# WaterWorks

OFFICIAL JOURNAL OF THE WATER INDUSTRY OPERATORS ASSOCIATION OF AUSTRALIA

November 2012



## Online Turbidity Meter Installation and Operation Guide

# GOING FORWARD, LOOKING BACK

*George Wall*

It seems that 2012/13 is one of those flukey dates in history in which many milestones occur – the 40th anniversary of the formation of WIOA, the 50th anniversary of the formation of AWA and the 75th Anniversary of the Victorian Water Industry Engineers and Operators Conference. We wonder whether the Victorian conference founder, Mr EA Hepburn, could ever have dreamed his legacy would stand such a test of time when the event began way back in 1938.

To help celebrate the milestone, WIOA researched and compiled the conference history into a book that was distributed to all conference delegates and WIOA Members. Extra copies can be purchased from the WIOA website. What our research uncovered was the amazing amount of change that has occurred in our industry and how much we forget as time goes by. Looking at the working conditions and equipment available to our forefathers in the early to mid-1900s and comparing them to today, their achievements were truly incredible.

Machinery and equipment improvements in the later decades of the 1900s made our daily tasks a lot easier and increased efficiency. The rate of change in our industry accelerated extraordinarily once the computer age arrived in the 1990s and, in many cases, in our continual quest to source and introduce even more technology, we haven't quite worked out how best to utilise what we already have at our fingertips.

Over the past few years, WIOA has been approached by a number of members to help provide some best practice information to top up their skills and knowledge on a variety of topics. In response, WIOA has engaged and worked with a number of experts to develop a range of publications relating to steps in the water treatment and distribution process. We are now working on a wastewater set as well. We have also developed a range of one-day seminars that have been successfully staged around the country where the information in the books is explained in detail. The important thing is that these seminars are not meant to replace accredited training; they are designed to provide some of the more practical information that is often not covered in training courses.

In 2012, we have developed and staged two new seminars – one on the operation and validation of UV disinfection systems for water, wastewater and recycled water, and the other covering calibration and operation of online turbidity meters for reliable process monitoring of drinking water quality. It is fair to say that the information provided by the suppliers, water corporation staff and industry experts has helped clarify a lot of operational, maintenance and calibration issues for all the delegates. Reports after both events indicate that attendance was extremely worthwhile.

A real positive from the turbidity meter seminar is the development of a guidance note outlining all the issues about the installation, operation and calibration of the meters in the workplace to ensure that the data provided is accurate and useful as a process monitoring step. The guidance note has been passed on to the Victorian Department of Health for their consideration and will also be provided to the NHMRC for consideration in future updates of the ADWG.

Looking to 2013, the content for a new seminar covering the operation and maintenance of membrane systems is currently being developed and it is planned for delivery in March 2013.

As winner of WIOA's 2013 Kwatye (Water) Prize, Mark McConnon will be investigating the development of a risk assessment process and procedure for the reconnection of water supplies following repairs to the distribution network. It is hoped that this work may lead to the adoption of a standard practice Australia-wide. This project has also arisen as a result of discussions in the existing WIOA distribution systems management seminar.

It is outcomes such as these that WIOA will continue to pursue – helping to drive best practice from the ground up and developing and implementing systems to ensure that our consumers are protected at all times.

## OUR COVER

**Our cover shot this issue shows East Gippsland Water's Wayne Stewart preparing to enter a sewer access point.**

WATERWORKS
OFFICIAL JOURNAL OF THE WATER INDUSTRY OPERATORS ASSOCIATION OF AUSTRALIA

### Editorial Committee

**Peter Mosse, Editor**
peter.mosse@gmail.com

**George Wall**
george@wioa.org.au

***Direct mail to:***
Peter Mosse
*WaterWorks* Editor
c/o WIOA, 22 Wyndham Street
Shepparton, Vic 3630

### Advertising & Production

Australian Water Association (AWA) Publications, Level 6, 655 Pacific Highway, PO Box 222, St Leonards, NSW 1590



### 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 Peter Mosse, *WaterWorks* Editor, c/o WIOA, 22 Wyndham Street, Shepparton, Vic 3630.

## CONTENTS

# WESTERNPORT'S WATER QUALITY JOURNEY

*Brett Beaumont & Dean Chambers*

Westernport Water (WPW) operates the Ian Bartlett Water Purification Plant (IBWPP) treating a single water supply system sourced from the Candowie Reservoir. The IBWPP is a three-filter, dissolved air flotation filtration plant (DAFF) commissioned in 1988.

In keeping with the concepts of the *Australian Drinking Water Guidelines* (2004) *Framework for the Management of Drinking Water Quality*, WPW decided to automate the IBWPP with the installation of a SCADA control system in 2006. WPW also conducted a fully independent operational review of the plant at this time. With the findings from the review, automation control and the installation of some online monitoring and other physical changes, this paper shows that a 20-year-old plant's performance can be dramatically improved to consistently produce high-quality drinking water.

**Figure 1. The condition of the filters at the start of the project. The top photo shows the heavy accumulation of mud on the surface of the filter and the bottom photo shows mud balls extending about 30–35cm into the media.**

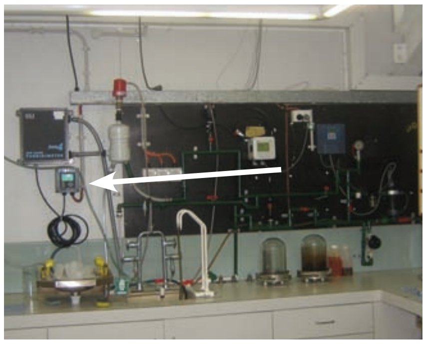


**Figure 2. The old instrument set-up showing the single turbidity meter (arrow).**

At the start of the project, the filters were in poor condition (Figure 1) and monitoring was poor with a single turbidity meter monitoring the final filtered water. It turned out that the water flowing through the turbidity meter wasn't, in fact, from where we thought it was from. There was some sort of cross-connection or backflow occurring in the instrument pipe work (Figure 2).

The following list summarises all the changes and improvements made over a period of about four years.

1. Installation of variable speed control on the raw water pumps to IBWPP.
2. Modification of the PLC to allow the plant to be run on 1, 2 or 3 DAFF filters. The combination of these two changes means the plant can now be run continuously. This has reduced turbidity spikes caused by previous stop-start operation and has reduced the ripening period because a rested filter is brought on line after a backwash in both the 1-filter and 2-filter mode of operation.
3. Installation of individual online turbidity meters to each filter linked to SCADA with performance and shutdown set points. The focus is now on each filter's performance rather than just the final combined filter water. This provides the ability to isolate an individual filter for further investigation if its performance is below that of others. The turbidity meters were installed in the filter gallery very close to each of the sample points.
4. Installation of an online pH meter in the coagulated water with SCADA shutdown if desired set points aren't met, indicating over- or under-dosing.
5. Continuous operation of coagulation flocculation mixing paddles to avoid sludge settling during filter off periods, reducing sludge carryover to the filters from the flocculation tanks on start-up.
6. Removal of floated sludge prior to backwashing a filter and prior to automatic plant shutdown upon treated water storage capacity being met. This helps to avoid any sludge from the float falling and settling onto filter media surfaces and subsequently forming sludge balls in the top media layer, significantly reducing filter performance.
7. DAF level has been increased to run level with weir to reduce filter turbidity spikes during floated sludge removals (Figure 3).
8. A soft start valve on the air scour blower during backwash has dramatically reduced initial violent eruptions of the filter media during the onset of the air scour. This has significantly reduced the likelihood of disrupting the media and filter nozzle damage.
9. The potassium permanganate and powdered activated carbon dosing points were within metres of each other and found to be competing, increasing

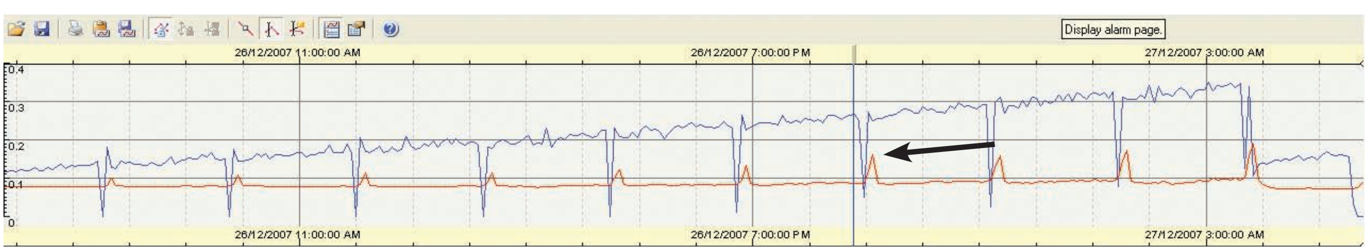



**Figure 3. Trend showing headloss and turbidity. Note the spike in turbidity each time a float occurs (arrow).**

Figure 4. The filter area before (left) and after (right) modifications.

chemical usage. With very little room for physical separation between points and by thinking outside the square, the simple solution was to insert a poly pipe into the raw water main pushing the potassium permanganate dosing point back to the reservoir draw-off as far as possible.

10. Building improvement to fully enclose the filters to protect the floated sludge blanket from outside wind turbulence (Figure 4). Prior to this, the wind caused insufficient floated sludge removal which, in turn, has eliminated pockets of sludge settling onto the filter media surface and forming sludge balls in the top media layer.
11. Installation of an online optical spectrometer analyser (Compass system) monitoring raw water to provide forward coagulation dose control.

As part of the project it became necessary to rebuild the filters, however, this was not a major contributor to the improved performance. Unfortunately, over the years and with lack of attention to their operation, underdrains had become blocked in the same part of each filter. Figure 5 shows the filters after they had been scraped and the area where there were blocked underdrains and nozzles.

Figure 6 shows some trends of filtered water turbidity with performance <0.1NTU.

## Conclusions

WPW had no previous major water quality non-compliances within the distribution system, indicating to the board and senior management at WPW that the IBWPP was in good working order – so why the need for all the works identified; why spend money?

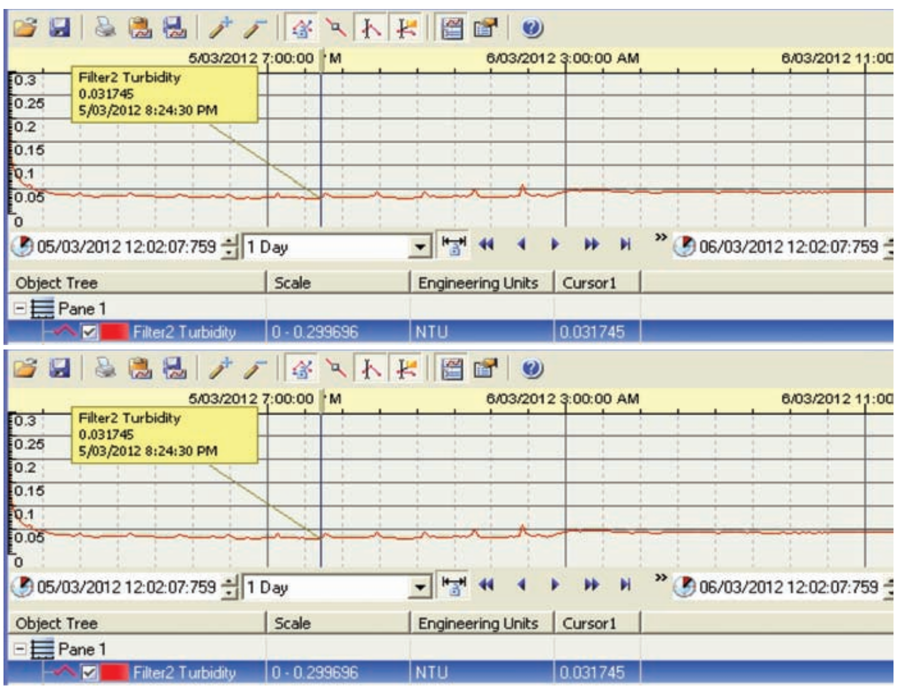



Figure 6. Trend showing filtered water turbidity. The top panel shows a clear spike every time a sludge float-off occurred. The bottom panel shows no or very small spikes only.

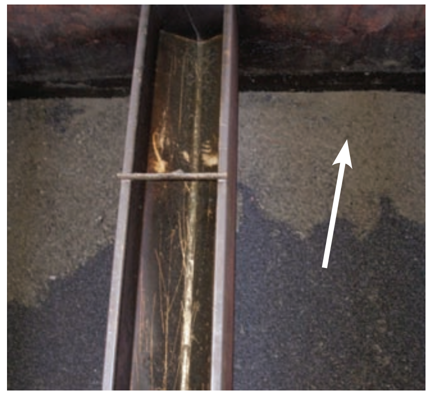


Figure 5. The rehabilitated media in the foreground and the mud-impacted media overlying the blocked nozzles at the back (arrow).

WPW has a commitment to continuously improving drinking water quality, so once this operational review and the concepts of the ADWG (2004) were presented to and fully understood by the board and senior management, it was just a matter of prioritising the works in the most critical order. Still, budget dollars can slow progress, so my advice is to complete thorough risk assessments to fully support your justifications.

Total cost including building enclosure was approximately $200K (excluding the filter rebuilds).

Overall this journey has been a rewarding and invaluable learning experience for all concerned at WPW on the importance of having very good monitoring and control to provide safe drinking water at all times.

## The Author

At the time of preparing the paper, **Brett Beaumont** was Treatment Plant Supervisor at Westernport Water. Brett now works at the Wonthaggi desalination plant. **Dean Chambers** (dchambers@westernportwater.com.au) is Treatment Plant Manager.

## Editor's Note

*The project at the Ian Bartlett Plant continues. In a recent audit, a number of PLC programming problems were identified that were causing high turbidity at the start and end of filter runs and also during float removal of the DAF sludge. Consequently, further changes will be made to the PLC code to rectify these faults.*

*It is important to note that apparently poor performance of many plants is due to silly PLC programming. PLC changes are relatively cheap and can result in major improvements in overall filtered water performance.*

# INSTALLATION, CALIBRATION, MAINTENANCE AND OPERATION OF ONLINE TURBIDITY INSTRUMENTATION

*This paper originates from a one-day seminar organised by WIOA in June 2012 entitled "Calibration and Operation of On Line Turbidity Meters for Reliable Process Monitoring of Drinking Water Quality". The consensus of those attending was that a formal guiding document would be a desirable outcome from the day. This paper is that guiding document. It has been put together with assistance from all of the presenters on the day. My thanks are extended to them for their help and commitment to the project. The guidance document has also been forwarded to the Victorian Department of Health for consideration for distribution as a formal guidance note and will be forwarded to the NHMRC Water Quality Advisory Board.*

*The seminar was a considerable success. Should members in states other than Victoria be interested in running a similar seminar, please contact WIOA.*

***– Peter Mosse, Editor***

## Turbidity and Public Health

Pathogens are the major hazard in water treatment and all treatment should be focused on the management of pathogens (Hrudey, 2004). Pathogens cannot be measured online. Laboratory testing introduces unacceptable delays between sampling and receiving results, which make it unsuitable as a process monitoring method.

Online monitoring of filtered water turbidity is the only *practical* way to monitor "pathogens" in a WTP and to monitor the removal of pathogens. While it isn't perfect, it is the best we have. In general, the lower the turbidity, the lower the pathogen risk to consumers. So it is very important to measure turbidity accurately. Turbidity also shields microorganisms from the effects of chlorine and UV disinfection.

Turbidity is a measure of the light-scattering property of water caused by the presence of fine suspended matter such as clay, silt, plankton and other microscopic organisms. The degree of scattering depends on the amount, size and composition of the suspended matter.

When light is passed into a solution of water with particles in suspension, the light can be affected in different ways.

1. The light may collide with a particle and be scattered;
2. The light may not collide with a particle and pass straight through the sample.

The main potential interferences for turbidity measurement include the presence of gas bubbles and colour. Small bubbles (that may not be visible) may appear as particles and add to the amount of light scattered. Alternatively, large visible bubbles may interfere with the scattered light and cause any measurement to vary. Coloured solutions can also cause absorbance of the transmitted or scattered light. As a guide, colour in filtered water samples with turbidity less than 1.0 NTU do not interfere up to approximately 100 Pt-Co colour units. However, colour at far lower Pt-Co values will result in greater measurement interference as the turbidity increases above 1.0 NTU.

Powdered Activated Carbon (PAC), used commonly in water treatment, can also have an impact on turbidity measurements. Since the carbon particles are black they will absorb light, hence less light will scatter back to the detector, producing an artificially low result. The maintenance and cleaning regime in place can also impact on the accuracy and precision of the reading.

## Approved Methods for Measurement of Turbidity

There are three light sources that can be used in turbidity instrumentation: white light, infra red and laser. Examples of approved methods for each of the light sources are respectively:

- USEPA method 180.1;
- International Standard ISO 7027 (1999);
- USEPA approved Hach Filtertrak 10133.

**Table 1. Comparison of USEPA 180.1, ISO 7027 and USEPA-approved Hach Filtertrak 10133 methods. The entries in this table relate to online meters that are operating continuously.**

| | USEPA 180.1 (APHA-AWWA) | ISO 7027 | Hach Filtertrak Method 10133 |
|---|---|---|---|
| Light Source | White light tungsten<br>Filament temperature between 2200–3000K<br>Intensity varies over time | Infrared LED | Laser diode |
| Wavelength | 400–600nm | 860 ± 30nm | 660nm |
| Detector | Scattered light detected at 90 ± 30° centred at the detector | Scattered light detected at 90 ± 20-30° centred through the axis of the sample | Scattered light detected at 90° |
| Measurement Range | 0.01–100 NTU | 0.001–1,000 NTU | 0.0001–5 NTU |
| Characteristics | More sensitive to smaller particles. White light is more effectively scattered by small particles. | Less sensitive to smaller particles | Increased sensitivity Detection of submicron particles |
| | Sensitive to colour interference | Low colour interference | No colour interference under 50 PtCo units |
| Typical Lamp Replacement Interval | 12 months.<br>Lamp intensity varies over time. | 12 months–2 years | 2 years + |

The AWWA-APHA Method 2130B is equivalent to the USEPA 180.1.

A brief comparison of the most commonly referenced approved methods of determining turbidity is provided in Table 1.

## Turbidity Meters

The basic principle common to all turbidity meters is that the intensity of the scattered light is measured at 90° to the light path. While still retaining this fundamental configuration, modern instruments have been designed to provide improved performance and to limit the impact of interferences. Modifications include, but are not limited to:

- Differences in light source, intensity and lamp stability;
- Differences in window slit width, angle of reflected light detected in relation to the angle of incident light, sample compartment width and detector types used.
- Technologies used to overcome interferences. For example *Ratio* versus *Non-Ratio* methods, modulated 4-beam designs and surface scatter designs.

### Single Beam Design

The single beam configuration is the most basic turbidity meter design using only one light source and one photodetector located at 90° from the incident light. The single beam design is the oldest of the modern turbidity meters and typically is used with a polychromatic tungsten filament lamp. The design is still in wide use today and yields accurate results for turbidity under 40 NTU provided the water has little natural colour.

The other type of single beam turbidity meter is one that uses a laser diode light source coupled with fibre optic technology to convey the scattered light signal to the detector. The high power source and very sensitive detector combine to produce a strong signal even at the lowest of turbidity levels.

The optimisation of the optical components results in an increase in sensitivity of more than two orders of magnitude over the sensitivity that is achieved with the conventional tungsten or infra red turbidity meters.

### Ratio Design

In a ratio turbidity meter, an additional detector is set at 180º to the incident light to measure the amount of light transmitted through the sample. The instrument then corrects the turbidity measurement for the amount of transmitted light and scattered light. The Ratio method combines transmitted light measurement and scattered light measurement and can help to overcome problematic samples such as those with very high turbidity and colour.

As well as detectors at 180º to the incident light, instruments may have additional detectors such as forward and backscatter detectors to achieve more reliable measurements.

- Backscatter turbidity meters measure the scattered light at a backscatter angle between 30º and 40º to the incident light beam. These are typically used for high turbidity samples *above 1000NTU.*
- Forward scatter occurs most frequently in turbidity above 40NTU with colour present and uses a detector between 30º and 40º to the detector.

### Units of Measurement

The main units that are likely to be encountered in the water industry are:

- **NTU** = Nephelometric Turbidity Unit Scattered light measured at 90° according to USEPA method 180.1 and section 2130 of the "Standard Methods for the Examination of Water and Wastewater", 22nd edition, 2012;
- **FNU** = Formazin Nephelometric Unit Scattered light measured at 90° according to EN 7027. This unit is only applicable if the instrument is calibrated with formazin standards.

NTU and FNU are equivalent (1:1) but are derived from different measurement techniques, and depending on the sample matrix, measurements via the USEPA 180.1 method (measured in NTU) and measurements via the EN ISO 7027 method (measured in FNU) may vary in the results recorded.

**Table 2. Turbidity meters for different applications.**

| Application | Turbidity Function | Meter Selection |
|---|---|---|
| Raw Water | Monitoring & Process Control | IR with wiper |
| Clarification | Monitoring & Process Control | IR with wiper |
| Filtration | Monitoring & Process Control | White light (Monitoring); FT660sc (Monitoring & Process) |
| Discharge Point to Distribution System | Compliance Only | White light |

## Recommendations for Installation of Turbidity Meters

- Only meters based on an approved method of measuring turbidity should be used.
- The same turbidity meter might not be the best option for all monitoring points e.g. raw water, clarified water and filtered water (see Table 2).
- Sample lag time should be minimised by using small diameter tubing and installing meters as close as possible to sample points. As a guide, the time from sampling to measurement should be < 5 minutes.
- Sample tubing should be rigid or semi-rigid and a minimum of 4mm inner diameter to prevent clogging.
- Sample lines should be made of polyethylene, polypropylene, nylon or teflon-lined.
- Sample lines should be opaque to limit growth of biofilms on the pipe wall.
- Meters should be installed in a vertical position, free from vibration, ambient light and excessively wet environments.
- Meters should be installed out of direct sunlight and, if situated outdoors, weather protection should be provided. At a minimum, this should constitute a sun hood but preferably a closed ventilated cabinet.
- Temperature should always be between 0-40˚C with an optimal range of 15-30˚C. If in doubt, follow the manufacturer's ambient temperature specifications.

### Sampling

- Sample spears should extend in to a minimum of one-third the diameter of the pipe.
- Sample flow rates should be as per the manufacturer's recommendations. Note that in a static head feed, the driving head will drop towards the end of a filter run such that flow can decrease to zero. Installation must ensure this does not happen.
- Sample flow should be able to be monitored.
- An air break should be provided on the discharge line so that the flow from the instrument can be easily seen and measured. Piping the discharge directly to a pipe or drain, while apparently neater, hinders critical observation.
- Flow switches are recommended for critical monitoring locations such as filter monitoring. These should be situated downstream of the meter and set to

generate an alarm on SCADA when flow drops below a minimum level.

- If pumping is required, ensure that the type of pump and installation does not adversely affect the floc and alter the turbidity reading.
- The sample line should be free of obstructions such as filters or as much as possible 90º bends.

### Degassing

Air bubbles (and sometimes other gases, for example, carbon dioxide in groundwater applications) interfere with measurement of turbidity, particularly in *low-flow* turbidity meters. Samples must be effectively degassed prior to measurement. In general the manufacturer should be consulted as to how to install the unit to eliminate the potential for degassing and, therefore, interference from bubbles.

Not every application will call for degassing, however, if it is required and the turbidity meter is not factory-fitted with a bubble trap, external bubble traps can be obtained off the shelf, or fabricated in-house, and can be adapted to any flow type turbidity meter. Any installation should be the smallest possible volume so that there is no significant increase in sampling delay.

Note that for high-flow turbidity meters such as the Hach Ultraturb and ABB standard infra red unit, bubble traps should not be fitted. These instruments rely on high flow and pressure to keep the air in solution. If a de-bubbler is installed, the problem is, in fact, aggravated. These units must be installed exactly as the manufacturer specifies.

### Cleaning

The manufacturer's instructions and recommendations for cleaning should be followed.

As a general guide, turbidity meters should be inspected, at a minimum, weekly and cleaned if required. More frequent cleaning will be required where there are high Mn, Fe, Ca, Mg or high DOC levels. Cleaning can be carried out with a soft, lint-free cloth. If there is evidence of fouling, a cleaning agent as recommended by the manufacturer should be used.

Remember, measurement of turbidity is an optical measurement and clean, scratch-free surfaces and clean sample compartments and sample lines are absolutely critical for plausible readings.

### Calibration

Calibration, verification and cleaning should be conducted as per specific manufacturers' recommendations.

### Primary Standards

The primary standard for all turbidity meters and stated in each of the approved methods (USEPA 180.1, EN ISO 7027 and Std Methods 2130B) is formazin. Formazin is a suspension made by mixing together solutions of hydrazine sulfate and hexamethylenetetramine with ultra pure turbidity-free water. The resulting solution is left for 24 hours, at 25°C ±3°C, for the suspension to develop. This produces a suspension with a turbidity value defined as equal to 4000 NTU/FTU/FNU. While turbidity standards can be produced by dilution of this standard with turbidity-free water, excellent laboratory skills are required to obtain reproducible and accurate results.

While formazin is non-toxic, one of the raw ingredients (hydrazine sulfate) used to prepare formazin is toxic.

For these reasons, the use of commercially prepared traceable stabilised formazin standards is recommended. Where used, the shelf life and storage requirements should be adhered to.

### Other Standards

The USEPA Method 180.1 recognises an alternate primary standard, AMCO-AEPA-1® microspheres (styrene-divinylbenzene copolymer), however, these standards are only cited as secondary standards in the EN ISO 7027 method. SDVB microspheres are commercially available from a number of suppliers.

The AMCO-AEPA-1 Standards have a minimum shelf life of 12 months and are typically available in ready-to-use diluted NTU/FNU concentrations of 0.02, 10.0, 1000, 1750 and 10,000 NUT/FNU.

These standards are instrument-specific and cannot be used universally. Many manufacturers may not recommend SDVB standards as a general calibration standard on their respective instruments. The manufacturer's calibration instructions should be consulted to see whether these standards are appropriate.

Calibration is typically carried out at 20 NTU. This may seem strange when measurements are required to be <0.2 NTU. There are two reasons for this:

1. A linear relationship exists between turbidity and nephelometric response up to 40 NTU;
2. Higher turbidity standards can be made up with less error. So small amounts of error in a 20 NTU standard will not affect accuracy of low-level measurements, however, the same error in low turbidity standards will greatly affect the accuracy of low-level measurements.

All instrument manufacturers should stipulate a primary standard calibration protocol and this should be implemented in the maintenance/calibration schedule for the meter.

### Secondary Standards

These are standards that a manufacturer has certified to give instrument calibration results equivalent to results obtained when an instrument is calibrated with user prepared primary standards (within defined tolerances). They must be traceable to a primary formazin standard.

Some examples include Gelex standards and ICE-PIC verification modules. Certified low-level formazin standards such as 0.3, 0.5 or 1.0 NTU are also available.

Secondary standards can only be used to check or verify calibrations. They cannot be used for calibration that complies with the approved *methods.*

### Zero Calibration

Zero NTU is defined as zero nephelometric light detected by the measuring system. This is generally only achieved when the incident light is turned off.

In water, light interacts with molecules to produce very low levels of scattering.

Therefore, even the purest solutions will never have zero turbidity, due to molecular scattering. In low-level measurements, a small portion of the measured turbidity results from molecular scatter. Using current technologies specified by regulatory agencies, particle-free water has an estimated turbidity of 0.010 and 0.012 nephelometric turbidity units (NTU).

Most manufacturers do not require the instruments to be zeroed with a zero sample. Individual manufacturers' manuals should be consulted regarding zero calibration.

### Verification

Verification should only be carried out using in-date secondary standards in excellent condition.

Verification should *not* be carried out using hand-held instruments, and online instruments should not be adjusted or calibrated based on comparisons with hand-held instruments.

A well-maintained dedicated laboratory meter could possibly be used, however, it is worth noting that the USEPA does not recommend calibrating an online meter by comparison with a bench *or* hand-held turbidity meter.

Any secondary standards held at the site or used at the site should be checked at the time when primary calibration is carried out and the "new" correct values noted.

#### Calibration and Verification Intervals

Not all instrument manufacturers recommend calibration/ verification intervals, as this is an unknown variable based on hours of use, the age of the lamp (in particular tungsten lamps that age more quickly), sample type and maintenance practices.

Ideally the calibration and verification intervals should be addressed in water quality risk management plans and based on historical data of turbidity meter stability and critical nature of the application.

However, as a general guide a calibration "check" (using a Secondary Standard or comparison to a calibrated laboratory bench instrument using the same methodology) should be carried out at a minimum interval of one week. If the verification indicates significant deviation from the standard value (e.g. greater than ±10%) then the instrument should be thoroughly cleaned and recalibrated using a primary standard.

To ensure independence, an annual calibration should be conducted by a registered external entity. Should a calibration be identified as necessary based on a verification check prior to the annual calibration, that calibration can be carried out by utility staff.

#### Comparison of Readings from Different Turbidity Meters

In general, comparison between different types of instruments should be avoided. Specifically:

- DO NOT use portable hand-held instruments to verify or calibrate online instruments. DO use quality-controlled secondary standards;
- DO NOT expect comparable results from instruments utilising different measurement technologies on the same sample type;
- DO NOT expect comparable results from instruments conforming to different standards (e.g. USEPA versus ISO 7027). Variations should be expected;
- Expect variations in measurement if the same instrument has been calibrated with different Standard types (ie. Primary versus Secondary Standards);
- If using laboratory bench-top instruments to spot-check online instruments, match the standards that they conform to (ISO 7027 or USEPA 180.1) and try to match the specifications and technologies employed for measurement. Under these conditions, verification is OK if the method is validated and tolerances applied and the laboratory benchtop instrument is traceable and calibrated to approriate norms.

### Representation of Turbidity Readings on SCADA

Most turbidity data is taken from SCADA systems. Therefore, it is important that the value recorded on the SCADA system is the same as the value registered by the turbidity meter.

- Ensure that the analyser 4-20 mA output span matches the PLC/SCADA expected digital input;
- Check that the SCADA display faithfully represents the instrument display.

### Data Analysis

Long-term analysis of individual filter turbidity data is now a requirement of the ADWG. SCADA systems need to be set up to allow extraction of meaningful data. Many systems are limited by how much data can be downloaded.

Turbidity should be sampled at an appropriately short interval to allow detection of a developing problem. As a general guide, sampling and analysis of long-term trends should be carried out at no longer than one-minute intervals.

### Signal Averaging

Turbidity meters have a signal averaging function. Signal averaging aims to reduce the fluctuations in turbidity due to foreign bodies or air bubbles and thereby provide a less "noisy" signal.

In most instruments, the signal averaging time can be set. For example, one instrument provides options for no averaging, 6 seconds, 30 seconds, 60 seconds and 90 seconds averaging with a default factory setting of 30 seconds. The signal averaging is a rolling average. So, for example, if the signal averaging period is 30 seconds, the instrument provides a new 30-second average each second thereby providing an essentially continuous readout.

- In setting up a turbidity meter for monitoring of filter performance, the signal averaging time should be less than one minute.

### Response Time

Turbidity meters also have a response time. This depends on both the signal averaging time and the volume and flow rate through the instrument. At any given flow rate it takes a finite time to flush out the volume of water in the instrument. Longer signal averaging times could also increase the response time. Therefore, in the case of a discrete step change in turbidity, it may take up to four minutes to accurately reflect the new value. Different instruments are likely to have different response times.

# UV DISINFECTION SEMINAR FOLLOW-UP

*In April 2012, WIOA hosted a seminar in Melbourne entitled "Operation and Validation of UV Disinfection Systems for Water, Wastewater and Recycled Water". As more utilities consider the use of UV disinfection to provide an extra barrier to protozoan pathogens, common questions and problems arise. The aim of the workshop was to address these issues. As usual, time got away from us at the end. One of the closing segments I had wanted to run was to set a scenario and get each of the presenters to give their thoughts and advice. So instead of doing that in the seminar, we submitted a scenario to a number of the presenters so that we could publish their responses.*

*The seminar was a considerable success. Should members in states other than Victoria be interested in running a similar seminar, please contact WIOA.*

**Peter Mosse, Editor**

### Scenario

As operations manager for a water utility I have responsibility for the operation of a 10 ML/d DAFF WTP, which operates intermittently with as many as 12 stop-starts per day.

Raw water is sourced from a reservoir with turbidity typically 2 to 15 NTU and True Colour 25 to 70 Hz. There have been two significant dirty water events in the past, with turbidity going to 150 NTU and colour 300 Hz. Turbidity and colour do tend to come up after heavy rain.

There is no UVT or DOC data. There have been a number of Mn events where soluble Mn has gone as high as 1.1 mg/L. There are no problems with Fe. The water is treated with alum as the sole coagulant.

There are cattle in the catchment. Filter performance is OK, but definitely not down to 0.1 NTU consistently – it averages, say, 0.15 to 0.25 NTU. As the ops manager, I am aware of *Cryptosporidium* and my concern is mainly for an additional barrier for crypto. I am considering UV disinfection.

What additional information do I need to provide you with to allow you to provide good advice, and what system would you recommend and why?

The intention is to continue to post-chlorinate to maintain a distribution system residual. I have heard about validation but don't really know that much, however, the CEO and Board think we probably should have some sort of validation. I am prepared to wait a bit to collect some data if necessary to help ensure I get the most appropriate system.

### Graham Smith from Berson/Hanovia replies:

Thank you for your enquiry. In order that we may correctly size the most suitable system for your needs, I have the following questions and comments regarding your application.

A UV disinfection system can only be correctly sized if we know the instantaneous maximum flow rate of the water to be treated. For this reason, can you please provide this flow rate? This is typically provided as litres per second, litres per minute or cubic metres (i.e. thousands of litres) per hour.

For example, if a 10 ML/d plant had a consistent flow over a 24-hour period, this would equate to an instantaneous flow of 116 l/sec or 417 $m^3$/hr. The maximum instantaneous flow rate is important as it governs the length of time the pathogens in the water are exposed to the UV radiation that will potentially inactivate them.

It is also important that we address the issue of 12 start-stop cycles per day. This is a large number of cycles and will need to be accounted for, not only with the selection of the most appropriate UV system, but also with the control philosophy of the plant. One way of accommodating this number of cycles would be to leave the UV system lamps constantly on. This would have the following advantages:

1. Lamp life would be extended as the more frequently UV lamps are power cycled, the lower their life expectancy. This, however, needs to be traded off against the lamp life being unnecessarily consumed when no water is flowing through the UV system.
2. The UV system would always be ready to disinfect as soon as water started flowing through it. If the UV system needed to be started prior to each of the 12 cycles, it would need to go through a warm-up period of approximately five minutes prior to peak disinfection performance being reached. This would need to be accommodated by either simply leaving the water "static" within the UV system during the warm-up period (in which case there may be a risk the system will overheat), or diverting (or circulating) water through the UV system during the warm-up period.

On the other hand, some of the challenges posed by leaving the UV system constantly "on" include:

3. Higher power usage. Power is wasted during the "no flow" period of the 12 cycles.
4. Depending on the number of lamps and/or if the UV system is using low- or medium-pressure lamps, the UV lamps may overheat the water during the "no flow" period, causing the UV system to automatically shutdown.

A further consideration that must be taken into account is the nature of the flow during the disinfection cycle. If the flow rate through the UV system rises gradually to a peak and then gradually falls to a stop, we recommend that the UV system operates at full power at all times. This is because if the UV system "flow paces" its power to match the flow, the UV system runs the risk of being unable to keep pace with the increasing rate of flow at the start of the cycle. As a result, it may "under-dose" as it fails to ramp the power quickly enough to accommodate the ever-increasing flow rate.

I see your water quality data refers to the true colour and turbidity of the water. While the ADWG makes reference to turbidity as a parameter to be considered when utilising UV disinfection, it is in fact the UV Transmissivity (UVT) of the water that is required to correctly size a UV system. UVT takes into account all water quality parameters (including colour and turbidity) that will affect the performance of a UV system.

Furthermore, it is important that the minimum UVT reading is determined in order that the UV system be sized according to a "worst case" situation. As such, UVT data over a prolonged period should be gathered in order that the minimum UVT be accurately ascertained. Should you not have a UVT monitor or analyser, they can be purchased from many UV suppliers. Indeed, on-line UVT monitors can be purchased along with your UV system so that a real-time UVT feed can be supplied to the UV system controller. This will facilitate an accurate calculation of UV dose.

It is important to supply water to the UV system that has no more than 20 mg/l of suspended solids. Any more than this will lead to a phenomenon known as "shielding", where pathogens are shielded from the UV light by the suspended solids in the water and inadequate disinfection may result. As such, particular attention should be paid to the filtration system prior to the UV.

The somewhat elevated levels of Manganese you have specified as being present in the water may (in time) result in a black deposit on the quartz sleeve of the UV system. There is no definitive level of Manganese in the water that will result in deposition, as it depends on a variety of both physical and chemical properties of the water being treated. Suffice to say that an auto wiper and UV intensity monitor should be fitted to the UV system.

While the wiper will keep the quartz sleeves from fouling, it will only have limited effectiveness in clearing the manganese deposit from the sleeves. The UV intensity monitor will alert you to any drop-off in UV intensity, at which time the quartz sleeves should be inspected and, if necessary, cleaned with a dilute citric acid solution.

If the sleeves are severely affected, thorough cleaning may be impossible and they may need to be replaced.

Pre-validation of UV systems is something that is increasingly being called for by water authorities both in Australia and throughout the world. While this provides surety to authorities that a UV system will achieve a particular disinfection result, it also potentially results in unintended drawbacks. Not only are pre-validated UV systems expensive, they also potentially lack the latest innovations. This is because the validation process requires a UV system to be delivered exactly as it was validated.

As new innovations are developed that improve the performance of UV systems, these same innovations potentially invalidate UV systems unless the UV system possessing them is once again validated.

Because the validation process itself is so expensive and time consuming, it is impossible for UV suppliers to be continually re-validating systems as every new innovation is introduced.

Perhaps in time this anomaly will be addressed by the validating authorities. Until then, a possible compromise may be for water authorities to utilise UV systems that have been fundamentally validated, while accepting that the innovations that have been included since validation improve rather than diminish the performance of the system.

# OPTIMISING DEWATERING AT PIMPAMA WWTP

*Mark Wilson, Joel Warnes, Charlie Suggate, Lee Davies & Dion Sleep*

Operation of the Gold Coast City Council Pimpama Wastewater Treatment Plant (WWTP) (Figure 1), commissioned in September 2008, showed sludge dewatering and removal costs represented approximately 20% of operating costs. As a result, these have become a prime focus for optimisation activities.

The Pimpama biological treatment process is currently loaded at one third of capacity; the bioreactor is operated at an exceptionally long sludge age to bring the solids concentration up to an acceptable level, averaging 2700 mg/L. Bioreactor mixed liquor is wasted directly onto belt presses with an integrated gravity section. Powder poly is batched and dosed at an average rate of 2.6 kg poly/dry tonne solids (kg/dt).

The dewatered cake total solids have averaged 14.3%, which is acceptable in comparison with other installations; however, the solids capture rate has been exceptionally poor at 73%, failing the performance criteria specified for this equipment.

To optimise dewatering performance it is essential to accurately measure the applied poly dose. This requires measurement of the:

- Sludge flow rate
- Sludge concentration
- Poly flow rate
- Poly concentration

The sludge flow rate is measured with magnetic flow meters. The sludge concentration is measured daily and changes only slowly due to the large volume of the bioreactor. However, measuring the poly flow rate and concentration was problematic.

Figure 1. Aerial view of the Pimpama WWTP.

Figure 2. The problem calibration cylinder.

The plant designers had elected not to install poly flow meters and instead estimated the poly flow rate from the speed of the positive displacement dosing pumps. This required drawdown tests to measure the flow rate at different pump speeds and the calculation of regression parameters defining the relationship between pump speed and flow rate. The calibration cylinder was installed at a height that made it only possible to fill when the batching tank was nearly full (Figure 2), being approximately 15 minutes out of every two hours, making it inconvenient and time consuming to perform drawdown tests. When these calibrations were performed it was found that the plant commissioners and control system programmers had confused the pump speed units of percentage with Hz, and consequently the pump was delivering half the dose that the control system calculated.

In the semi-continuous poly batching system that had been installed, poly overflowed from the batching tank into the dosing tank, rather than comprising separate batching and dosing tanks. When this system batches, the powder poly is added for only a fraction of the time that

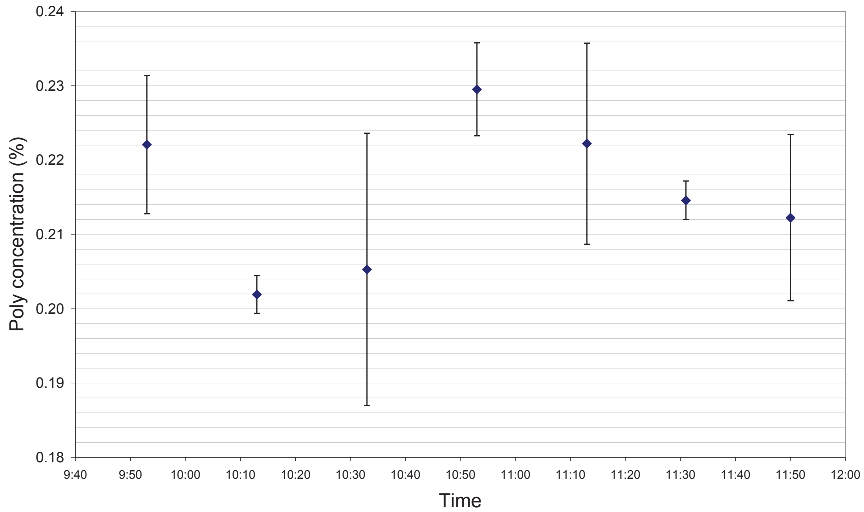



**Figure 3. Variation in poly solution concentration. The values are the mean and standard deviation of three replicate samples.**

the make-up water is added, resulting in the plug of high-concentration poly flowing through the system, despite the presence of mixers. The concentration of poly being drawn from the system was measured at intervals, while a volume equivalent to one batch was drawn from the system. The results, presented in Figure 3, confirm that the concentration of poly varies, on average, between 0.202% and 0.228%.

Our poly supplier advised there was a possibility that alternative polymers could improve the dewatering performance, in particular the poor solids capture rate. We agreed to investigate this line of enquiry by performing an initial jar test screening followed by full-scale belt press trials if a promising alternative poly was identified.

## Poly trials

Initial screening carried out by the supplier identified one alternative powder poly with the same cationic charge but a higher molecular weight, and one cross-linked liquid poly that displayed good flocculating performance in the jar.

It was believed that the poor capture rate was caused by shallow cake thickness with a substantial proportion of solids becoming enmeshed in the belt, sliding under the doctor blades and being washed off into the filtrate. Lab-scale testing using a small sample of belt demonstrated that less sludge stuck to the belt when flocculated with the liquid poly, raising the likelihood that this poly may improve the capture rate to an acceptable level.

The alternative powder poly was batched and dosed over the course of a three-day trial. The batching equipment onsite was unable to batch liquid poly, so it was initially batched in a 1000L container for a one-day trial, then in a portable liquid batching system for an extended one-week trial.

For each dose rate, three samples of dewatered cake and three samples of filtrate were collected and analysed for solids concentration. Feed solids concentration was measured once per day as it does not vary significantly over the course of several hours.

There are many settings on a belt press that can be varied, including belt speed, sludge feed flow rate, belt tension, dilution water flow rate, poly injection location and poly dose rate. Our strategy was to keep these settings as constant as possible with the exception of belt speed and poly dose rate. Trials were conducted at the normal belt speed setting of 50%, and at reduced belt speed settings as low as 25% to produce a thicker cake, based on the theory that the capture rate could be improved with a thicker cake that clung together, rather than becoming enmeshed in the belt.

## Results

The dewatered cake produced by the alternative powder poly was not significantly drier than the baseline. The capture rate with the alternative powder poly was a couple of per cent higher at a higher poly dose rate, but not high enough to be considered adequate. No further results are shown.

The results from the liquid poly trial are presented in Figure 4, showing both cake solids and capture rate as functions of poly dose rate. This data includes both normal belt speed and slow belt speeds.

Figure 4 reveals that the capture rate can be lifted above 90% at dose rates greater than 10.5 kg/dt. At this dose the cake solids are likely to be approximately 15.0% – 15.5%. These results were achieved at a slow belt speed. The results measured at 8.1 kg/dt were also of interest, being 87% capture rate and 15.4% cake solids. These results were achieved by heavily loading the belt press to achieve a thicker cake. It was interesting to observe that results measured at higher dose rates did not achieve better results unless the belt press was heavily loaded.

Therefore two scenarios were carried forward for costing:

- Poly dose of 8.1 kg/dt, achieving 15%

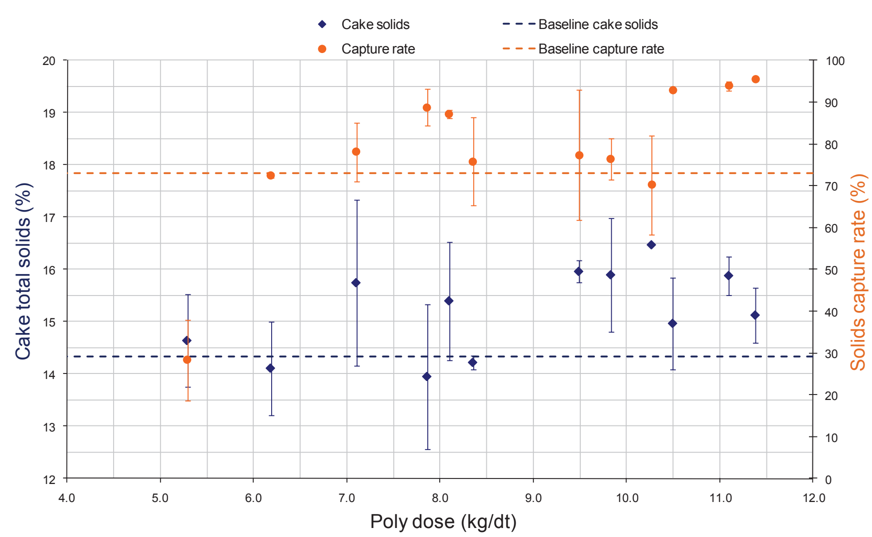



**Figure 4. Results of the liquid poly trials.**

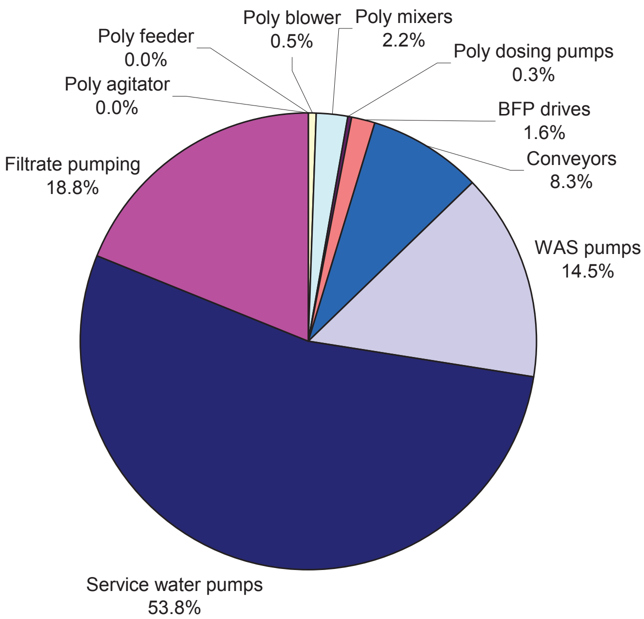



**Figure 5. Dewatering equipment electricity consumption breakdown**

cake solids and 87% capture rate.

- Poly dose of 10.5 kg/dt, achieving 15% cake solids and 93% capture rate.

As previously stated, the baseline powder poly performance from historical data was:

- Poly dose of 2.6 kg/dt, achieving 14% cake solids and 73% capture rate.

## Cost analysis

The scenarios were costed on the basis that each produced the same mass of dry solids for offsite haulage. Therefore, the liquid poly scenarios required less run time to achieve the same dry solids production due to the improved capture rate.

To determine whether switching to liquid poly permanently would reduce costs it was necessary to perform an analysis of total dewatering costs, including:

- Biosolids haulage
- Poly
- Maintenance
- Electricity

Maintenance costs can be further broken down into corrective and preventative categories. Reduced run hours will r educe the wear on the machines and reduce the frequency of corrective maintenance requirements. Preventative maintenance, performed monthly and six monthly was assumed to be unaffected by reduced run hours and has been excluded from this analysis. An estimate of corrective maintenance costs per run hour was made by accounting for all spare parts and labour spent on the machines over the previous 3.5 years of service.

Electricity costs were calculated taking into account service water pumps for spray bars, filtrate pumping, belt press drives, sludge feed pumps and poly batching and dosing. Both peak and off-peak electricity rates were captured by these calculations.

Corrective maintenance costs were calculated to be approximately $2.50 per run hour.

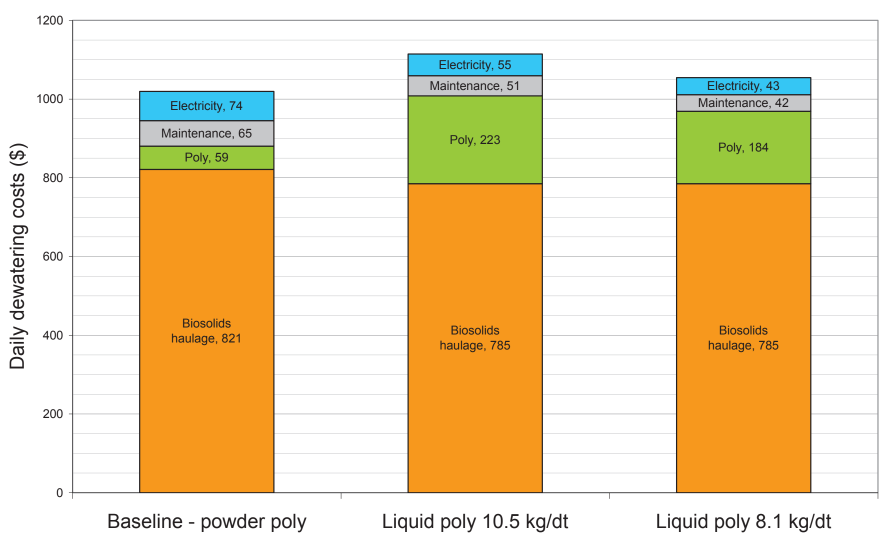



**Figure 6. Total dewatering costs scenario comparison.**

The electricity consumption breakdown for dewatering equipment is presented in Figure 5 and shows that over half the electricity is consumed by the service water pumps to provide cleaning of the belts. The belt press drive constitutes less than 2% of dewatering electricity consumption.

It was calculated that baseline total daily dewatering costs were approximately $1000, as shown in Figure 6. By comparison, the scenario of liquid poly dosed at 10.5 kg/dt was calculated to cost approximately $1100 per day – reduced costs for electricity, maintenance and biosolids haulage were more than offset by the increased expenditure for poly. The scenario with liquid poly dosed at 8.1 kg/dt was calculated to cost approximately $1050 per day.

The greatest degree of uncertainty in the costing is likely to be caused by uncertainty of the cake solids achieved under the liquid poly dosing scenarios. It can be seen in Figure 4 that the error bars are quite large and indicate that the cake solids could be anywhere between 15% and 16%. The previous costing used 15% to be conservative, but to test the sensitivity of the costing to cake solids, the costing has been recalculated using a cake solids of 16% for the liquid poly scenarios.

Electricity, maintenance and poly costs remain the same, but biosolids haulage costs reduce for the liquid poly scenarios. The liquid poly scenario dosed at 10.5 kg/dt is now only 5% more expensive than the baseline and the 8.1 kg/dt scenario is approximately equivalent to the baseline.

## Conclusions

Based on the total dewatering costing, it was determined not to proceed to liquid poly dosing permanently. The liquid poly dosing costs would need to be substantially lower than the baseline to justify the capital expenditure required to install liquid poly batching equipment.

A substantial increase to the biosolids haulage rate in the future would make the use of liquid poly more attractive and may alter the outcome.

## The Authors

**Mark Wilson** is a Process Engineer – SEQ Water (formerly Gold Coast Water), **Joel Warnes**, **Charlie Suggate** and **Lee Davies** are Operators, and **Dion Sleep** is a Supervisor, all with Gold Coast Water directorate of Gold Coast City Council.

# INCREASED BIODIVERSITY AT JUNEE WWTP

*Micheal Summerell, Sheree Shuttleworth & Will Barton*

Junee is a rural town with a population of over 4000 located midway between Sydney and Melbourne on the main Southern railway. The surrounding countryside is cropped with wheat and canola and is some of the most productive cropping country in New South Wales.

The town is serviced by a gravity-fed treatment plant comprising an old Trickle Filter plant built in the late 1930s and a Pasveer Channel built in 1977 (Figure 1). The total capacity of the treatment plant is 4700 EP and is currently running close to its limit. The Junee Correctional Centre (population 800) has its own pumping station feeding to the treatment plant, as does the local abattoirs (domestic waste only).

### Treatment Plant

Prior to 1997, a small amount of effluent was piped to the Junee Golf Course, however, this accounted for little in terms of total volume reused. The effluent was piped directly from the third tertiary pond to a holding dam located on the golf course. The remaining effluent was discharged to Houlaghans Creek.

The land surrounding the Wastewater Treatment Plant (WWTP) is predominantly agricultural with cropped and grazed paddocks adjoining three out of four boundaries (Figure 1). This monoculture type of environment is limited in its capacity to support biodiversity, with many species relying on remnant vegetation along roadsides and on rural properties for food and shelter.

The introduction of load-based fees on Environment Protection Licences under the *Protection of the Environment Operations Act 1997*, forced the Council to examine alternative options for disposal of treated effluent. The decision to expand and diversify the reuse of treated effluent to limit fees was made.

The reuse expansion project began in 1997 with the construction of a 140ML storage dam (Figure 1). The dam's capacity represented approximately half of the annual flow into the WWTP and would, when also taking into account ongoing inflows, store sufficient effluent during the cooler months of autumn and winter to be used for irrigation on the High School oval and the Junee Golf Course over the hotter months of spring and summer.

Algae (mainly diatoms) quickly colonised the storage pond and provided the foundation for the establishment of a thriving local ecosystem. Micro and macro fauna such as fly larva, molluscs, mud eyes, grubs and worms quickly followed the algae. In an attempt to establish a balanced ecosystem, the storage pond was stocked with 1000 silver perch, 1000 Murray cod and 1000 golden perch.

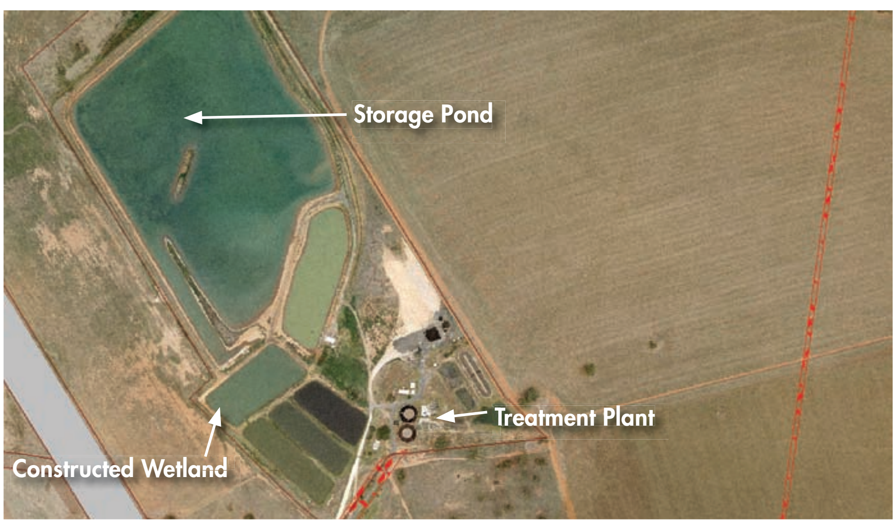



**Figure 1. The Junee Wastewater Treatment Plant.**

In 2000, the pond was full and was already home to a vast array of wildlife. Council saw this as an opportunity to further enhance biodiversity within the local environment and planned several projects to better accommodate the birds frequenting the area.

**Figure 2. Grey teal inspect their nesting boxes.**

In 2002, a group from Conservation Volunteers Australia undertook several projects including the construction and erection of five nesting boxes (Figure 2), a floating pontoon and a fox-proof fence. The aim of the project was to provide safe nesting habitat for some species of ducks and swans and to protect turtles' eggs from being preyed on by foxes. Although it took some years, the nesting boxes now see a number of species such as grey teal using them throughout the year.

The group also planted a mixture of 200 native trees and shrubs around the nesting boxes and down a small stretch of land separating the inlet channel from the main storage. The aim of the planting was to create sufficient habitat to support the food chain between the micro and macro fauna and the larger birds of prey. This small area of native scrub continues to play an important role as a refuge for native animals. Annual tree planting projects continue to enhance the habitat, creating an environment recognised as favourable habitat by many bird species. Over 40 species of birds have been spotted, from ducks and moorhens to crakes and rails, herons and ibis, spoonbills, avocets and the Hoary Headed Grebe!

In early 2003, Council put forward a proposal to the Environment Protection Authority to expand reuse of treated

Figure 3. Black swans now breed successfully in the storage ponds.

effluent to include Willow Park, Loftus Oval and Burns Park (our main sporting fields). Once approved, the Council now had the capacity to irrigate all the major sporting facilities with treated effluent, providing a safeguard against drought and nearly entirely eliminating discharges to the environment.

2003 also saw drought take a stranglehold on the region. However, the damage to our sporting facilities and the social impact from this drought, when compared to neighboring towns and councils, was minimal. This assurance was provided at minimum cost when compared to irrigating with potable water, the latter being approximately double the cost and subject to considerable restrictions on its use.

There was also a significant environmental benefit realised during this time of drought. The storage pond and surrounding environment became an important refuge for birds and other animals in the area. Although the water level in the pond varied considerably, it never completely dried up and, therefore, continued to provide food and shelter for many bird, amphibian and reptile species.

Prior to the drought, a flat island in the middle of the storage pond was regularly inundated as the storage reached top water level. When this occurred, considerable amounts of manure, deposited by roosting birds, would be washed into the storage, leading to heightened suspended solid and nutrient levels. The nests of ground-roosting birds such as the black swan would also be inundated, despite the birds' best attempts at elevating the nests. This would often result in eggs and/or juvenile birds being washed into the pond and perishing.

The Council took the opportunity presented by the extremely low water levels to raise the island by approximately one metre and provide protection against erosion, plant out the island with native vegetation and provide additional habitat in the form of hollow logs. These works not only had the benefit of minimising nutrient and turbidity rises, but helped to protect roosting birds from being flooded and provided a fox- and cat-free location for turtles to lay their eggs. Successful black swan breeding resulted (Figure 3).

On New Year's Day 2006, the storage pond became an invaluable resource as a major grass fire burnt 20,000ha in and around Junee. The volume of effluent present and, more importantly, the depth of the pond, allowed for the quick turnaround of aerial fire-fighting units. In this regard the pond played a pivotal role in the protection and ultimately saviour of a number of public and private assets.

The most recent project undertaken at the WWTP was the conversion of the fourth tertiary pond into a constructed wetland.

During periods of extended dry weather, the main storage suffers from algal blooms, of which high nutrient levels are a key factor. During these times the main storage can be bypassed, with effluent from the wetlands delivered directly to the discharge

Figure 4. Constructed wetland, October 2010.

**Table 1. Suspended solids and pH changes across the wetland.**

| | Suspended Solids (mg/L) | | | pH | | |
|---|---|---|---|---|---|---|
| Date | Inlet | Outlet | % | Inlet | Outlet | Difference |
| 05 Jun 11 | 21 | 28 | -33 | 8.6 | 7.9 | 0.7 |
| 01 Nov 11 | 48 | 9 | 81 | 8.17 | 7.79 | 0.38 |
| 24 Nov 11 | 125 | 8 | 94 | 8.71 | 8.08 | 0.63 |
| 01 Dec 11 | 22 | 9 | 59 | 8.07 | 7.51 | 0.56 |
| 15 Dec 11 | 23 | 5 | 78 | 8.38 | 7.65 | 0.73 |
| 05 Jan 12 | - | - | - | 9.38 | 8.83 | 0.56 |
| 31 Jan 12 | 33 | 6 | 82 | 8.42 | 7.89 | 0.53 |
| 20 Feb 12 | - | - | - | 8.94 | 7.89 | 1.06 |

**Table 2. Changes in BOD, Phosphorus and Total Nitrogen across the wetland.**

| | BOD (mg/L) | | | Phosphorous (mg/L) | | | Total Nitrogen (mg/L) | | |
|---|---|---|---|---|---|---|---|---|---|
| Date | Inlet | Outlet | % | Inlet | Outlet | % | Inlet | Outlet | % |
| 05 Jun 11 | 9 | 7 | 22 | - | - | - | 13.2 | 9.4 | 28 |
| 16 Nov 11 | 9 | <0.1 | 99 | 4.8 | 4.3 | 11 | 11 | 8 | 27 |
| 12 Mar 12 | 3 | 2 | 33 | 3.2 | 2.7 | 13 | 8 | 6.1 | 24 |
| 21 Jun 12 | 5 | 3 | 40 | 4.25 | 3.9 | 8 | 15.6 | 12.6 | 19 |

pond, thus minimising the time for algae to establish.

The aim of the project was to reduce nutrient levels (nitrogen and phosphorus), reduce pH and reduce suspended solids in the effluent prior to it entering the main storage pond or discharge pond.

The bulk earthworks and pipework for the twin-constructed wetlands – operating in parallel – was completed in mid-2010 and the first planting took place in October 2010 (Figure 4). Figure 5 shows the wetland in 2012.

**Figure 5. Constructed wetland, February 2012.**

Vegetation establishment took approximately eight months and during this time there was little impact on effluent quality. However, since establishment, we have observed reductions in all effluent quality indicators occurring across the wetland, the largest reduction being in the level of suspended solids and BOD (Table 1 and Table 2). An additional achievement has been a reduction in water temperature, an important factor in the prevention of algal blooms. In the absence of baseline data for nutrients for the main storage, the reductions in phosphorus and total nitrogen across the wetlands have been used as proxies to estimate the reduction in the effluent.

The benefit of these wetlands has not been exclusive to effluent quality. The densely vegetated wetlands have expanded the biodiversity significantly and, most importantly, have created additional habitat for small mammals, birds, reptiles and amphibians, protecting them from foxes and cats.

The alternative to the constructed wetlands to address high pH levels was to install an acid dosing system. Reductions in pH aside, such a system would have had zero benefit on remaining effluent quality indicators or on biodiversity and habitat creation.

With works done over the last 15 years, the ponds now provide a diverse habitat for many species of birds and animals and have helped to link disjointed patches of remnant vegetation, while at the same time enhancing the quality of the product produced by the wastewater treatment plant. The whole system is now recognised as a resource with favourable social, economic and environmental outcomes.

## The Authors

**Micheal Summerell** (summerellm@junee.nsw.gov.au) is a Senior Operator, **Sheree Shuttleworth** is an Environment Officer and **Will Barton** is an Assistant Engineer, all with Junee Shire Council.

# CORROSIVITY MONITORING IN CANBERRA

*Timothy Crockford & Cameron Patrick*

A recent study was undertaken to assess the corrosivity of Canberra's water supply, which affects the asset life of water pipes and fittings in the distribution system. The aim of the study was to determine appropriate targets for treated water pH and alkalinity, to minimise the potential for corrosion. Water Treatment Plant operators need to be aware of the importance of the controls in place to manage corrosivity.

Eighty per cent of Canberra's water is supplied from the Cotter Catchment. Alkalinity levels of Cotter River water are very low, around 11–14mg/L. Low alkalinity water is unusual for surface water sources in Australia, and presents a challenge to water treatment in managing the corrosivity to water pipes of the final water.

For many years, Cotter River raw water was only disinfected, fluoridated and pH corrected at Stromlo WTP before supply to the distribution system. During this period the alkalinity of treated water was typically around 12–16mg/L. These conditions existed for over 80 years, during which time the water is assumed to have been corrosive in nature.

In 2004, the Stromlo WTP was upgraded to include coagulation and filtration. The existing lime dosing system was also upgraded to provide pre-treatment with lime, to increase alkalinity and assist in the coagulation and flocculation processes.

The post-treatment lime dosing upgrade included provision of a lime saturator to manage turbidity resulting from lime dosing in the filtered water. The post-lime dosing system controls the final pH and increases alkalinity of the treated water. Limitations in the hydraulic capacity of the lime saturator result in variability in meeting pH and alkalinity targets. High alkalinity increases the buffering capacity of the water; therefore the quantity of "milk of lime" required to achieve pH correction increases and the water flow through the lime saturator exceeds the hydraulic capacity of the system.

A further problem results from the large ambient temperature fluctuation in Canberra's climate, which affects the stability of the lime sludge blanket in the saturator. At times this affects the treated water turbidity. Given the lime saturator system limitations, compromises must be made to balance the performance for treated water turbidity, alkalinity and pH.

The result is that the corrosivity of the treated water is variable. The most significant water treatment processes for corrosivity and their effect on pH and alkalinity are summarised in Table 1.

Treated water is delivered to Canberra and Queanbeyan via 3,080km of water mains and pipes made up of several varieties of material. Material selection was largely dependent on the technology available at the time of construction (Figure 1). The various pipe materials throughout the distribution system indicate that there may be differing corrosion issues within water pipes at various locations around Canberra.

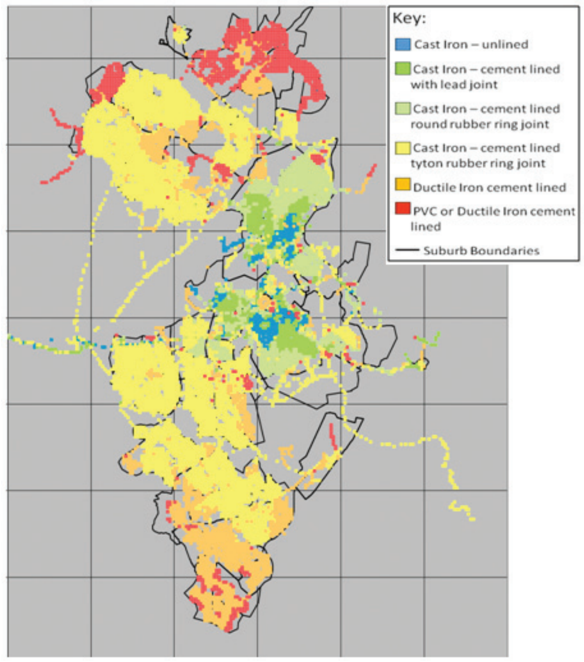



Diagram supplied by McRae (2011).

**Figure 1. Location of pipe materials in Canberra's water distribution system.**

**Figure 2. Samples of cement-lined pipe.**

Samples taken from the distribution network indicate that the cement linings in pipes have been effective in preventing internal corrosion. Even some of the oldest cement-lined pipes still have linings intact (Figure 2); however, it is uncertain to what extent the calcium carbonate may have leached out, or whether the lining has thinned over time.

## Water Quality and Corrosion

The corrosivity of water depends on its chemical and physical properties. Water with a low pH has the potential to cause corrosion. In contrast, high pH reduces

**Table 1. Significant stages of treatment for pH and alkalinity levels. "↑" indicates an increase; "↓" indicates a decrease.**

| Parameter | Raw Water | Pre- Lime | Carbon Dioxide | Coagulation & Flocculation | Post- Lime | Fluoride | Treated Water |
|---|---|---|---|---|---|---|---|
| pH | 6.9–7.3 | ↑ | ↓ | ↓ 6.1-6.2 | ↑ | ↓ | 7.4 |
| Alkalinity | 11–14mg/L | ↑ | - | ↓ | ↑ | ↑ | 30–40mg/L |

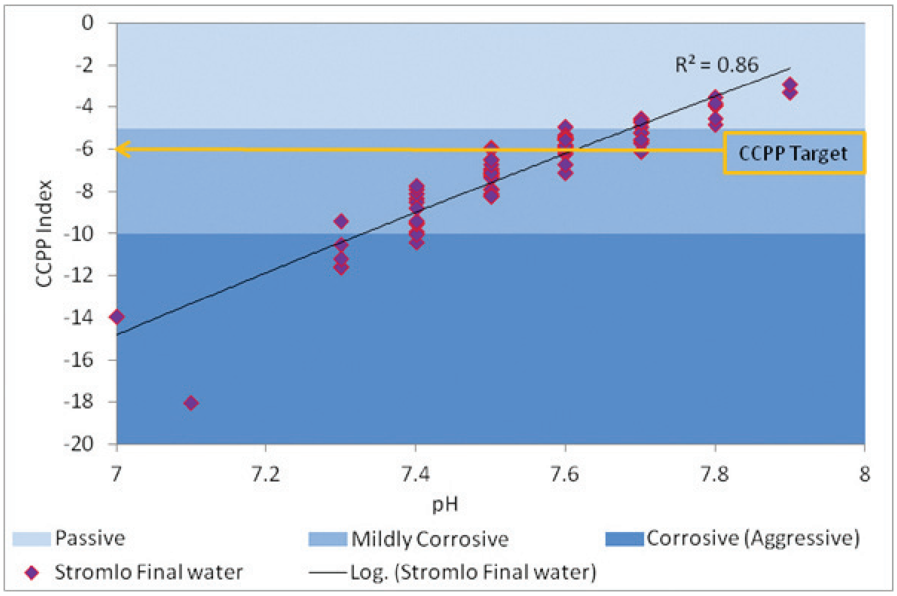



**Figure 3. Correlation of pH and CCPP for Stromlo treated water (2005–2011).**

the solubility of any calcium carbonate ($CaCO_3$) present, and the tendency to produce scale increases. Adjustment of the pH by water treatment plant processes is, therefore, important to the management of water corrosivity.

Alkalinity is also an important factor affecting corrosion. Higher alkalinities are generally associated with lower iron corrosion rates. Low alkalinity water tends to be corrosive – leaching calcium carbonate from cement linings, thus leading to significant increases in bulk solution pH, calcium and alkalinity. The alkalinity should also be high enough to maintain a high buffering capacity, ensuring the stability of pH as it moves through the distribution system.

While high pH is advantageous for corrosion control, it has a negative impact on chlorine disinfection due to the relationship between hypochlorous acid and hypochlorite ion. At a lower pH, hypochlorous acid dominates, while at a higher pH hypochlorite ion dominates. Hypochlorous acid is a much more effective disinfectant.

Stromlo WTP has two disinfection barriers: ultraviolet light treatment followed by chlorination. Chlorine is dosed to a mg/L setpoint which is seasonally adjusted based on temperature, water age (demand) and verification monitoring in the distribution system. ACTEW Water maintains a relatively high free chlorine residual (i.e. 2011/12 mean free chlorine residual was 0.75 mg/L at customer taps) to ensure that disinfection is not compromised.

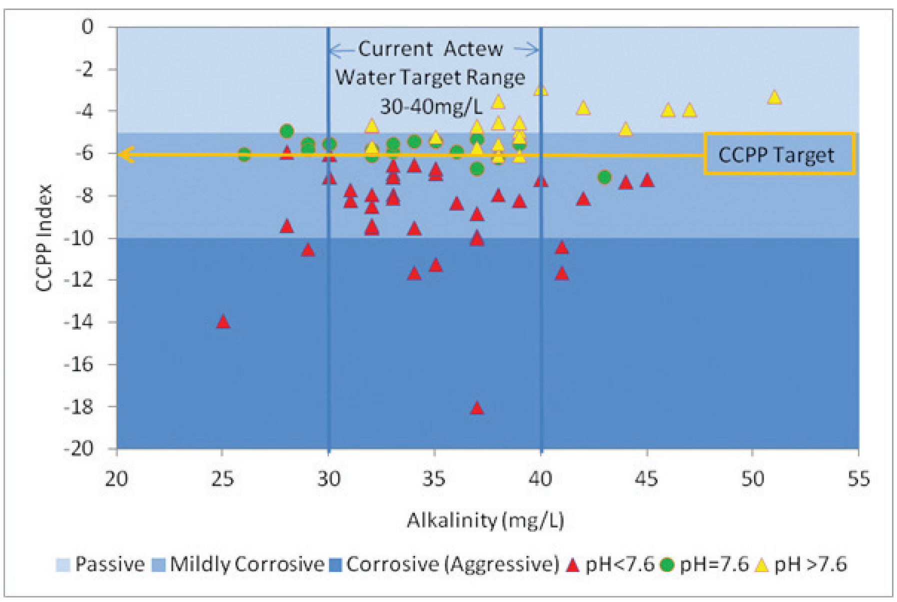



**Figure 4. Correlation of alkalinity and CCPP for Stromlo treated water (2005–2011).**

## Saturation Indices

Saturation indices are used to provide a guide of calcium carbonate ($CaCO_3$) stability in water. The indices quantify the potential of water to be either scale forming or dissolving.

The indices were primarily developed in the US and the UK, where the deliberate precipitation of $CaCO_3$ was a common solution for protecting the large amount of unlined pipes (WSAA, 2008). In Australia there has been widespread use of mortar-lined pipes since the late 1920s, reducing the need for deliberate $CaCO_3$ precipitation. The saturation indices are important for cement-lined pipe networks when water quality is at the extremes of the saturation index.

Two commonly used indices are the Langelier Saturation Index (LSI) and Calcium Carbonate Precipitation Potential (CCPP).

LSI estimates the theoretical tendency for a water to dissolve or precipitate $CaCO_3$. While this index is commonly used by water utilities because it is simple to calculate, it only highlights the existence of a driving force, and provides a qualitative indication for the occurrence of scale or corrosion.

CCPP is a more reliable index, providing a quantitative measure of $CaCO_3$ that will precipitate or be dissolved in order to reach equilibrium in solution.

The most sensitive parameters for CCPP calculation include pH, alkalinity, calcium and temperature. The use of CCPP has previously been limited in day-to-day use as it is time consuming to calculate. However, the development of computer software has made quick data processing possible.

**Table 2. Guide for corrosivity state of water for various CCPP values (Gebbie, 2000).**

| Corrosivity State of Water | CCPP Value, mg/L $CaCO_3$ |
|---|---|
| Scaling (protective) | > 0 |
| Passive | 0 to -5 |
| Mildly Corrosive | -5 to -10 |
| Corrosive (aggressive) | < -10 |

Table 2 provides a guideline for CCPP indication.

Following literature review and benchmarking against several water utilities around Australia, ACTEW Water revised its target range for CCPP to be "greater than -6".

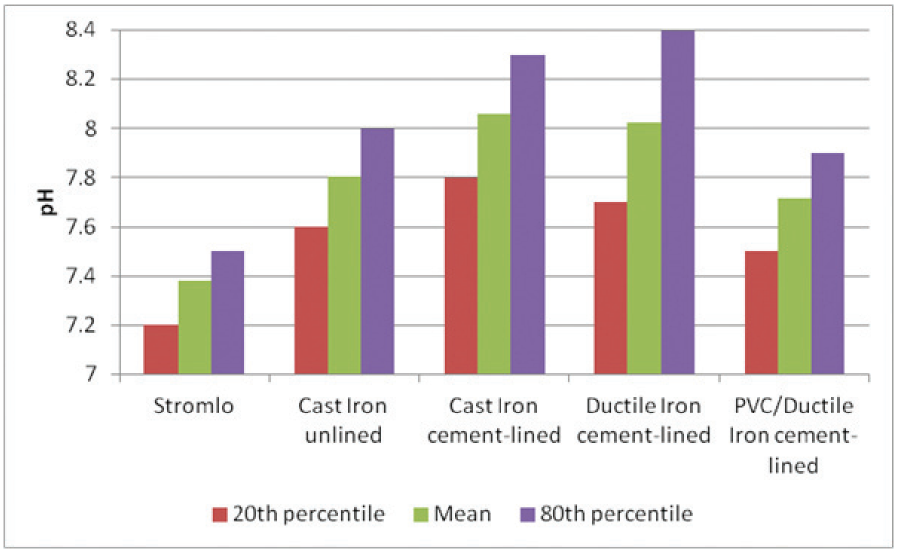



**Figure 5. Statistics of pH for Stromlo WTP and customer taps (2005–2011).**

## Analysis

The CCPP for Stromlo WTP treated water leaving the plant was calculated using StaSoft 4.0 software for the available water quality data between 2005 and 2011. The CCPP results revealed occasional cases of highly corrosive (aggressive) water, while most of the samples showed only mildly corrosive or passive conditions. The CCPP results were then correlated with the parameters of pH and alkalinity to draw conclusions about the specification of targets for Stromlo WTP treated water. The correlation analysis shows a strong relationship between CCPP and pH (Figure 3). On average, the benchmark CCPP of -6 can be achieved at pH 7.6.

The correlation between alkalinity and CCPP is shown in Figure 4. The analysis showed that a reasonable CCPP index can be achieved at pH 7.6 for a wide range of alkalinity values (see data points in green).

Thus the current alkalinity targets for Stromlo WTP treated water of 30–40mg/L are appropriate for minimising corrosion.

To investigate the effects of corrosivity within the existing distribution network, analysis was also undertaken comparing water quality data from Stromlo WTP with water from customers' taps for 2005–2011. Topographical maps were used to divide the list of customer taps into groups according to the pipe material present. Statistical data was calculated for pH, alkalinity and calcium. The pH was found to be higher in the cement-lined pipe areas of the distribution system compared to the treated water from Stromlo WTP (Figure 5). This is due to the leaching of calcium hydroxide from cement linings. The plots for alkalinity and calcium showed similar trends. This information provides a basis for a further detailed assessment and monitoring of target areas in the distribution system which will inform ongoing management practices.

## Outcomes

The study highlighted that water corrosivity is very sensitive to pH. Although alkalinity also affects corrosivity, it is possible to produce corrosive water (with low CCPP results) with reasonable alkalinity with pH that is too low.

As a result of this study, ACTEW Water raised the final pH set-point controlling the post-lime dosing system to pH 7.4, while maintaining the current alkalinity target range of 30–40mg/L. A treated water pH of 7.6 was identified as an appropriate target to achieve the revised CCPP target of -6. ACTEW Water is continuing to investigate the balance of pH, alkalinity and disinfection potential throughout the distribution system, to manage corrosivity without compromising disinfection. The water quality monitoring program was reviewed to ensure all the required data for CCPP calculation is routinely collected. CCPP results for Stromlo WTP treated water are regularly reviewed to confirm corrosivity targets are being achieved.

The study highlighted the importance for WTP operators to understand the long-term implications of corrosivity and the impact of processes they control. Water utilities can use simple software to monitor corrosivity so long as the required data is collected.

## Authors

**Timothy Crockford** (tjcrockford@gmail.com) is a Graduate Engineer from the Australian National University.

**Cameron Patrick** (cameron.patrick@actew.com.au) is a Senior Water Treatment Engineer at ACTEW Water.

# SAMSON'S IMPROVED FILTER CORE SAMPLER

*Owen Bull*

"Filter media core sampling made easier" … with just a few simple modifications, these changes allow for the operator's strength, size and dexterity. They will also assist in reducing the risk of any manual handling injuries occurring while collecting media core samples.

Previously, the tool used by our operators was simple, but difficult to use. Operators inspecting a filter would collect filter media core samples at various points across the filter bed, or at suspect areas of the filter. To do this, the operator would push a length of PVC pipe into the media to a depth that would provide the best profile, then place their palm over the end of the pipe to create a vacuum (see above right); they would then pull the PVC pipe out of the media with their free hand. Once extracted, the hand creating the vacuum could then be removed to allow the core sample to fall free from the PVC pipe for inspection.

This method of sampling was a bit hit-and-miss; while some operators had some success, others struggled to either push the PVC pipe into the media or to then remove the pipe while maintaining an airtight seal and vacuum so that the media would remain in the pipe.

To improve the tool to make the task easier, firstly a tee-handle was glued onto the top of the PVC pipe with end caps glued on each end. A ¼ inch BSP thread was then tapped into the pipe; this was placed on the tee at one of the glued joints, this being one of the thickest and strongest points on the tool (see below).

This point was chosen to reduce the possibility of cracking and breaking when tapping the pipe. A ¼ inch ball valve was then threaded into the pipe at this point.

The ball valve allows for the air within the pipe to escape when pushing the pipe into the filter media, but can then be closed to create a vacuum within the pipe when pulling the sample from the media.

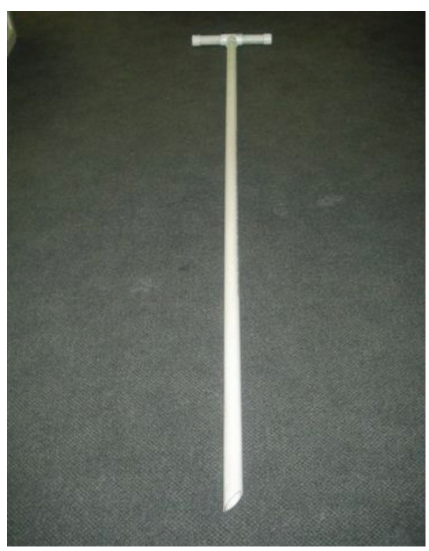
This would now make it much easier for the operator taking the sample to push the pipe into the media using the tee-handle, requiring very little strength but also making it simple to then retrieve the sample, creating the vacuum required within the pipe to hold the sample by closing the ball valve and creating an airtight seal.

The new sampler was successfully trialled and used by the operators at the Samson Brook WTP during their last filter inspections. All operators found the new tool simple to use, with no failures recorded while collecting samples from each filter.

The cost involved in making the modifications is seen to be very low compared with the benefits found when using the tool. This demonstrates that continuous improvement and operator safety does not have to be expensive or elaborate when optimising your filter operation.

## The Author

**Owen Bull** (Owen.Bull@watercorporation.com.au) is the Operations Supervisor at the Samson WTP in Western Australia.



CRS
INDUSTRIAL WATER TREATMENT SYSTEMS

# GEOTUBE® DEWATERING CONTAINERS

Ten Cate Nicolon

Made in Australia

Traditional methods of dewatering industrial and municipal high water content sludges involve the use of expensive operating and capital cost equipment such as centrifuges and belt presses. The alternative is passive dewatering using Geotube® Dewatering Containers made from woven polypropylene geotextile. Sludge can be fed from storage ponds or directly from the process / digesters, using lower dosage rates of polymers and producing exceptional quality filtrate. Depending upon the length of time sludge remains within the Geotube® units to dry, solids of > 45% w/w can be achieved, as with water treatment sludges.


- High volume containment
- Contained sludge will not rewet in rain events
- Cost effective
- Double the dry solids vs mechanical dewatering
- Lower polymer dosage rates
- 24 hour unattended dewatering
- Automated level controller available

## For application details contact...

JAS-ANZ

CRS
INDUSTRIAL WATER TREATMENT SYSTEMS

**CRS Industrial Water Treatment Systems P/L**
P - 61 2 9899 7811
F - 61 2 9899 7336
crs@watertreatment.net.au

Unit 4, 9 Packard Avenue
Castle Hill NSW 2154 Australia
www.watertreatment.net.au

**New Zealand Office:**
10 Victoria Road
Nelson 7010 New Zealand
P - 64 21 480 141