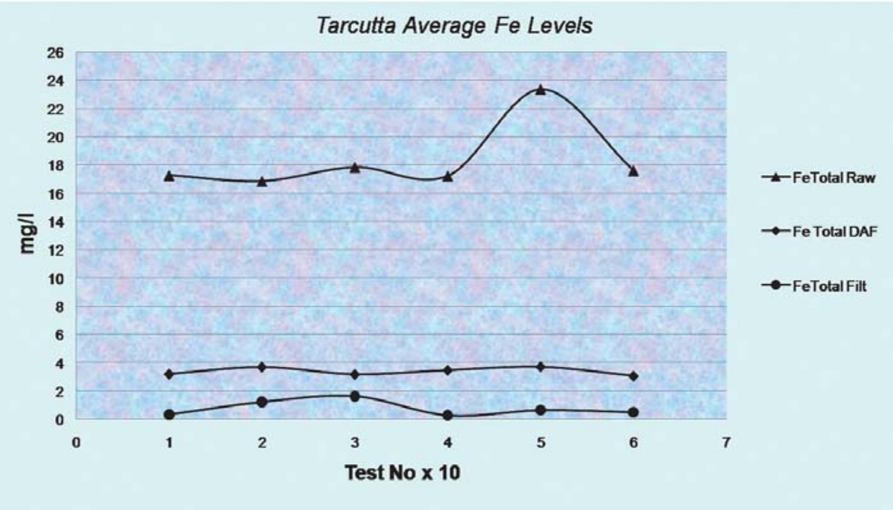

Figure 2. Performance of the DAF trial plant for iron removal.

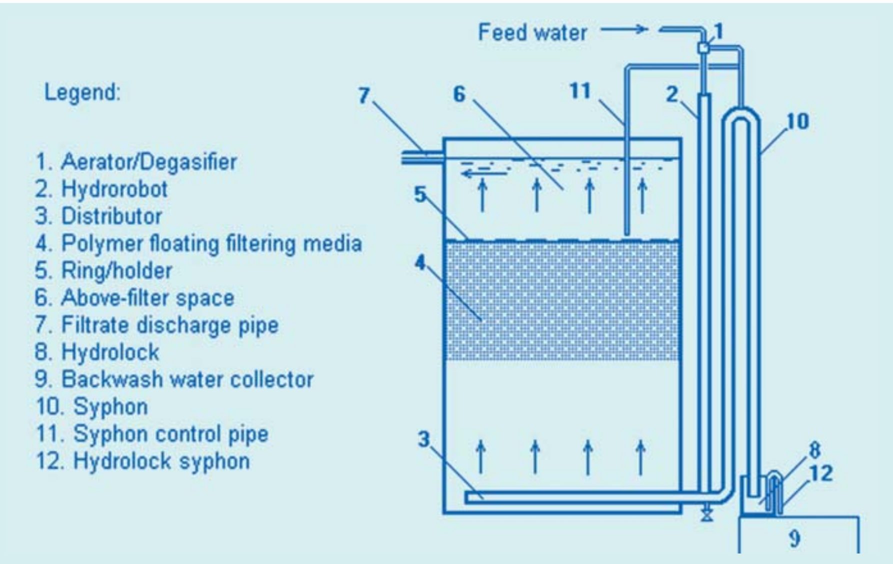

Figure 3. The Deferum filter.

residual after clarification and this also proved difficult.

Pilot Trial No 2 DAF

After being unsuccessful with conventional clarification we decided some outside expertise may be of assistance. Hunter Water were contacted and asked to conduct trials on the suitability of a DAF process. DAF jar tests were conducted on site to assess what was required to achieve successful clarification.

Various coagulants and flocculants were tested, these included:

- Alum
- Ferric sulphate
- Poly ferric sulphate (PFS)
- Aluminium chlorohydrate (ACH)
- Flocculants - LT20, LT22 and LT22s

All of these were used after dosing with chlorine.

The best performing were ferric sulphate, LT22 cationic polymer and ACH. Iron flocs using chlorination only were difficult to float without coagulation/flocculation treatment.

We then decided to conduct a large scale pilot test using a DAF Plant which was hired from Water Treatment Australia. Water Treatment Australia conducted their own jar tests on the raw water and recommended the use of ACH (megapac23) as the principal coagulant. Aeration was still incorporated and caustic soda was also introduced to speed up iron and manganese oxidation prior to entering the DAF unit.

This trial went on for all of 2007 with the full plant flow being directed through the DAF unit.

During the nearly 12 months of trialling the DAF unit there were many problems encountered:

- Taste issues – metallic taste after addition of hypochlorite early in the process stream. This led to many complaints from residents.
- Dirty water events – Any slight problem with the DAF process led to iron passing through the filters. Iron + chlorine in the reticulation system!
- Use of increasing amounts of chemicals.
- Lack of a robust process chain - DAF was struggling with the quantity and type of floc produced.
- Manganese removal was not effective – approximately 30% removal only.

Figure 2 summarises the DAF/Filtration train performance over an extended period.

Prior to Christmas 2007 the plant was reverted back to its original process train and chlorination was stopped. Residents had lost confidence and patience with what we were trying to achieve. Back to the drawing board!

Pilot Trial No 3 "Deferum" & DMI 65 Filtration

Early in 2008 our Senior Project Engineer received feedback about a process called "Deferum" which was capable of oxidising and filtering large amounts of iron from feed water.

A pilot filter was borrowed from Infinity Environmental and a flow of 0.6 litre/second directed through it. Positive results were obtained from the start.

The Deferum process uses feed water supplied at around 65 psi to an aerator/degasifier. The feed water travels at up to 180km/hr and this creates a vacuum which speeds up gas removal and also allows atmospheric air to be sucked into the device causing the water to break up and form very high air/water contact surface. This combination accelerates gas removal and oxidation of iron. The water then flows upward through a polymer floating filtering media (PFFM) and is decanted from the top of the filter.

Backwash is achieved using a hydro-automatic function. Simply put, as the filter becomes loaded with solids the water level builds up in the hydro- robot until a siphon is commenced and the filtered water at the top of the filter is used to backwash the media. There are no power requirements. Figure 3 shows a schematic of the filter.

Figure 4. Tarcutta WTP upgrade progress to date (February 2009).

To remove manganese after the Deferum process, a pool filter was purchased and filled with DMI 65 media from Quantum Filtration.DMI 65 is a catalytic filter media that is activated by soaking in an oxidant, in our case sodium hypochlorite. Once the media is 'activated' all that is required is a constant dose of hypochlorite while the filter is operational. This also achieves the required outcome of disinfection of the village supply. Table 1 gives an outline of the results from the pilot dual filtration system.

Finally we had found a process that seemed to achieve the results we were after.

Table 1. Summary of iron and manganese removal. All figures are mg/L.

Raw Water		Deferum Filter		DMI 65 Filter	
Raw Fe	Raw Mn	Outlet Fe	Outlet Mn	Outlet Fe	Outlet Mn
18.4	0.67	0.08	0.67	0.01	0.03
18.4	0.67	0.04	0.74	0.07	0.04
18.4	0.67	0.08	0.62	0.04	0.03
17.6	0.66	0.07	0.48	0.00	0.02
19.4	0.65	0.06	0.6	0.05	0.02
16.6	0.67	0.07	0.63	0.00	0.02
19.1	0.67	0.16	0.37	0.06	0.02
22.5	0.68	0.12	0.42	0.02	0.03
11.9	0.7	0.01	0.7	0.00	0.03
18.2	0.65	0.09	0.66	0.0	0.01

Progress

Currently the new treatment plant is under construction (Figure 4). A Deferum filter has been purchased from Pure Water Corporation based in Western Australia and installed on-site; the filter is capable of approximately 500 kL/day production. Stainless steel filters for the DMI65 media have been supplied by Water Treatment Australia.

The upgraded plant should be commissioned and brought on line by the end of winter 2009 after which the old plant will be knocked down.

Conclusions

Riverina Water never envisioned the problems and the time and resources it would take to find a suitable process to remove iron and manganese at Tarcutta. Our persistence with the DAF plant trial contributed to the loss of confidence of our consumers that will take some time to repair.

The dual filtration plant should achieve the following outcomes:

- Iron removal prior to addition of hypochlorite – less taste and odour issues.
- Minimal chemical use on site – hypochlorite only
- Manganese removal and disinfection in one process.

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MANAGING MELBOURNE'S WATER AFTER STORM EVENTS

Noel Miles, Kathy Northcott & Daniel Ellis

Much of Melbourne's water supply comes from protected catchments and is delivered without any conventional treatment. Managing the impact of reduced water quality as a result of extreme weather events, poses significant challenges.

The Yarra Valley Conduit (YVC) transfers water from the Upper Yarra reservoir into the Melbourne metropolitan supply system. Flows in the YVC fluctuate throughout the year in response to the need to maintain storage levels in the downstream Silvan and Cardinia reservoirs.

At the end of June 2007, a storm event occurred. Overnight 74 mm rain fell in the Upper Yarra catchment and 155 mm fell in the Thomson catchment. Record volumes of highly turbid water entered the Upper Yarra reservoir. The combination of a parched catchment and damage from a fuel reduction burn in part of the Upper Yarra catchment allowed rapid run-off of high turbidity water. In addition, around 4 GL of high turbidity water entered the Upper Yarra reservoir from the Thomson River, prior to this supply being turned off.

Turbidity in water leaving the Upper Yarra Reservoir peaked at 25 NTU and stayed above 20 NTU for several weeks. While this may not represent high turbidity for many systems it represented high turbidity for the Melbourne system that usually sees turbidities of between 1 and 3 NTU. As a result, the flow in the YVC was reduced to minimise the effect of high turbidity coming from the reservoir. The major problem with the high turbidity water was its impact on the disinfection. There was no certainty that the UV disinfection plants would be able to adequately disinfect water with turbidity above 15 NTU.

To manage this possibility, a precautionary boiled water notice was issued to the Yarra Valley townships supplied by the YVC for a period of approximately one month. In addition, water quality monitoring and particularly pathogen monitoring was increased to identify any risks to public health and to better manage aesthetic issues of turbid and coloured water. This monitoring confirmed the low pathogen risk from the protected catchment, even with water containing relatively high turbidity. Table 1 shows the pathogen monitoring results for each of the water treatment plants located along the YVC.

Figure 1. The double curtain system in place at the Silvan Reservoir.

The YVC Recharge Strategy

Low flows could not be maintained in the YVC for extended periods. In September/October 2007 the water harvesting plan required that flows in the YVC be increased. In the past, such increases have always resulted in turbidity spikes, and since the flow had been much lower than usual even higher turbidity events were expected.

The need to increase flows in the YVC created two major operational issues for

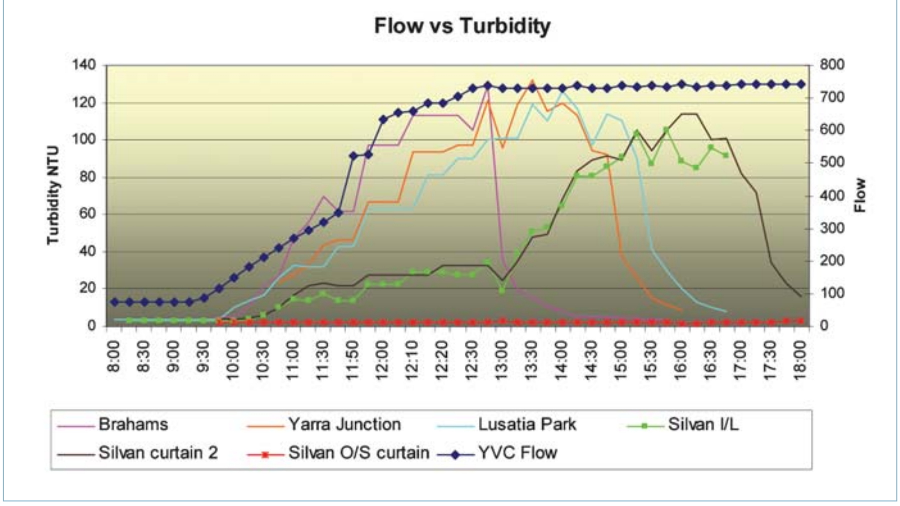

Figure 2. Flow and turbidity results during the YVC recharge.

Table 1. Results of pathogen monitoring at treatment plants along the YVC. Samples taken between July 1st and December 5th 2007.

Location	Parameter	No Samples	Average	Min	Max
Brahams Rd East Warburton Raw Water	Coliforms	49	30	<1	210
Brahams Rd East Warburton Raw Water	*E.Coli*	48	4	<1	17
Brahams Rd East Warburton Treated Water	Coliforms	66	<1	<1	<1
Brahams Rd East Warburton Treated Water	*E.Coli*	65	<1	<1	<1
Lyrebird Ave East Warburton Raw Water	Coliforms	49	24	<1	150
Lyrebird Ave East Warburton Raw Water	*E.Coli*	48	3	<1	17
Lyrebird Ave East Warburton Treated Water	Coliforms	64	<1	<1	1
Lyrebird Ave East Warburton Treated Water	*E.Coli*	63	<1	<1	<1
Martyr Rd Warburton Raw Water	Coliforms	19	9	1	24
Martyr Rd Warburton Raw Water	*E.Coli*	18	3	<1	12
Martyr Rd Warburton Treated Water	Coliforms	56	<1	<1	<1
Martyr Rd Warburton Treated Water	*E.Coli*	55	<1	<1	<1
Yarra Junction Raw Water Raw Water	Coliforms	209	4	<1	25
Yarra Junction Raw Water Raw Water	*E.Coli*	208	1	<1	12
Yarra Junction Raw Water Treated Water	Coliforms	66	<1	<1	<1
Yarra Junction Raw Water Treated Water	*E.Coli*	65	<1	<1	<1
Lusatia Park Treated Water	Coliforms	224	<1	<1	<1
Lusatia Park Treated Water	*E.Coli*	223	<1	<1	<1

Melbourne Water. The first and most immediate problem was the potential increase in turbidity and associated health implications for the towns supplied directly from the YVC. The second (and potentially more significant) was the downstream impact on the water quality in the Silvan reservoir. Silvan is the transfer hub for much of Melbourne's unfiltered water supply and hence a major turbidity incident in this reservoir could not be risked.

An incident management plan was developed to minimise the impact of the expected increased turbidity on customers in Melbourne. Two strategies were implemented. Yarra Valley townships were switched to an alternative disinfected supply so they would not be affected during the recharge of the YVC. With the townships isolated, a decision was taken to recharge the main rapidly over a two hour period compared to the normal period of around 8 hours. This was to achieve maximum suspension of silt that had settled in the conduit during and after the high turbidity storm event.

To minimise the impact of the scouring of the YVC on water in Silvan reservoir, it was decided to install silt curtains in the reservoir as a barrier to the high turbidity water that would be entering Silvan. Due to the location of the inlet and the force of the flow, a double curtain system was installed (Figure 1). The first curtain was configured to reduce the velocity of the water entering the reservoir and to spread the flow across the length of the curtain. In addition the primary curtain would provide primary removal of large particles (>70micron). The second curtain featured a high strength polyester skirt to screen fine particles >10 microns.

Figure 3. The silt curtain in operation with high turbidity water on the upstream side.

Monitoring of YVC Recharge

During the recharge of the YVC, monitoring was carried out at various locations along the conduit in Silvan Reservoir. The aim of the monitoring was to:

- Monitor changes in water quality at the different locations,
- Determine the effectiveness of the silt curtain, and if necessary reduce the flows in the YVC
- Measure the impact of the recharge on water quality in the Silvan Reservoir.

Modelling and flow calculations for the YVC recharge allowed for accurate estimates of travel times and made monitoring simpler.

When the recharge commenced, the flow increased more slowly than expected, with the flow only increasing to 325 ML/d during in the first two hours. Extra valves were opened at the Upper Yarra reservoir outlet and the flow increased rapidly to reach the maximum output of 720ML/d. As a result of the slow start, the total time for the recharge was approximately three hours.

Figure 2 shows the changes in turbidity at various sites along the YVC, and Silvan reservoir. Turbidity in the YVC started to increase as the flow increased, with maximum turbidity's being associated with the maximum flow and corresponding to the time taken for the water to arrive from Upper Yarra. Based on the results, much of the turbidity appeared to have come from sediment resuspended in the top section of the YVC close to the Upper Yarra Reservoir. Once the peak flow had reached a site, the turbidity started to reduce and was back to normal levels in less than two hours.

Transmissivity of UV light (UVT) was also monitored to better understand the impact of the water on the ability of the UV lamps to provide disinfection. The UVT followed a similar but opposite trend to that of turbidity, with the minimum transmissivity (37.4%) not surprisingly corresponding to the highest turbidity. The UVT was found to decrease to below 50% when the turbidity reached approximately 70 NTU.

Silt Curtain Performance

The turbidity of the water behind the second curtain reached a maximum of 114 NTU recorded three and a half hours after the peak flow had been reached. The turbidity then declined over the next two hours to quite low levels. The water inside the first curtain resembled a sludge blanket with a swirling mass of particles. Colour increased and decreased in a similar way.

The turbidity of the water beyond the second curtain remained reasonably constant throughout the recharge (Figure 3) and only started to increase towards the end of the day when the turbidity gradually rose from 2 to 3 NTU. There was an obvious plume that short circuited beneath the curtain mainly via the inlet channel but this water only extended approximately 20m from the curtain and settled quickly.

Conclusions

The deterioration in water quality that occurred in the Upper Yarra reservoir as a result of a significant storm event in July 2007 was successfully managed without any adverse impact on customers in Melbourne.

The installation of a double silt curtain showed that high turbidity could be controlled at the inlet to Silvan Reservoir to minimise any affect on water quality in the reservoir.

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SEWER RESPONSE UNIT (SRU)

David Errey, Winner of the Prize for Best Paper Overall at the Victorian Water Industry Engineers & Operators Conference, Bendigo, September 2008

During a long dry period such as that being experienced in much of Australia presently, tree roots become progressively more aggressive in finding water, increasing the number and severity of roots penetrating the sewers. In areas with a clay soil, the clays contract and shift causing connections from the house to the sewer to become misaligned allowing further root intrusion and blockage.

Sewer blockages can occur in the branch where the customer's sewer pipes connect to the reticulation main (Figure 1). This connection is known as the House Connection Branch (HCB). Yarra Valley Water's (YVW) responsibility begins at the branch known as 27A (see Figure 1). Everything upstream of the 27A is known as the House Connection Drain (HCD) and is the customer's responsibility.

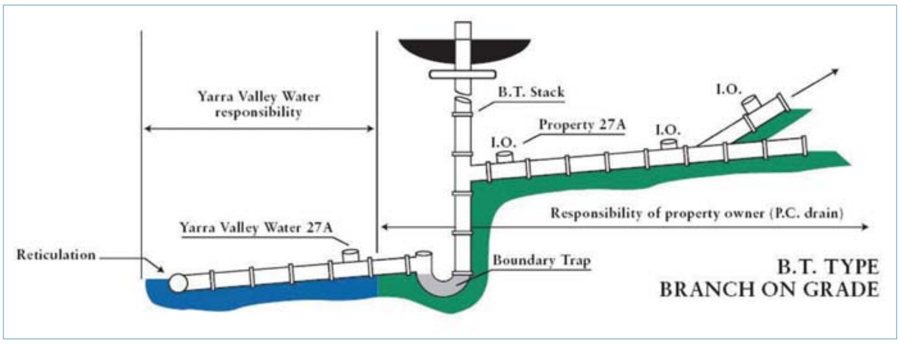

Figure 1. Example of a HCB and HCD.

HCB blockages can be caused by a build up of silt, stones, fats, tree roots, broken or collapsed pipes and other foreign objects limiting the flow through the HCB and into the reticulation main.

HCB clearances and dig outs generally involve crews attempting to clear the blockage using a "through the pipe" method which involves "rodding" the pipe with a sewer rooting machine. This machine performs the task of clearing the blockage, but it may not completely cut and clear the pipe of all tree roots, fats and other objects. The effectiveness of the clearance depends on the arrangement of the HCB and availability of fittings, the length of the branch, the size, type and amount of roots and the size of cutting head that can be passed through the available fittings.

Figure 2. CCTV being used in the field.

In cases where the blockage is difficult to clear or there is evidence of broken pipes, the contractor will proceed to issue a scheduled job to CCTV (closed circuit television) the HCB (Figure 2).

This process will determine the cause of the blockage and allow YVW to assess the asset condition and arrange for any follow up rehabilitation. Where blockages are unable to be cleared using a "through the pipe" method, it must be cleared by digging it out. This decision is made without the use of CCTV assistance and therefore may not accurately determine the best solution to rectify the HCB service.

A dig out requires a 3 man crew, confined space conditions and an extended interruption to the customers' service. The dig out often involves removal of trees, replacement of fences, reinstatement of paved areas, gardens and property which can be quite expensive. The dig out will be either a spot repair or a complete replacement depending on the length and condition of the HCB pipe.

The number of HCB blockage and HCB emergency dig outs have increased significantly from 2005/06 to 2006/07 by 13% and 20% respectively. With the increasing HCB blockages, associated clearances and increasing number of dig outs required, an alternative approach to HCB clearance was needed.

In August 2007 a four week trial commenced using a contractor's specially fitted out Sewer Response Unit (SRU). The SRU consisted of a light commercial van with high pressure pipe clearing (Figure 3) and CCTV equipment.

The van operator was able to CCTV blocked HCB's and get an accurate picture of what they were dealing with before attempting to clear the blockage. Once the clearance was performed, the second CCTV recording provided an accurate diagnosis of any faults including root intrusion, broken or misaligned pipes, other objects and general condition of the asset.

During the trial the van attended 20 emergency jobs where a blockage clearance was immediately required and 42 scheduled assessments, where previously cleared HCB's suspected of having further problems required CCTV. Of the emergency jobs, 85% would have normally resulted in an emergency dig out, however the attendance of the SRU prevented these. Of the scheduled assessments, 26% would have normally resulted in a dig out. It is estimated $70K in dig out costs were saved and these results provided a strong business case for YVW to invest in two SRU's vans of its own.

In September 2007 two SRU vans fitted out with specialist high pressure pipe cleaning and CCTV equipment were purchased by YVW for a cost of $275K

Figure 3. A high pressure nozzle.

(Figure 4). Two new operators were employed and trained in the SRU's use.

When the SRU attends jobs, the CCTV results are recorded on to a DVD and entered into YVW's Asset Management database. This information can be utilised when developing renewal strategies or targeting particular jobs by order of priority. The results of the CCTV also assist in future maintenance decisions, auditing, customer advice and negotiations over responsibility of the blockage. This last point is particularly important as customers and plumbers often dispute whether the pipe was cleared correctly in the first instance and whether the blockage was located in YVW's HCB or the customers HCD. With this pre and post clearance DVD recording, YVW can present the facts to the customer and plumber, therefore making it clear what has caused the blockage and where it was located. This also assists the reimbursement process for customers and plumbers when required.

Between September 2007 and June 2008 the SRU's attended 231 HCB blockages where "through pipe" clearance method had been carried out previously and had subsequently had a HCB emergency dig out recommended. By using the SRU, 166 dig outs (or 72%) were avoided, saving approximately $400K. The SRU program has therefore contributed to the overall reduction in the number of emergency dig outs by 19% from 2006/07 to 2007/08.

In circumstances where a HCB is cleared with the standard "through pipe" method, the current practice would involve waiting until customers experience their second blockage in the next 12 months before scheduling a planned job to CCTV the branch. This can take up to two weeks to get the recording and a further week to assess. If rehabilitation was then required, up to another three months may pass before rehabilitation is completed.

With the total time from the blockage to completion taking up to four months, there is significant benefit in time and cost savings and customer service by dispatching the SRU's to the initial job and undertaking CCTV of the HCB pre and post clearance. The SRU's in most cases provide an effective clearance and clean and provide an immediate accurate diagnosis of the most appropriate pipe rectification if it is required.

Of the 166 HCBs in the SRU program that would normally have resulted in an emergency dig out, almost 50% were relined which avoided significant disruption to customers.

Other benefits of using the SRU include:

- Reduction in customer impact, inconvenience and site visits
- Increase in customer service levels
- Large reduction in scheduled jobs & backlog of scheduled jobs
- Unnecessary confined space entries are avoided
- Quicker response and turn around of dig out jobs
- Efficiencies in dealing with reimbursements for plumbers
- Prompt and accurate electronic recording of asset condition

Future Opportunities

YVW will continue to investigate expansion and improvements to its SRU program including:

- Camera improvements in line with technological advancements providing the ability to download and store digital images directly rather than having to rely on disk format.
- Consider CCTV of HCD's to further assist YVW and customers diagnose problems in the HCD.
- Target second blockages to ensure YVW pursues its strategic objective to have no customer experience more than one sewer service interruption within 12 months

Figure 4. One of the new sewer response vans.

In conclusion, the SRU's provide an accurate diagnosis of the problem and avoid the need for multiple attendances to pin point the cause of a blockage. and recommend the most appropriate resolution. The SRU's provide a "one stop shop" which achieve an improved HCB clean on the "through the pipe/rodding" method and ensure there is no need to return to a job for CCTV, as it is all done during the initial site visit.

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