ADWG COMPLIANCE IN REGIONAL VICTORIA

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ABSTRACT

The introduction of the Australian Drinking Water Guidelines (ADWG) is posing a substantial challenge to water corporations to provide safe drinking water to all citizens. Of particular concern are regional network supply systems, delivering drinking water to small rural communities. Traditionally, water corporations have used chlorine gas for disinfection at the source of the network yet this method can have limitations in carrying through to the extremities. This paper presents the results of a trial by Coliban Water of a novel water disinfection technology (Smartaflow) that enables micro-dosing for a remote community in Victoria (Bealiba). The technology described automatically meters sodium hypochlorite into a pressurised water stream in a way that overcomes the limitations of traditional systems. Despite challenging conditions, the results of the trial demonstrate the capability of the technology to safely and reliably dose the water within acceptable residual levels and to provide significant benefits in health and safety and in monitoring and management.

KEY WORDS

ADWG, Water Disinfection, Hypochlorination, Drinking Water, Remote Communities

1.0 INTRODUCTION

In July 2004, the Victorian State Government introduced legislative changes to the Safe Drinking Water Act (2003). A key component of the act, which was adapted from the national Australian Drinking Water Guideline Standards (ADWG), was the need for water providers to meet strict standards relating to the safe disinfection of drinking water. This component of the legislation is likely to impact on regional network supply systems, particularly those delivering drinking water to small rural communities. Prior to the act, it was considered acceptable to treat a network of these localities with a single disinfection unit. Traditionally, this broad application technique would use chlorine gas (Cl_2), at the source of the network, dosed at a rate capable of carrying the chlorine through to the extremities of the network.

There are a number of irregularities that this type of chlorination creates, such as:

- the potential to over-chlorinate at source of system resulting in taste and odour problems, contravention of the ADWG standards and risk to public health,
- the potential to under-chlorinate at extremities of system resulting in irregular chlorine residual levels, non-compliance with ADWG standards and severe risk to public health,
- stringent regulations associated with the potential hazards of chlorine gas, requiring expensive safety/security infrastructure and the need for checks by skilled personnel.

Given these issues and the need to meet the new standards, many Victorian regional water utilities are being challenged as to how to improve the rural network disinfection process.

Considering that regional Victoria is made up of more than 212 urban localities where populations of less than 1,000 dwell within a network of small (often remote) townships and communities, enormous challenges are emerging for water utilities to be able to provide safe drinking water for all citizens.

This challenge is not unique to Victoria, or even Australia. The World Health Organisation's (WHO) "Guidelines for Drinking-water Quality" have become the international reference point for standard setting and drinking water safety and are being adopted by countries throughout the world. In the US alone it is estimated that there are 165,471 public drinking water systems, 82% of which supply populations of 500 or less[1], all of which must comply with standards regulated by the US Safe Drinking Water Act.

Suppliers of urban potable water, driven by these exacting standards also have serious issues with regard to how to chlorinate (or re-chlorinate) in a safe, reliable and economical way. This is particularly the case in *variable flow* scenarios where the treatable reticulation system is downstream of the treatment plant. Ideally, chlorination of this type is far better administered into a fixed flow scenario – disinfection taking place using the fixed flow replenishment cycle of a summit tank, or similar. In such cases chlorination takes place on the tank inflow and the town reticulation is gravity fed via the outflow of the tank. In this scenario an acceptable minimum flow rate (> 1 L/s) can easily be obtained, enabling conventional chlorination to be used with acceptable effect. Unfortunately, this is often neither a practical nor a viable alternative for suppliers and variable flow chlorination is the only option. Therefore, in cases where flows drop below 1 L/s conventional chlorination is not possible.

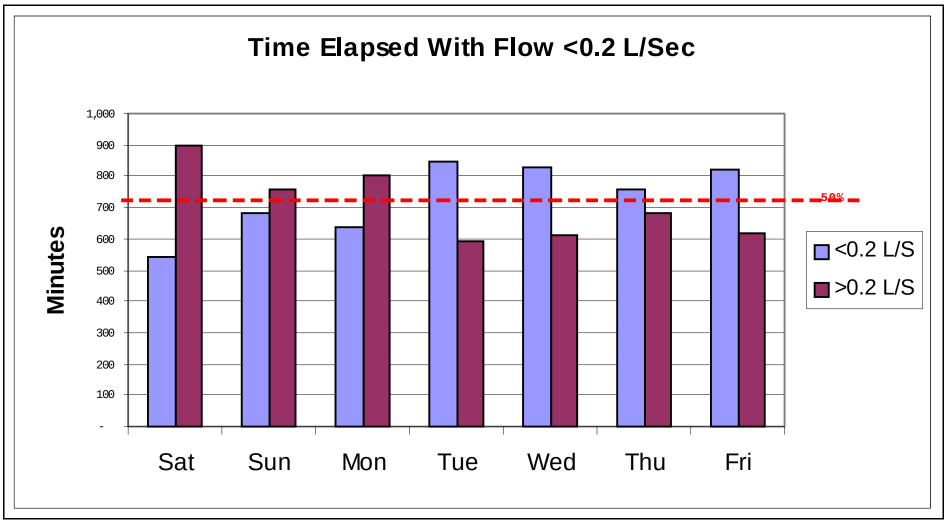

Figure 1: ***Typical weekly winter flow pattern of a small town water supply***

Typical variable flow patterns experienced in small town water supplies are often far lower than what would have been previously thought. Research undertaken during a typical winter flow pattern in the Western Australian town of Ballidu in June 2002 is shown in Figure 1. This shows that the flow into the town reticulation failed to achieve a flow greater than 0.2 L/s for more than 50% of the week. This has been found to be a common scenario throughout WA rural townships with similar demographics.

The chlorination of a town water supply with variable flows of this nature, commonly referred to as micro-flows, is the primary focus of this paper. The paper outlines the implementation of an alternative, patented, disinfection technology developed by the WA company, AQ2 Ltd.

The Smartaflow technology is capable of dosing precise amounts of disinfection agent into variable and sometimes near zero flows. This technology has enabled one Victorian rural water utility, Coliban Water, to retain its existing gas chlorination system for primary disinfection at the source of a major water distribution network with the new technology playing a secondary role for disinfection at the point of use, as and when required. The technique not only ensures that network extremities – in this case a remote rural township, Bealiba, with a population less than 100 – always conforms to the ADWG standards, but it will also lead to a reduction in primary chlorination in the longer term.

2.0 THE SMARTAFLOW TECHNOLOGY

Coliban Water was aiming to achieve 100% ADWG compliance for Bealiba, located at the extremities of the Laanecoorie water distribution system, situated in the Goldfields region of Central Victoria. As conventional disinfection technologies were considered impractical and not viable for regional ("micro") water supply systems, alternative technologies were sought. The Smartaflow Chlorisafe system has already been extensively trialled and implemented in a number of locations throughout regional WA. Commonly referred to as a "hypochlorinator", the turnkey-packaged Smartaflow unit automatically meters sodium hypochlorite (NaOCl) into a pressurised water stream and overcomes the vapour lock problem that has long been associated with traditional hypochlorite dosing technologies. The Smartaflow Chlorisafe system is illustrated in Figure 2.

Figure 2: ***The Smartaflow Chlorisafe System***

The Smartaflow Chlorisafe system provides a number of distinct benefits:

Safety – unsafe work practices, such as manual decanting, are eliminated and operators are not exposed to chemical hazards. Removes/reduces reliance on gaseous chlorine, eliminating risks associated with the transport, handling, storage and application of chlorine gas.

Versatility – can be used on all types of water in any location, adaptable to any type of chemical container and can be used in any industry requiring precise, effective and safe dosing of hazardous or other chemicals.

Cost effectiveness – doesn't need extensive supporting infrastructure or buffer zones. Uses negligible power and costs less than a third of an equivalent gaseous system to install. Maintainable by a single operator and monitored remotely, reducing site attendance and maximising operator efficiency. Auto-decant system reduces chemical wastage.

Accuracy – turndown ratio is 20 times higher than conventional pumps and far greater than chlorine gas systems. Controller ensures accurate dosing at all times, under all field and chemical conditions, with a range of control regimes.

Reliability – Highly reliable system. Signal sent to the operator or central control point well before chemical replenishment is required ensures system never runs out of liquid. Battery backup ensures non-stop dosing, even with loss of power. Independently bench and field-tested, the system has been proven to be reliable even in extreme operating conditions.

3.0 SMARTAFLOW TRIAL BY COLIBAN WATER

To help with the introduction of the new technology into Victoria, Coliban Water undertook a comprehensive trial of the Smartaflow system. The main objectives of the trial were to demonstrate the Smartaflow system's capabilities in particular to: (i) overcoming the vapour lock problems associated with traditional hypochlorite dosing technologies, (ii) overcoming Occupational Health and Safety (OHS) issues in handling the chemical, (iii) overcoming the need for mains power, and (iv) providing dial-out and dial-in access for remote monitoring.

The trials of the Smartaflow unit in Victoria commenced in October 2004, using the standard purpose-built PLC based Smartaflow controller. The controller uses a conventional flow pace/ residual trim loop program and, in order to accommodate the micro-dosing capabilities of the pump, a special algorithm has been formulated. By using a combination of the conventional proportional derivative (in the form of variable pulse frequency proportional to flow), in conjunction with a novel by-pass auto positioning method, the desired turndown is achieved.

The successful metering of micro amounts of full strength hypochlorite solution in water flows as low as 0.02 L/s (or zero) to above 15 L/s (at peak), creates a need for a specialised method of infusion. In order to facilitate acceptable dilution, particularly under low velocity conditions, a novel type of injection spear – the SpearSafe, incorporating an inbuilt pressure sustaining device at its tip, is also used. The successful use of this combination of devices and control methods enables set-point disinfection to be achieved under all seasonal conditions.

Early operation of the system at Bealiba showed the need for the replacement of the original chlorine residual analyser in order to cope with greater than expected fluctuations in pH. It was also recognised that, due to the drought, there were increasing occurrences of higher than anticipated flows into the Bealiba town site. Particularly prevalent during the early summer months, there were many instances of flow "spikes" in excess of the anticipated peak of 3.5 L/s, thought to be caused by water carting from either of the town's two agricultural stand pipes.

A third issue though was the hydraulic design. The first design plan had been to locate the system adjacent to the Bealiba 500m^3 reservoir, approximately 3 km upstream of the town site. This positioning was based on the idea that the chlorination would take place using the standard variable flow pace control regime with residual trim on the outflow of the tank. As already described, this is a very difficult method of reliably disinfecting to within a set residual. The original design was to divert the tank outlet via a side stream arrangement, in association with a vertically orientated looped manifold, situated directly above the metering pumps (within the hypochlorinator cabinet).

The purpose of the vertical loop was to facilitate "upward discharging" to eliminate potential pump discharge vapour lock. Under normal conditions, this would have not been required, but given the likelihood of prolonged micro-flow conditions during dormant winter periods, it was considered essential. However, due to the fact that the treatable water levels in the reservoir were sometimes dropping below the highest point of the manifold, there were occasions, during these abnormally high flow conditions, when the system would malfunction. High flows created within the manifold resulted in a reverse siphon effect within the residual analyser sample cell, causing air to be drawn into the manifold via the residual analyser cell drain line from atmosphere.

To remedy this, the vertical loop needed to be removed. However, the potential for downward discharge problems were then of concern. If the manifold was to be lowered, then there was the likelihood that "downward discharging" could result in a vapour lock condition. As a safeguard, the "auto purge" facility, which initiates a pre-self-bleed regime immediately before the stand-by pump assumes duty, was successfully adopted. The introduction of this self-bleed function ensured that if a duty pump failed to maintain a pre-determined minimum chlorine residual it would initiate the auto-purge function.

Table 1: ***Site Conditions of Bealiba Trial***

Trial item	Specified	Actual
Controllable flow range, Variable	0.02 L/s to 3.00 L/s	0.01 L/s to 10 L/s
Min/Max Pressure	200/200 kPa	-050 to 200 kPa
pH	7.5	8.2
Chlorine residual set point	1.0 mg/L	2.0 mg/L

Whilst the adverse conditions at the site, summarised in Table 1, did create unusual challenges, the modifications were effective, allowing extremely precise dosing and set-point maintenance even at zero flows. The performance of the system was monitored over two 3-month periods, October to December 2004 and January to March 2005.

4.0 RESULTS OF THE TRIAL

As already mentioned, the combination of auto bypass, specialised software and a unique method of injection has proved to be particularly effective in enabling swift switching between flow ranges, resulting in a far higher degree of turndown than that of any conventional metering pumping system. This facility is particularly useful at this site, where a combination of broad flow ranges (a consequence of seasonal water carting for agricultural purposes) and the varying incidence of ammonia-N, creates a need for a responsive turn down that caters for almost all conditions.

4.1 Dose Rate Control

It is important to note that there are two known exceptions where control is unable to respond within a sufficient timeframe. Referred to as a disruption period, during these times flows become unusually erratic. Invariably these disruption periods tend to be for short periods of time, resulting in the residual trends going outside the acceptable band and can be categorised into two types of conditions:

Transitional - these are regular occurrences specific to small town water supplies, where the flow rate fluctuates in an erratic manner as it enters into and out of the dormancy period.

Flow spikes - a condition where high flows, likely to be initiated by the use of agricultural water supply stand pipes (or similar) occur for short periods of time.

In both of these cases, the duration tends to be less than 30 minutes, inevitably causing the residual to initially rise, resulting in the duty metering pump to go out of bounds as the pre-set threshold is exceeded. This in turn causes the metering pump to turn off (pump-off) and the pump only resumes operation once residual falls bellow a pre-determined point where the pump turns on again (pump-on). However, given that we know these periods tend to be short lived, it has become possible to manage these disruption periods, rather than trying to effect control as they are taking place. To do this, a dose-rate suppression method is used.

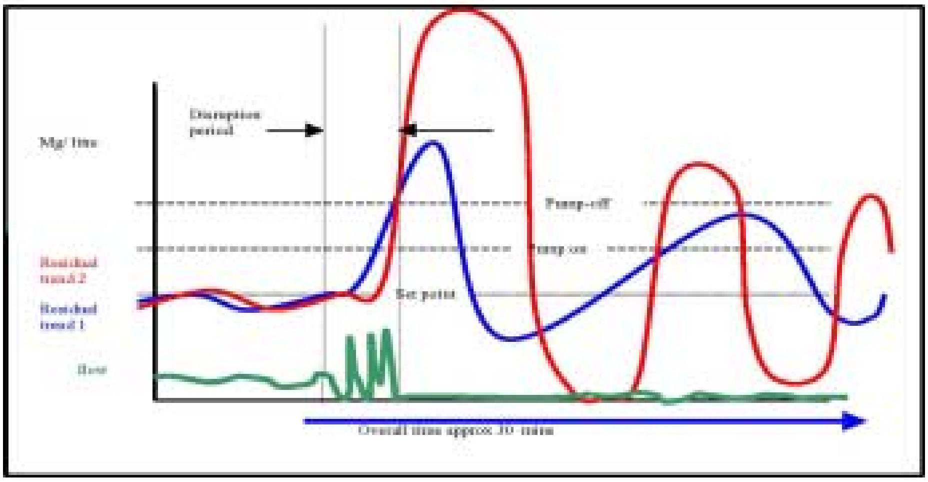

Figure 3: ***Comparison Diagram On The Effects Of Dose Rate Suppression***

As already mentioned, a specially formulated algorithm had to be developed to manage control of pulse rate – proportional to water flow, whilst at the same time determining the chemical volume per pulse by varying the auto by-pass. Because these disruption periods tend to be limited in duration and occur infrequently, by suppressing the auto by-pass activity in favour of pulse rate control, it was found that control during these periods became far more manageable. This is evident in Figure 3 where the dose rate in trend 1 is suppressed, ensuring that the auto by-pass remains constant for much longer than it does in trend 2.

Therefore, it has been determined that in cases where disruption periods occur, it is acceptable to allow the residual trends to exceed the limits, as long as the dose rate suppression method is used to minimise the effects. In cases where flow spikes become more frequent as a consequence of increased agricultural stand pipe use, it would be far more advisable to consider engineering-out the community based facility – by the use of a dispensing tank with a restricted inflow, rather than attempting to change the residual control methods used.

4.2 Performance

The performance is well illustrated in Figures 4 and 5, clearly showing the chlorine residual and flow rate as a function of time of day during two opposing seasonal conditions – winter and summer at Bealiba. It is evident that even at near zero flow conditions, the Smartaflow unit was able to maintain an appropriate chlorine residual within the required limits.

The manner in which the charts, each representing a 24-hour period (8:00 am to 8:00 pm), are presented, are described as follows:

1) **Flow rate**: a linear (blue) depiction, presenting 10 minute averages of the instantaneous flow rate throughout the period, as measured using the ABB magnetic flow meter. The chart depicts the rate in litres per second, using a zero to 6 litres per second flow range

2) **Residual**: a linear (red) depiction presenting 10 minute average of total chlorine residual as measured using a Trent Micro-Chem analyser, sampling continuously down stream (within three metres of the point of injection), having a lag time of 4 minutes duration and using a zero to 3mg per litre residual range.

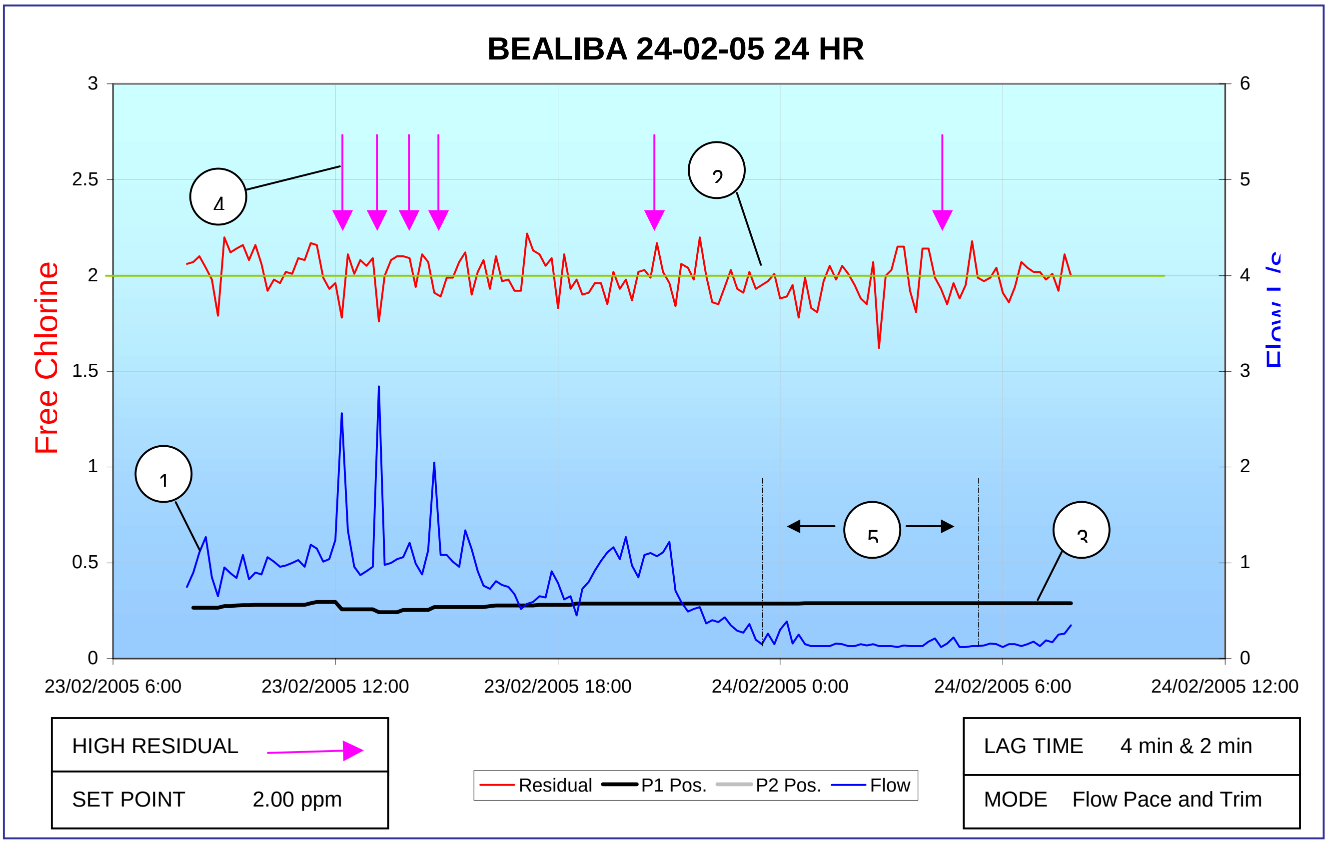

Figure 4: ***Chlorine Residuals and Flow Rates – Summer Flow***

3) **By pass**: a linear (black) depiction presenting movement in the position of the duty pump's auto positioner, utilising the zero to 1 flow range axis, where 1 = 1000 ohms (by-pass fully open)

4) **Residual Hi**: An arrowed marker (Lilac) depicting the precise time (within 10 minutes) where the chlorine trend went higher than is normally acceptable - referred to as the disruption period. This condition (already described – Dose Rate Control), refers to the instances where the residual trends have gone out of bounds, resulting in a "Hi" appearing on the logged data. In the case of Figure 4, there were six individual instances where the residual trends exceeded the threshold value.

5) **Dormancy:** depicting a recognisable timeframe where flow remains consistently low for a prolonged period of time - a situation that regularly occurs between the hours of midnight and dawn. Additionally, dormancy periods have been known to

occur during mid-morning and mid-afternoon at certain micro-flow sites – particularly during winter.

Following the successful trials, Coliban Water purchased the Bealiba unit.

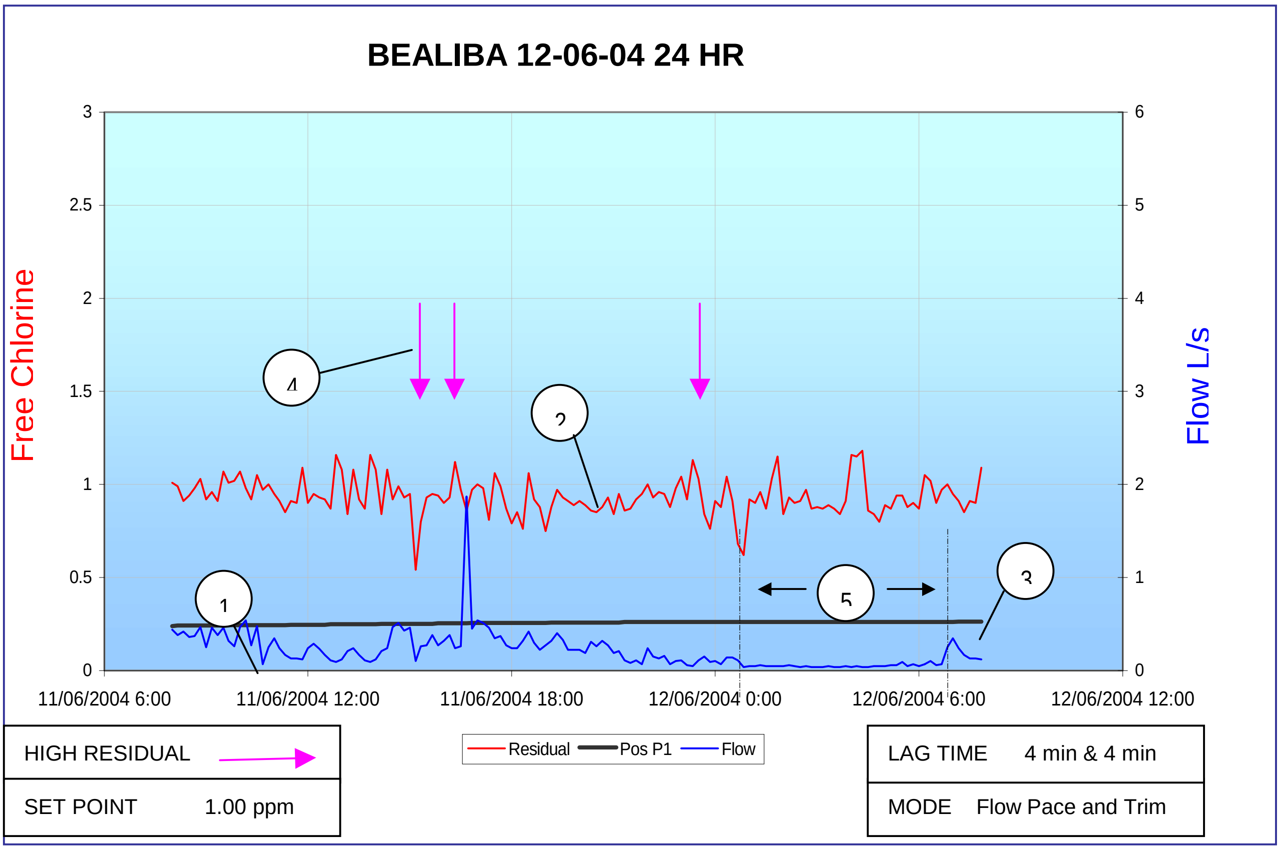

Figure 5: ***Chlorine Residuals and Flow Rates – Winter Flow***

5.0 CONCLUSIONS

This paper describes the results of the trial of a novel water disinfections system, Smartaflow Chlorisafe, in a remote community in regional Victoria. The trials enabled modifications to be made to the unit in order to cope with particular challenges at the site related to hydraulic and power requirements and the fluctuating pH levels in the water. Following these modifications, the system demonstrated its capability to provide consistent performance within acceptable chlorine residual ranges. The system therefore clearly overcomes the challenge of dosing precise amounts of disinfection agent into variable, and sometimes near zero flows, often in unfavourable conditions. The system also overcomes OHS concerns related to the handling of sodium hypochorite.

The Smartaflow Chlorisafe system offers a solution for water corporations to be able to meet the challenges of ADWG compliance, enabling the safe, reliable and efficient dosing of disinfection at the extremities of water networks, that is not viable using traditional technologies.

6.0 REFERENCES

United States Environmental Protection Agency (2001), "Factoids: Drinking Water and Ground Water Statistics for 2001". ABS – Census of population and housing.