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SOLIDS HANDLING AND DISPOSAL AT LOWER MOLONGLO WATER QUALITY CONTROL CENTRE

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ABSTRACT

The Lower Molonglo Water Quality Control Centre (LMWQCC) solids handling process is unique in that it processes solids using the only large Sewage Sludge Incinerators (SSI) in Australia. The other unique fact being that the sterile by-product ash is disposed from site and sold as “Agri Ash” an agricultural soil conditioner.

Since its inception in 1978 the way this multi hearth furnace is operated has evolved to account for increased stringencies in the environmental emissions license, greater solids loads due to population increase and a secondary augmentation upgrade, as well as a result of the maintenance issues associated with running large pieces of plant continuously. Given its inherently complicated and chaotic nature, operating this dynamic process is a task that requires considerable training and operational experience as does understanding its interrelationship with the broader treatment process used at the LMWQCC.

To meet these changes, safeguard environmental obligations and strive toward operational and asset management best practice, Icon Water has committed funding for substantial project works being undertaken and planned for the future. The aim of this paper is to outline the unique solids handling and incineration process employed at LMWQCC, detail how operability has changed and what projects are in place to renew this facility.

1.0 INTRODUCTION

The solids handling process employed at the LMWQCC is based on technology largely developed and used in the United States of America and Europe which relies on incinerating solids a Multi Hearth Furnace (MHF). The system was designed in the early 1970’s and installed from 1974 to 1978 as part of a joint venture developed for the design and construction of the larger LMWQCC WWTP. Incineration was seen as favourable over other methods of solids handling due to a number of factors. While the location of LMWQCC meant that flows could be gravitated to the plant, it placed challenges on removal of large quantities of solids from site and increased the demand on landfill sites on a growing city. Incineration allowed for solids to be reduced by a third with an average of 45 tonnes of dry solids per day reduced to 15 tonnes of ash material. It also created an opportunity to reuse the ash from site and to be on-sold as a lime enrichened agricultural soil condition under the name “Agri Ash”. Incineration also offered the option of energy recovery by heated scrubber filter water being returned to the screened waste water flow which is extremely useful to the biological process during the cold Canberra winter months, where the difference between 15-17 degrees Celsius results in an almost exponential amount of biological activity.

1.1 Overview of Solids Handling Process

The below schematic in figure 1 outlines the solids handling process at LMWQCC. As it can be seen typical treatment processes such as screening and grit collection are employed, although unlike the majority of most WWTPs in Australia these products are not disposed of at landfill sites.

They are instead incinerated with the other solid waste streams such as settled primary solids and waste streams from the biological nutrient removal process.

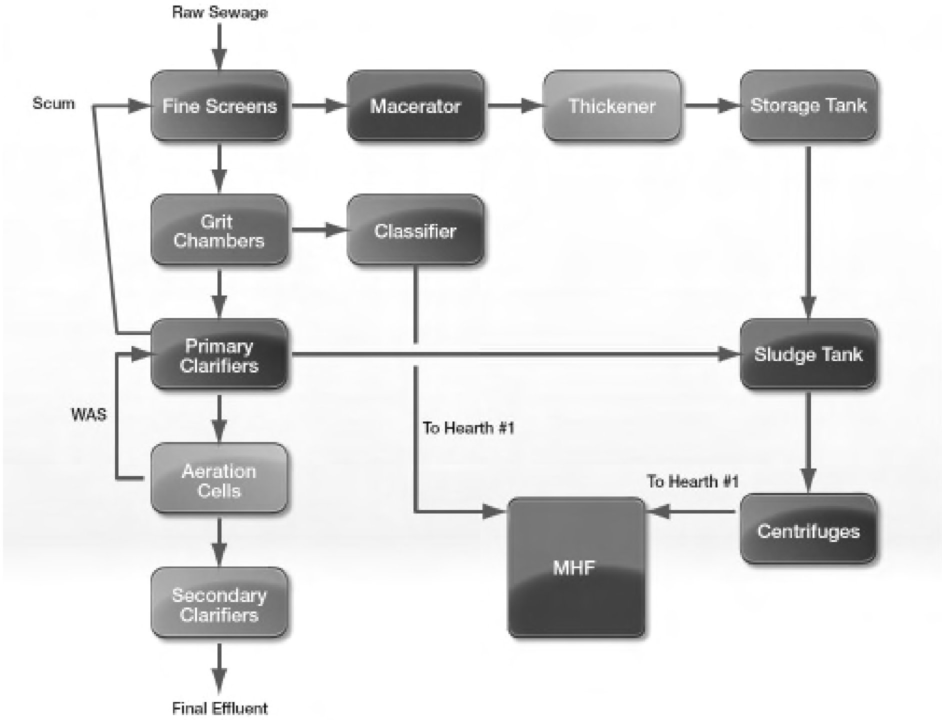

Figure 1: ***Overview of LMWQCC solids handling process***

1.2 Overview of LMWQCC MHF

The Screenings and Incineration building at LMWQCC houses the two identical combustion trains comprising of:

- x 6.8 metre outside diameter - 9 hearth Incinerators, both 13m tall
- A multi-clone cyclone system for separation of heavy particulates
- A wet scrubber exhaust system with pre-cooler and impingement plates for capture of fine particulates
- An Induced Draft fan and butterfly valve air dampers to maintain negative pressure conditions within the furnace
- Multiple types of stack emission instrumentation
- Ash cooling and handling system
- 6 x auxiliary fuel oil burners in hearths 5, 6 and 7

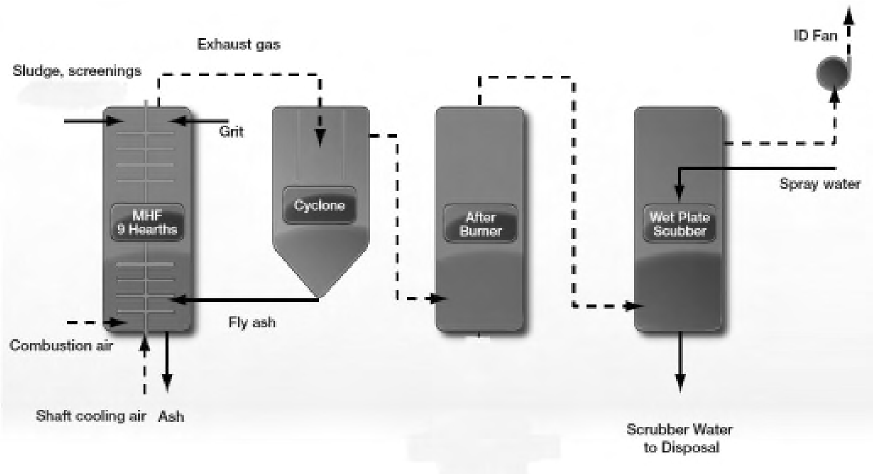

Figure 2: ***Overview of MHF process***

Combined thickened sludge and macerated screenings are pumped from the sludge holding tank to one of three centrifuges. Dewatered sludge or “Cake” is fed via a series of conveyors to hearth 1 of the online furnace; centrate is piped to the buildings drainage sump and from there pumped back to the screened waste water flow at the head of the plant.

The MHF can be divided into three zones. The first zone, which consists of the upper hearths, is the drying zone. Most of the water is evaporated in the drying zone. The second zone, generally consisting of the central hearths, is the combustion zone. In this zone, the majority of combustible material is burned, and temperatures reach 760 - 1150 degrees Celsius. The third zone includes the lowest hearths and is the cooling zone before ash is conveyed to storage bins.

2.0 OPERATION AND OPERABILITY OF LMWQCC MHF

The MHF is operated, monitored and controlled 24hrs a day 7 days a week by a Water Industry Operator in a control room in the same building as the furnace. Due to the constantly changing characteristics of sludge feed to the furnace, operation could not always be described as in a stable condition and can dive and climb rapidly. This requires an immense amount of interaction and fine tuning to changing conditions. For example, the control room can’t be left without someone monitoring trends and alarms because of the likely possibility of rapid changes. Typical operating conditions have evolved substantially compared to those when it was designed and built some 40 years ago, below is an outline of the main factors that affect operability.

- *Variability of feed characteristics:* The furnace was originally designed to burn sludge at approximately 8 l/s at a sludge density of 12 - 17%. Typical operating conditions today, 40 years on are 10-12 l/s at 30-40% solids. This change in sludge density (being twice as dry as design) has resulted in the burn or onset of combustion occurring in the upper hearths, so instead of combustion taking place in hearth three, it occurs in hearth one or two. These values have changed because of population increase and a secondary augmentation to the process, adding an anoxic bioreactor which has resulted in tonnes of additional biomass in circulation. Additionally, density has been affected by competing economies – lime re-use V’s combustion costs. Lime was originally reclaimed and recycled through the incineration process, as at the time lime was more expensive than fuel. More so feed density has increased because of more efficient dewatering equipment. During a shift, proportion of volatiles in the feed can change dramatically which effects overall burn and furnace stability, this is because of a daily flush of the plants inflow structure. Grit loadings on the furnace are constant but due to poor grit classifier performance water can be transferred through to the furnace resulting in high emissions and temperature drops, all making the operation of the furnace more challenging.

- *Inherent Risks Associated with Incineration:* As it can be expected with any incineration process there are a multitude of interlocks associated with protecting the asset and personal safety of employees. These range from pressure drops on a fuel line, whether or not a scrubber water supply pump is running, fire detection alarms and many more. These examples and many other interlocks some 24 in total are all capable of tripping feed to the furnace causing an unstable environment to “burn out” the furnace.

Some safety measures are put in place from lessons learnt. For example on the 10th of May 1995 the screenings and incineration building caught fire due to ignition of combustible material in a foul air duct as a result all fibreglass in the furnace hall was replaced with steel and more importantly a hot work permit system was put in place. Others can be general nuisance from alarms due to smoke and ash which are not uncommon. This can be managed reasonably during normal conditions but when projects or major maintenance is occurring the operators focus is not only devoted to furnace monitoring and shutdown but also site management procedures. During an emergency all site work ceases and site personnel muster, with operations acting as site safety wardens.

- *Sludge Inventory:* As sludge from the primary settling tanks is the main feed source for the furnace, whether or not the furnace is running bears great influence over sludge inventory and variables such as Waste Activated Sludge (WAS) rate. Inversely sludge inventory is a main driver for sludge feed rates to the furnace. Prolonged periods of high inventories must be combated with high feed rates to the furnace sometimes running dual centrifuges at rates of 14 l/s; although this is achievable the furnace requires even closer monitoring of hearth temperatures, oxygen demands and emission parameters as it operates in an even more meta-stable condition.

- *Design Legacies:* The successful operation of the furnace depends on obtaining accurate, reliable and most importantly truly representative combustion temperatures. Gaining truly representative temperatures from the furnace is just about impossible; the thermocouples on an IN hearth (where the gases flow OUT) give a representative reading. However, the thermocouples on an OUT hearth (where the gases flow IN towards the shaft) read a combination of the temperature of the flue gases coming up through the drop holes from the hearth below and flame radiation from the hearth below, especially in the combustion zone. A compounding issue is that each hearth contains only one thermocouple, reducing operator feedback and resulting in difficulty to pre-empt the "burn" moving from one hearth to another, which can cause flare ups as combustion rapidly moves to material not yet burnt.

  The burners are as they were installed forty years ago and can be hard to start, which happens when they are generally needed the most, which is in a rapid temperature loss situation. Furthermore, they cannot be controlled automatically or to set points as the thermocouples do not return reliable information about conductive heat transfer.

  While not truly representative at least temperature is reported to the operator in real time whereas time lag from the stack emission analysers can be between 5 and 15 minutes. This essentially means that by the time emissions readings are out of specification relative to our atmospheric license parameters, the conditions within the furnace causing the issue have already occurred. This is more often than not overcome by the intuitiveness of operators piecing together multiple other inputs and pre-empting changing conditions.

- *Ageing Infrastructure and Equipment:* As the plant was built some forty years ago with equipment generally replaced as necessary, ageing infrastructure begins to present issues as equipment failures become more frequent resulting in more scheduled shutdowns.

While condition monitoring can predict certain equipment failures others are unpredictable, for example loss of a core in a multi core cable causing an Induced Draft Fan trip and a prolonged shut for fault finding. These planned or unplanned shutdowns result in situations where maintaining the atmospheric license is difficult. Also, the loss of production and increased sludge age in the primary and secondary clarifiers puts other stresses on the rest of the plant.

2.1 Project Works to Overcome Operability Issues

A Computational Fluid Dynamics (CFD) model of the LMWQCC furnace has been developed and significant amount of money through four packages of capital works projects is being invested by Icon Water in the LMWQCC solids handling process to improve operability. The design phase of all of these projects are complete and construction already underway. An outline of these projects and how they will improve operability and efficiency of the solids handling process is detailed below.

- CFD modelling of the incineration process - Developing a CFD model of the furnace enabled a platform to assess different upgrade options to the furnace. This provides confidence that the engineering changes will reduce emissions and energy costs.

- Stage #1 - Furnace and Exhaust System: This project will involve a broad equipment upgrade including the installation of new additional thermocouples, new dual fuel burners, new natural gas supply for these burners and a new drop chute to allow cake to be fed directly into hearth three moving the combustion zone down into hearths three and four as originally designed. A complete electrical, instrumentation and control upgrade will also be undertaken involving installation of new variable speed drives, motors, emissions analysers and an ash handling system upgrade.

- Stage #2 - Centrifuges, Polymer Dosing and Ventilation upgrade. This project will deliver three new centrifuges, new and modified centrifuge diverter chutes and a centrifuge hot swap changeover tank to enable centrifuges to be run in different modes simultaneously, building sump pump and instruments. An upgraded polymer dosing system to handle projected plant flows into 2030 and upgrade to the Screening and Incineration ventilation system.

- Stage #3 - Sludge Holding Tank and Ventilation upgrade. This project will deliver a new Sludge Holding Tank which anticipates spreading the load of % solids in feed to create a more consistent sludge feed. This consistent feed should eliminate the peaks and troughs of temperatures throughout the shift. It also addresses capacity and reliability improvements to the Solids handling portion of the plant, in particular with the existing lime sludge and recirculated sludge pumps and the flow of sludge from the proposed Sludge Holding Tank again targeting projected plant flows to 2030 and management of sludge age.

- Stage #4 - Screenings and Grit. This package will achieve increased capacity for the inlet screens to handle increased inlet flows and morning flush solids loadings to the design horizon of 2030. Increased screenings handling capacity and macerator performance to handle these projected flow increases. Enhanced safety with double isolation around the inlet channel for operations and maintenance activities.

Increased performance and stability in the grit dewatering process reducing the moisture content of material being fed into the furnace with subsequent emissions control benefits.

3.0 CONCLUSION

In summary the challenges presented to operators of the furnace at the LMWQCC are as a result of the type of process used to deal with solids at the plant as well as design legacies, changes to feed characteristics, downstream process interactions and having to operate infrastructure that has aged significantly. In its current state the organisation relies heavily on their operators to ensure emissions license compliance and process monitoring and control. Given the complexities and risks associated with operating the furnace it is a testament to both operator and organisation that it is operated and maintained to the standard that it is. Significant investment into the renewal of the sludge handling and incineration process and associated control technology will yield more efficient, safe and compliant operation of this facility.

4.0 ACKNOWLEDGEMENTS

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Ian Bruce – Principal Process Engineer
Kyleigh Victory – Senior Process Engineer
Azhar Ashfaq – Sewerage TP Program Design Manager

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BLOWER TECHNOLOGIES AND ENERGY EFFICIENCY OPPORTUNITIES

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BLOWER TECHNOLOGIES AND ENERGY EFFICIENCY OPPORTUNITIES

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ABSTRACT

The operating principles of today's Wastewater Treatment Plants (WWTP) are permanently under review against world best practice. Not only does the right treatment selection play a vital role, but the energy efficiency is also of utmost importance with energy consumption a major cost factor during the lifetime cycle of installed equipment. It is no longer good enough to purchase individual components. Plant managers, design engineers and consultants must work together to find world best practice system solutions for today's needs that flexibility cater for future requirements. With ever increasing energy costs, it is vital to understand the importance of the working principles of compressed air equipment, and its influence on the overall plant performance and lifecycle cost. Knowing that energy is the single highest operating cost in a WWTP, where blowers for aeration play a crucial role, knowledge of the different blower operating principles is important.

This paper outlines; the traditional approach to WWTP design and its associated efficiency problems, system solutions and an alternate design approach with key efficiency gains, guidance on how to calculate specific power for an individual unit and an entire system.

1.0 INTRODUCTION

The needs of commercial and municipal WWTP's vary substantially in size and projected period of planned operation cycle. It is not unusual that the designs for municipal plants are based on projected populations and demand 10 to 30 years in the future. As project funding is available now and may not be there later on, system engineers must build a system that will continue to serve the community's growing needs, in the most cost-effective, energy-efficient way possible. This is no simple task. Although the volume of air and pressure changes seasonally, each day, even hour to hour, the general practice is to design the plant's capacity for the worst case, maximum future load, resulting in oversizing the blowers. However, oversized blowers do not operate at their most efficient design point and spend as much as 90% of their operating time wasting costly energy.

2.0 DISCUSSION

2.1 Blower Operating Principle Efficiency

There are two main groups of compression principles; compression by dynamic and displacement design. An overview of the different operating designs available is shown in Figure 1. Standard for all applications with pressure requirements below 1000 $mbar_{(g)}$ is roots type blowers - a robust design where the compression process happens in the associated pipework. Displacement rotary blowers are of oil free design and so require clearance between blower housing and both rotating rotors. This results in slip (backflow) of air, resulting in reduced efficiency.

Figure 2 illustrates the differences between external and internal compression. With increased pressure influence, system engineers do their best to combat wasted energy by selecting energy efficient equipment.

This has led to an increased focus on energy and has helped spur innovations in blower technology. It is important to make the right decision on the blower package and its operating principle.

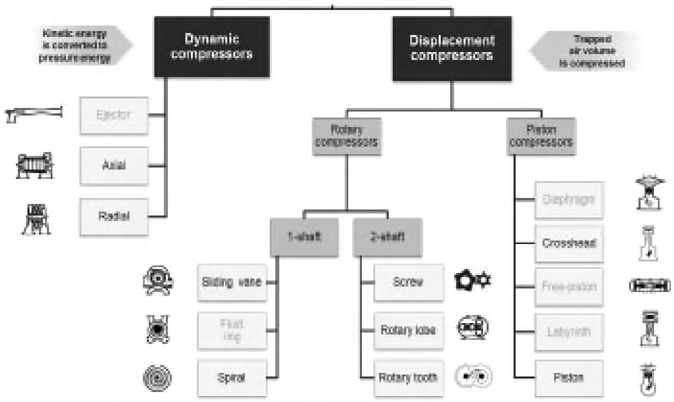


Figure 1: ***The various designs on compression principles for gaseous mediums***

External compression: Air is pushed out against the pressure losses in the process and therefore compressed in the piping between blower and application:

Internal compression: a certain pressure is always built up, independent of the process requirements:

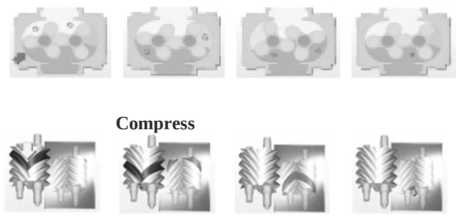
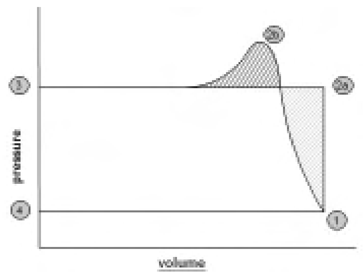


Figure 2: ***Compression principle three lube rotary blowers with pre-inlet channel design and screw blower***

Blower manufacturers are taking advantage of the increasing interest in energy savings and offer low pressure equipment in the form of Roots Type Three Lobe Blowers, as well as Screw Type Blowers. The question therefore is, 'what blower type for what application?' The trade off on work required to compress a gas, using internal or external compression principle is shown in Figure 3: an energy advantage of internal compression at precise adjustment of the screw geometry (green area), compared to additional consumption at over-compression (top area).



4-1: suction process
1-2b: polytropic compression screw profile
1-2a: isochoric compression blower
2-3: pushing out against pressure

Figure 3: ***Comparison on required work associated with blower using internal and external compression***

Energy savings are achieved as long as the area enclosed by 4-1-2b-3-4 is less than the area 4-1-2a-3-4. When choosing a blower with internal compression (helical rotors), the operating point must exactly comply with the by design (geometrically) determined optimum design pressure or else this will lead to over-compression and unnecessary energy consumption.

The internal compression of screw blowers operating in idle load, is always connected to higher power consumption. Pressure requirements of 500 $mbar_{(g)}$ and above should be considered as a base line where the use of screw blowers can be more efficient.

2.2 Plug & Play Solutions

The next step is "Wire-To-Air" efficiency. Here, the drive system, motor and starter, are carefully matched, ensuring minimum mechanical and electrical losses. A basic tool for the plant operation and system design engineer is simply total energy used to provide the specified flow and pressure and is expressed as a ratio of the power to the flow. While this metric is relatively new to the blower market, it is widely used for industrial compressors and compressed air systems and is often referred to as *specific power*.

Whether using the term plug & play, wire-to-air or specific power, it is important to differentiate between each individual piece of equipment's efficiency and the overall *system* efficiency. The traditional system design approach for WWTP's focuses on individual blowers instead of considering how each piece will work with one another. However, even if the most energy efficient blowers are selected, if they are not properly applied and controlled, they will not yield the anticipated energy savings. This is why system specific power is crucial in system design.

2.3 Specific Power Explained

In its most basic form, specific power is a product of input kilowatt to the machine divided by cubic metre per minute of air at standard conditions.

$$\text{Specific Power} = \frac{\text{Input kW}}{m^3/min}$$

While the equation is relatively simple, the process for calculating the value is not, no unified testing standard currently available to serve as a baseline for the calculations. There are a number of international standards manufacturers can use for determining equipment efficiency, depending on the compression principle of the equipment. Most commonly used is ISO1217-2008 annex C for compressors, operating on displacement principle. Furthermore, these international standards don't use a common baseline, or unified protocol for manufacturers to publish their performance on datasheets. Because the testing procedures aren't standardised, end-users aren't able to make true 'apples-to-apples' comparisons when considering different equipment to purchase.

As there is currently no testing standard and no published datasheets for blowers, the burden of making uniform calculations is on the user. To calculate specific power, it is possible to measure the input kW at the package control panel and install a flow meter at the outlet of the package to determine flow. However, when specifying equipment, this is not possible as the equipment is not on hand.

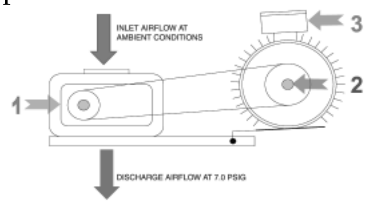


Figure 4: ***Blower consumption (1), drive losses (2), and motor efficiency (3), all impact specific power***

This necessitates understanding how to calculate specific power for the entire package and how each component will affect the overall efficiency.

Looking at the specific power of only a blower block from one manufacturer versus that of an entire package from another will not give a true efficiency comparison. To calculate specific power, first the flow rate needs to be determined. For positive displacement blowers, this is a function of the blower's displacement per revolution, blower slip, operating RPM, ambient conditions, and operating pressure.

$$\dot{V}_1 = V_0 \left(n - n_{slip} \cdot \sqrt{0.0371 \cdot \frac{T_1 \cdot \Delta p}{p_1 \cdot 1K}} \right)$$

V_1 =	*Suction Volume*	*n_{slip} =*	*Slip Speed (basis 100mbar)*	*p1 = Inlet Pressure*
V_0 =	*Displacement/Revolution*	*T1 =*	*Inlet Temperature in Kelvin [K]*	
n =	*Block Speed*	*Δp =*	*Pressure Differential*	

Next, we need the required blower power (1) which is a function of mechanical design and pressure differential. As ambient conditions are the same as normal conditions in this example, Nm^3/min and m^3/min are equal. Now we have blower power (1), but this is not what the user is paying for. The user is paying for electrical input at the motor (3).

To calculate motor input power (2), we need to determine the losses associated with the drive. For most v-belt slide base designs where the motor can be moved to adjust centre distance and apply tension, we can expect a 5% loss. For more advanced tension systems, these losses can be reduced to 2-3%. Finally, we need the rated motor efficiency as given on the motor nameplate. Therefore, input kilowatt (3) is given by;

$$\frac{\text{Blower Horsepower} \times (1 + \text{Drive Efficiency}) \times 0.746}{\text{Motor Efficiency}}$$

Once input power is calculated the specific power can be obtained.

$$\text{Specific Power} = \frac{\text{Input kW}}{m^3/min}$$

The lower the specific power value, the more efficient the blower is. Here we only evaluated the blower, belt drive, and motor, and we assumed ambient conditions to be the same as standard conditions, which helped simplify the flow values and calculations. In reality, most blower systems include accessory components such as silencers, filters, and valves, which all present flow restrictions. Flow restrictions result in a greater pressure differential across the blower and result in more power consumption. In addition, other package designs utilise cooling fans (shaft or separate), pumps for cooling, or some other electrical or mechanical device, which add to the power requirements of the machine. We also need to consider the different internal pressure between rotary lobe and screw blowers. For the best accuracy, input kilowatt should be measured at the input of the machine's control panel. This takes into account all losses associated with the package as well as other relevant components. In addition to system losses and power consumers inside the package, power consumers in the control panel also need to be considered. The sum of each of these gives the total package input kilowatt consumption.

So far we have evaluated the elements of a blower package, power transmission, and accessory power consumers to represent the performance of the physical package. For a fixed speed machine, the specific performance of the machine is mostly constant (excluding the effects of ambient conditions). However, the vast majority of modern wastewater systems utilise variable frequency drives and the demand is split between the units enabling handling flow and pressure requirement at constantly changing needs.

2.4 Variable Frequency Drive

Variable frequency drives (VFDs) allow equipment to operate at different speeds by adjusting the voltage and frequency delivered to the motor. This gives the machine versatility by varying blower performance to match system demand; however, this comes at a price. Most variable frequency drives have an efficiency rating just like motors. The 97% VFD and 95% motor efficiency do not apply when the unit is running at ¼ or ½ speed. At these reduced speeds, the efficiency is decreased; therefore, VFD usage should be limited to applications where the demand actually fluctuates.

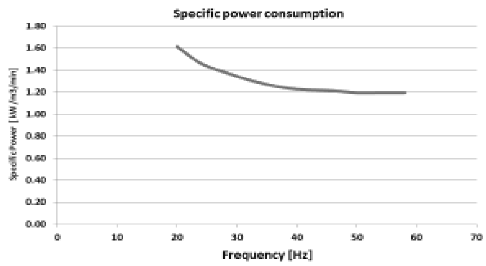


Figure 5: ***Running at reduced capacity greatly impacts the energy efficiency of a variable frequency drive unit***

VFD's are beneficial in handling fluctuations in demand, especially when compared to blowing off excess air to atmosphere. What should be avoided, however, is using a VFD on an oversized machine.

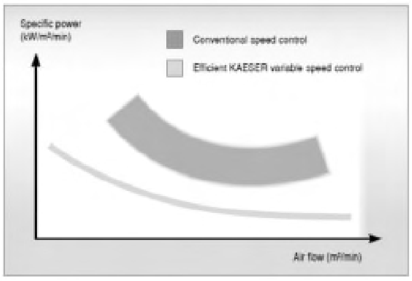


Figure 6: ***Specific power consumption conventional speed control and blower manufacturer speed control***

2.5 Focus on the System

For a multiple blower system, the focus must be on system efficiency. It is not enough to simply use the most efficient blowers. Well-designed blowers are a great start but to operate as an efficient system, they must be applied correctly and controlled properly.
Now that we have examined the efficiency for individual units, we can apply those concepts to understanding the overall efficiency of the entire system and how sizing and selection affects the efficiency of the system. This means, system design engineers should actively investigate the possibility of using rotary lobe- and screw- blowers in one system. Conventional aeration system designs include two large blowers. This needs to be critically reviewed, knowing that WWTP's are designed for the future, and that for a long time blowers are underutilised and operating most of the time in part load. Also the impact of large variable speed blowers with an identically sized back up unit, are the main reason for the high energy consumption. In-house basic control systems are set to share the demand and the units cost more to purchase, their drive losses must be factored into the unit's efficiency.

Flexibility and energy efficiency can be achieved by an alternate method of system design, so called system splitting. With system splitting, the maximum load is split among several cycling online/offline fixed speed machines to cover the large portion of the demand and a variable frequency drive (VFD) machine to cover the trim load. This method of system design allows much more efficient control without sacrificing the ability to meet the occasional periods of higher demand. Simulation programs can assist working out the best combination on rotary lobe blowers, screw blower and which one should be driven by variable speed drive.

2.6 Adaptive Control

For system splitting, only one or two machines are VFD units. If there are two VFDs in the system, only one runs at a time, with the second acting as back-up. The remaining blowers are fixed speed units. By limiting the number of VFD units in the system, initial investment costs are considerably lowered. The final component of system splitting is controls. Adding an adaptive master controller makes it possible to find the best combination of units to meet the current demand. Since the fixed speed units run on auto-dual control, the units can run idle for a defined period of time before shutting down. This gives the adaptive master controller enough time to observe the system's response and signal the units to reload if needed. The VFD is sized no larger than required, reducing the initial investment cost while covering the supply gaps that occur when the fixed speed machines are offline.

Adaptability: A master controller that learns the system and adapts to fluctuating demand can better respond and choose the most efficient unit combination to meet the demand and improve pressure stability. **Integration:** Chances are you have a plant SCADA system for monitoring. Look for a master controller with communications capabilities that will easily integrate into what you already have. **Back-up:** The right controller can help reduce maintenance costs, with some able to rotate like-sized machines to equalise run times and spread out maintenance intervals. Some will also let you specify the units to run as back up only, ideal where you want older/less efficient units to only operate if a unit fails.

Table 2: ***Adaptive master controller; key criteria to consider when selecting a controller***

3.0 CONCLUSION

Wastewater treatment is a critical utility and the system must be designed to reliably meet its highest expected load. When it comes to the blower system, bigger is not always better. The best air system design is a holistic one that takes into account the range of demand, future growth, the entire system's specific power, and optimised energy efficiency. System splitting, using rotary lobe and screw blowers, and using an adaptive control scheme can provide reliable supply without unnecessarily burdening the community with higher energy costs. Understanding system dynamics can save initial costs as well as maintenance and power costs for many years to come.

4.0 ACKNOWLEDGEMENTS

Co-authors; Albin Hess & Stephen Home, KAESER Compressors

UPGRADE OF CALALA WATER TREATMENT PLANT FILTER PNEUMATICS AND CONTROLLERS

Paper Presented by:

Rick Cowley & Norm Priestly

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Tamworth Regional Council

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UPGRADE OF CALALA WATER TREATMENT PLANT FILTER PNEUMATICS AND CONTROLLERS

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ABSTRACT

Tamworth Regional Council (TRC) Mechanical staff were engaged to assess the operation of the Calala Water Treatment filtration control system. The system was comprised of antiquated 240v electric/air solenoids with pneumatic cylinders and was identified to not meet Council's Work, Health and Safety (WH&S) requirements with a number of quality and operational issues also raised. Based on the assessment a new system was successfully designed and installed by the TRC fitters.

1.0 INTRODUCTION

Following an assessment of the filtration system of the Calala Water Treatment Plant in Tamworth NSW, the pneumatic cylinders and control solenoids were identified as having exceeded planned life expectancy and due for replacement or upgrade. This report will be focused on the design and installation of new pneumatic cylinders and controls for the 12 filters at the water treatment plant and subsequent work involved to rectify identified WH&S, water quality and operational issues.

<u>Figure 1:</u> ***Calala Water Treatment Plant***

1.1 About Tamworth Water Supply and the Calala Water Treatment Plant

Located inland between Sydney and Brisbane, Tamworth has a population in excess of 42,000 people. Tamworth sources its water from nearby state owned Chaffey dam, via the Peel River, and the Dungowan Dam, owned and operated by TRC. During periods of drought, water can also be sourced from a series of 12 wells located at the junction between the Peel River and Cockburn River.

The Calala Treatment Plant is the sole water treatment plant in Tamworth and is a fully flow paced plant. Commissioned in 1980, the plant was technologically advanced for the time and has benefited from ongoing upgrades in terms of automation and process control. The plant remains unique due to its simultaneous treatment of water obtained from two distinct sources. Each source has a distinctive raw water quality and requires differing levels of treatment to meet minimum quality guidelines

The plant has a design capacity of 80 Megalitres (ML) per day and has been designed to meet the requirements of the city until the year 2020. It has also been designed to accommodate short term influxes of up to 96 ML per day due to water demand peaks.

1.2 About the Filters and Filter Control

The Calala Water Treatment Plant utilises 12 filters; eight designated for Peel supply and four for Dungowan supply. Water arrives at the filters after being chemically treated with coagulants and pH adjusters and passing through the clarifier. Operating specifications of the filters at Calala Water Treatment are as follows:

- Direct Filtration
- Rated capacity - 6.8 ML/day each
- Filter bed size - 6.4m x 4.2m
- Filter rate - 10.5 m/h
- Up wash rate - 0.3-0.6 m/min
- Surface cross flow wash rate - 737/L/min /m2
- Filter media has dual layers of anthracite and sand and gravel to a maximum size of 16mm.

Under normal operating conditions, the pneumatic cylinders operate the inlet and outlet actuated valves, and are operated by an automated computer system. The outlet valve is usually closed and the inlet valve is open to allow a controlled flow of clarified water to enter the filters. Following treatment via the filters, the water flows through to a chlorine contact tank and is treated with soda ash to balance pH and fluoride. Subsequent to chemical treatment, it is pumped to storage reservoirs, ready for distribution to the customers.

Figure 2: ***The filters at Calala Water Treatment Plant***

Backwashing of the filters is generally undertaken after 30 hours of active filtration, or can be triggered by turbidity or head loss set-points. When the timeframe is reached, or the set-points are triggered, an automated program implements a filter backwash cycle by alternating the position of the inlet/outlet valves. The filters are air and water scoured, and backwash water is transported to an onsite storage pond. Once the backwash cycle completes, the valves return to normal position and filtration resumes.

The treatment plant can continue to operate while up to three filters are in a backwash cycle, with a standard backwash taking 40 minutes. If a fourth filter initiates a backwash cycle, the plant is unable to process the incoming water and will shut down. To prevent unnecessary shutdown and potential water hammer in raw water supply pipes, the reliability of the pneumatic cylinders and control solenoids is crucial to the effective operation of the filter process and overall plant operation.

2.0 DISCUSSION

2.1 Issues Identified with Existing Infrastructure

There were a number of WH&S issues identified with the existing filter system. The use of 240v solenoids in a designated wet area created a potential electric shock risk to operators, and deteriorating fibreglass cylinders could potentially burst under the operating pressure of 600 Kpa. Pinch points were also identified on the air cylinders between the exposed cylinder shaft and manual override wheels.

<u>Figure 3:</u> ***The old cylinders (L), control panel (TR) & operator access (BR)***

During the assessment a number of operational issues were also identified. Ageing infrastructure was resulting in a higher frequency of call outs, at times requiring a partial or complete shutdown of the water treatment plant. The location of the oil lubrication systems created the potential for contamination of the treated water, and access was impeded by poorly placed handrails and walkways. Air leaks were causing losses in efficiency, replacement parts were becoming difficult to source and operators were required to manually open and close the inlet/outlet valves when the automatic system failed to initiate.

2.2 System Re-Design and Repair Methodology

In order to rectify the issues identified in the assessment, a new system was designed and installed by TRC mechanical staff. The new cylinders were required to fit into the existing hardware and 24v air/electric solenoids compatible with the computerised control system. Aluminium and stainless steel pneumatic cylinders were utilised for their smaller size and higher efficient, and the control cabinet and solenoids were replaced.

The fitting began with the adaption of the new cylinders to the existing penstock valve frames and shafts. The shaft adapters were machined to a uniform size and new base plates manufactured allowing for the installation of the cylinders. The old cabinets were then removed and new control cabinets and solenoid manifold were assembled and installed. New airlines were installed between the cabinets and cylinders and power was connected.

Following initial testing, some minor alterations to the airline configuration were made and a two week trial was commenced. No issues were raised during this trial and the system was cleared for full time operation. A further eleven sets of components were ordered and subsequently installed into the remaining filters over the following eight months.

The final aspect of the project was to improve operator safety when undertaking maintenance, inspections and cleaning of the filters. Walkways to improve operator access were manufactured and installed along with new handrails to ensure adequate protection. The operators are now able to access the filters for cleaning and routine inspection in an easy and safe manner.

Upon completion of the filter upgrades, senior members of Council visited the water plant. Management were impressed by ingenuity of the new system and commended the staff involved on their workmanship, which was described as world class.

Figure 4: ***The new cylinders (L), control panel (TR) & operator access (BR)***

3.0 CONCLUSION

Following the completing of the Calala Water Treatment Plant filter system upgrade, many improvements have been observed during the two years since project was completed. There has been a significant decrease in call outs, improving overall plant efficiency and reliability. Increased reliably of the filters has resulted in a higher water quality and superior product for consumers. Maintenance requirements have also been reduced and the new filter system will continue to be of benefit to the Calala Water Treatment Plant for future water requirements.

4.0 ACKNOWLEDGEMENTS

Many thanks to all the fitters at the TRC Workshop who helped with this upgrade, and the onsite assistance provided by the Calala Water Treatment Plant Operators.

JOURNEY TO DISCOVERING DAFF LIMITATIONS & IDENTIFYING PROCESS IMPROVEMENTS AT GOOGONG WTP

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JOURNEY TO DISCOVERING DAFF LIMITATIONS & IDENTIFYING PROCESS IMPROVEMENTS AT GOOGONG WTP

Alice Liao, *Process Engineer,* Icon Water

ABSTRACT

Icon Water has two water treatment plants that produce safe and clean drinking water to Canberra: Stromlo Water Treatment Plant (SWTP) and Googong Water Treatment Plant (GWTP). Following the Canberra bushfires in 2003, both plants were upgraded simultaneously in 2004. Due to issues outside the control of the project team, process commissioning and proving of the GWTP Stage 2 Upgrade Project was limited when the plant was prematurely parked.

GWTP is nominally operated for two months per year when SWTP is shut-down for annual maintenance. Intermittent operation has limited the opportunities of operational exposure for Operations, Engineering and Automation staff, to continue to learn and troubleshoot the Stage 2 process. In conjunction with poor water quality and tighter filtered water turbidity requirements, this resulted in the plant not being able to meet its design capacity over the past few years.

In 2015, Icon Water prioritised recommissioning and optimisation of GWTP Stage 2. In order to address ongoing reliability issues, additional resources and an extended GWTP run, allowed troubleshooting and changes to be made.

This paper discusses the results of recommissioning and process optimisation carried out during the 2015 and 2016 runs. Further improvements identified for future upgrades that will promote DAFF functionality and improve the reliability of the treatment plant are also discussed.

One conclusion that can be drawn from this work is that when upgrading treatment infrastructure that is only operated intermittently, sufficient time should be allowed for commissioning and proving under a range of expected conditions *prior* to shut down for extended periods. Equipment reliability issues combined with the passage of time reduce the available pool of staff with working knowledge of the upgraded asset. This increases the challenge of producing drinking water that meets the design performance specification for both flowrate and turbidity targets.

1.0 INTRODUCTION

Googong Water Treatment Plant is only turned on for Operate-To-Maintain purposes when Stromlo Water Treatment is offline for planned annual maintenance, or rare emergency shutdowns, or to supplement SWTP during periods of peak demand.

There are two parallel process stages at GWTP which can be operated independently or together. Stage 1 is the original plant which comprises of clarification and direct filtration to achieve pathogen and sediment removal of up to 180ML/d. Stage 2 of the process was added on to the existing plant in 2004 to increase plant capacity by 90 ML/d (total of 270ML/d) which comprises the use of DAFF for pathogen and sediment removal.

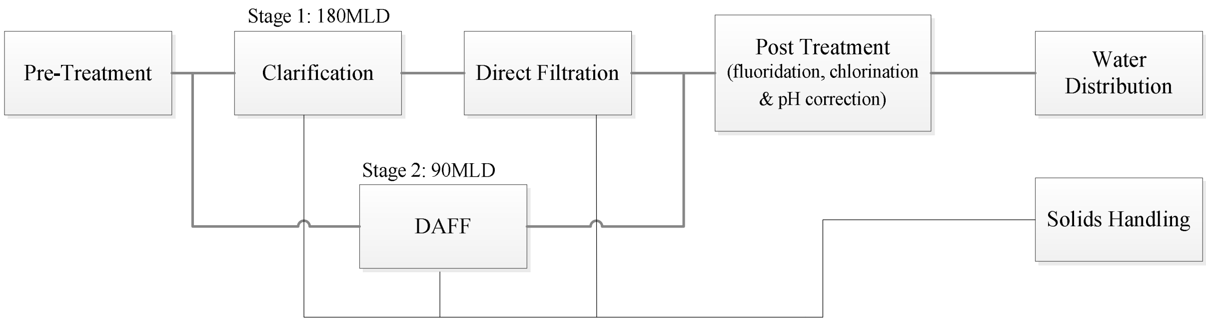

Figure 1: ***Googong WTP process flow diagram***

The Stage 2 Dissolved Air Flotation Filtration (DAFF) plant has 6 filters with a design capacity of 90ML/d (15ML/d per filter). In theory, DAFF should have the ability to start up and produce water more quickly than Stage 1 where it relies on filling up large volume of clarifiers first. However, due to unresolved residual project commissioning defects, infrequent operations of the plant, and deteriorating raw water quality and tightening of filtered water turbidity requirements in ADWG, GWTP Stage 2 has not being able to meet its design capacity. Over the past 5 tears, there has been limited success in operating DAFF due to seasonal run duration which has restricted the available time focus dedicated to the DAFF unit.

In 2015 and 2016, the process engineering team and operations team allowed additional resources to focus on re-commissioning of DAFF. The goal was to determine the actual capacity and condition of the system whilst addressing any automation sequence errors and equipment capabilities, and identify optimisation opportunities.

2.0 DISCUSSION

2.1 2015 DAFF Process Recommissioning

In 2015, GWTP operated for 9 weeks (Aug-Oct). During this time, several limitations were found that restricted DAFF's production capability and reliability. From a capacity viewpoint, each filter was only able to produce up to 20MLD with short run hours, <17hours, compared to the plant design of 25 hours. From a quality perspective, the 95th percentile filtered water turbidity of 0.12NTU was achieved, compared to the ACT Health requirement of 95% percentile filtered water turbidity of 0.2NTU.

Production capacity was limited due to rapidly changing flows causing premature and terminal turbidity breakthrough (reducing filter run times) due to DAFF control logic issues. Faults with the backwash sequence reduced capacity further. From a reliability viewpoint, a faulty pneumatic actuator on the Stage 2 DAFF inlet valve would unexpectedly close, causing unexpected flow changes and overflows.

During the 2015 run, the process engineer made the following automation improvements:

<u>Changes to backwash queuing logic</u>

The global backwash queue was implemented to allow the stage 1 and stage 2 filters to queue for backwashes together, without one filter type knocking other filters out of the queue. This change improved the operation of the system because it provided a logical queuing system for the filters which did not exist within the initial code.

Changes to DAFF recycle control

The DAFF recycle water flow rate was previously flow paced only. As a result, this caused uneven distribution of flow feeding into all the saturators due to the water pressure not being great enough to overcome this. This was rectified by changing the control to be both pressure and flow based. Hence, at a target pump discharge pressure of 610kPa, each saturator is now able to receive water at a stable flow rate of 12 L/s.

The process engineering also identified equipment replacement:

Stage 2 DAFF inlet valve

The pneumatically actuated Stage 2 DAFF inlet valve failed close multiple times during the 2015 run. This mainly occurred on mornings when the overnight temperature has been sub-zero. Even though this pneumatic valve has been investigated and parts have been replaced many times, these efforts have been unsuccessful. When this valve failed to shut, this caused hydraulic issue to the inlet channel and triggered it to overflow the structure. Overtime, this has caused erosion to the road, flooding to the clarifier gallery and unplanned discharge via the stormwater system. The sudden increase in flow into DAFF also created significant increases in filtered turbidity which is difficult to recover. To solve these problems, a project was initiated and completed to replace this valve with an electric valve.

Therefore, in 2016 Operate-To-Maintain run, new assets and new control logic from the 2015 run were tested to confirm the changes were effective, and to allow opportunities for process optimisation.

2.2 2016 DAFF Process Optimisation

In 2016, the plant operated for about 8 weeks (15-Aug to 10-Oct 2016). The main targets for the DAFF system optimisations were:

- To meet or exceed the same filtration achieved last year of 12ML/d, or better
- Optimise filter water level and scum roll off (sludge removal)
- Obtain stable filter operating condition

Table 1: ***Summary of the DAFF run log in 2016***

Date	Flow Rate	Description
Week 0-2	N/A	Stage 2 DAFF offline
Week 3 05/9/16	N/A	Stage 2 DAFF offline; Commenced pre-start work Jar tested- Initial chemical dosing set point: Alum- 43 mg/L, Polymer- 0.20 mg/L
Week 4 12/9/16	40 MLD (4 filters)	DAFF officially started on 14/09/16 Wednesday. DAFF was started with filter #1 and #2 at 20ML/d. 15/09/16 DAFF flow increased to 30 ML/d- filters started to stabilise 17/09/16 Increased DAFF to 40ML/d
Week 5 19/9/16	40-45 MLD (4 filters)	Plant more stable, plant- flow adjusted with flow split 70/45, stage 1/ stage 2. Alum was increased to 45 mg/L and polymer to 0.24 mg/L as flow increased.
	55MLD (5 filters)	During mid-week, DAFF was able to achieve 55 ML/d 60 ML/d was attempted on 23/09/16 Friday with filtration rate of 9m/h (5 filters), but filters were unstable, therefore flow was dropped back to 55ML/d.

Date	Flow Rate	Description
Week 6 26/9/16	60MLD (6 filters)	As flow rate increases, the run hours are significantly shorter (10-13 hour) and turbidity increases with every scum roll off. DAFF #3 and #6 had the most stable performance, whereas DAFF #5 struggled. Polymer dosing was also increased to 0.25mg/L
Week 7 03/10/16	45-52 MLD (5 filters)	Process optimisation and trial: Sat 8/10/16 Operators to attempt produce **13ML/d** per filter (4 filters online/ 1 standby); DAFF #5 offline (52 ML/d to DAFF, 63ML/d to DF) Operator feedback: DAFF seem happy with the high poly dose & recycle rate of 13.5L/s at 13ML/d. Process optimisation and trial: Sun 9/10/16 Operators to attempt produce **14ML/d** per filter (4 filters online/ 1 standby); DAFF #5 offline (56 ML/d to DAFF) Process not stable- still require further adjustment to the system; saturation vessel pressure will need to be increased to 500kpa or more, high polymer dosing at 0.35mg/L and alum dosing at 47-50 mg/L. Scum roll off time also adjusted.

During the 2016 run, progress was made in the following areas identified during the 2015 run:

<u>DAFF Recycle Control</u>

During initial start-up, the coding for DAFF recycle water flow that was implemented in 2015 was not enabled due to programming issue. Therefore start-up took longer than expected as there was not enough water pressure to distribute flow to the saturators. Once the coding was enabled, the system proved to be running smoothly and maintained set flow of 12.5L/s into each saturator. With the pump discharging pressure maintenance at 610kPa, the reduction of erratic flow has minimised shocks to the filters.

<u>Backwash Queuing Logic</u>

The global backwash queue implemented in 2015 was still in place and worked for the first 5 weeks of operation. Nevertheless, as more filters were brought online, the coding was still not fully correctly encrypted and there were programmable logic issues which faulted the backwash sequence on several occasions for several hours, limiting the number of filters available, and reducing plant production. This is still a work in progress with the Automation team. To ensure continuous run of the filters, it is recommended that the functional specification be revisited and the sequence possibly reprogrammed.

<u>Valve Replacement</u>

Conversion from pneumatic to electric actuation has addressed the root cause of the valve failure (freezing from morning sub-zero temperatures). This has had a major improvement to the DAFF flow stabilisation allowing the DAFF to run more consistently than during the 2015 run.

<u>Additional Equipment Replacement</u>

Apart from above changes, some additional assets were replaced and renewed since the 2015 run. These include DAFF no.4, no.5 and no.6 flocculators VSDs, Stage 2 polymer and alum dosing pump VSDs, and DAFF recycle pump VSDs. With some of these asset renewals, the DAFF system has improved its reliability. However, the commissioning of these new assets was not visible and communicated through to the relevant stakeholders. Therefore this was also a bottleneck in the process of starting up DAFF and a lesson learned experience.

2.3 DAF Filter Optimisation

DAFF had similar performance to 2015 run in 2016. However the filter ran more continuously and longer (18-21 hours) due to the changes implemented in 2015 and the additional operational resources delegated to this process. On average, 95th percentile turbidity in September and October 2016 was 0.12 NTU and 0.11 NTU respectively. The graph below is a snapshot of the DAFF performance in September, 2016. It also shows how filters are performing from turbidity changes when filtration rate increases.

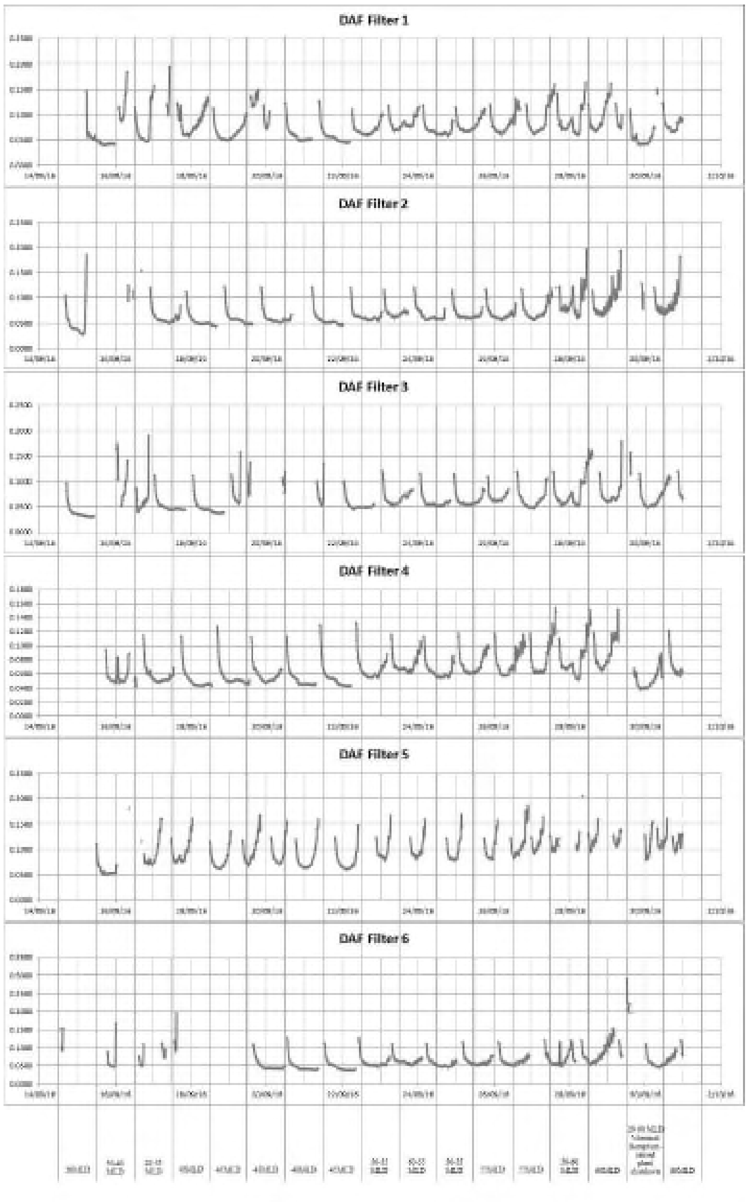

Figure 2: ***DAFF filter- turbidity performance in September 2016***

Additionally, during the final weeks of operation, we were able to achieve 13MLD out of each filter and attempted 14MLD per filter for a short period of time. It was identified that in order to filter at higher filtration rate, the saturator vessel pressure will need to be increased to >500kpa. Nevertheless, due to the sensitivity of the vessels, much attention, resources and time is required to implement this.

Scum Removal

A scum roll off frequency trial was conducted in 2016 is the. In 2015, minor attention was made to the scum roll off hence caused some mud-balling issue to the filters.

Therefore, during 2016 run, observations were made on the scum blanket on a timed interval and frequency is adjusted to ensure one-quarter to one-third of the blankets lengths is left on the surface of the filter. As a result, the filter ripening period reduced and mud-balling is minimised.

Figure 3: ***DAFF scum blanket roll-off***

DAFF Diffusers

DAFF diffuser adjustments were also a new fine tuning process done in 2016. A spreadsheet was used to monitor and keep track of the changes that were made to sixteen diffusers per filter. This also recorded the saturator vessel pressure and recycle water ratio so the effects of the changes from the diffusers were captured. Minor changes were made to the diffusers as we were in an observation phase. However, it was noted that the diffusers position tend to change due to vibration of the infrastructure. A baseline data on the diffusers has now been collected. Therefore, for future operations, it is in our team's intent to investigate the relationship between saturator vessel pressures, recycle ratio and diffuser position on our DAFF system, and optimise the process to reach its design capacity.

3.0 CONCLUSION

A significant amount of progress was made in 2016. With the level of repair and problems identified in 2015, DAFF was able to consistently produce 13ML/d per filter giving a total flow rate of 78ML/d (87% of design capacity). Even though there are still a number of issues to be addressed, there is now a baseline filter performance and a record of asset information. With continuous improvement, monitoring and necessary upgrades, the filters will be less prone to failure and will continue to improve the overall performance and reliability of the DAFF system.

It also highlights that when upgrading treatment infrastructure that is only operated intermittently, sufficient time should be allowed for commissioning and proving under a range of expected conditions prior to shut-down for extended periods. Equipment reliability issues combined with the passage of time reduce the available pool of staff with working knowledge of the upgraded asset. This increases the challenge of producing drinking water that meets the design performance specification for both flowrate and turbidity targets.

4.0 ACKNOWLEDGEMENTS

I would like to acknowledge all the members of the operations team for their contributions and commitment. Valuable information was greatly appreciated from Sarah McLaren who summarised the 2015 re-commissioning process and addressed some of the physical limitations. Special thanks to all my mentors, Ian Bruce, Laura Fuhrman and Kimberly Lawson and manager, Cameron Patrick, who have been very supportive in this learning process.

ICE PIGGING – A TARGETED APPROACH TO MAINS CLEANING

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ICE PIGGING – A TARGETED APPROACH TO MAINS CLEANING

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ABSTRACT

Ice Pigging is a relatively new technology in which an ice-slurry is inserted into a main as a liquid and once pressurised, creates a solid 'pig' which conforms to the inside of the main offering an alternative to conventional swabbing without the need to do any major modifications to the main. This property allows ice pigging to be utilised for different applications including cleaning transfer and trunk mains with a high sediment content as well as cleaning reticulation networks which experience high numbers of customer complaints due to discoloured water.

Two such projects conducted for Bega Valley Shire Council and Bathurst Regional Council demonstrate the ability for ice pigging to be tailored for the water provider's specific need. In 2015, Suez Water & Treatment Solutions undertook a project with Bega Valley Shire Council to remove the sediment build up in their transfer and trunk mains which provide water to the townships of Bega and Tathra. In 2016, Suez undertook a project with Bathurst Regional Council to remove sediment in their reticulation network which had a high number of discoloured water complaints.

1.0 INTRODUCTION

Ice Pigging is the process of inserting an ice slurry into the water main and once pressure is applied the slurry turns into a solid pig allowing for the main to then be cleaned. Once the main is isolated, the required quantity of ice slurry is then pumped into the main via a hydrant or similar fitting, the water displaced by the ice exits the main via a discharge hydrant as to not exert any excess pressure on the main.

Once the insertion is complete, both insertion and discharge fittings are closed and the upstream valve is fully opened, this compresses the ice to form a solid pig and provides the pressure which will propel the ice through the main. The discharge fitting is then opened to discharge the water allowing for the pig to move through the main.

The ice pig progresses through the main as a solid plug, but its properties as a two-phase material allow it to flow around solid obstacles such as partially closed valve gates, bends, constrictions and even tubercles on cast iron mains. A further benefit of this two-phase characteristic is that the pig does not "bulldoze" the sediment in front of it; rather it lifts the sediment from the pipe walls and carries it in suspension between the ice particles.

At the discharge fitting, pressure; flow rate; conductivity; temperature and turbidity are monitored and recorded in real time. As the front of the pig nears the outlet, an increase in conductivity is seen, caused by the salt added to the ice during manufacture; this indicates that the arrival of the pig is imminent. Once discolouration of the discharge water is observed the flow is diverted into waste tankers, ensuring all of the sediment and salt within the main body of the pig is collected and disposed of safely.

Finally, a short period of flushing is undertaken to ensure that all traces of salt and sediment have been removed. The main is returned to the customer when water quality indicators recorded exceed those taken pre-clean.

As the ice pigging process relies on both a shear force exerted from the ice crystals as well as turbulence of the flow of water before and after the pig, it provides the effectiveness of conventional foam pigging without the need for any excavation works saving on preparation time and operation time.

2.0 DISCUSSION

Bega Valley Shire Council and Bathurst Regional Council both experience discolouration of their water network due to sediment build-up which leads to customer dissatisfaction and complaints. In order to reduce the occurrence of these events as well as improve customer satisfaction throughout the network, Bega Valley Shire Council and Bathurst Regional Council both undertook an extensive mains cleaning program utilising the ice pigging technology. Due to Bega Valley Shire Council using an unfiltered source for their water supply, ice pigging was utilised on the large transfer mains to remove the build-up of sediment in these pipes, as Bathurst Regional Council already utilise a water filtration plant, ice pigging was undertaken on the reticulation water network to remove any sediment build-up.

To measure the effectiveness of the ice pigging operations, turbidity readings were taken before and after the operation as well as sediment samples collected and analysed for total suspended solids (TSS), these samples were then compared with the flow rate to give an estimate on how much sediment was removed in the process.

2.1 Bathurst Regional Council Reticulation Network

Bathurst Regional Council provides water services to some 42 000 residents in Central Western New South Wales, due to sediment build-up in the reticulation pipes discoloured water is often experienced from changes to flow conditions in the reticulation network. Ice pigging was chosen as the method to remove this sediment as it was able to utilise the existing reticulation network valve and hydrant configuration. The sediment is mostly manganese.

In March & April 2016, Suez conducted the ice pigging project for Bathurst Regional Council to remove the sediment build up, this project consisted of 74 individual operations on reticulation pipes totalling 50.82km of mains less than 250mm in diameter with an average distance of 687m cleaned per operation.

In order to complete the ice pigging operation, the section of main to be cleaned was required to be fully shut down for the ice pig to remain solid throughout the operation. This relied heavily on the experience and expertise of the network operators. Once the shutdown was achieved, an ice slurry consisting of approximately 10-15% of the main volume was inserted and pushed along using the existing pressure of the network.

To measure the success of the operation, the turbidity was recorded before the ice was inserted and before the main was returned to service. The average turbidity decrease for all operations was 59.95 NTU with a maximum decrease of 538.8 NTU. A graph showing the turbidity results for all operations is shown below.

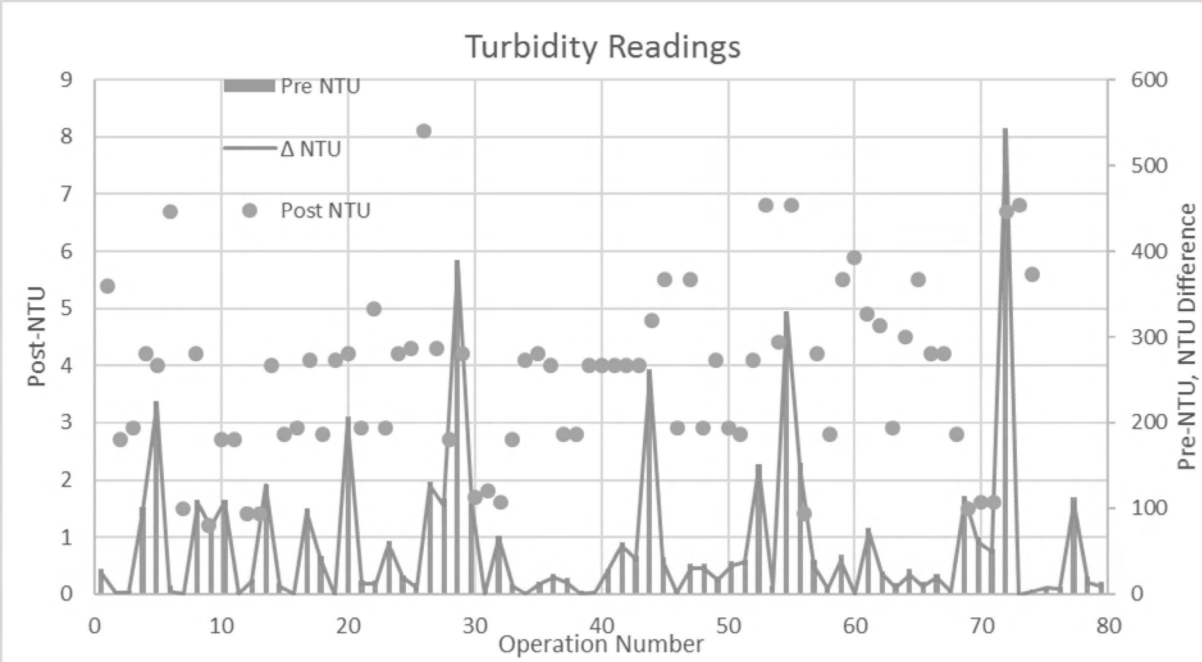

Figure 1: ***Graph showing turbidity readings for all operations***

As can be seen from the above graph, there was a significant decrease in turbidity in the majority of operations, which lead to a reduction of discoloured water events experienced by customers and an improvement in overall customer satisfaction.

In addition to the turbidity readings, samples were taken at constant intervals throughout some operations, these were then analysed for their suspended sediment content. The sediment concentration was then matched to the recorded flow rate to gain an estimate of the total sediment, on average, 7 kg per kilometre was removed during the project. This has resulted in a significant reduction in customer complaints.

2.2 Bega Valley Shire Council Transfer Mains

Bega Valley Shire Council located on New South Wales South Coast provides water to some 33 000 residents, due to no sediment filtration of the source water, discoloured water is often experienced throughout the network, particularly in the townships of Bega and Tathra. Four trunk mains ranging from 250mm to 500mm in diameter and a bore water main were chosen to be cleaned using ice pigging as it allowed for the easy insertion and discharge of ice without any major modifications to the mains.

In November & December of 2015, Suez conducted 17 ice pigging operations which concentrated on mains including the 450mm trunk main from the pumping station to the South Bega reservoir, the 500mm trunk main from South Bega to the Belmore St balance tank, the 300mm trunk main from South Bega to the Tathra reservoir as well as the 250mm trunk main from South Bega to Belmore St.

As with the Bathurst Regional Council project, turbidity and sediment data were obtained for the operations. On average the turbidity readings were 5.7 NTU lower for all operations with a maximum improvement of 26 NTU. As multiple flushing points were used for the mains over 450mm in diameter, accurate flow rates could not be obtained to gain a total amount of sediment removed, however the average sediment concentration for these operations was 35.83 g/L.

For operations where accurate flow data could be obtained, the total suspended solids concentration and overall sediment content was able to be calculated. For the South Bega to Tathra 300mm main, the average sediment concentration was 6.60 g/L with a total estimate of 62.96 g/m of sediment removed, in comparison, the 375mm bore line, the average sediment concentration was 60.92 g/L with an overall estimate of 1069.57kg of sediment removed throughout the operation with a concentration of 1944.69 g/m. The table below shows the sediment data for all operations:

<u>Table 1:</u> ***Ice Pigging operation sediment data***

Location	Operation Number	Diameter (mm)	Length (m)	Mass of Sediment (kg)	Concentration (g/m)
South Bega-Belmore	1	500	1004	135.17	134.63
South Bega-Belmore	2	500	809	427.89	528.91
South Bega-Belmore	3	500	624	476.59	763.77
High St-South Bega	4	450	1420	642.27	452.30
High St-South Bega	5	450	1350	933.38	691.11
South Bega-Tathra	6	300	2280	25.31	111.03
South Bega-Tathra	7	300	2336	34.31	147.01
South Bega-Tathra	8	300	2642	9.97	37.77
South Bega-Tathra	9	300	2433	50.63	20.81
South Bega-Tathra	10	300	3007	116.82	38.85
South Bega-Tathra	11	300	1203	77.95	22.29
Bega Borefield	12	375	550	1069.57	1944.69
Tathra	13	250	900	20.06	22.29
South Bega-Belmore	14	250	1400	52.39	37.42
Belmore-West	15	250	1400	48.28	34.48
South Bega-Belmore	16	250	1440	18.17	12.62
Belmore-West	17	250	700	97.75	139.64

Please note for operations 1-5, an estimated flow rate of 80 L/s was used as multiple points were used in the discharge process. This only gives an indication of the sediment in the mains.

3.0 CONCLUSION

The two projects detailed above for Bathurst Regional Council and Bega Valley Shire Council demonstrate the adaptability of ice pigging as a method of mains cleaning. In cases where customer complaints are experienced due to discolouration in the reticulation system, the two-phase property of an ice slurry allow for the easy insertion and removal of the ice pig which utilises the existing network configuration. An average improvement in turbidity of 59.95 NTU after the ice pigging operation has reduced the number of discolouration events and customer complaints in the Bathurst Regional Council reticulation system improving customer satisfaction and council reputation.

In water systems where source water with a high sediment content is utilised such as in the Bega Valley Shire Council network, sediment build up in the larger trunk mains can become dislodged during high flow events causing discoloured water to enter into the reticulation network leading to a large number of customer complaints. Ice pigging can effectively remove this sediment build up from the network without the need for any major modifications to the network, the high quantity of sediment removed throughout the project demonstrates ice pigging's effectiveness for these larger diameter pipes.

Since the removal of this sediment the number of discoloured water events has decreased causing a significant reduction in customer complaints which allows for the valuable time operations staff spend to rectify these events to be freed up for other network maintenance.

4.0 ACKNOWLEDGEMENTS

I would like to thank the following people:

Damien Tom and the operations team at Bathurst Regional Council for their knowledge and experience to contribute to a successful and fun project.

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Ed Petts and the operations team at Suez for helping deliver the ice pigging services.

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COMMISSIONING OF ACTIVATED SLUDGE PLANT AT THE DUBBO SEWAGE TREATMENT PLANT

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COMMISSIONING OF ACTIVATED SLUDGE PLANT AT THE DUBBO SEWAGE TREATMENT PLANT

Prakashbabu Radhakrishnan, *Water Treatment Supervisor*, Dubbo Regional Council

ABSTRACT

The Dubbo STP Major Upgrade is the third joint venture project built by CCB Envico and Cockram. The upgrade ensures Dubbo has adequate facilities in place to serve the needs of an estimated population of up to 55,000 people in 2035. The new Plant was constructed with the existing STP with a new biological nutrient removal plant which includes the following;

- The existing Inlet works were upgraded to a sealed system including covering the inlet works and proving an odour control system to extract and treat air to mitigate odours emanating from the Inlet Works. An epoxy coating was applied to the concrete channels at the inlet works to prevent degradation.
- Provision of two 6 ML/day bioreactor trains with a total of 12 ML/d capacity. Two trains of 4-stage Bardenpho bioreactors with a fine bubble disc aeration system and internal recycles pumps. Each train process contains four zones of pre-anoxic Zone, aerobic Zone, post-anoxic zone and re-aeration zone designed for biological treatment of wastewater.
- Two 31m diameter secondary Clarifiers for solid separation, as well as chemical dosing and storage facilities plus an in-channel UV unit to disinfect the clarifier effluent.

This paper discusses the Testing, Commissioning and Process performance in the first year of operation for the new biological nutrient removal plant.

1.0 INTRODUCTION

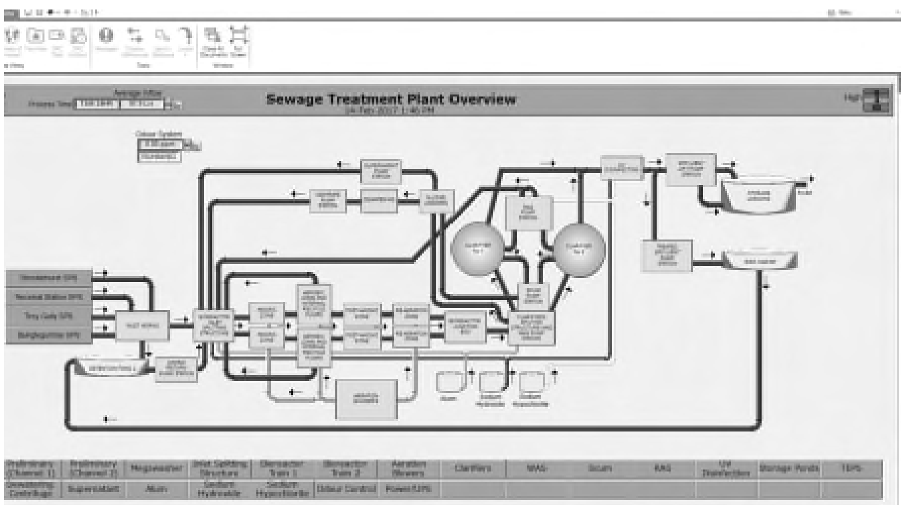

Figure 1: ***SCADA Screen – Dubbo Sewage Treatment Plant Overview***

Testing and Commissioning of the Dubbo STP Upgrade was carried out in the following sequence;

- Stage1 Testing
- Stage 2 Pre- Commissioning
- Stage 3 Equipment Commissioning
- Stage 4 Process Commissioning
- Stage 5:Post Completion

1.1 Stage 1 - Testing

The following tests were conducted

1) Factory Acceptance Testing;
2) Hydrostatic Testing;
3) Mechanical Installation of Plant and Equipment;
4) Electrical Installation of Plant and the Equipment;
5) Chemical Systems;
6) Aeration Systems;
7) Diffuser Test and Oxygen Transfer Test prior to pre-Commissioning;
8) Aeration Blower Factory Tests;
9) UV Disinfection;
10) Instrumentation;
11) PLC IO testing.

1.2 Stage 2 - Pre-Commissioning

Pre-Commissioning could not commence until testing has been completed

Pre-Commissioning Activities

- Checking Completeness of installation
- Checking all equipment is correctly labelled
- Ensuring all equipment's are lubricated.
- Checking electrical circuit continuity in accordance with drawings.
- Checking calibration of instruments, meters, signal converters etc.
- Checking the PLC and SCADA system monitoring and control displays.
- Checking chemical and building services water system operation etc.…

Pre-Commissioning Plan

The Contractor (Cockram) provided a Pre-Commissioning plan to the council two weeks in advance of Pre-Commissioning of any component. This plan includes final test plan, calibration certificates for equipment's, factory acceptance testing and inspection reports, all regulatory certificates and approvals, all drawings including Process and Instrumentation Diagrams.

1.3 Stage 3 - Commissioning of Equipment

Equipment Commissioning took place after all pre-commissioning has been successfully completed. During the equipment Commissioning period, Cockram ensured that the plant is fully operational and reliable and the following works been completed;
Activation of alarms including fault conditions,

- Functional checks on interlocks and control system for the plant.
- Calibration of all instruments and results sheets completed.
- Develop, monitor and control equipment commissioning procedures.

1.4 Stage 4 Process Commissioning

Following the successful completion of Equipment Commissioning, Council, Contractor and Public Works was responsible for Process commissioning includes determining dosing rates, set points, sludge feed, sewage quantity and testing regime.

Figure 2: ***Aerial view of the Old & New Sewerage Treatment***

Seeding/Cut-Over

The Summary of matters discussed regarding the Seeding are as follows;

- As the Sludge from the old plant was poor due to the over population of the biomass in the ditch and also foaming issues ,we have considered few options to seed;
- Bathurst STP can provide 3% solution which could be dosed into the plant, however the volume makes this solution impractical. 11% solution could also be provided however this would be very difficult to get into the plant for seeding.
- Challenge to follow the EPA regulations in transport & environmental issues.
- Time and cost factor.
- Need huge volume of the quality sludge?
- Council has therefore decided to use sludge from the existing plant.
- <u>The following process was undertaken to seed the new plant:</u>
    - The bioreactor will be seeded one train at a time. The first train of the new STP will be running concurrently with existing STP (each taking half of the load) for two weeks while the new bioreactor train is seeded and the process proved.
    - The above will mean that the existing plant will be at half its current load and water levels will need to be correctly maintained so that the surface aerators work as expected.

- ➢ Once the first train of the new plant is successfully established the seeding of the second train will commence following a similar procedure to the first.
- ➢ The timing of the shutdown of the existing STP Carousel will be considered once the first train of the new STP has been successfully commissioned and the seeding of the second train has commenced.
- ➢ Council has therefore decided to use sludge from the existing plant.

- **August 2015,** Started seeding Bio reactor Train 2, started testing program .Begin pumping from the old RAS to Bio reactor Train 2. Also, done chemical dosing inspection.
- **September 2015**, also done seeding for the Bio reactor Train 1.

According to the above planning, the cutover/seeding was successfully completed by the removal of isolation or connection to allow the process flow (Sewage) into the new plant. These included the screened influent and return lines. PLC/SCADA works for the relevant Component for operator use was installed by the Contractor before the cut-over was implemented.

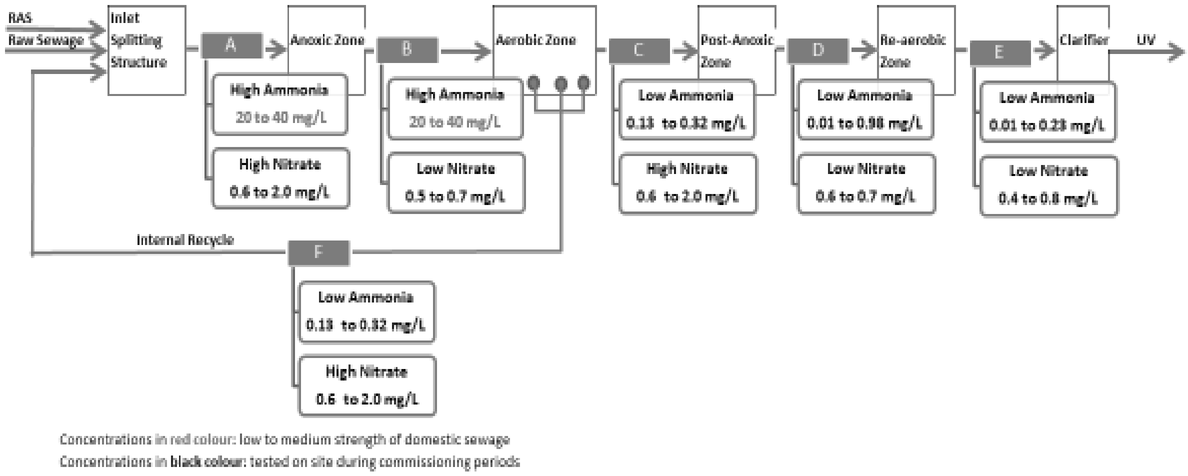

Figure 3: *Control Ranges for 4-Stage Bardenpho Process*

Process Proving Period
The Council conducted Process Proving trials over differing seasons for 1 year after commissioning is complete. The Contractor continued to attend the defects during this period and resolved efficiently. Some of the Defects include;

1.4.1 Aeration Blowers

Issues: There was few issues with the Blower fault such as Internal water Temperature, Under Temperature, Unreliable aeration control, Aeration system power usages, Aeration system control investigations and rectification.

Solution: ***New exhaust fan for the blower room installed. Also, fixed 4 new filter pads to the Blower room doors to prevent dust. Swapping Duty Blower at midnight on a 24 hours basis to get run time across the units. In September 2016, Atlas Copco and EDC Commissioned the Screw Blower which had been installed to achieve better aeration and power saving.***

The aeration system was shutdown to fix the new feed and valving arrangement. Also, Control method for all the blower system have been changed for better aeration control.

1.4.2 Odour Control Unit

Issues: During November 2016 & December 2016, we had couple of times issues with the Odour Control unit exhaust fan tripped out due to the unit filled with water. Cockram repaired the fan and advised council to install drain to resolve this problem happening again.

Solution: Drain was installed and no issues raised till now. The odour issue from the head of works has been improved and also the unit is working efficiently.

1.4.3 RAS Pumps

Issues: 6 Pumps have been installed according to the design, with 3 per Clarifier .Few Pumps have been faulted few times with the no flow and also high Temperature faults. We reset the Pumps and kept running and it happens again in few weeks, So through further investigation, Experts found the clogging up of RAS Pumps were causing due to the pump is installed in vertical position , instead of Horizontal leaving the pump minimal head ,we cannot complete bleeding the pump volute.

Solution: Try running only one or two pumps for each clarifier to meet the parameters for daily demand and install additional bleed points on all the pump volute. Two new Flow Switches were replaced by the Electrician. Still working on it.

1.4.4 WAS Pumps

Issues: One of the Pump faulting regularly on Stator High Temperature.

Solution: Xylem local pump technician inspected and serviced the pump. Fixed the faulty mini cast relay and our council Electrician checked, still faulting and finally found the issue was due to wrong wiring. At present, the pump is running efficiently.

1.4.5 UV System

Issues: Few of the wipers faulting often, the wiper cards need to be replaced. Isolation switch not working. Wiper ran continuously due to algal growth in the UV Channel. Also, the Air-Condition to the UV System couldn't cope with these conditions causes the high ballast temperature faults.

Solution: Service maintenance agreement with Xylem have been implemented and the Flex Board been replaced which affects the lamps/ballast fault generation. Also, checked Air Condition and the system is working fine.

1.4.6 Clarifiers

Issues: Due to enormous amount of algal growth on the Clarifier Launders, affects the UV Lamps /Wipers and also leads more work /time for the Operators to clean the algae.

Solution: ***Clarifier launder covers have been installed during September 2016 by Nextep Contractor which was not part of the original upgrade contract. This launder cover inhibits algae growth within the launder troughs and weirs by minimising sunlight penetration to these surfaces.***

1.5 Stage 5 POST Completion

NSW Public Works ensured;

- ✓ Reviewed Work as Executed drawings and operations manuals prior to issue to Dubbo Regional Council,
- ✓ Co-ordinated the rectification of Defects during the Defects Liability period.
- ✓ Finalized the contract and provided Dubbo Regional Council documentation with regards to the final contract value.
- ✓ Conducted and closed out workshop with the Contractor and Dubbo Regional Council.

2.0 CONCLUSION

Challenging elements of construction included:

- Swift mass excavation of over 50,000m^3 for the in-ground bioreactor tanks.
- Up to 1500m^3concrete pours commencing in some cases at 10pm and conducted throughout the night due to very high day time temperatures.
- Installation and testing large diameter 7 meter deep pipework beneath the clarifier Structures.
- 7 meter deep shielded excavation through a 60degree batter for the inlet feed pipe, in very close proximity to adjacent operating STP.
- The Dubbo STP upgrade and associated inlet works odour control project at over $25m represent the biggest single capital works project ever carried out by the Dubbo Regional Council was Completed Successfully by December 2015.The Contractor Performance was evaluated with high and improving scores on communication, time, cost, quality, safety, issue resolution and contract relations. The Process during the First year of Operation regarding was successful in meeting the EPA Licence limits which is user friendly in operation of the plant for the Operators. The recommended Scope for the next project for the Council would be to build extra Sludge Lagoons due to the large volume of the sludge produced in the new Dubbo STP.

3.0 ACKNOWLEDGMENTS

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MANGANESE REMOVAL AT BATHURST WTP

Paper Presented by:

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MANGANESE REMOVAL AT BATHURST WTP

David Cashen, *Water Filtration Supervisor*, Bathurst Regional Council

HISTORY

Bathurst Regional Council caters for an estimated 40,000 population at any one time and over a period of many years, has suffered due to the naturally occurring minerals Iron and Manganese.

Is was not uncommon for the Engineering department to receive large quantities of calls from the general public complaining of discoloured water or quality issues, especially around the high draw off or warmer weather periods when demand was at its highest. Following on from the complaints were then the expected compensation payments which at times due to the nature or location of the complaint, council obliged as it was a very big issue especially for businesses relying on water quality like dry cleaners.

Due to Bathurst having all facets of industry from food production to education and medical and the dry cleaning sector cleaning whites, obviously weighed in on the decision to provide compensation over the years. Council as a business also has a duty of care and responsibility to the ratepayers, so started to look at alternatives to find a long overdue remedy for the problem.

1.0 Problem 1

Bathurst Regional Council is a wide spread, fast growing region and it only has one Water Filtration Plant which can treat and supply up to 60ML/d or 695 L/s. It was built in 1972 so has limited augmentation potential.

The WTP consists of conventional treatment processes from floatation deflector tube with 300mm of debris wire on the raw water source or Macquarie river to 50mm vertical bar screens on inlet channels to the vertical lift raw water pumps. These pumps lift the water up to the Rapid Mix chamber or where the coagulant (Aluminium sulfate - Liquid Alum) is added as the chemical part of the process. This process changes or adds ions to the existing ions to form bonds or floc particles which bond up the dirt particles.

At this stage, the plant also utilises a coagulant aid to strengthen the floc formed which is a polymer that can be charged either way or neutral. Flow then travels into three bays called flocculation chambers which are tapered which means lower in speed as water travels through each one so to not break up or shear the floc. Flows then move into the sedimentation part of the process where the physical settling process takes place. The newly formed large and now heavy floc settles under gravity and is scraped away and wasted to drying lagoons. The clean water travels out of this part and into channels which go to the duel media Rapid Sand Filters (14 in use). The water filters through to a quality of about 0.05- 0.10 NTU's under normal running conditions. It is at this stage that pH post correction chemical is added, Fluoride for Dental Health and most importantly Gaseous Chlorine for disinfection to a Free Chlorine level of 2.5mg/L in order to maintain the furthermost distribution location minimum free residual of 0.2mg/L. At this stage it is then pumped out to the service reservoirs fit for safe human consumption.

This is where the problem presented itself, as once the Chlorine was added, oxidation would occur in the distribution system and reservoirs and then ultimately to the consumer.

2.0 Problem 2

We experienced high levels of Manganese in the source water at various times of the year due to our Dam being a surface water Dam and prone to mineral wash in. Levels ranged from 0.015mg/L to as high as 0.8mg/L.

Remedy trial:
Potassium Permanganate - (KmNo4) was trialled for several years however was unsuccessful due to lack of contact time even at various % strengths and dose rates. A 2% solution was found to be the most suited to Bathurst, but was found to not have sufficient Mn removal over all mineral ranges and we could not get it under the recommended 0.02mg/L minimum in our treated water so the problem remained.

Study: Stage 1:
Trial by Catalyst - Force the minerals to oxidise before filtration so they could then be removed before the disinfection stage promoting the problem.

Clear tubes filled with a similar sand media used in the filters, conditions adjusted to match plant flows, temperature. The Catalyst used was Sodium Hypochlorite at 13% but most importantly, the location and pH of the water had to be corrected. This was to allow the right conditions for the hypo to oxidise and force out of solution the black problem Manganese mineral so that the filters could remove it.

Summer and Winter trials were also completed (2 years to cover all running conditions). Results were above expectations with levels of not only under 0.02mg/L but as low as 0.01 and under. This was classed as complete removal for around 90-95% of the time. Due to this, a full scale trail utilising two of our 14 Filters was warranted.

Study Stage 2:
Trial ongoing utilising 2 full scale filters, all conditions tested and noted. Results backed up those identified in the stage 1 trial.

Funding was sought and plant augmentation was completed at a cost of around $5M. Testing is ongoing with over expected results and system performance.

DEWATERING CENTRIFUGE OPTIMISATION - A BETTER WAY

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DEWATERING CENTRIFUGE OPTIMISATION-A BETTER WAY

Lachlan McTaggart, *Production Officer,* Sydney Water Corporation

ABSTRACT

The disposal of dewatered biosolids has both significant cost and environmental implications. The varying nature of feed sludge and poor understanding of the dewatering process make it difficult to fully optimise. In addition, the commonly applied one factor at a time optimisation approach is time consuming and only achieves adequate not optimal performance.

A full-scale design of experiments approach was taken to better understand the importance and interactions of operational parameters (factors) relating to centrifuge dewatering. An initial two stage screening test was used to identify the top three factors that influence dewatering performance. These were further investigated and described using a full factorial design.

It was found that torque was the top factor affecting dewatering performance. By establishing a deeper pond, increasing the feed flow and maximising the bowl speed it was possible to increase the torque and maximise the cake dryness. Factors such as the pond depth, bowl speed and polymer dose were shown to be important for maintaining the centrate clarity.

The dryness of the dewatered cake was increased from 20.3% to 23.5% representing a financial saving of AUD $176000pa. The lessons learnt during the full-scale design of experiments may represent significant savings if replicated elsewhere.

1.0 INTRODUCTION

The management and handling of wastewater sludge is one of the largest problems facing Wastewater Treatment Plants (WWTPs) (Spinosa et al., 2011). Even though the volume of sludge is small in comparison with the amount of wastewater treated, the costs associated with handling of wastewater sludge may comprise of up to 50% of the operating budget of the WWTP (Barber, 2014, Spinosa et al., 2011).

The nature of wastewater sludges makes them both inherently difficult to dewater (Chen, 2013) and unique (Włodarczyk et al., 2014). Their properties and characteristics are dependent on both the sewage entering the WWTP and the treatment processes used at the WWTP (Thomas, 2009, Włodarczyk et al., 2014).

There are many parameters (or factors) that may affect the performance of centrifuge dewatering. While the effects of changes to each parameter are mostly agreed upon (Table 1), there is still some debate found within the literature, particularly in the case of pond depth. Furthermore, the extent to which each operational parameter influences cake dryness and centrate clarity is unknown.

Centrifuge optimisation usually involves using a one factor at a time (OFAT) approach. This aims to identify the optimum setting for each operational parameter by changing one factor at a time across its range while keeping the other parameters constant.

Table 1: ***Summary of literature findings on effects of changing main operational parameters***

	Increasing				
	Bowl speed	**Feed rate**	**Torque**	**Polymer dose**	**Pond depth**
Cake Dryness	Increase	Decrease	Increase	Increase	Decrease
Centrate Clarity	Increase	Decrease	Decrease	Increase	Increase

While useful, this fails to fully optimise the process, or to identify the key operational parameters that provide the most influence to the outcome. It is also a slow and costly process.

2.0 DISCUSSION

2.1 Aims and Methodology

The aims were to validate the effects of factors in published literature, determine which are the significant and ultimately optimise the dewatering process to achieve the maximum dewatered cake TSR% whilst still maintaining a good quality centrate.

A two-stage design of experiment approach was taken using an initial screening design followed by a more targeted full factorial design. The statistical design of experiments is an excellent way to design or plan experiments, analyse the results to achieve objective conclusions and also the most effective means of optimising a process (Gündoğdu et al., 2016). MINTAB was used for experimental design and analysis.

2.2 Study Site

Cronulla WWTP is a tertiary wastewater treatment plant located in Sydney's south. It treats an Equivalent Population (EP) of 210000 with an ADWF of 56.8 ML/day and generates approximately 6.6 dry tonnes of biosolids each day. The sludge at the plant is a mix of Thickened Primary Sludge and Thickened Waste Activated Sludge. This sludge is anaerobically digested and then dewatered using a High G centrifuge. These centrifuges were installed in 2011/12, and had been optimised by the plant team using an OFAT approach to achieve an average TSR of 20.3%.

2.2 Screening Design

A screening design using a fractional factorial design was used to identify the vital factors that had the greatest effect on cake TSR% and centrate quality. This is an excellent way to consider the effect of a large number of factors in a minimum number of runs, thus reducing the time and budget required (Antony, 2014). This two-level factorial investigated the effects of the all six factors: Torque, polymer dose, bowl speed, feed rate, dilution water and pond depth (Table 2). The high and low levels were selected based on the normal operating levels, as well as relevant site knowledge and relevant literature.

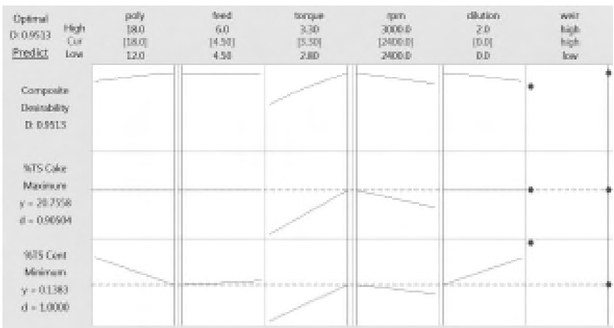
<u>Table 2:</u> ***High and low levels used for each factor investigated in the initial screening design***

Factor	Low level	High Level
Bowl Speed (rpm)	2400	3000
Torque (kN)	2.8	3.3
Polymer Dose (kg/dT)	12	18
Dilution Water (l/m)	0	2
Feed Rate (l/s)	4.5	6
Pond Depth (mm)	120	110

The average result for each run in the initial screening design are presented in Table 3 below, along with the factor levels used in that run. The analysis of the screening experiment data identified two critical factors for the cake TSR response, torque and bowl speed. The analysis of the screening experiment data also showed two critical factors for the centrate TS% response, weir height and torque. Polymer dose rate and dilution water were shown to have a moderate effect. The responses to the varying of the factors in stage 1 are displayed in Figure 1.

<u>Table 3:</u> ***Summary of runs for screening design including factor level and observed responses***

Run Number	Bowl Speed	Torque	Poly Dose	Dilution Water	Feed rate	Weir (Pond Depth)	Mean Cake TS%	Mean Centrate TS%
1	(+1)	(-1)	(+1)	(+1)	(+1)	(-1)	**19.44**	**0.190**
2	(-1)	(+1)	(-1)	(+1)	(+1)	(+1)	**19.83**	**0.180**
3	(-1)	(-1)	(-1)	(-1)	(-1)	(-1)	**19.88**	**0.208**
4	(-1)	(+1)	(+1)	(-1)	(+1)	(+1)	**20.97**	**0.215**
5	(+1)	(+1)	(-1)	(+1)	(-1)	(-1)	**20.24**	**0.760**
6	(+1)	(-1)	(-1)	(+1)	(+1)	(+1)	**19.24**	**0.193**
7	(-1)	(+1)	(+1)	(+1)	(-1)	(-1)	**20.90**	**0.370**
8	(+1)	(-1)	(+1)	(-1)	(+1)	(-1)	**18.85**	**0.270**
9	(+1)	(-1)	(-1)	(-1)	(-1)	(+1)	**18.81**	**0.167**
10	(-1)	(-1)	(+1)	(+1)	(-1)	(+1)	**19.00**	**0.160**
11	(-1)	(+1)	(-1)	(-1)	(+1)	(-1)	**20.66**	**0.940**
12	(+1)	(+1)	(+1)	(-1)	(-1)	(+1)	**20.45**	**0.157**



<u>Figure 1:</u> ***Optimiser plot showing how changes to factors affect the responses of cake dryness and centrate clarity based on the initial screening design***

2.3 Full Factorial Design

A full factorial design using the three most significant factors identified in the screening design was used to describe the effect of the factors on the responses and also to identify any significant interaction between them. After reviewing the results from the screening design and output from MINITAB the factors chosen were: Bowl speed, Torque and Polymer dose. The low and high levels were used from the screening design, and a mid-level was added (see Table 4). The exception to this was torque as it was identified in the screening design that certain combinations of factors were not able to achieve the torque set points, hence lower values were chosen.

Table 4: ***Factors and levels investigated in the full factorial design***

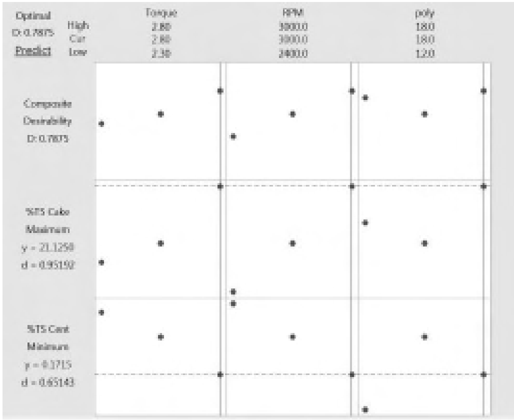
Factor	Low level	Mid Level	High Level
Bowl Speed (rpm)	2400	2700	3000
Torque (kN)	2.3	2.55	2.8
Polymer Dose (kg/dT)	12	15	18

The factors not investigated in the full factorial design were set at the optimal points that were identified in the screening design. As such a feed rate of 4.5l/s, no dilution water and R-110 weir plates (deep pond) were used. The responses and factor levels used for each run are presented in Table 5 below.

Table 5: ***Summary of runs for full factorial design including factor level and observed responses***

Run Number	Torque	Bowl Speed	Polymer Dose	%TS Cake	%TS Centrate
1	(-1)	(-1)	(-1)	**19.41**	**0.1605**
2	(-1)	(+1)	(-1)	**18.65**	**0.1737**
3	(0)	(0)	(0)	**19.87**	**0.1732**
4	(+1)	(-1)	(-1)	**19.39**	**0.1562**
5	(-1)	(-1)	(+1)	**18.65**	**0.1655**
6	(-1)	(+1)	(+1)	**19.72**	**0.1900**
7	(0)	(0)	(0)	**20.05**	**0.1856**
8	(+1)	(+1)	(+1)	**21.00**	**0.1853**
9	(+1)	(-1)	(+1)	**19.78**	**0.1778**
10	(0)	(0)	(0)	**20.22**	**0.1667**
11	(+1)	(+1)	(-1)	**20.60**	**0.1677**
12	(0)	(0)	(0)	**20.71**	**0.1744**
13	(-1)	(+1)	(-1)	**19.70**	**0 .1995**
14	(-1)	(-1)	(+1)	**20.01**	**0.1934**
15	(+1)	(-1)	(-1)	**20.45**	**0 .1978**
16	(+1)	(+1)	(+1)	**21.25**	**0.1576**
17	(0)	(0)	(0)	**20.17**	**0.2078**
18	(+1)	(-1)	(+1)	**18.93**	**0.1846**
19	(-1)	(+1)	(+1)	**19.98**	**0.1701**
20	(0)	(0)	(0)	**20.00**	**0.1520**
21	(+1)	(+1)	(-1)	**20.42**	**0.1655**
22	(-1)	(-1)	(-1)	**19.22**	**0.1709**

The analysis found that there were two critical factors for cake TSR, torque and bowl speed, and one critical interaction between torque and bowl speed. The analysis for the response centrate TS did not find any critical factors or interactions. The responses of the factors investigated in the full factorial design are shown in Figure 2.



<u>Figure 2:</u> ***Optimiser plot for full factorial design showing the effect of changes to factor level for each response. A composite of both responses is shown at the top***

2.4 Findings and Application

Using the results of both stages it was possible to develop a site-specific response matrix (Table 6). This information better allowed the operational team to understand the influence of centrifuge parameters on the dewatering performance. Changes were then made to the process which sacrificed ‘low influence’ parameters to greatly increase ‘high influence’ parameters. In particular, the bowl speed was maximised and the feed rate was increased to allow the most important factor torque to be maximised. Even though an increased torque and feed rate was shown to be detrimental to centrate quality, the deeper pond and higher bowl speed could maintain the centrate quality at an acceptable level.

<u>Table 6:</u> ***An example of a site specific response matrix showing significance and effect for both Cake TSR and centrate clarity***

	Most significant ---→ Least significant				
	Torque	**Bowl Speed**	**Weir Height**	**Poly Dose**	**Feed Rate**
Increase Cake TSR	Increase	Increase	Increase	Not linear	NA
	Weir Height	**Torque**	**Poly Dose**	**Bowl Speed**	**Feed Rate**
Decrease Centrate TS	Increase	Decrease	Not linear	Increase	Decrease

When fully optimised an ultimate cake TSR% of 25.11 could be achieved. A maximum cake of 23.5% was achievable before the centrate quality deteriorated to an unacceptable level. This was an overall improvement of 3.2%. This improvement in cake TSR will result in a reduction of sludge transport, which equates to a financial saving of $176000 each year.

Contrary to the literature and recommendations from the manufacturer the deeper pond provided for better sedimentation within the centrifuge resulting in both dryer cake and a much cleaner centrate. This allowed for the feed rate to be increased and the torque to be maximised producing a much dryer cake without compromising the centrate.

2.5 Future research opportunities

The following have been identified as potential future research opportunities:

- Conduct similar studies on other sludge types (i.e. Primary only and WAS only) and dewatering processes (belt and screw presses) to determine if there are any general rules that can be applied
- Test the experimental design process on thickening centrifuges where the desired responses are different (high capture rate and a specific TSR for TWAS).

3.0 CONCLUSION

This process has shown that design of experiments is an excellent statistical approach to the optimisation of a dewatering centrifuge. It enables for the development of a site-specific response matrix that shows both the significance and response of each factor investigated. It was found that increases to the torque and pond depth were the most important factors for producing dryer cake and cleaner centrate.

4.0 ACKNOWLEDGEMENTS

Thanks to Professor Richard Stuetz and Dr Juan Pablo Alavrez Gaitan from UNSW, for your support and technical expertise. Thanks also to Robert Aurisch and the plant team at Cronulla WWTP, for your encouragement and for allowing me to undertake my experiment.

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REHABILITATION OF VICTORIA ST RAW WATER PUMPING STATION

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REHABILITATION OF VICTORIA ST RAW WATER PUMPING STATION

Marty Woodhead, *Corowa Water Treatment Plant Operator,* Federation Council
Geoff Lewis, *Manager Water & Sewerage,* Federation Council

ABSTRACT

The Victoria St water supply pump station pumps water through an in-river gravel media filter bed built for the purpose of providing clean water to the town of Corowa. The gravel filter cannot be easily cleaned and this paper reports on its development, the method of backwashing and the level of success of recent rehabilitation work.

It demonstrates the importance of realistic planning to meet customer expectations and the high operational costs associated with projects proposed on low capital expenditure budgets and the importance of good design which considers operational costs as important as capital costs.

1.0 INTRODUCTION

Corowa is a town of 6000 people situated on the Murray River about 50km west of Albury. It has two raw water pumping stations delivering water to a distant water treatment plant which supplies water to the town.

The old Netherby Pump station was built in 1926 and comprises a 10m deep dry well with 2 duty pumps and is built on a rocky bend with deep water good for low river conditions in drought and a good high bank giving good access in times of flood.

In 1967 a new pump station was built at Victoria St to replace the old pump station and for the purpose of providing good quality water by pumping through a natural gravel filter bed in the river in lieu of building a treatment plant. The pump station struggles with high suction head problems when the river is low. When the river is in flood, the pump station can only be accessed by boat.

In 2002 a DAF water treatment plant was built and can receive water from either pump station.

The problem is that at the Victoria St pump station the gravel filter bed cannot be successfully backwashed and we cannot easily maintain the 3 pumps working at their design duty points.

<u>**Figure 1:**</u> ***Victoria St P/S Intake 1967***

<u>**Figure 2:**</u> ***Netherby P/S Intake 1926***

2.0 PUMPING STATION CONSTRUCTION

How did this backwashing problem develop?

In 1963 Council's consultant was authorised to undertake preliminary investigations in to ways of improving the town's water quality. The consultant produced a plan comprising a treatment plant but a referendum was held and the project proceeded no further.

In 1966 the consultant was again asked for further advice on improving the town water supply. An alternative scheme for providing a filtration system was put forward.

The scheme was to find a location somewhere on the river where a suitable natural gravel profile existed through which water could be pumped thus delivering clean water to the town. A pump station would be built at this location and the old pump station retained only for emergency use.

The Victoria St pump station site was selected as potentially suitable and test boring was undertaken and core samples were sent off for testing at a Sydney laboratory. Tests confirmed the suitability of the grading and the permeability of the material to act as an effective filtration medium for the town water supply.

Plans and specifications were then prepared for the intake screens and the pumps and approval received from the Department of Local Government and contracts were let to undertake the work.

Once work commenced it was found that the supposed suitable gravel bed was a small deposit only and that the sand and gravel composition was not as anticipated. It was decided to create artificial sand and gravel bed by excavating the river bed and carting in the necessary gravel to form a satisfactory filter bed.

By 1967 the work was complete and the pump station was commissioned. The pumps were operated and duly delivered water as expected. The filter bed was to be kept clean by backwashing by reversing flow through the filter from the rising main. When the backwashing was undertaken the adjacent river bank collapsed into the river and partially covered the filter media with silt. This occurred because the filter media was fluidised by the backwashing to make it like quick sand with no strength and suddenly provided no support for the river bank.

According to the record the Council's solicitors were not informed precisely of what took place following the collapse.

The record states that the river bank was then reconstructed using locally available sand selected by field inspection. With subsequent rise in the river level of about 1.5m the new bank again slumped over the intake. Remedial action to clear the media cost a considerable sum with drawings prepared showing details of the work which required considerable labour, drag lines, the council bulldozer and the hire of a pump at $120/week!

Council held the consultant responsible for the failed work and the attendant expenditure which was duly accepted. Nevertheless the consultant took the view that it could not be expected to have foreseen and forestalled what happened and that it consequently could not be held to account for it.

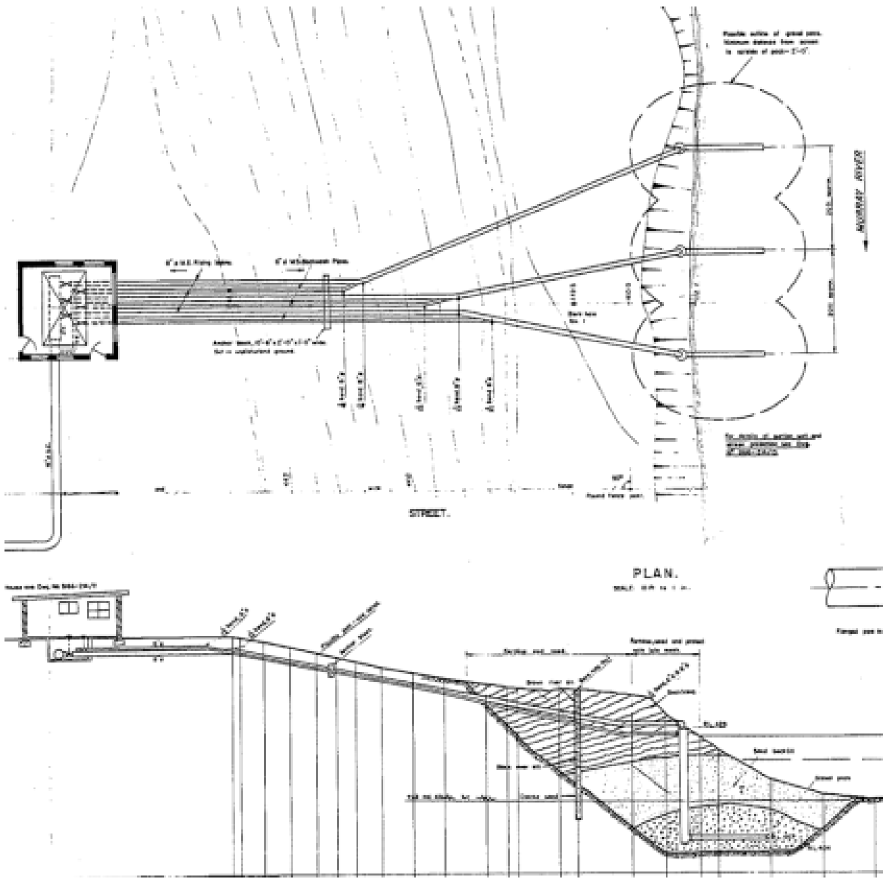

Figure 3: ***Victoria St Pump Station Plan and Cross Section***

3.0 BACKWASHING METHODOLOGY

Two methods for backwashing were employed; the original water purging method, and an augmented air scouring system.

The original practice was to reverse the flow through the intake screens by opening valves allowing water in the rising main to flow back through the draft tubes between the pump and the casing and out through the screens and the filter media. This must have been only of limited success.

Within a couple of years of the initial commissioning a new air scouring backwash system was installed. It comprised an air vessel connected to a series of lateral and vertical galvanised pipes of about 50mm diameter embedded into the media. The air vessel was 10m long and 600mm in diameter and from the drawing it appears that the air was driven through the system by water from the rising main. There is no reference on the drawings to compressors and there is no evidence in the pump station building of a compressor ever having existed.

By 1985 after 15 years this augmented system was completely defunct and had not operated for an unknown period of time. The pipework was rusty and eventually all the accessible pipework was removed and it is expected that all of the pipework in the media bed has long since rusted away to nothing.

In 2002 a water treatment plant was built rendering the need for an in-river filter unnecessary. Nevertheless it remained in place and had to be maintained. Because there was no longer pressure from the rising main to the reservoirs to generate backwashing pressure the new design provided for 2 of the 3 pumps to pump the water to backwash the third pump. Consequently 3 pumps have to be working for any pump to be working.

4.0 BACKWASHING REHABILITATION

Pump performance has always been at its worst when the river is low and suction conditions are at their worst. Fortunately this occurs in mid-winter when demand is at its lowest. The Murray River is low in winter because it is a regulated river and all flow is driven by irrigator demand. In winter there is no irrigation water requirement and flows are reduced to the environmental minimum which is 1,200ML/day – in summer it is typically about 20,000ML/day with a maximum allowed flow of 25,000ML/day. All of the water stored in the Hume Dam and Dartmouth Dam is for irrigation usage, the towns on the river use only about 2% of the total.

The first serious attempt to improve the filter media performance was undertaken 10 years ago when a diving company was employed to suction clean the 2m deep media with a barge mounted pump. The success of this operation was dubious at best.

The filter screens are 5m long with one for each of the 3 pumps and are about 5m apart. When backwashing is undertaken entrained air allows easy identification of where the backwash water is discharging. The localised points at which this would occur, and not over the length of the screens, suggested that the stainless steel screens may have rusted through jeopardising the whole backwash system.

The diving company was re-employed to investigate the integrity of the screens. The report received was that the screens were intact but no video evidence or comprehensive data supported this information.

One year ago as the performance further deteriorated a CCTV company was employed which managed to get a camera into 2 of the screens which showed them to be intact although there was a lot of scale and growth on the screens and it was obvious that water was only passing through part of the screens.

It was decided a major effort was required to clean the media to the point of dredging it completely off the screens. Considerations were:

- Excavate the gravel media using shore based equipment or barge mounted.
- Use a suction dredge to break up the media.
- Use a venturi suction system with land based pump and sedimentation basin.
- Jet the media using compressed air with a lance.
- Blast compressed air through the media from within the screens.

The venturi suction system was first tried but although the gravel was successfully sucked out of the river it blocked the delivery pipe to the sedimentation basin and was discontinued. With bigger equipment it could have been successful.

The compressed air approach was then employed. A compressor was hired and a pontoon tethered to the bore casings. Air lines were tapped into the backwash pipes and air jetted into the media using a 5m long 50mm PVC lance which was able to reach the screens through the 2m deep media. Air was also injected into the media from inside the screens. The compressor was of limited capacity and deliberately so for fear of high pressure air rupturing a screen making it unusable.

The exercise was relatively successful. At the end of one week, the filter performance had increased from about 15% to 50% of full functionality.

Figure 4: ***Pontoon in position***

Three months after the work was finished one of the pumps stopped pumping and was removed to find gravel in the impeller bowl. The camera was brought back in and this showed the filter screen half full of gravel indicating that the screen had ruptured confirming our worst fear.

Currently a diesel pump with its own suction line has been connected into the pump station so that the pump station can still function but the 1926 original pump station is now back on line as the duty pump station.

<u>Figure 5:</u> ***Jetting with lance while compressed air blowing from inside the screen simultaneously***

5.0 CONCLUSION

A new pump station is to be built to replace this facility with the intention of having it constructed before next summer. The challenge for the new pump station will be to provide an installation that can pump water from a depth of less than 450mm, not have infrastructure that impacts on recreational water skiing activities on the river, and not have infrastructure that is underwater that requires maintenance.

The Victoria St pump station was built as a compromise to building a water treatment plant. Its record is one of low design capital cost but high construction cost and high operating cost. The project development and the geotechnical and design process has led to the pump station being a liability for the duration of its 50 year life.

It will be replaced not because 2 pump stations are needed but because of the value in having redundancy in pump intakes where low river conditions will be a greater risk in the future.

DISINFECTION OF A MAJOR TRUNK MAIN

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DISINFECTION OF A MAJOR TRUNK MAIN

Danny Roberts, *Water Treatment Supervisor,* Port Macquarie-Hastings Council

ABSTRACT

The Southern Arm Trunk Main (SATM) project is a major component of the ongoing augmentation of Port Macquarie-Hastings Councils (PMHC) Bulk Water Scheme. When complete the Southern Arm Trunk Main will provide a direct link between Cowarra Dam and the Camden Haven region.

In 2016, construction of a 10.5km section of The Southern Arm Trunk Main was completed in the Bonny Hills area. This paper outlines the planning of the disinfection of this trunk main. This is the largest disinfection task attempted by our Water Treatment Operators and presented many new challenges.

Disinfection is the process designed to kill most microorganisms in water, including all pathogenic (disease-causing) bacteria.

It is best practice to disinfect new mains prior to bringing them into service to control the risk of pathogens entering the water distribution network. This is outlined in the following documents:

- The ADWG (appendix I table AI.7) recommends development of mains disinfection procedures to control pathogen risk in distribution networks.
- WSA Appendix I outlines a best practice example to achieve disinfection of mains.
- NSW DPI Circular 18 recommends water authorities develop mains disinfection procedures to control pathogen risk in distribution networks.

1.0 INTRODUCTION

1.1 Port Macquarie-Hastings Water Supply Schemes

Port Macquarie-Hastings Council operates and maintains a major bulk water supply scheme and five reticulation systems. This paper is primarily concerned with the staged expansion of the bulk water scheme. A description of the existing bulk water scheme is provided below.

1.2 Hastings Bulk Water Supply Scheme

The Hastings Bulk Water Supply Scheme includes the bulk water supply pumping stations, water conditioning/treatment, off-creek storage dams and trunk main network to the townships of Wauchope, Port Macquarie and Camden Haven.

Raw water is pumped from the Hastings River at Koree Island (5km south-west of Wauchope). The three Koree Island pumping stations have a combined pumping capacity of 120 Megalitres (ML) per day via rising mains into Rosewood Reservoirs #2 & #3. The raw water is treated in the rising mains at the Wauchope Water Treatment Plant with lime and carbon dioxide (water conditioning) to increase alkalinity and stabilise the pH of the raw water. Fluoridation and chlorination is also completed at the Rosewood Reservoir site, prior to the water being stored in Rosewood #2 & #3 Reservoirs.

The water in the Rosewood Reservoirs #2 & #3 is then gravity fed to the 2,500 ML Port Macquarie and 10,000 ML Cowarra Off-Creek Storage Dams.

Water is pumped from the Port Macquarie Off-Creek Storage Dam to supply zones within the Port Macquarie area. Water is also distributed from the Port Macquarie Off-Creek Storage Dam via an existing trunk main to supply the Camden Haven region south of Port Macquarie.

When extraction is not possible from the Hastings River at Koree Island then water is pumped from the Cowarra Dam to Port Macquarie Dam.

1.3 Secure Yield Study

Port Macquarie-Hastings Council is in the process of completing a Secure Yield Study. The study has assessed the Bulk Water Scheme to –

1. Identify critical operational limitations within the existing Bulk Water Scheme
2. Determine the impact of growth in the region on the existing Bulk Water Scheme
3. Re-assess existing plans to expand the Bulk Water Scheme.
4. Recommend actions and priorities for future augmentation of the Bulk Water Scheme.

The study reaffirmed that the SATM project is a major priority to secure the Supply in the Camden Haven area south of Port Macquarie.

1.4 Future Bulk Water Scheme

When complete, the SATM will provide a direct link from Cowarra Dam to the Camden Haven region and will provide a secure water supply to this rapidly expanding area.

The SATM will connect to the existing trunk main at Bonny Hills. This connection will ultimately provide an alternative flow path from Cowarra Dam to Port Dam.

<u>Figure 1</u>: ***Bulk Water Scheme and proposed SATM***

2.0 DISCUSSION

2.1 Disinfection Method

PMHC's standard disinfection method is to super chlorinate by injecting Sodium Hypochlorite.

1. The water main is charged and pressured tested
2. The water main is flushed until turbidity is < 2 NTU (lower if possible)
3. Water is drawn through the main at a predetermined flow rate.
4. Sodium Hypochlorite is dosed into the main until a residual of 100mg/L is measured at the draw out point.
5. The main is left to stand for a calculated detention time.
6. After detention time the chlorine residual is again measured.
7. Should there be a > 50% decline in the measured chlorine residual after the detention time, the disinfection would be deemed inadequate and the injection process repeated.
8. When the measured residual chlorine decline is <50% the main is flushed until the chlorine residual and turbidity is ≤ the parent main.
9. After an additional standing period of 16-24hrs microbiological samples are taken for analysis in the laboratory.
10. Samples are tested for E coli and Total Coliforms.
11. If lab results are clear of contaminants the main is approved for service.
12. If lab results fail the process is repeated.

2.2 SATM Disinfection Task Outline

Table 1: ***Pipe sizes, volumes & flushing flow required***

Task - Disinfect 10.5km of new trunk main			
Pipe size (mm)	**Length (m)**	**Volume (L)**	**Flushing flow (L/s)**
450	2000	318,086	159.04
750	7500	3,313,399	441.79
600	800	266,195	282.74
600	200	56,549	282.74
Total	**10,500**	**3,954,229L**	**441.79**

2.3 Operational Requirements and Limitations

In addition to the sheer scope of the disinfection of the SATM, several additional operational requirements needed to be considered:

1. Bonny Hills reservoir to remain in service
2. Existing trunk main to remain in service.
3. No interruption to normal operation of the scheme.
4. New main to be brought into service after disinfection

2.4 Disinfection Planning

The first consideration was to establish a flow path for the disinfection.

Option 1 - Feeding water from the Bonny Hills reservoir via the new inlet from south to north

Option 2 - Open the existing trunk main just south of Bonny Hills to create south to north flow.

We decided to utilise both options and establish two chlorine dosing points. The disinfection could then be completed in two stages.

We now needed a viable discharge point for flushing and for discharge during disinfection.

Option 1 - Opening hydrants on the new main and discharging to water tankers. Considering the volume of water and the limited heavy vehicle access we decided this was not a good option.

Option 2 - Opening hydrants on the new main and using de-chlorination chemicals to discharge water to the environment. We considered the environmental risk was too high.

Option 3 - A 300mm reclaim water main had been laid adjacent to the existing trunk main. This main provided a path back the Bonny Hills Waste Water Plant. It could easily be interconnected to the new main for the purpose of disposing of disinfection wastewater. We decided to pursue Option 3 as the best environmental, operational and economical outcome.

- Two (2) dosing sites were established for chlorine injection.
- A pH correction unit was set up at the discharge point.
- Eight (8) Sample points were established along the new main to monitor dosing progress.
- The max flushing flow available was only 50 L/s, significantly less than the 441.79 L/S required providing high velocity scouring of the internal pipeline surface.
- Calculations completed to determine dosing requirements and time estimates.

Table 2: ***Flow and volume calculation results***

Disinfection Calculations Results		
total length	**volume to be dosed**	**constant flow time**
10,500 m	3,954,229 L	21.75 hours
hypo strength	**cl 2 residual start**	**cl 2 residual target**
12.5%	1 mg/L	100 mg/L
flow rate	**hypo flow rate**	**hypo quantity**
50 L/s	142.56 L/h	3100 L

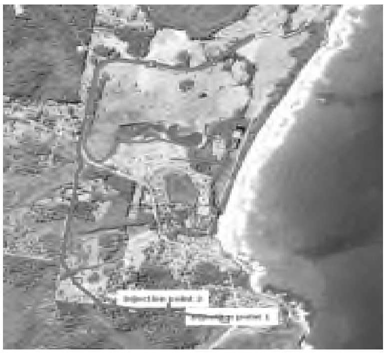

Figure 2: ***Disinfection map***

2.5 Commissioning of Reclaimed Water Main

The reclaimed water main had been laid over a number of years and had not been pressure tested. The interconnection between the new trunk main and the reclaimed water main was put in place.

The reclaimed water main was extended at the Bonny Hills Wastewater Treatment Plant to allow direct access to a sludge lagoon. The sludge lagoon was emptied to hold the volume required for the commissioning and disinfection task.

The new inlet was opened at Bonny Hills Reservoir to charge all of the pipework. Construction crews spent the next 2 weeks pressure testing, finding valves and repairing leaks.

The flow path was finally established.

2.6 Resource and Work Planning

The task required 24hour monitoring during dosing and flushing.
At this point we consulted with our team of Water Treatment Operators. Both on-site and off -site meetings were conducted and the following **resource/work flow plan** was developed.

1. Set up and test checklist

a) Relevant safety equipment is on site, available and checked.
b) Spill kit, SDS for hypo, PPE for hypo, Shower / Eye wash
c) Solo and remote workers procedure in place (check in times & iota)
d) Lights for access and work area, amenities trailer set up
e) Final check that all equipment, is set up connected and pressure tested.
f) Chemical tank in place secure, fenced.
g) Power available, pump installed connected and tested (no leaks)
h) Correct chemical stock available
i) Injection points x 2 installed and tested
j) Sample points x 8 installed and tested
k) Confirm flow control valve location & who is operating SCADA
l) Confirm isolation valve locations & operator
m) Flow meter reading available and tested at injection point 1
n) Flow meter reading available and tested at injection point 2 (and on SCADA)
o) Chlorine & pH test meter (check range and dilution procedure)
p) Communications method between staff off site confirmed(UHF radios and mobile phones)

2. Chlorine injection point 1 work flow plan

a) Set up trailer at injection location #1
b) Carry out pre start checks Hypo, Power, Safety equip, Temp fencing
c) Establish agreed flow rate as per Disinfection Calculator
d) Establish contact with Bonny Hills STP to monitor inflow & lagoon level (maintain communication with STP operator)
e) When flow rate is stable start dosing at agreed dose.
f) Monitor dose and residual at 30min intervals or more frequent if flow or dose rate deviate from target (record on log)
g) Sample at SATM D1 at calculated volume to that location to track progress (record in log sheet)
h) When target volume and time have been met take a sample at SATM D2 sample point to confirm chlorine concentration is at the target.
i) When confirmation of the above shutdown flow and dosing then relocate to injection point #2
j) Inform Bonny Hills STP that flow has stopped for location change

3. Chlorine injection point 2 work flow plan

a) Set up trailer at injection location #2 for safety shower and eye wash
b) Carry out pre start checks Hypo, Power, Safety equip, Temp fencing
c) Establish agreed flow rate as per Disinfection Calculator
d) Establish contact with Bonny Hills STP to monitor inflow & lagoon level (maintain communications with STP operator)

e) When flow rate is stable start dosing at agreed dose.
f) Monitor dose and residual at 30min intervals or more frequent if flow or dose rate deviate from target (record on log)
g) Sample at SATM D3, 4, 5, 6, 7 & 8 at calculated volume to that location to track progress (record in log sheet)
h) When target volume and time have been met take a sample at SATM D2 sample point to confirm chlorine concentration is at the target.
i) When confirmation of the above shutdown water flow and dosing
j) Inform Bonny Hills STP that flow has stopped for contact time

4. Sample Super chlorinated at sample locations 1, 2, 3, 4, 5, 6, 7 & 8

a) Carry out chlorine testing at each of the above locations to determine chlorine demand during the contact period **(if <50% demand from initial sample at all locations then step #1 is a pass)**

5. Purge out super chlorinated

a) Establish agreed flow rate & contact with Bonny Hills STP to monitor inflow & lagoon level (maintain communications with STP operator)
b) Sample at locations 3, 4, 5, 6, 7 & 8 at calculated volume to that location to track progress of purge (record in log sheet)
c) Once target volume and time have been met for purge and super chlorinated water has been purged from the system isolate main for stand duration
d) Inform Bonny Hills STP that flow has stopped

6. Collect samples

a) Collect 8 Bacto samples SATM D1, 2, 3, 4, 5, 6, 7 & 8 following sampling procedure
b) Deliver to lab

7. Review

a) Carry out a review of the process and update for next time
b) Review water volume in STP lagoons and consider treatment options required to reduce levels so that re-run can be carried out if required

8. Re-run

a) Carry out re-run if sample failure occurs
b) Review method prior to re-run to identify if procedure was the cause of failure

3.0 CONCLUSION

All subsequent monitoring samples following disinfection passed laboratory testing and the main was put into service. Micro bubbles of dissolved air were entrained in the new section of main when full flow was applied from Port Dam. This caused false turbidity readings in the early weeks of operation. Extensive monitoring was carried out and no customer complaints were received.

The project required extensive communication between all groups within the Water Section including planners, water treatment operators, process/ head works engineers and construction crews. Detailed planning and outstanding teamwork by all involved ensured the task was completed successfully.

4.0 ACKNOWLEDGEMENTS

Many thanks to the PMHC Water Process and Construction teams for their dedication, cooperation and teamwork during these works.

LEARNINGS FROM DAMAGED CHLORINE VALVES AND EXAMPLES OF BEST PRACTICES

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LEARNINGS FROM DAMAGED CHLORINE VALVES AND EXAMPLES OF BEST PRACTICES

Dmitri Lobachevsky, *Lead Mechanical Engineer***,** Ixom

ABSTRACT

In early 2016 there have been a number of Chlorine Institute valves that developed a crack and reported by Australian customers. These valves are used on chlorine cylinders and drums. The location of cracks was consistently above the valve seat which made it possible to isolate the leak path by closing the valves. In total there were 5 Chlorine Institute valves that failed, which makes up 0.1% of annual container valve consumption by Ixom. An investigation was performed to identify the mode of failure. It was performed by a team of Ixom Engineers with assistance from ALS Industrial.

Valve crack investigation consisted of heat exposure test, a visual examination, dye-penetrant inspection, chemical analysis, hardness testing, microstructural evaluation and scanning electron microscopy (SEM) with energy dispersive analysis of X-rays (EDX). The results of the investigation indicated that the mode of failure was a combination of fabrication flaw and certain conditions of service environment.

1.0 INTRODUCTION

Chlorine Institute (CI) valves are commonly used in ChlorAlkali industry for plant purge points and transportable containers. In Ixom over 99% of CI valves are installed on chlorine drums and cylinders.

The design aspects of the CI valves are guided by Chlorine Institute Pamphlet 17 which are then adopted by the manufacturer. These valves consist of several main components; including the valve body, spindle, gland packing and gland nut, see Figure 1.

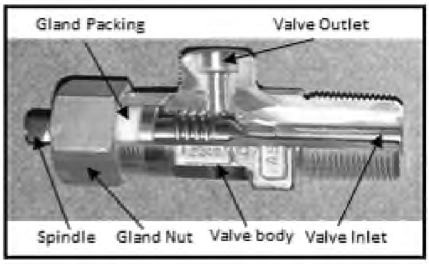


Figure1: ***Chlorine Institute Valve Layout***

The material selection for the components follows the recommendations of the Chlorine Institute Pamphlet. In particular, the valve body material is Aluminium Silicon Bronze (ASB) alloy C64210 to ASTM B 124-04. This material provides excellent corrosion resistance properties when used in chlorine duty.

In 2008, Ixom has adopted CI valves in configuration mentioned above. In early 2012 there has been several cracks detected in a batch of valves. This was quickly investigated and addressed by the supplier and the manufacturer of chlorine valves. At that time the cracks were attributed to poor temperature control during valve body forging process. To address the issues the process was automated. Until 2016 there has been no more crack failures of the CI valves.

The issue with cracks in the valve bodies reoccurred in early 2016. Initially, there were 3 chlorine cylinders identified with visible cracks in valve body. Several months later a drum was identified with both valves exhibiting cracks. In all of these cases of valve failure there was only a small weep that, due to crack position, was possible to be isolated. This makes up 0.1% of the CI valves purchased and used by Ixom annually. Investigation was triggered to identify root cause of the cracks in valved bodies.

Cracks in chlorine container valves are rare. A similar investigation has taken place in 2004 in USA. A number of valves from a reputable manufacturer began to exhibit valve body cracks at gland packing area. This resulted in a recall of a number of specific valve batched and a requirement to inspect valve that were manufactured in 2004 for cracks. The incident was followed by Chlorine Institute Notice to all chlorine users with a set of recommendations.

2.0 DISCUSSION

2.1 Valve Cracks and Initial Investigation

In March 2016 there were 3 cylinders returned from customers that were quarantined for inspection. These cylinders developed a minor leak from the chlorine valves. Upon close inspection it was identified that the crack has developed in both cases at the threaded section where the gland packing is located. The valves were traced back to the same batch BS 08/11. The total number of valves in this batch was 1250, making it 0.24% failed cases. Fabrication data sheets (including material certificates) for this batch of valves indicated compliance with the valve purchasing specification. Initial investigation has shown that the crack location and appearance were very similar to what the cracks in CI valve were experienced in 2004 in USA. It was decided to adopt the same recommendation as in 2004 by USA valve consumers provided by Chlorine Institute: perform non-destructive testing in the form of dye penetrant on all the valves from BS08/11 batch to release them for service.

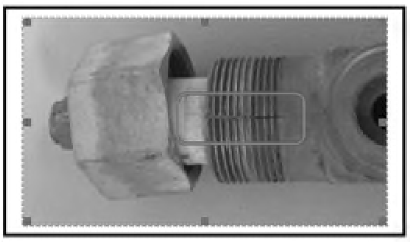


Figure 2: ***Cracked valve from BS 08/11 batch***

In May 2016 a customer has reported chlorine drum that has shown a minor leak when connected and both valves opened. Cracks were suspected by the customer so special valve clamps were design and supplied to ensure the valve cracks didn't propagate during transport. This chlorine drum was returned and inspected. It was discovered that both valves had a crack in the valve body right above the valve seat. The valves were traced back to the same batch CL 10/12. The total number of valves in this batch was 750, making it 0.27% failed cases. Like with CI valves from cylinders, inspection of the original fabrication data sheets didn't reveal any deviations from the valve purchasing specification. Same recommendation to perform dye penetrant crack detection testing was applied to CL 10/12 batch of valves before returning them to service.

2.2 Valve Heat Exposure Test

As part of the investigation process of cylinder valves it has been discovered that the PTFE packing is heavily extruded in the cracked area of the valve. The extrusion of the packing material was contributed to high gland nut torque and the ambient heat that the valves were subjected to during service. The expansion and subsequent extrusion of the packing may have applied additional pressure in the gland area which resulted in a crack. This process can potentially be accelerated by applying aqua ammonia to the valve body.

Figure 4: ***Gland packing extrusion in BS 08/11 after test***

It was decided to carry out a heat test which consisted of:

1. Valves from BS 08/11 batch
2. New valves from B2 12/12 batch
3. Valves with applied gland nut torque values from 34Nm to 130Nm (test #1)
4. Valves with re-tightened gland nut when hot to 34Nm to 130Nm (test #2)
5. Applying aqua ammonia to valves from test #1 (test #3)

During each test the valves were left in an oven at a temperature of 67^{o}C for 7 days before being inspected for cracks. The test results are shown in Table 1.

Table 1: ***Heat Exposure Test***

Heat Exposure Test			**Valve Batch**	
			BS 08/11	**B2 12/12**
Test #1	**Gland Nut Torque**	**34Nm**	√	√
		70Nm	√	√
		105Nm	√	√
		130Nm	√	√
Test #2 Hot re-torque	**Gland Nut Torque**	**34Nm**	√	√
		70Nm	√	√
		105Nm	√	√
		130Nm	√	√
Test #3 Ammonia exposure	**Gland Nut Torque**	**34Nm**	√	√
		70Nm	√	√
		105Nm	√	√
		130Nm	√	√

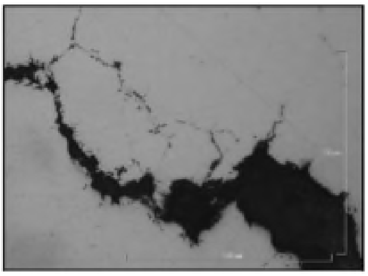
Note: √ indicates that test did not produce a crack in a valve
x indicates that test did produce a crack in a valve

As can be seen from Table 1, none of the test was severe enough to produce a crack in the valve body. Valves were disassembled and internal components investigated. It was noted that the PTFE gland packing had severely extruded, refer to Figure4. This however did not manage to cause the gland area to overstress and crack. The achieved result demonstrates that the cause of crack failure was not directly associated with gland nut being over-torqued and/or exposed to high ambient temperatures. These however can be a contributor if other fabrication aspects aren't followed as the over-torque creates unnecessary stress in the gland packing area of the valve.

2.3 Detailed Valve Investigation

Damaged valves from chlorine cylinders and a drum were sent to ALS for analysis. The scope included a visual examination, dye-penetrant inspection, chemical analysis, hardness testing, microstructural evaluation and scanning electron microscopy (SEM) with energy dispersive analysis of X-rays (EDX). Finding from material testing were very similar amongst the tested cracked valves from chlorine drums and cylinders.

In examining a defective cylinder valve, it exhibited a longitudinal crack at the threaded spindle end of the valve. The crack was considered to be the result of a mixed mode failure which consisted of intergranular and transgranular fracture. It was considered likely that several defects, such as laps and also oxide related inclusions were created during the forging stage of manufacture. Although cracking was not through thickness at installation (due to no observable leaks), it was also considered likely that the crevice-like features formed by the manufacturing defect created ideal nucleation site for a secondary failure mechanism to initiate. Further, exposure to ammonia (during leak testing), in the presence of moisture may have diffused via capillary action into the crevice sites initiating a stress corrosion cracking (SCC) mechanism, as noted by the presence of widespread transgranular and intergranular cracks.



<u>Figure 5:</u> ***Magnification view of the intergranular and transgranular cracking. (Un-etched)***

The nature of the defective valves from chlorine drum appeared to be very similar to what was discovered with valves from chlorine cylinder.

Valves appeared to have failed (leaked) as the result of a multi-stage cracking mechanism. The multi-stage mechanism predominantly consisted of branched intergranular cracking with some transgranular cracking. The nature of this cracking was considered to be indicative of a stress corrosion cracking mechanism which would typically be associated with either ammonia or some other nitrogenous complex. In addition to this, some de-alloying (copper rich) features were also identified and considered to be the result of a secondary corrosion mechanism, likely to be attributed to de-aluminification in the presence of chlorine. The SCC and secondary de-alloying mechanisms also appeared to have initiated at a surface breaking defect which was considered to be related to forging and oxide filled defects.

In all investigated samples there was evidence of oxide and what appeared to be entrapped scale, either from the forging process or impurities associated with the original cast slug, were considered to be a contributing factor toward failure. In addition to this, microstructural evaluations conducted opposite and away from the crack zone revealed the presence of lap-like features and further evidence of globular oxide filled networks. The presence these features away from the crack zone suggested that these were likely to be associated with manufacturing. The transgranular nature of the some of the defects could also indicate the beginnings of a secondary corrosion mechanism.

In the case of cylinder valves, the chemical analysis results were not consistent with that expected for ASTM B283 grade C64210 aluminium bronze. The silicon content of 1.17wt% was below the minimum requirements specified in the range of 1.5-2.0wt%. This was not consistent with material certificates that were provided with the batch of valves (BS2 08/11) to Ixom. Silicon has an effect of material fluidity and shrinkage during casting. The low contents of silicon may have contributed to the surface defects examined during the investigation.

In the case of drum valves, the microstructure exhibited evidence of a secondary phase which was considered to be unusual, based on the nominal aluminium content of <7.0wt%. The presence of this phase was likely to be present due to casting related chemical segregation which has resulted in localised regions within the core structure exhibiting higher than desired aluminium contents. This would then give rise to the possibility that an undesirable gamma phase structure may have formed, depending temperature and cooling rates which may reduce the overall corrosion resistance. A consequence of this would be a material that is more susceptible to an environment which consists of ammoniacal complexes and chlorine.

2.4 Valve Exposure to Aqueous Ammonia

Investigation of valve cracks in 2004 USA has highlighted the danger of exposing aluminium-silicon-bronze body of the CI valve to aqueous ammonia. Although it was not directly contributed to the failure of the valves, as a result, Chlorine Institute has provided clear guidelines regarding testing leaks with ammonia. As it states in Pamphlet 155, clause 4.3.1:

"When a leak is suspected, it is recommended that ammonia vapours be used to find the source. When ammonia vapour is directed at a leak, a white cloud will form. To produce ammonia vapour, a plastic squeeze bottle containing commercial, 26 degree Baume or stronger, aqua ammonia (ammonium hydroxide solution) should be used. A weaker solution such as household ammonia may not be concentrated enough to detect minor leaks. If a wash bottle is used, the dip tube inside the bottle should be cut off so that squeezing the bottle directs only the vapour, and not liquid, from the nozzle. To prevent corrosion, liquid aqua ammonia should not come into contact with any metal parts. "

During Ixom investigation, it has been discovered that the practice of testing chlorine connections for leaks with aqueous ammonia is present on some sites. In particular, it has been noted that this practice is common in Fiji. It has also been identified that at some point prior to failure, the investigated chlorine cylinders and drums have been delivered to Fiji. As stated in section 2.3, the valves exhibited initial forging defects that provided crevice creating ideal nucleation sites.

When these sites trapped and accumulated aqueous ammonia it has triggered SCC resulting in a crack in the prestressed areas of the valve.

3.0 CONCLUSION

During Ixom's investigation of multiple chlorine valves with cracks, it has been discovered that:

1. Over-tensioning gland nut will create additional stress in the gland packing area and subsequently deform PTFE packing rings by extruding them past the gland follower.
2. The cracks demonstrated mixed mode of failure which consisted of intergranular and transgranular fracture.
3. There was evidence of initial forging defects that have formed crevices on the surface of the valve body.
4. Surface crevices created ideal deposit sites for aqueous ammonia. This has initiated stress corrosion cracking mechanism.
5. Inconsistent valve body material, low silicon content in tested cylinder valves and non-uniform contents of aluminium in drum valves
6. It was discovered that some customers apply aqueous ammonia when testing chlorine connections for leaks.

As a result of this investigation, an alternative supplier (Tekno Valves) was identified for CI valves. Tekno Valves are a member of Chlorine Institute and participated in the investigation with valve body cracks. They have demonstrated understanding of the problem and suitable controls to avoid them in their production facility. As far as we know, Tekno Valves has no track record of product that has failed by developing a crack in the valve body.

4.0 ACKNOWLEDGEMENTS

The completion of this paper could not be possible without the assistance from colleagues at Ixom ChlorAlkali team. Their contributions is acknowledged and sincerely appreciated. Special mention to:

Mr. Rohit Behani (Senior Executive Manager, Tekno Valves) for providing information of Sherwood valves investigation from 2004 USA.

Mr. Matthew J Hogan (Senior Metallurgical Engineer, ALS) for material analysis work and reports during the investigation of valve body cracks.

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Winner of the Best Paper Overall at the
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Bendigo, 2016

INVESTIGATING THE BENEFIT OF UTILISING FISH IN SEWAGE TREATMENT

Paper Presented by:

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11th Annual WIOA
NSW Water Industry Operations Conference and Exhibition
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29 & 30 March, 2017

INVESTIGATING THE BENEFIT OF UTILISING FISH IN SEWAGE TREATMENT

Ben Pohlner, *Manager Aquaculture,* Wannon Region Water Corporation

ABSTRACT

Wannnon Water has been undertaking a research and development project to determine the impact of fish on the accumulation of sludge in lagoon based sewage treatment plants. Trials have been underway for 7 years in partnership with Deakin University. Tank trials using primary effluent show fish can reduce the total volume of sludge up to 46% over 70 days. Full scale trials are now underway at Hamilton and Port Campbell Water Reclamation Plants (WRP's) to quantify the impact of fish in primary lagoon systems. This paper gives an outline of the research undertaken, what we currently know, and the potential for this innovative technology in the Water Industry.

1.0 INTRODUCTION

De-sludging sewage treatment lagoons is a costly and messy process, and can be a lengthy disruption to the operation of the sewage treatment facility. Reducing the frequency of de-sludging has the potential to lead to significant OPEX savings and potentially lower greenhouse emissions.

Wannon Water (in conjunction with Deakin University) have been trialling the use of fish as a method of sludge removal in lagoon based sewage treatment plants since 2009, and are now in the process of undertaking full scale trials in the Hamilton and Port Campbell sewage treatment facilities. This paper details the work undertaken to date on the use of fish to assist in the remediation of sludge, including the potential savings to the water industry.

Wannon Water regard this research as significant for the water industry as a whole. Subsequently, this paper provides all relevant outcomes of aquaculture research to date to inform the water industry. Wannon Water are seeking interested water utilities to help complete the research and implement this technology.

2.0 DISCUSSION

Developing new technology can take time, and understanding the potential of fish to improve sewage treatment processes is no different. The following is a brief history of the research undertaken by Wannon Water and others.

2.1 Getting Started: 2008-2010

Wannon Water initially became interested in the concept of using fish to improve sewage treatment through earlier work undertaken by the Victorian Department of Primary Industries. Their early work to demonstrate possible aquaculture production in wastewater lagoons concluded that:

- Key drivers for development of integrated aquaculture use of recycled wastewater exist at a regional, state and federal level.

- Key stakeholders for aquaculture use of recycled wastewater in Victoria include the federal government, Victorian state government, and regional water authorities.
- Major scientific and technical information gaps exist in relation to aquaculture use of recycled wastewater

Following a review of the DPI work in 2008, Wannon Water invited Deakin University to investigate the concept of aquaculture in sewage lagoons, and the organisations jointly developed a “Road Map” outlining the research required to get from concept to commercialisation. This Road Map has been extremely valuable and has enabled Wannon Water to take a strategic approach to R&D for integrated aquaculture in sewerage treatment lagoons.

Step 1 in the Road Map was to undertake a review of Wannon Water facilities to determine their suitability for aquaculture and to determine the location place to undertake research. Hamilton (Victoria) was chosen as the preferred site to undertake aquaculture research as the relevant licences and permits were able to be obtained, and the effluent quality was deemed suitable for the purpose.

A research facility was constructed on the banks of the Hamilton WRP primary lagoon and trials were set up to assess fish growth, sludge and water quality.

2.2 Establishing the Science: 2010 - 2013

Wannon Water has supported a number of Honour student projects at Deakin University to establish the basic science of using fish to improve the sewerage treatment process.

The initial project was to determine the impact of Goldfish (*Carassius auratus*) culture on Total Nitrogen (TN) and Total Phosphorous (TP) in primary effluent lagoon water. The trial also examined Goldfish survival at different stocking densities, and fish flesh was tested for accumulation of pesticides and heavy metals.

The early results showed very little impact on water quality including TN & TP concentration over the duration of the trial. No accumulation of heavy metals in fish flesh was detected. An extension of this trial also showed no accumulation of pesticides.

Fish were trialled at 3 stocking densities with high survival in all categories. Growth was also assessed and was directly correlated with stocking density – the lower stocking densities showed much faster growth.

One major point of significance was noted in this trial. Approximately 50 – 100mm of sludge accumulation was observed in the control tanks at the conclusion of the trial, however almost zero sludge accumulation was noted in the tubs containing fish.

This discovery was the inception of further research focusing on the potential for fish to reduce sludge volumes in sewage lagoons.

In an effort to identify a suitable native fish species for sludge remediation, a second Honours project was undertaken to assess a range of potential fish species including two species of Mullet, Silver Perch and Tench.

Figure 1: ***Control tank – No fish heavy sludge accumulation***

Figure 2: ***Tank with goldfish zero sludge accumulation***

These species were assessed for survival and their ability to remove sludge from the trial tanks. The results showed that there were no native species suitable for sludge remediation and that Goldfish were the best performers in the trial. These new trials also found a significant decrease in accumulated sludge in tanks with goldfish, confirming the earlier results.

Figure 3: ***Goldfish at the time of stocking - trial tanks***

Figure 4: ***Goldfish after 5 months in primary effluent***

In 2012, a third Honours trial assessed the impact of Goldfish on a set volume of sludge in a static tank with no inflow or outflow. The trial used sludge and water directly from the Hamilton primary effluent lagoon.

Results over 70 days showed fish survival of 89 – 93% and rapid early growth. All treatments containing fish displayed significant decreases in sludge and treatments without fish showed very minor decreases that were not significant.

A Probiotic was also included in these trials as a comparison. The probiotic was promoted as being able to significantly reduce sludge volume by enhancing the natural bacteria populations in a sewage treatment system, and thereby significantly contribute to the decomposition of sludge.

Our results showed an average of 13.5% reduction in sludge volume when probiotic was used alone compared to Goldfish which recorded an average of 32.4% reduction in sludge volume. Of most interest was the combination of fish and probiotics which recorded from 37.6% to 46.2% reduction in sludge volume.

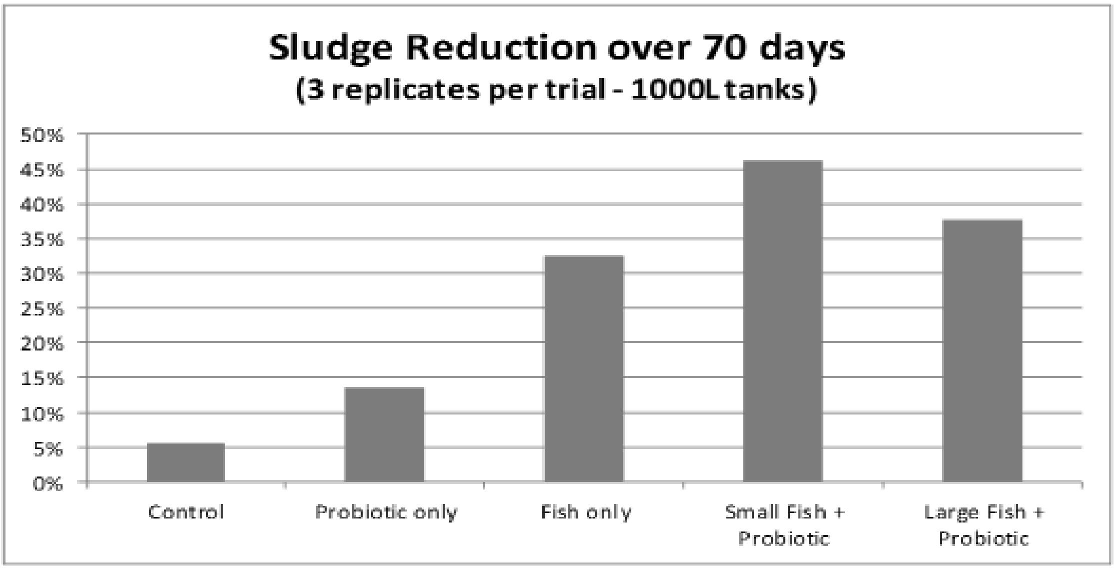

Figure 5: *Sludge reduction over a 70 day period in static trial tanks*

This trial demonstrated that fish are very effective at removing solids; however utilising fish in combination with probiotics appears to be a more effective technique for sludge remediation.

2.3 Growing Our Own Fish: 2013 - 2015

Based on the trial results, Wannon Water secured an unused commercial aquaculture facility in Warrnambool (Victoria) capable of producing up to 2M fry (young fish) annually. This facility is now producing goldfish specifically reared for sewage sludge treatment.

Wannon Water also invested in the development of a Juvenile Fish Production Facility in Hamilton. This involved the conversion of an obsolete biosolids drying bed facility comprising 16 cells. This facility is currently used to grow 15mm fry from the Warrnambool hatchery up to 50mm in size ready for stocking into operational sewage treatment plants.

2.4 Finding The Ultimate Sludge Sucker - Goldfish x Carp Hybrids

Common carp (*Cyprinus carpio*) are seen as superior to goldfish for the purpose of sludge remediation as they grow faster, grow bigger, and are able to tolerate extremely harsh water quality environments. Carp are classified as noxious and invasive in Victoria, meaning the biosecurity requirements for culturing carp would be so restrictive that any proposal to use them in sewage treatment could not practically proceed.

During 2013 Wannon Water investigated Goldfish x Carp hybrids which are cultured overseas as a food fish. This fish (when crossed correctly) has significant advantages over both carp and goldfish in that it grows faster and to a much larger size (15kg+). It is very hardy and able to tolerate very poor water quality conditions (much tougher than a both carp and goldfish). It also has enhanced disease resistance and it is **almost** sterile.

Deakin University undertook a literature review into the fertility status of Goldfish x Carp hybrids. This review found that male hybrids are sterile, however there is a slight chance that female hybrids may be fertile. It is not known if hybrids could develop a self-sustaining population in the wild if inadvertently released.

In 2015 Wannon Water received the appropriate DPI licences and commenced a program to breed goldfish x carp hybrids in Warrnambool to develop hatchery methods (in conjunction with a commercial hybrid hatchery in America). As a result of this work, successful spawning, larval rearing, and grow out of hybrids was achieved. Further work is now being undertaken to demonstrate acceptable levels of sterility using different larval rearing techniques in an effort to gain DPI approval to stock this fish in primary effluent lagoons.

2.5 Confirming This Will Work Operationally - Hamilton and Port Campbell

Initial lagoon stocking using goldfish was undertaken at the Hamilton WRP in 2015/16 to investigate the impact on sludge on a full lagoon scale. Approximately 150,000 fish were raised by Wannon Water and stocked into the primary lagoon. The assessment of their impact is ongoing, with sludge surveys using novel sonar technology undertaken at 6 monthly intervals to determine impact on sludge volumes.

A more structured research trial was also recently implemented at the Port Campbell WRP. Port Campbell has a twin primary lagoon system, with influent distributed evenly between the two lagoons. One Primary lagoon at Port Campbell was stocked with goldfish to enable a direct comparison between the primary lagoons and the impact of fish on sludge volumes. Monitoring of fish and water quality is undertaken on a weekly basis, and sludge volume monitoring is undertaken on a 6 monthly basis. The trial will also assess overall treatment plant efficiency and any implications for EPA licencing.

To date this trial is going well, with sampled fish showing good growth and no symptoms of disease or stress. Fish are able to tolerate the primary effluent lagoon environment and have no impact on the daily operation of the facility. This trial is due for completion in mid-2017.

2.6 Potential for the Australian Water Industry

Wannon Water has estimated the financial benefits of using fish to reduce the rate of sludge accumulation within suitable water reclamation plants in South West Victoria. Whilst these estimates are encouraging, the potential is limited by the size and number of the primary effluent lagoons in the Wannon Water service area.

Extrapolating these estimates to an industry wide figure for Victoria indicates that the technology has the potential to reduce operating costs in the sector by many millions of dollars. Completing the current research phase of the project at Wannon Water is vital to properly quantify this potential.

3.0 CONCLUSION

Wannon Water's aquaculture research program has demonstrated that the use of fish to slow the rate of sludge accumulation in lagoon based primary effluent lagoons is possible and significant.

Tank trials show that fish actively reduce the rate of sludge deposition in primary effluent lagoons. Wannon Water is now undertaking full scale trials at Port Campbell and Hamilton to confirm the concept will work operationally.

Wannon Water believes this research is significant to the Australian water industry, and is seeking interested water utilities to help finalise the research and implement this technology.

4.0 ACKNOWLEDGEMENTS

There are many people to thank who have contributed to this research. This includes the Wannon Water Aquaculture Team, the Wannon Water Board and Management, Wannon Water Treatment Operators, Deakin University Researchers, Lecturers, and students.

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CURLEWIS PUMP STATION CHLORINATION UPGRADE

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CURLEWIS PUMP STATION CHLORINATION UPGRADE

Brock Stone, *Water Quality Officer,* Gunnedah Shire Council

ABSTRACT

In 2016, Gunnedah Shire Council planned a major upgrade to the Curlewis Pump Station and chlorination site.

We had to take into consideration that this site is the only water source for Curlewis so an uninterrupted supply would have to be maintained during the build. These bores will more than likely be discontinued in the future due to the hardness of the ground water and a proposed pipeline extending to the village from Gunnedah. The pipeline will be a long term project as it will require pipeline over 15 km in order to provide the village with Quality water however we needed to fix the current problem of the dilapidated building and aging chlorination system regardless of future plans. We also had to recognise and overcome the limited budget that was given for this project.

1.0 INTRODUCTION

Curlewis lies on the Kamilaroi Highway, 17kms South of Gunnedah. Water for the village is pumped from the Liverpool Plains Bore field located approximately 5km from the town. I mentioned before the hardness of the water. If you were to ask anyone in Curlewis how their water tastes the standard reply would most likely be "**Don't know, don't drink it".** The hardness is some two and a half times the Guideline Value of 200mg/L and high in Sodium and Chloride and in the range specified by the World Health Organisation as "unpalatable". Drinking water mostly comes from private rain water storage tanks. This inherently creates health risks through lack of maintenance of rainwater collection systems, water age issues and lack of disinfection in the tank supply. As mentioned, there is a future proposal for a water pipeline from Gunnedah to alleviate some of these issues.

The problem was the state of disrepair of the dosing site and the building. The building was established in 1970, made of brick and mortar with a tin roof. It was a sturdy construction at the time and it kept the weather out. With the introduction of disinfection in 2004, extra funds were not available to support an upgrade to the asset and so year after year the project was put on the back burner as other concerns were dealt with.

Gunnedah Shire Council employed one Water Quality Officer at this point in time, Greg Ellis, affectionately known as 'Slim'. He had to cover 16 bore sites, 6 dose sites, 12 reservoirs, 31 telemetry sites over 4 townships spanning a distance of some 250kms. Effective time management was a fantasy, and as it was, a lot of jobs were put aside as priority was given to break downs, DAL sampling and Chlorine Monitoring.

In 2014 I was a Water Meter Reader, but also being trained in Water Quality so I would be ready to perform relief duties for Slim as they arose. I was first made aware of the issues at Curlewis during a training day with Jill Busch from Aqualift. Jill had been extremely helpful to me as I had limited knowledge about the Water Quality role and with the new Safe Drinking Water Guidelines that Gunnedah Shire Council (GSC) had adopted both Slim and I were fast learning that this thing called 'Water Quality' was going to eclipse all previous understanding of our roles within council.

Jill was taking me through the various issues of the Curlewis plant and making a few discoveries that she thought would have to be preserved for posterity. As her camera started clicking away, Jill could be heard saying “Do you mind? I just have to get a photo of that!”.

Some of the issues discussed included:

- Corrosion to the block work and slab
- Rusting supports to the bore perch
- Leaks to the bunding under the hypo tank
- Aging dose pumps and lines with rusted and corroded support brackets
- General housekeeping and maintenance

With Jill’s help, patience and guidance we were able to get on top of the basics and were provided with options and recommendations for an upgrade to the site.

August 2015 was a tough month. Slim passed away in a tragic car accident while coming back from Mullaley after completing DAL samples that morning, he was out doing some field work and never made it home. I was now thrust into a position I didn’t expect to be in, and the next few months would prove to be one of those ‘sink or swim’ scenarios as one thing after another would either break down, stop working or just get struck by lightning as I was adjusting to this new role without my mentor. My respect for Slim only grew during this time considering what he was able to accomplish day in and day out.

It wasn’t until the summer of 2015 when Curlewis Pump Station suffered one of those lightning strikes which fried one of the bore pump cables, one of the dose pumps, different boards in the telemetry cabinet and the electrical switchboard. We were promptly motivated to act on some of the recommendations Jill had previously provided as we had to rebuild so much at the site after the strike.

Figure 1: ***Curlewis Pump Station and Dose Site 2014***

2.0 DISCUSSION

After much discussion and number crunching concerning the replacement of lightning affected components, it was decided that we would attempt a complete upgrade during this process with the exception of the previously reconditioned bore pumps.

The proposed new plant would get the full treatment up to $85,000.

The upgrade would include:

- Dose plant;
- Two new dose pumps;
- Hypo storage tank;
- Two new mag flow meters;
- New electrical switch board and cabinet; and
- Security fencing around the site.

In addition to this consideration had to be made for the plant to be easily relocatable to accommodate the plans of the future. We looked into various solutions to the 'easily relocatable' aspect of the work and realised pretty quickly that a pre-fabricated module designed for dosing was well out of our price range due to the strict budget constraints. Finally after researching and brainstorming ideas we decided a cool room was our best option.

2.1 Not Quite a Cool Room

Gunnedah is a small community and we like to buy locally when we're able. GSC approached local business owners H & M Refrigeration & Air-conditioning and discussed the idea of a small plant for our dose pumps with them. They thought the build wouldn't be a problem and began to design what would become our own version of a pre-fab Dose Plant. The unit size is 2.4m x 2.4m with a solid skid base that can be lifted by crane or forklift. Using the lightweight cool room materials the internal walls and ceiling are poly vinyl lined and the floor has 2 pack resin coating so that none of the alloy panels could be affected by the Hypo. Ventilation windows were cut into all sides of the room and designed to keep out weather, vermin and insects and an inclined corrugated roof finished off the design. The construction of the building cost just under $20,000.

Table 1: ***Breakdown costs of Curlewis project***

Description	Cost
Pre-fab building on skid	$ 19,922.73
New Dosing Pumps & installation	$ 24,244.00
Electrical & Switchboard upgrade	$ 13,809.09
Fence	$ 8,337.91
Demolition, Labour & plant hire	**$** 12,662.38
Total build cost	**$78,976.11**

2.2 Demolition

The demolition of the old building was challenging for the fact that we still had to provide disinfected water to the reservoir during the process.

Local contractors lifted the roof and once removed started knocking down the walls one block at a time careful of dose pumps and lines, control boxes, bore and pipes all housed and attached to the walls inside the structure.

During this process our electrician was starting to set up temporary power to a timber framed stand to support the dose pumps and control cabinet that were previously mounted to the block walls. We then wrapped it in plastic to keep the elements out of the electrical components as it would spend the next few weeks with only that for protection during the build. It wasn't pretty but it worked.

2.3 Completed Works

Once all the components were delivered to the site the build came together quickly. As soon as the plant was in place the electrician and Prominent moved in. Dose pumps and pipes were installed in one day and tested the next. Some work between the two contractors to get the pumps and bores talking to each other was quickly undertaken. The fencing went up just as quick and the painting and bore perch repairs were done in between other projects over the next few weeks. It was great to see the finished product from concept to completion.

Figure 2: ***New Curlewis Dose Plant***

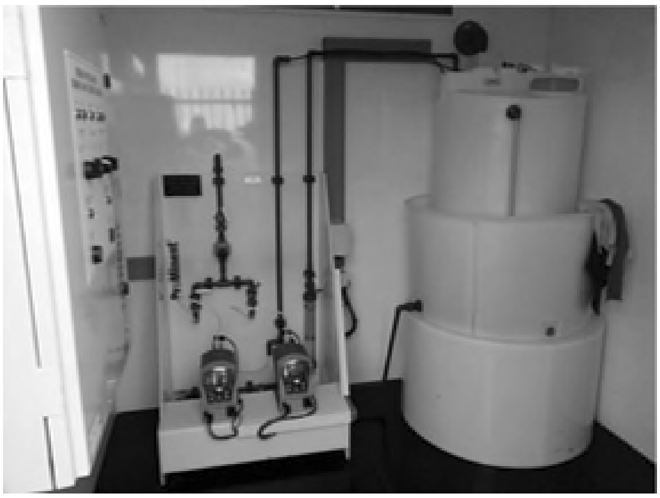

Figure 3: ***Completed internal works***

Figure 4: ***Completed external works***

3.0 CONCLUSION

By thinking outside the box and receiving input from members external to our organisation we achieved a result that has met all of our requirements.

We came in under budget, not by much, but with the need to upgrade switchboards, dose pumps and flow meters it increased the build cost considerably. The sharp, clean and professional looks of the Dose Plant reflects the Gunnedah Shire Council approach to water quality management. We can relocate the plant in the future

The site is now an asset that our organisation can be proud of and in the future it will be relocated to a new site where it will ensure the small community of Curlewis has safe drinking water piped direct from Gunnedah.

This project has shown that you can achieve a lot even if the budget is quite small. You just have to keep an open mind when exploring all options.

4.0 ACKNOWLEDGEMENTS

Thanks to Gunnedah Shire Council's Kevin Sheridan (Manager Water Services) and Mick Ludlow (Water Project Officer) for the ongoing support of Water Quality, Lester Watterson (Water Meter Reader/Water Quality Officer) for the great paint job, Doug Barr (Water Operator) for his great work with the perch rebuilds.

Appreciation is also extended to H & M Refrigeration and Air-conditioning, ProMinent Fluid Controls for the internal fit out and Thomson Electrical Gunnedah for the 24 hour support and their 'we can do it' attitude.

PORT MACQUARIE STP SLUDGE DEWATERING OPTIMISATION

Paper Presented by:

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Port Macquarie-Hastings Council

11th Annual WIOA
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PORT MACQUARIE STP SLUDGE DEWATERING OPTIMISATION

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Wayne Ducat, *Sewer Attendant Dewatering Operations* Port Macquarie-Hastings Council

ABSTRACT

This paper outlines the trial of blending activated and digested sludge for treatment at our onsite Dewatering system at the Port Macquarie Wastewater Treatment Facility. The strategy was trialled with a view of implementing permanently as an optimisation opportunity to manage the ever increasing sludge volumes.

The trial firstly assessed the compatibility of blended sludge with our existing dewatering system in regards to plant operation, chemical dosing and sludge cake moisture content. It will also convey the viability of permanent implementation into the process.

Dewatering is the process of removing as much water from the bio-solids for easy cost effective transportation and disposal off site.

1.0 INTRODUCTION

1.1 Port Macquarie-Hastings Sewerage Schemes

Port Macquarie-Hastings Council operates and maintains five (5) sewerage schemes and treatment plants throughout the Local Government Area from Dunbogan in the South, Port Macquarie in the North and to Wauchope in the West.

This paper details the optimisation of one of the processes at Port Macquarie Sewage Treatment Plant (STP).

1.2 Port Macquarie Sewerage Treatment Plant

Port Macquarie STP is located on the Mid North Coast of NSW and has a design loading of 52,000 Equivalent Persons (EP) and is currently running at 99% design loading.

The current average dry weather flow is 13ML/d however Port Macquarie is prone to heavy rainfall events that can cause a peak of 66ML/d. Council has plans in place to build new infrastructure in the coming years to meet the rapidly growing demands and reduce the loading on this plant.

Port Macquarie STP has three (3) extended aeration tanks (EAT) with a capacity of 12,000, 13,500 and 26,500 EP. The plant includes an onsite sludge dewatering plant to treat activated sludge and lagoons for the storage of Waste Activated Sludge (WAS). WAS is generally pumped from the EAT's to the aerated sludge lagoon for immediate dewatering with excess WAS being sent to the anaerobic sludge lagoons.

<u>Figure 3</u>: ***Aerial view of the Port Macquarie STP***

2.0 DISCUSSION

2.1 Dewatering Process

Port Macquarie STP currently runs a sludge dewatering process consisting of two (2) Gravity Drainage Decks with the sludge being fed into two (2) Alfa Laval NX4500 centrifuges.

Historically the dewatering plant is run five (5) days a week during normal working hours processing the Waste Activated Sludge (WAS). Outside of these times the WAS overflow is directed to two (2) sludge lagoons.

Polymer is dosed as part of the process and the final bio-solid is taken for recycling. The sludge lagoons were typically dewatered every five years.

In recent years there has been a significant increase in sludge produced at the plant. This increase in sludge volume is largely due to –

1. A change in process i.e. aluminium sulphate dosing has been relocated from the plant outlet to the plant inlet.
2. Population growth.

2.2 Process Optimisation

This increased WAS production has resulted in the anaerobic sludge lagoon dewatering life span being reduced to from 5 years to 18 months.

This has significantly increased the cost of plant operation. The cost incurred for contractual dewatering of the digested sludge lagoons exceeds $150,000 each time.

The Plant Operations Team recognised the problem and considered operational changes that could be implemented to optimise the dewatering process with a view to reducing costs.

The plans were to trial returning digested sludge from the sludge lagoons to the aerated sludge lagoon and then blend it together with the activated sludge. This blended sludge could then be processed in the dewatering plant.

If the trail proved to be successful the digested sludge in the lagoons could be processed on site and therefore eliminate the need to engage contractors to dewater the digested sludge.

This would result in a significant cost saving for Council.

2.3 Operational Trial Plan

The team formulated a plan for a trail run of the modified process.

1. Set up a temporary pump at the sludge lagoon.
2. Trial pumping digested sludge into the aerated sludge lagoon
3. Introduce digested sludge directly in to the dewatering process
4. Adjust the ratio of digested to activate sludge
5. Introduce the blended sludge into the dewatering plant process
6. Monitor bio-solid moisture content
7. Monitor and adjust Polymer dosing
8. Monitor and adjust dewatering process variables

2.4 Implementing the Trial

In consultation with the Process Engineer the decision was made to go ahead with the trial. The Plant Operations team went ahead and implemented the trial as per the above plan.

Table 1: ***Outline of the trial process***

Action Implemented	Effect on Process
Temporary pump set up at the sludge lagoon	• Transfer digested sludge directly to dewatering plant • Transfer digested sludge up to aerated lagoon.
Introduce 100% digested sludge directly into the dewatering process	• Increase in % feed solids • 100% Digested sludge could be adequately treated at the dewatering plant.
Pump digested sludge into the aerated sludge lagoon	• Transfer implemented on a staged basis. • Blended sludge introduced to dewatering plant
Adjust the ratio of digested to activate sludge	• Ratio gradually increased to the process • Increase in % feed solid
Introduce the blended sludge into the dewatering plant process	• Behavioural characteristics of dewatering plant showed little variation in performance as the blend was introduced and the ratio increased.
Monitored bio-solid moisture content	• Samples collected & analysed. • Calculated moisture content of bio-solids. • Minimal variation in bio- solid produced.
Monitor and adjust Polymer dosing	• Polymer dosing remained within normal operational range.
Monitor and adjust dewatering process variables	• Flow and plant operational parameters adjusted as required to meet bio-solid production targets

The process trial showed that blending the Digested and Activated sludge had no adverse effect on the dewatering process.

2.5 Operational Trial Results

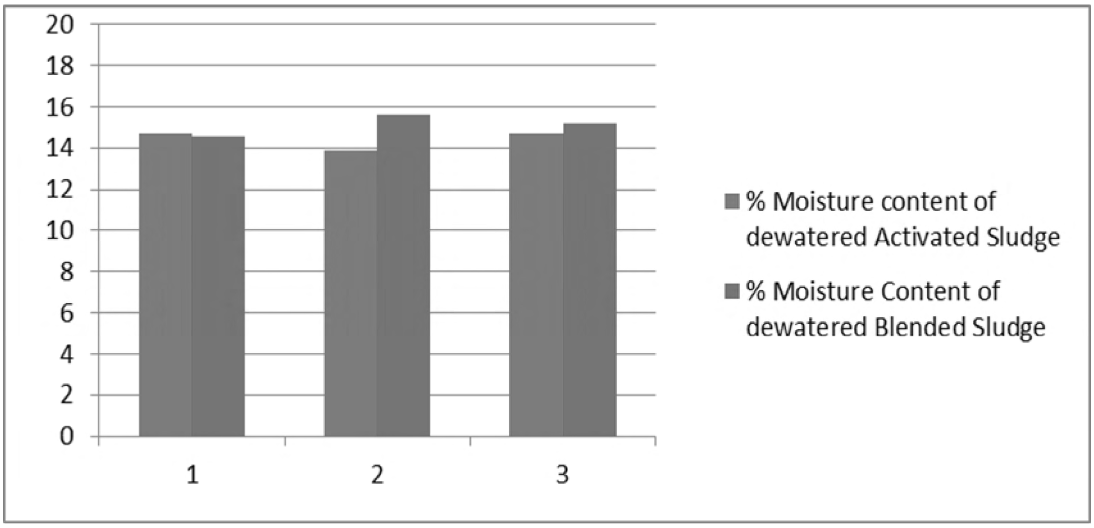
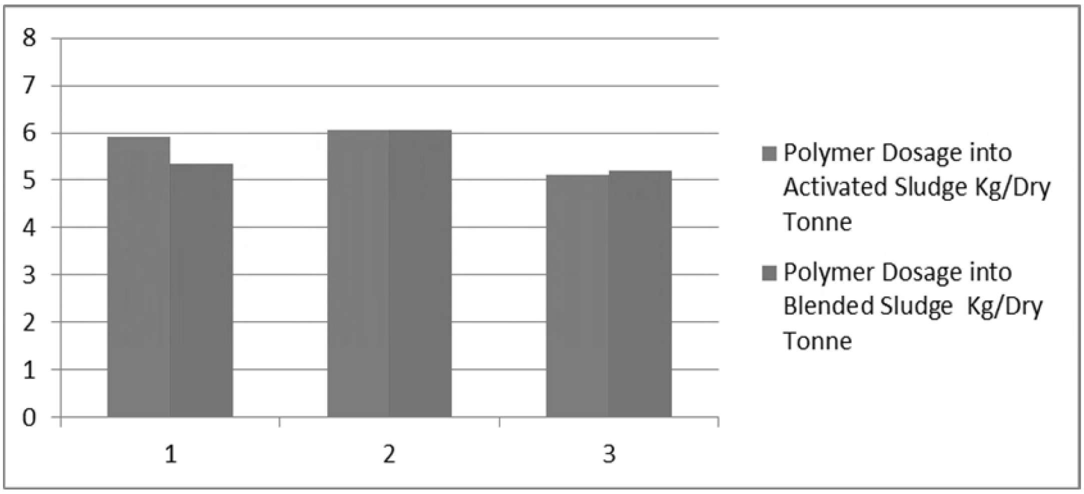


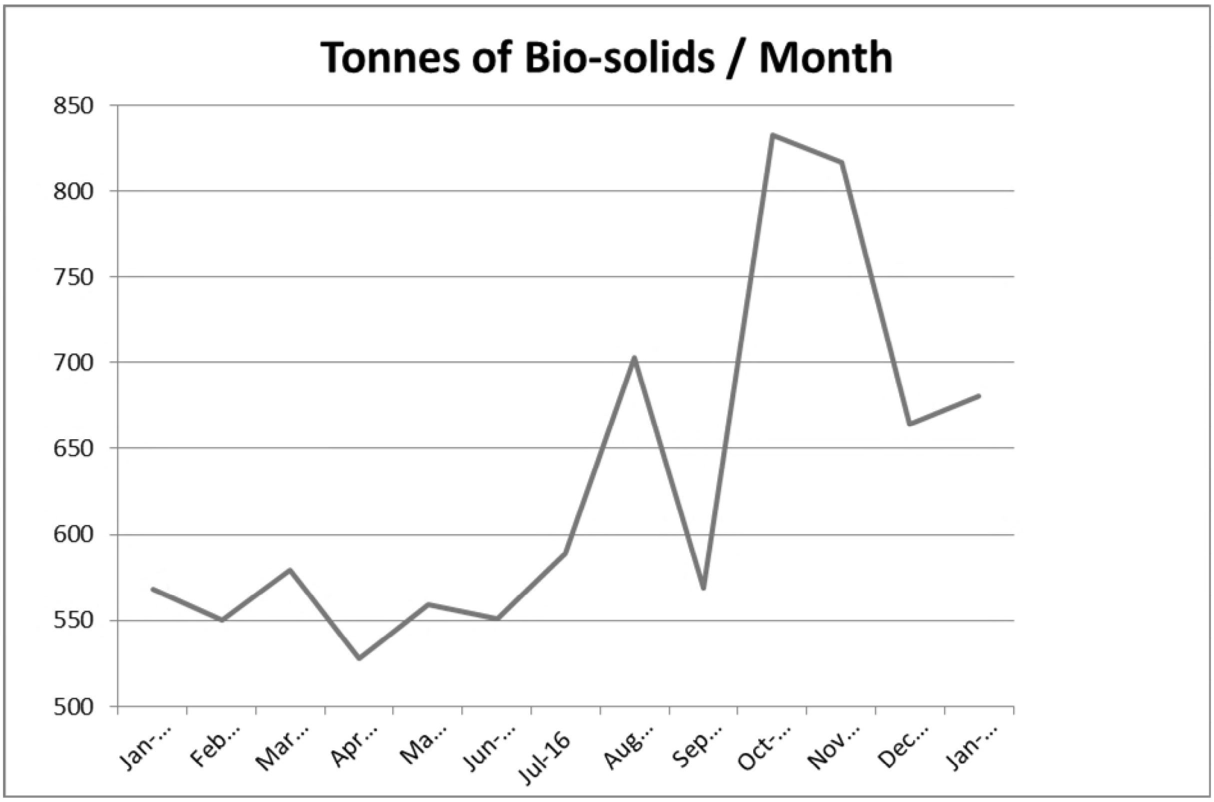
Figure 2: ***Moisture Content of processed sludge***



<u>Figure 3</u>: ***Polymer dosing***

The graphs in Figures 2 &3 display that there is no significant difference in moisture content of the treated sludge or in the Polymer dosing required.

Based on the trial results a permanent pumping system was set up on the anaerobic sludge lagoon and the modified process was implemented.



<u>Figure 4:</u> ***Bio-solids Removal graph***

Figure 4 displays the monthly bio-solids removed from the plant over the period of one year. It shows a significant increase in tonnage processed since the implementation of the sludge handling optimisation program.

3.0 CONCLUSION

The trial that we have undertaken has proven that a blend of digested sludge and activated sludge has had no negative effect on the existing dewatering process and has enhanced bio-solids production. Prior to implementing the modified process when our sludge lagoons were full we could not shut down the dewatering of the activated sludge. Therefore the dewatering plant could not be utilised to process the digested sludge from the lagoons. To dewater the Sludge lagoons contractors were hired at a cost of approximately $150,000 every 18 months. Now with this new strategy utilising our onsite dewatering system we are always ahead with our sludge lagoon management as they are constantly being dewatered. The modified dewatering process has now been successfully implemented resulting in a significant cost saving to Council.

4.0 ACKNOWLEDGEMENTS

Many thanks to the PMHC Water Process Technical Officer for assistance in developing this Paper, and the Port Macquarie STP Process Team for their involvement and efforts throughout the project.

IMPROVING OPERATIONS THROUGH BETTER PROJECT MANAGEMENT

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11th Annual WIOA
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IMPROVING OPERATIONS THROUGH BETTER PROJECT MANAGEMENT

Austin Morris, *Manager Works,* Riverina Water County Council
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ABSTRACT

This paper outlines the ways in which projects and operations are linked, and how water operators can improve their operations through greater involvement in project management. Projects and operations are often seen as competing objectives that are managed and delivered in different ways. Projects are viewed as the 'glamourous' side of the water industry with numerous award ceremonies celebrating multi-million dollar projects. Operations is often only considered when it comes time to analyse an organisation's performance, with a focus on efficiency and sustainability. Rather than treat projects and operations as two distinct and separate functions, integrating both functions can improve overall outcomes for water utilities. For example, a change in operation or process may be the focus of a dedicated project, or more commonly, a finished project can become part of operational management. Integration is not always recognised, as project management literature often tends to omit the operational phase, even though good operational performance is part of good project management. This has greater importance in the government water industry where organisations generally become the owners of the newly delivered project, so a better quality project means lower operational costs.

1.0 INTRODUCTION

Project and Operations are both used in private and public organisations and the differences and importance of both will be discussed. Riverina Water County Council (RWCC) is in the process of implementing several large projects including a new depot store and Water Treatment Plant (WTP). Using examples from the WTP, the influence of engaging the operator in the project delivery phase will be examined.

2.0 DISCUSSION

Projects differ from day-to-day operations or 'business as usual' (BAU) because of their uniqueness and finite characteristics. BAU incorporates repetitive processes undertaken to produce the same service or product which contrasts with the characteristics of a project (Bentley 2010; Anderson 2009). A major distinction between operations (BAU) and projects, is that the first is ongoing and repetitive while the second is temporary and unique (Dobie 2007).

In government more focus is placed on projects rather than ongoing management of day-to-day services. This can be due to their 'glamorous' nature, clear goals and specified timeframes (Rosenthal 1989, p.111). This is despite the fact that operational costs of councils generally far exceed the project costs. The greater focus is also apparent in other ways such as various Local Government Awards, which are primarily centred on large capital projects, and even the way Councils communicate with its ratepayers and wider community. Often newsletters and websites will showcase the latest capital project to be completed by a Council. Reading about how a Council has saved money with new processes is unlikely to generate the same enthusiasm or interest. Within council's themselves, the priority to projects is a common occurrence. Operational staff are expected to pause their operational work, if a project requires further assistance.

Whilst advocating for more attention for day-to-day services in government, Rosenthal (1989) accepts that projects in government are important, and gives the following reasons:

- interesting and challenging projects may attract managers who would not otherwise consider working in government;
- successful projects can increase public faith in government as well as build political support for better routine services in the same field; and
- public projects may hold lessons for the private sector who have turbulent and competitive business environments.

Dobie (2007) in contrast to Rosenthal, contends that neither projects nor operations are of greater or lesser importance than the other, but that they must work effectively together. Dobie (2007) also acknowledges that whilst they must be integrated, they must also be managed in a fundamentally different way. A change in an operation may be the focus of a dedicated project, hence the two are linked in that case. The Project Management Institute (Project Management Institute 2013) states projects and operations can intersect at various points including: at each closeout phase; when developing a new product; while improving operations; or until the end of the product life cycle. As de Wit (1988) notes this is not always recognised as project management books tend to omit the operational phase, even though as he states ‘a good operational performance is vital for all projects’ (de Wit 1988, p.167). Since a project turns into a product or service to be maintained, then the delivery of a poor product or service (project), would mean higher operational costs, to maintain that project throughout its operational life cycle. If the project were implemented successfully, then this would have a flow on effect to the operating results. In private organisations, the end use may not be such a concern, as they have often made their profit once the project is delivered. However in local government, the council is the one that will eventually take ownership of the project, which may mean better quality is sought, but this may come at a higher cost.

Figure 1: ***Wagga Wagga Water Treatment Plant***

2.1 Case Study– Water Treatment Plant

Riverina Water County Council, located in Wagga Wagga, NSW, is currently constructing a new 55 ML/d Water Treatment Plant (WTP) at the cost of $35 million. RWCC has three engineering sections: Works; Operations; and Projects. The works section is responsible for laying new pipe and associated fittings.

The project section is responsible for all large capital projects such as treatment plants, reservoirs etc. The operations section is responsible for the running of the treatment plants. The new WTP is being managed by the project section, but will ultimately be run by the operations section. To recognise this need for integration over the WTP life cycle, operations and projects worked together in the project phase. During the initiation and design stage of this project, the operations needs were considered and design concepts incorporated. Project staff visited existing Water Treatment Plants around the country to see how the design could enhance operations and safety. A few of examples of including operations requirements will be discussed.

Figure 2: ***Construction of the new Wagga Wagga Water Treatment Plant***

Example 1

Project staff had visited sites where operators on their daily checks had to walk over and around pipe work in the plant. In some instances steps were retrofit so that the large pipes could be safely crossed. To avoid this access issue and the need to provide access structures, the design of the WTP placed the pipes below the ground level with access grates above as shown in Figure 4. This means that operators can walk through the site on one level.

Figure 3: ***Pipework below floor with access grates***

Example 2

From speaking with WTP operators, cleaning the filters was raised as a difficult exercise due to access. Complying with confined space requirements and easily being able to reach staff if required was inhibited in older treatment plants. The design of the Wagga WTP including large access ports underneath the filter tanks which are specifically for maintenance access. These are also shown in Figure 4 and in Figure 5 and all on one level. A gantry was been built overhead to avoid manual handling of large maintenance equipment.

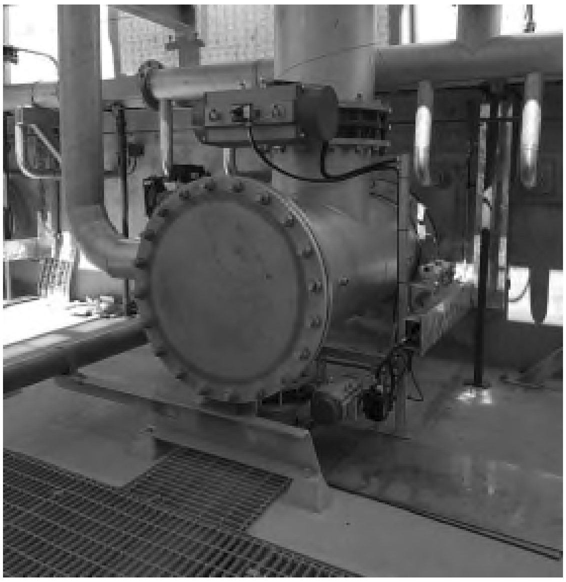

Figure 4: ***Access for maintenance***

Example 3

At the old WW WTP, operators were unable to view outside the control room. If the operator needed to do a quick visual check, they need to exit the building with their full PPE. The new control room has been designed to be integrated so that the operator can conduct a quick visual inspection without leaving the control room. This is shown in Figure 6.

Figure 5: ***View from operators control room***

Example 4

Similar to the pipe obstruction, bunding in many existing plants means the operators need to climb over short walls, or stair are constructed to go up and over the bund wall. Materials need to be carried in as machinery such as forklifts etc, cannot access storage areas. The new WTP was designed so that everything can be accessed on one level. The material storage silos sit on concrete pads with the bund below. Corrosive resistant plate was then placed at ground level, which allows any liquid to be captured by the cavity below, but operators and machinery have level access to the area. This is shown in Figure 7 and 8.

Figure 6: ***Bunding below floor level***

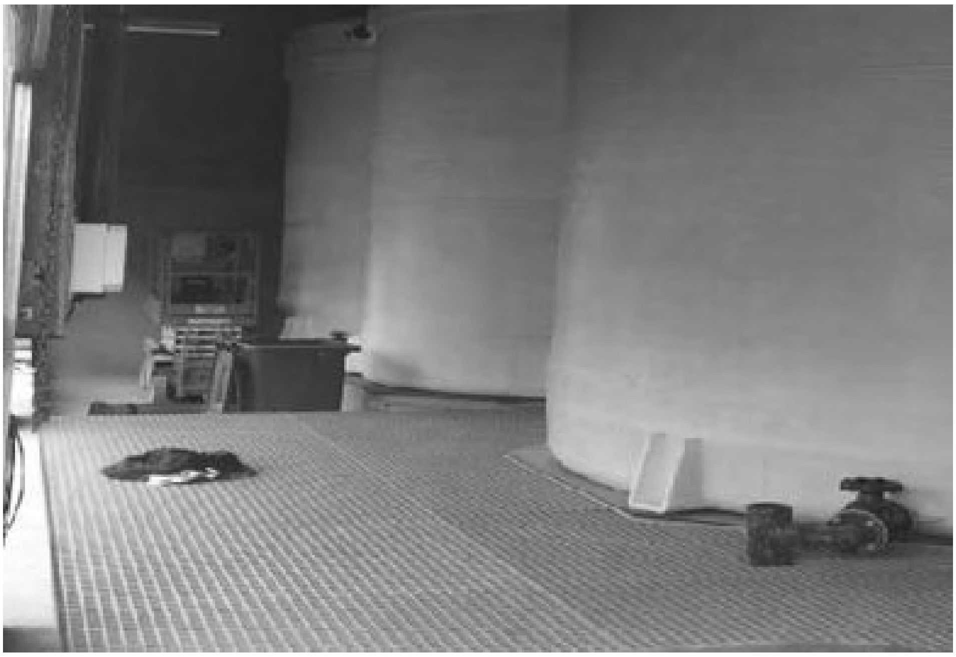

Figure 7: ***Bunding below floor level***

Figure 8: ***Sign in the old WTP***

3.0 CONCLUSION

The literature has shown that projects and operations are linked. The examples of the Wagga WTP have demonstrated that including the needs of the final user, in this case WTP operators, in the project design phase, means the operation of the new plant will be improved. The new WTP will be safer and more efficient for the operators, when commissioned in 2018.

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UNDERSTANDING BACKFLOW PREVENTION – THE THINGS YOU NEED TO KNOW

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11th Annual WIOA
NSW Water Industry Operations Conference and Exhibition
EPIC – Exhibition Park in Canberra,
29 & 30 March, 2017

UNDERSTANDING BACKFLOW PREVENTION – THE THINGS YOU NEED TO KNOW

Peter McLennan, *President*, The Backflow Prevention Association of Australia Inc.

ABSTRACT

Design, installation and hydraulics of backflow prevention devices. Understanding the pressure drop and flow restrictions.

Backflow prevention devices have become an integral part of the water supply asset. With the protection of the drinking water being paramount, backflow prevention is required by the Plumbing Code at any connection that is subject to being affected by a cross connection. The operation and subsequent restraints backflow prevention devices present is not well understood. This paper discusses the design requirements and the performance characteristics of Reduced Pressure Zone backflow prevention devices so that water supply personnel can be cognizant with potential issues before they occur.

Topics covered include:

- Backflow Basics
- Pressure drop Vs flow rate and the issues
- Installation guidelines
- Discharge from Reduced Pressure Zone valves

Backflow prevention devices are like smoke detectors. They both save lives. Ignorance in understanding how they operate within your network is not an excuse when the coroner knocks at your door.

1.0 INTRODUCTION

Backflow is the term used to describe the reversal of flow in a water supply pipe or system. Backflow prevention devices are used to protect drinking water from contamination where cross connections occur.
The Australian Plumbing Code Section 4 relates to Cross Connection Control and covers the design and use of backflow prevention devices. Australian State and Territory Governments reference the Australian Plumbing Code in their regulations therefore mandating the management and use of backflow prevention devices.

Since the introduction of backflow prevention devices to the plumbing code in 1998, it is estimated that there are more than 500,000 testable backflow prevention devices installed across Australia. Other than a few in the plumbing industry, many people responsible for managing and maintaining drinking water systems know little of backflow and how the devices affect the system.

This paper attempts to demystify backflow and presents the basics so that even non-plumbing people can understand how they interact with the water supply.

2.0 DISCUSSION

Whether a plumber, hydraulic designer, plumbing consultant, water officer, water engineer, contractor or property owner, there are several things you must understand when considering installing or requiring the installation of a backflow prevention device.

A backflow prevention device is a safety valve that protects the drinking water supply. They are used extensively but many people don’t understand the operation or the limitations and constraints applicable to these devices.

The following topics need to be addressed when considering the use of a Reduced Pressure Zone Valve (RPZ) backflow prevention device.

Backflow Basics
Pressure Drop
Flow rates
Discharge from RPZs
Installation Guidelines

2.1 Backflow Basics

The Plumbing Code:

AS/NZS3500.1-2015 is referenced in the National Construction Code, Volume 3, the Plumbing Code of Australia. Section 4 is Cross Connection Control and lays out the backflow prevention requirements mandated through legislation. When a State or Territory references the National Construction Code in their plumbing regulations, unless otherwise stipulated, it makes the use of backflow prevention devices mandatory.

The Standard:

Backflow prevention devices are Watermarked to AS/NZS2845.1-2010 or AS/NZS2845.1-1998. The Watermark is your assurance that the device has been manufactured and tested in accordance with the relevant Standard. If it does not have a Watermark it should not be installed in the drinking water network.

Hazard Ratings:

The Standard identifies 3 levels of hazard (the contamination or pollutant that can come in contact with the drinking water)

High Hazard – The pollutant or contaminant if ingested could kill you. Facilities connected to the water supply likely to have this level of potential contamination would include mineral processing, meat processing plants, hospitals, mortuaries, plating works, etc.

Medium – The pollutant or contaminant if ingested is unpleasant and may make you ill. Facilities connected to the water supply likely to have this level of potential contamination include commercial buildings, schools, public parks, food processing plants etc.

Low – The pollutant or contaminant is non-toxic but is objectionable and should not be present in drinking water. Facilities connected to the water supply likely to have this level of contamination include residential homes, rainwater tanks etc.

Two types of cross connections:

1- A direct connection. This is where the cross connection is 'hard piped' and is often installed by people unaware of the possible consequences. It could be a bypass line or a submerged tank filling connection.

2- An in-direct connection. The most common cross connection is a hose. A hose is an in-direct connection as the outlet can be used and left in all sorts of situations. For example, drain cleaning, chemical mixing, pipe flushing, pool filling etc.

Two types of backflow:

Backsiphonage – the pressure in the supply line is reversed causing the water to be sucked or run backwards. This is usually caused by a water main break in the street but can be caused by mechanical devices that rely on venturi action to draw water from the supply line.

Backpressure – the water pressure within the facility is greater than the supply pressure. Causes can include high head pressure found in high rise building and at the top of hills and mechanical equipment failures.

Two types of backflow preventer:

1-Testable – for use in high, medium or low hazard applications

2- Non- testable – for use in low hazard applications

Testable backflow prevention devices are designed to be able to be tested for operation effectiveness and for maintenance whilst installed inline and are suitable for use in high, medium or low hazard applications.

Non-testable devices need to be removed from line for maintenance and testing hence they are only suitable for installation in low hazard applications (see Table 1 for a list of common devices and the applicable hazard ratings).

Table 1: ***Common devices and the applicable hazard ratings***

Reduced Pressure Zone Device (RPZ)	Testable	High hazard applications
Double Check Valve (DCV)	Testable	Medium hazard applications
Pressure Type Vacuum Breaker (PVB)	Testable	Low hazard applications
Dual Check Valve (DUCV)	Non-Testable	Low hazard applications
Vented Dual Check Valve (DCAP)	Non-Testable	Low hazard applications
Atmospheric Vacuum Breaker (AVB)	Non-Testable	Low hazard applications
Hose Connection Vacuum Breaker (HCVB)	Non-Testable	Low hazard applications
Single Check Valve Testable (SCVT)	Testable	Medium hazard applications only on fire lines

2.2 Pressure Drop & Flow Rates

Backflow prevention devices rely upon pressure drop across the check valves for effective operation. The minimum spring differentials are stipulated in the Standard and all Watermarked devices must comply.

Testable backflow prevention devices are field tested for effective operation upon commissioning and at least annually by an accredited tester trained in backflow prevention.

Always check the manufacturers published literature for the pressure drop curve to ensure you have enough available pressure to supply the amount of water required. It is especially important where a fire connection is concerned.

The following examples are from manufacturers published literature and should be used as a minimum.

100mm Reduced Pressure Zone Valve at 20 L/s has a head loss of 68 kPa *(Apollo Valves All Valve Industries product catalogue page 7)*
100mm Double Check Valve at 20 L/s has a head loss of 20 kPa *(Apollo Valves All Valve Industries product catalogue page 6)*
100mm Double Detector Check Valve at 20 L/s has a head loss of 68 kPa *(Apollo Valves All Valve Industries product catalogue page 8)*
100 Single Check Valve Detector Testable at 20 L/s has a head loss of 57 kPa *(Pentair Valcheq backflow prevention catalogue page 4)*

These figures are devices only and do not include strainers or isolating valves. These values must be considered where pressure is limited. It is not unusual for a complete assembly comprising of isolating valves, strainer and the RPZ having a pressure drop close to 100 kPa.

1.3 Discharge From RPZ Valves

All RPZ backflow prevention devices will dump water through the vent in the valve. It is a safety feature that ensures that if the device fails or there is a backflow event, the drinking water is protected.

The spillage of water is often inconvenient, but when installed where it cannot get away, it can become dangerous to property and humans.

All manufacturers publish the discharge rates applicable to their devices so be aware of these when you install an RPZ.

Otherwise you may have a flood on your hands as for example, a 50mm RPZ with a pressure of 700 kPa can discharge around 660 l/min, sufficient water to empty an Olympic sized swimming pool in 6 hours. See figure 1.

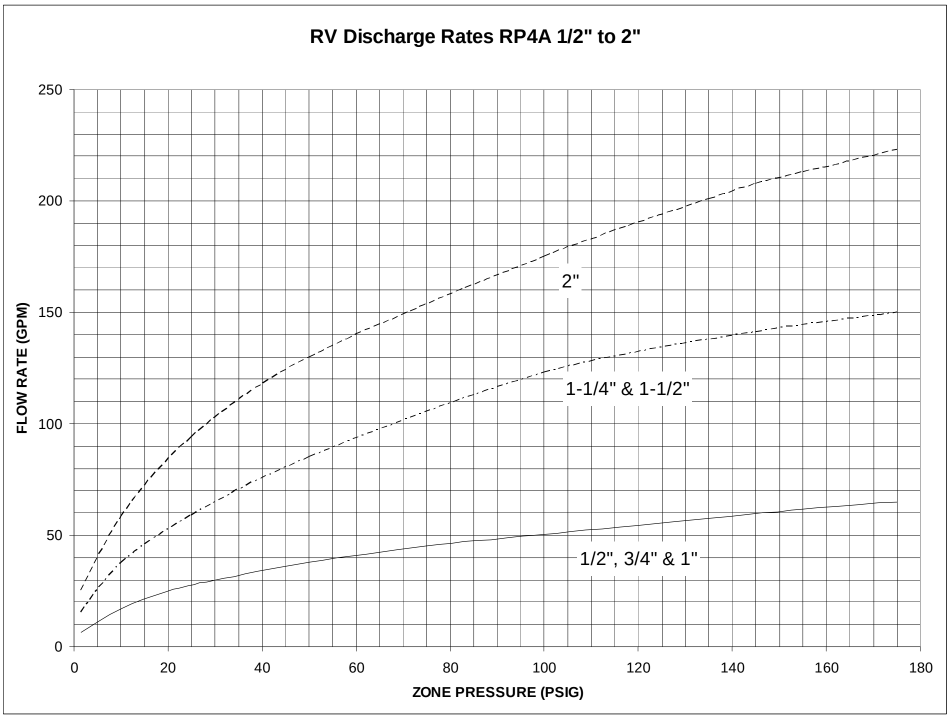

Figure 1: ***Apollo Valves RPZ discharge Rates***

3.0 INSTALLATION GUIDELINES

Backflow prevention devices are mechanical devices that require regular testing and maintenance. To facilitate this, they must be installed where ease of access is available. The Standard addresses some aspects, but each manufacturer outlines specific installation requirements in their published literature.

The three questions you need to ask yourself are:

1 Is the device I am installing suitable for vertical and horizontal installation or just horizontal?
Reduced Pressure Zone backflow prevention devices are designed to discharge water either during pressure fluctuations or mechanical failure. To not compromise the level of safety, they are to be only installed in the horizontal plane. There is no Watermarked RPZ device approved for vertical installation.

2 Is the device I am installing suitable for concealing in a valve box or pit?
Due to the discharging of water, a valve box is susceptible to flooding. Once the water level covers the discharge vent, the valve is compromised and the safety reduced.

3 Does the device I am installing have ease of access for regular testing and maintenance without the need for special equipment or dismantling from the line?
AS/NZS2845.1 2010 stipulates that testable backflow prevention devices are to be commissioned upon installation and tested at least annually to ensure effective operation. Work place health and safety guidelines would dictate that backflow prevention devices not be installed in confined spaces, near hazards, in elevated positions or in ceiling cavities.

4.0 CONCLUSION

It is an everyday occurrence where the installation of a backflow prevention device is utilised to protect the drinking water, but to other than a few trained professionals in the industry backflow prevention devices remain confusing and are not understood by the very people responsible for providing the safe drinking water.

With the Australian Plumbing Code being referenced in most State and Territory legislation, it is mandatory for backflow prevention devices to be installed to protect the drinking water.

Understanding what backflow is and the limitations of the various devices will not only allow you to satisfy your duty of care where these devices are used, but to be able to understand the impacts the installation of these have within your network.

Backflow prevention devices are like smoke detectors. They both save lives.

5.0 ACKNOWLEDGEMENTS

Thanks to Apollo Valves / Conbraco Industries and the numerous 'unsung heroes', the dedicated backflow professionals who have inspired me to develop this presentation.

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IMPLEMENTING AND MANAGING SYDNEY WATER'S BACKFLOW PREVENTION DEVICE REGISTER

Paper Presented by:

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James Milton, *Technical Specialist,*

Sydney Water

11th Annual WIOA
NSW Water Industry Operations Conference and Exhibition
EPIC – Exhibition Park in Canberra,
29 & 30 March, 2017

IMPLEMENTING AND MANAGING SYDNEY WATER'S BACKFLOW PREVENTION DEVICE REGISTER

James Milton, *Technical Specialist,* Sydney Water

ABSTRACT

A progressive policy developed and implemented to manage Sydney Water's connection requirements for installing and testing backflow containment devices in Sydney Water's area of operation.

Backflow is a term in plumbing for an unwanted flow of water in the reverse direction.

1.0 INTRODUCTION

Under its charter, Sydney Water is responsible for supplying clean, safe drinking water to over five million people.

Sydney Water used to be the regulator for plumbing and drainage. We were responsible for inspecting all plumbing and drainage work in our area of operation, from Gerroa in the South to the Hawkesbury River in the North, throughout the Blue Mountains and the City of Sydney. Backflow prevention has always been a priority for Sydney Water, as outlined in the plumbing standards, and we have retained responsibility although no official Sydney Water policy had existed.

The dedicated backflow prevention program began in 1996. Its aim was to identify potentially hazardous industries with existing backflow prevention devices as well as properties needing devices to be installed to prevent cross connections within their properties. The program has continued to evolve since its inception.

The importance of backflow containment has become more relevant as regulatory requirements have changed, with recognised on-site cross connection risks from alternative water supplies, chemical production, trade waste operations, burst water mains and irrigation systems, to name a few.

While Sydney Water is no longer the regulator for plumbing and drainage, we must still protect greater Sydney's drinking water and recycled water supplies.

2.0 OBJECTIVE

To protect customers and assets by managing and controlling risks caused by potentially harmful contaminants backflowing into our water mains from customers' private properties.

Register backflow containment devices installed Sydney Water's area of operations, build a list of accredited plumbers available to test devices and manage this data using a system that will automatically send letters and notices to customers.

3.0 OPERATIONAL PRINCIPLES

Sydney Water will:

- identify properties that pose a backflow risk to the drinking water supply including Sydney Water assets, for example pump stations, wastewater treatment plants, commercial and industrial properties
- consult customers throughout the implementation process and be able to demonstrate due diligence and duty of care to customers
- implement and maintain a cost-effective management system, including a database, reporting system and management control procedures
- promptly identify, record, report and rectify non-compliant properties.

3.1 Implications, If Not Implemented

- Sydney Water would not demonstrate the expected level of due diligence.
- Sydney Water customers would be exposed to contaminated water sources from cross connections on private properties.

3.2 Benefits

- Minimisation of risk to customers.
- Due diligence requirements met.
- Reduced regulatory role within customers' properties.
- No contamination of drinking water from backflow.
- Reduced administration costs to Sydney Water.

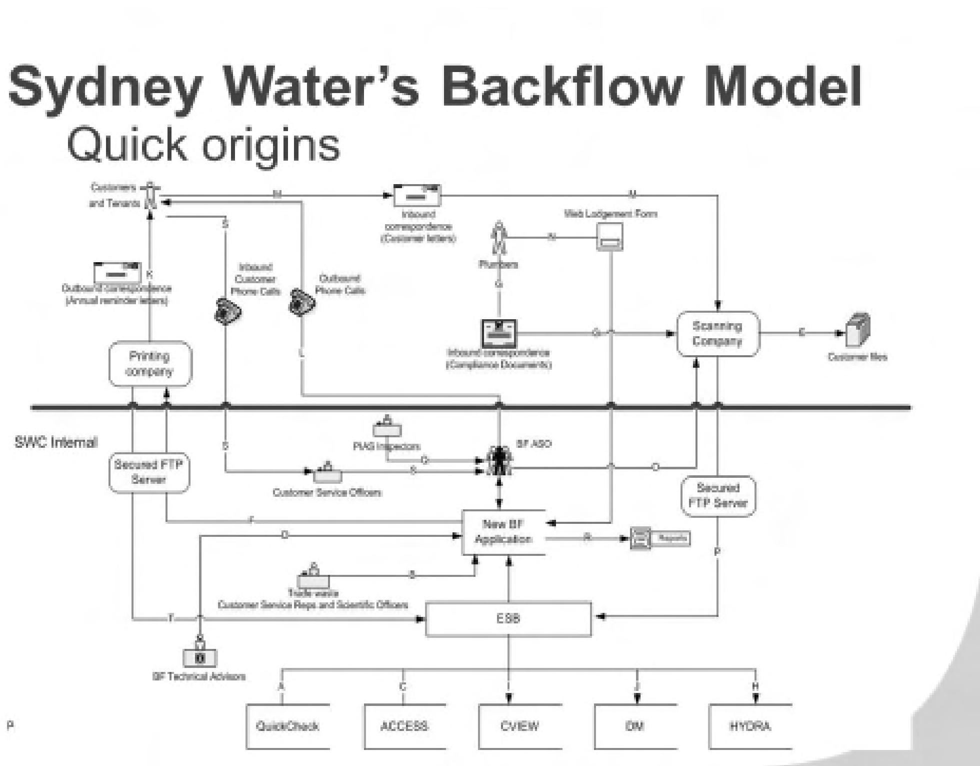
4.0 CONSULTATION

Sydney Water consulted customers throughout our operating areas as implementation would have ongoing consequences for all areas. This included consulting relevant industry group and associations.

5.0 DEVELOPING THE PAPER-BASED BACKFLOW DATA BASE

From 1996–2004, we progressively moved towards a fully computerised system by:

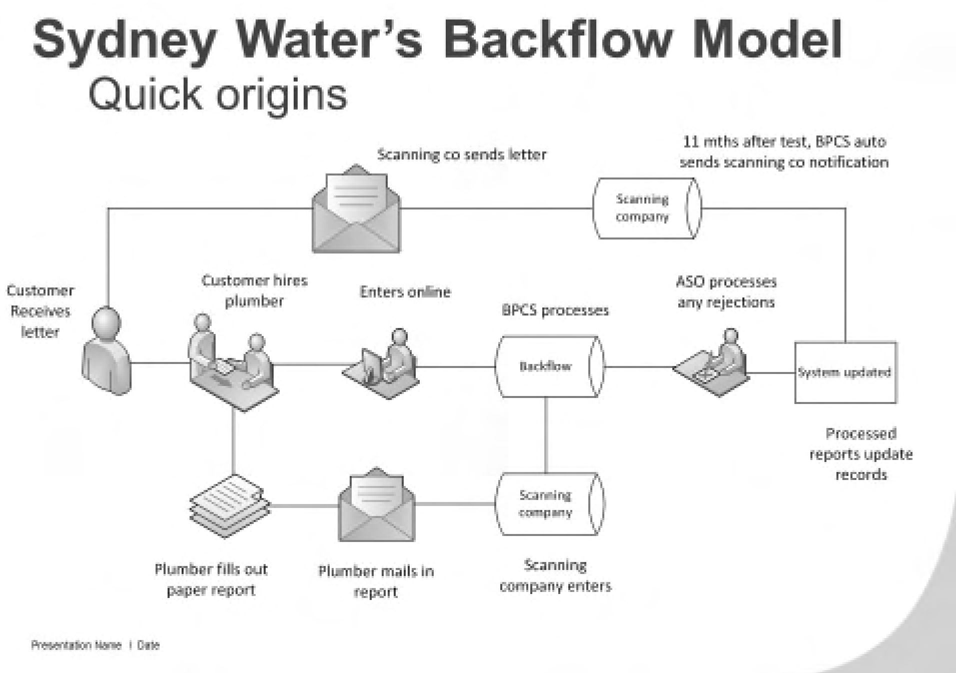
- utilising Sydney Water systems to identify properties requiring backflow prevention
- writing to customers who needed to install devices
- receiving Compliance Certificates from plumbers completing testing work
- retaining associated paperwork on-site so we can match and issue notices
- developing spreadsheets to manage outgoing notices and incoming reports.



6.0 DESIGNING AND DEVELOPING THE ELECTRONIC DATA BASE

From 2004–2009, we:

- proposed a business plan to the Sydney Water executive team for development approval
- assembled a team of subject matter experts
- identified system requirements and operational functions
- engaged in-house information technology teams to liaise and develop software
- built, tested and deployed the backflow data base.



6.1 A Fully Functional Online Lodgement System

From 2009, we notified the industry and designed implementation to progress over 12 months, allowing plumbers to lodge test reports online while continuing with paper based lodgement.

Sydney Water moved to a fully online lodgement system in 2011, rejecting paper-based lodgement except in exceptional circumstances, for example no computer.

Plumbers could lodge and store test reports for containment, zone and individual devices into the system. Plumbers can retrieve all reports lodged under their name.

All annual retest request letters, install, and non-compliance letters are sent through the online data base.

Sydney Water technical advisers continue with industry education by attending TAFE college backflow accreditation classes and supporting the plumbing industry.

Annual targeted auditing of all industries is a key function of the Sydney Water Backflow Management Program.

6.2 Devices Installed and Registered

2005	2009	2016	2017
9,000 devices	23,000 devices	38,000 devices	Continued growth

6.3 Benefits of Online Lodgement

- It is user friendly.
- It helps us meet customer expectations.
- We have reduced the time needed to manage paper-based exceptions in the backflow system.

7.0 CONCLUSION

The backflow database is now an essential management system, which allows Sydney Water to accurately and reliably manage incoming and outgoing data from the online management system.

Recent improvements have allowed accredited plumbers to update property reports with accurate device information, changes to serial numbers and complete a simplified report.

Overall efficiency benefits have reduced manual adjustments of errors in the data base from up to a staggering 75% down to an outstanding result of 3%.

8.0 ACKNOWLEDGEMENTS

Tegan Van Der Linden: Sydney Water, Business Analyst Business Customer Services
Stephen Murphy: Sydney Water, Manager Business Customer Assurance
Sydney Water Digital Services
Licensed plumbers working in the backflow prevention industry

WHAT IS BACKFLOW & QLD BACKFLOW PREVENTION LOCAL GOVERNMENT MANAGEMENT REQUIREMENTS

Paper Presented by:

Stephen Jennison

Author:

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President Backflow Prevention Association QLD Chapter,

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WHAT IS BACKFLOW & QLD BACKFLOW PREVENTION LOCAL GOVERNMENT MANAGEMENT REQUIREMENTS

Stephen Jennison – *President Backflow Prevention Association QLD Chapter*, Moreton Bay Regional Council

PRESENTATION

- Queensland laws to protect the water supply;
- What is backflow prevention;
- Why do we need a backflow prevention device;
- Authorised testers' requirements;
- Local Government licensing and registration of backflow prevention devices.

1.0 INTRODUCTION

When the *Sewerage and Water Supply Act 1949* (Qld) was amended in April 1992 it made way for Backflow prevention to be written into law in Queensland for the first time.

Having previously worked in the private sector, specialising in the testing and certification of testable backflow prevention devices, I joined the Pine Rivers Shire Council (now Moreton Bay Regional Council) as a plumbing inspector in 2005 and later became President of the *Backflow Prevention Association QLD Chapter* in 2014.

In 2008, the amalgamation of Pine Rivers Shire Council, Caboolture and Redcliffe Councils saw the Moreton Bay Regional Council established, creating the third largest Council in Australia with an area of 2,037 km2. **Moreton Bay Regional Council** is now one of the fastest developing regions in Australia, situated between Brisbane and the Sunshine Coast, and is currently home to 8600 registered testable backflow prevention devices.

2.0 DISCUSSION

This presentation is based on backflow prevention requirements in Queensland:

1. Plumbing and Drainage Act 2002;
2. Standard Plumbing and Drainage Regulation 2003;
3. National Construction Code Volume 3;
4. AS/NZS3500:2015 (Individual, Zone and Containment protection);
5. Submitting the testing reports with the Local Government;
6. Local Government creating a backflow licence and register.

3.0 ACKNOWLEDGEMENTS

I would like to thank George Wall and the entire conference organisation team for allowing me to speak on backflow prevention and provide a brief overview on how, why and where backflow prevention is required.

OLD FILTERS IN A NEW WORLD: AN OPERATORS PERSPECTIVE

Paper Presented by:

Michael Hearn & Justin Miller

Authors:

Michael Hearn, *Process Operator,*
Justin Miller, *Process Operator,*

Tamworth Regional Council

11th Annual WIOA
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29 & 30 March, 2017

OLD FILTERS IN A NEW WORLD: AN OPERATORS PERSPECTIVE

Michael Hearn, *Process Operator,* Tamworth Regional Council
Justin Miller, *Process Operator,* Tamworth Regional Council

ABSTRACT

Tamworth's main Conventional Water Treatment Plant [Calala] was commissioned in the 1980's. The 80 mega litre plant has 12 filters. In 2016 we had numerous concerns of high NTU which affected a number of the filters. We conducted a series of tests on the filters which concluded that we would need to replace the media, and that was just the start of our problems!

1.0 CALALA WATER PLANT BACKGROUND

In 1980 the Tamworth Regional Council commissioned the Calala Water Plant. The facility has an initial capacity of 80megalitres a day but has been designed to provide even greater water supply as Tamworth's population continues to grow. The majority of Tamworth's water is supplied from the 100,000 mega litre recently upgraded Chaffey Dam. This is located on the Peel River about 50 km south of the city.

Water from Chaffey Dam is released into the Peel River which flows downstream where it is pumped via a large-capacity intake works, and then fed to Calala Water Treatment Plant. Tamworth's supplementary water supply is piped from 56km to the south east, out of Dungowan Dam. This dam has a capacity of 6300megalitres. Additionally there is six 12 metre deep Drift Wells adjacent to the Peel River. These are maintained as an important alternative water supply for when dam levels are low.

Tamworth's Calala Water Treatment is a conventional plant, consisting of two round solids-contact clarifiers [Clarification]. The clarified water then flows through to the filter stage. There are 12 filters at Calala. The filter media consists of Anthracite [fine coal] over sand and gravel filters through which water passes for final purification. Impurities are removed from the filter by agitation with an air scour, followed by a large volume of clean water "backwashed" upwards through the media. After filtration, water from the filters flows through a common channel to a chlorine contact tank where chlorine is injected for disinfection. The water is then treated with soda ash to balance pH, fluoride for dental health and then eventually pumped to the reservoirs for distribution to consumers.

<u>Figure 1:</u> ***Clarifier 1 at Calala- WTP***

2.0 ISSUES WHICH ARISED AFTER MOTHER NATURE

In June 2016 Tamworth's WTP had a high rain fall event in the surrounding catchments. This changed the chemistry of the water significantly and overloaded some of the 12 filters at Tamworth WTP. All the filters are set up with set points that shut down the filter if the turbidity is too high.

During this time of unstable water we had to manually run the problem filters. This was achieved by lowering the effluent value setting to drain the filters at slower rates before backwashing. We found at the automatic valve setting the filters were breaking through during the backwash stage. This was starting to become labour intensive, having operators manually backwashing after normal operating hours.

The water quality from Chaffey and Dungowan dams are generally stable. Our filters treat this water quite efficiently; however when we combine these raw waters our filters struggle. We could treat this water effectively although we found that the water from Dungowan was not constant .This is due to the fact that Dungowan Dam has an automatic gate that releases water when it hits a trigger point. Large amounts of water are released which sends surges of bulk water downstream. This sends slug doses of different quality water through the plant which cannot be predicted. This in turn alters the treatment process (Coagulation/flocculation) with raw water of low alkalinity, low PH and high colour.

Figure 2: ***Dungowan Dam – Tipping***

2.1 The Adverse Effect of Faulty Filters on Consumers

Tamworth WTP uses filters as part of a multiple-barrier treatment process designed to remove particles, including water-borne pathogens such as Cryptosporidium, from potable water. Cryptosporidium is present in raw water and could possibly cause diarrhoea or gastrointestinal illness in humans. As it's highly resistant to chlorine disinfection, the removal of Cryptosporidium relies upon effective sedimentation and filtration processes. Detection of Cryptosporidium within the water system would require a boil water notice to be issued for all affected customers. This could be a costly exercise.

3.0 OPERATORS OBSERVATIONS

- Turbidity breakthrough on backwash drains down evident as dirty water in the baths.
- When filter breakthrough occurs the process can no longer be guaranteed to form an effective barrier to pathogens such as Cryptosporidium, and may compromise the effectiveness of chlorine disinfection

- Some filters have a considerable quantity of mud-balls.
- A lot of these mud-balls are located at the inlet end of the filters and this zone of the bed typically appears to be less agitated than the remainder of the bed. This indicates blockages of laterals/nozzles in this area. Air and backwash velocities in the remainder of the bed may be excessive, which can result in media intermixing and migration of sand to nozzle depths.
- Floating filter nozzles in cells
- When nozzles are missing from the plenum floor filter bed sand will migrate into the underdrains of the filter. This leads to additional nozzles in those cells also being blocked and then the underdrains being over-pressurized. As these issues continue to worsen, the risk of significant over-pressure increases. This will eventually lead to a failure of the underdrain system. This will lead to complete failure of the filters.
- Significant quantities of sand observed in the filtered water chambers;
- This indicates that there has been migration of sand from the filters into the underdrains
- In some filters air can be observed to bubble up along the concrete edge at the washout channel during the backwash,
- This is a sign that excessive pressures have resulted in lifting of this section of the floor and complete failure of the underdrain may be imminent. .

4.0 CONSULTATIONS

This filter report will assess the current condition of the filters in respect to comply with the Australian Drinking Water Guidelines 2011.

Initial consultation about the filters at the WTP was with Craig Jakobski (Hunter Water) and methods of initial filter investigation were taken from the WIOA journal *Practical Guide to the operation and Optimization of Media Filters.*

Recommended actions to ascertain the condition of filters include;
Visual filter checks

- Filter bed appearance

  This is visual observation of the bed for uniformity and media depth. When in service filters may lose media which reduces their ability to produce clean water and hold particles. Uneven and lumpy beds are signs of problems with mud balls.

- Air scour pattern

  This should be established evenly and gently across the entire filter. Violent eruptions or disjointed appearance is cause for concern as this indicates blocked or missing nozzles.

- Underdrain pressure

  This is important as high underdrain pressures in a plenum type arrangement can rupture the floor and lead to total failure of the filter.

High pressure in the underdrain is generally due to sand that has migrated to the underdrain blocking the nozzles and laterals. As part of the investigation process pressure gauges linked to SCADA have been installed into the backwash and air scour line respectively

- Underdrain leaks

  These are the result of excessive underdrain pressure. Leaks in the underdrain indicate the plenum floor is starting to lift. This will relieve excessive pressures to some extent but also indicates the structural integrity of the Plenum underfloor is failing.

- Dirty water treatment.

  A filters ability to maintain good water quality is tested vigorously when the treatment plant is dealing with 'dirty' water. Filter problems during this time can become especially evident.

Initial investigations were a visual observation of each filter completing a backwash

Figure 3: ***Air scour pattern-Filter 2 leaks evident along drain and 1/3 media not agitated***

After installation of pressure sensors in the backwash and air scour line data was collated and graphed.

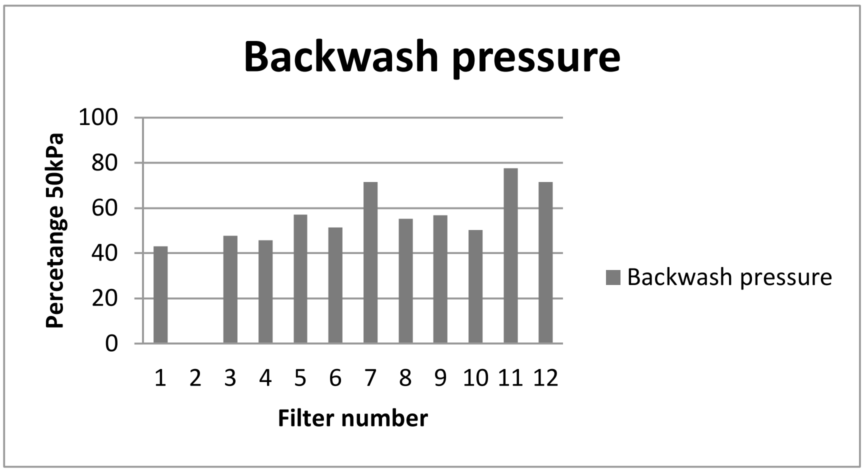

Figure 4: ***Backwash pipe pressure during backwash.-Filter 2 is currently offline***

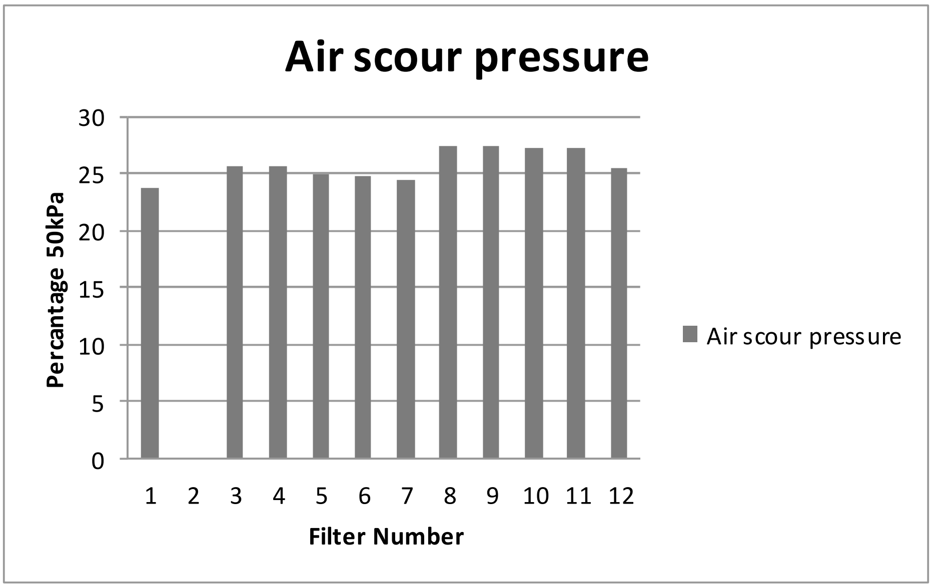

Figure 5: ***Air scour pressure results***

The information collected on each filter has been put into the table below and rated from 0 to 10 with 0 good condition and 10 filtration may be severely compromised.

Table 1: ***Rated performance indicators***

	Filter bed appearance	**Air scour pattern**	**Underdrain pressure**	**Underdrain leaks**	**Dirty water treatment**	**Total score**
Filter 2	10	8	6	10	10	44
Filter 11	8	6	10	0	9	33
Filter 12	7	4	9	2	9	31
Filter 8	5	4	6	7	8	30
Filter 7	4	4	9	2	8	27
Filter 10	5	4	6	7	2	24
Filter 5	5	6	5	5	1	22
Filter 6	5	3	6	3	4	21
Filter 3	4	4	4	5	3	20
Filter 4	4	4	4	0	3	15
Filter 9	0	0	6	0	9	15
Filter 1	2	2	4	0	2	12

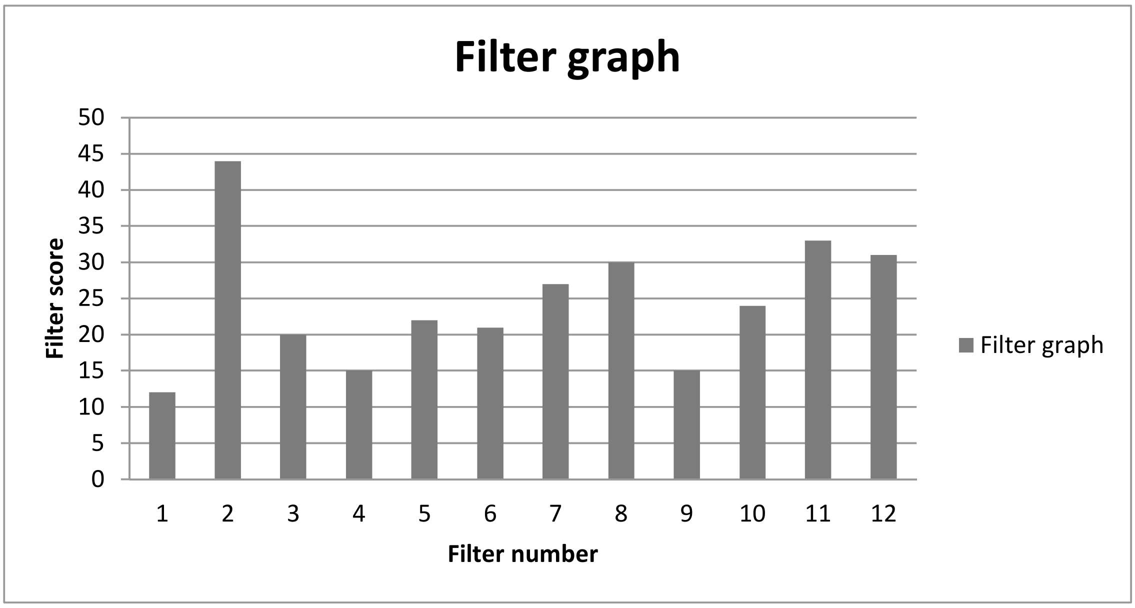

Figure 6: ***Results of investigation***

Filter 2 is in very bad condition and can no longer be guaranteed to form an effective barrier to pathogens such as Cryptosporidium this filter has been taken offline.

Filters 11, 12 and 7 have very high underdrain pressure and the high pressure indicates a large amount of sand has migrated to the underfloor. All filters are showing some signs of performance problems.

5.0 CONCLUSION

While the filters play a very important role in the treatment of the water, it is important to note that without continual media replacement and filter up-keep dirty water can cause significant harm to the consumers.

Operators need to be vigilant in addressing any issues that arise before the turbidity reaches the baths.

It is important that the Australian Drinking Water guidelines are continually met and correct testing and monitoring will ensure that the guidelines are achieved.

6.0 ACKNOWLEDGEMENTS

Thanks to Tamworth Regional Council for giving me the opportunity to present this paper and the team from Calala WTP for their input.

7.0 REFERENCES.

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www.wioa.org.au/publications/documents/MediaFilters

Australian Drinking Water Guidelines 2011.

Craig Jakobski (Hunter Water)
Tamworth Regional Council - http://milo.tamworth.nsw.gov.au/

Winner of the Best Operator Paper at the
79th Annual WIOA Victorian Water Industry Operations Conference,
Bendigo, 2016

INCIDENT AT YERING GORGE PUMPING STATION. HOW WHAT YOU DON'T KNOW CAN HURT YOU

Paper Presented by:

John deBoer

Author:

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Melbourne Water

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29 & 30 March, 2017

INCIDENT AT YERING GORGE PUMPING STATION. HOW WHAT YOU DON'T KNOW CAN HURT YOU

John deBoer, *Operations Specialist, Water Supply Operations,* Melbourne Water

ABSTRACT

On the 12th of May, 2015, a sequence events began that, 10 days later, would culminate in a major hydraulic incident leaving the Yering Gorge pumping station critically damaged and exposing the operator on site to significant risk. This event would result in the station being out of operation for two months before partial pumping could be reinstated and a total of eight months before the station would again operate at its full capacity. The ultimate cost of this incident included approximately 10 Gigalitres of lost water harvest and a significant restoration operation costing over $1.2 million. This paper describes the events leading up to the incident, the investigation process and the key learnings identified.

1.0 INTRODUCTION

The Sugarloaf Reservoir is a 96 Gigalitre storage located 35 Km North East of Melbourne in Christmas Hills and supplies potable water to the Northern suburbs via the Winneke Water Treatment Plant. The Yering Gorge pumping station delivers water from the Maroondah Aqueduct and the Yarra River into the Sugarloaf Reservoir and is the primary source of inflow to Sugarloaf.

The total pump station capacity is approximately 1100 ML/day and comprises of 4 main pumps each with a capacity of 250ML/day and two additional supplementary pumps each with a capacity of 40 ML/day. The station is operated to harvest approximately 200 ML/day from the aqueduct together with the maximum available river flow excluding the minimum required environmental passing flow of 350 ML/day.

2.0 DISCUSSION

2.1 Pump Station Configuration

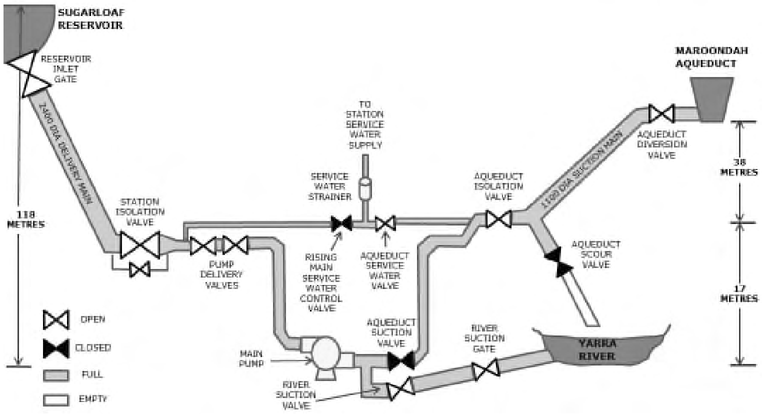
The Yering Gorge pump station can deliver water from either the Yarra River or the Maroondah aqueduct which is supplied from the Maroondah Reservoir in Healesville. The pump well is situated approximately three meters below the river bed and 55 meters below the Maroondah Aqueduct, with the station delivering water into Sugarloaf Reservoir which is approximately 120 meters above the pumping station. The aqueduct suction main is an 1100mm diameter pipeline which drops almost vertically from the aqueduct into the station below (see Figure 1). There is a manually operated diversion valve at the aqueduct, an actuated isolation valve on ground level 17 meters above the pump well, and an 1100mm actuated suction valve at each of the two aqueduct duty pumps.

The station draws water from the aqueduct suction main to supply critical station services such as motor cooling, bearing cooling and seal ring flushing systems. Whenever the aqueduct is taken out of service, the station services supply is re-valved to be supplied from the pump delivery main via a pressure reducing, service water control valve (see Figure 1).

2.2 Station Emergency Shutdown System.

In order to protect the station against critical flooding events, the control system includes a ***"Station Shutdown"*** function. When this occurs all pumps are stopped and the Station Isolation Valve, River Suction Gate and the Aqueduct Isolation Valve immediately close to protect the station from external sources of stored energy. Critical faults that initiate a station shutdown include:

- Delivery main reverse flow
- Pump well flooded alarm
- 110 Volt DC system failure
- Pressing the manual "Station Shutdown" E-stop button.



<u>Figure 1:</u> ***Pump Station normal configuration (River Duty)***

2.3 Event 1: May 12 -13

On May 12th the Maroondah aqueduct was dewatered to the Yarra River to enable structural repairs to take place upstream of the pump station. The aqueduct scour valve was opened to dewater the aqueduct and the suction main down to the same level as the aqueduct isolation valve. During this time the station was offline as the river flow was too low to allow pumping and the aqueduct supply was now unavailable. The following day river levels had risen sufficiently to allow river harvesting to resume. To facilitate this, the station services supply was transferred to the rising main and one of the main pumps was started on river duty.

2.4 Event 2: May 19

During the 6 days between May 13 to May 19 the remaining section of the aqueduct suction main gradually dewatered a further 17 meters to river level through, what was later discovered to be, a passing suction valve on one of the main pumps. With the aqueduct service water valve now closed, there was no means to ensure the suction main remained fully charged and there was no online pressure monitoring available to alert the operator that the main was now empty.

In the afternoon of May 19, operators shutdown the pump station as river flows had once again declined to below minimum environmental levels. During the pump stopping sequence a minor "*reverse flow*" was detected in the rising main. This alarm initiated a ***"Station Shutdown"*** sequence which automatically closed the Station Isolation Valve, River Suction Gate and Aqueduct Isolation Valve. The reverse flow alarm during a pump stop sequence was not uncommon and was known to occur periodically.

As the pumping station was no longer required to operate it was left offline in "Shutdown" mode with the major isolation valves remaining closed (see Figure 2).

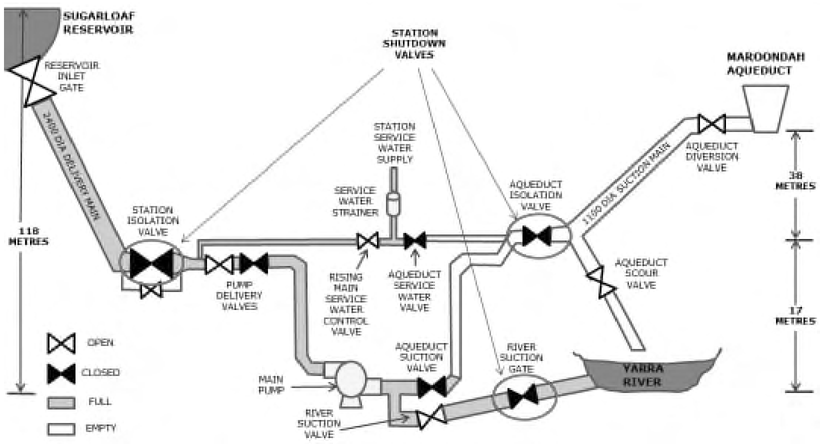


Figure 2: ***Station in "Emergency Shutdown" Mode with Aqueduct suction main dewatered***

2.5 Event 3: May 21

With the Aqueduct maintenance works now complete, the aqueduct is slowly recharged but only filled as far as the, now closed, aqueduct isolation valve leaving approximately 17 meters of empty 1100mm diameter suction main beneath it (see Figure 3).

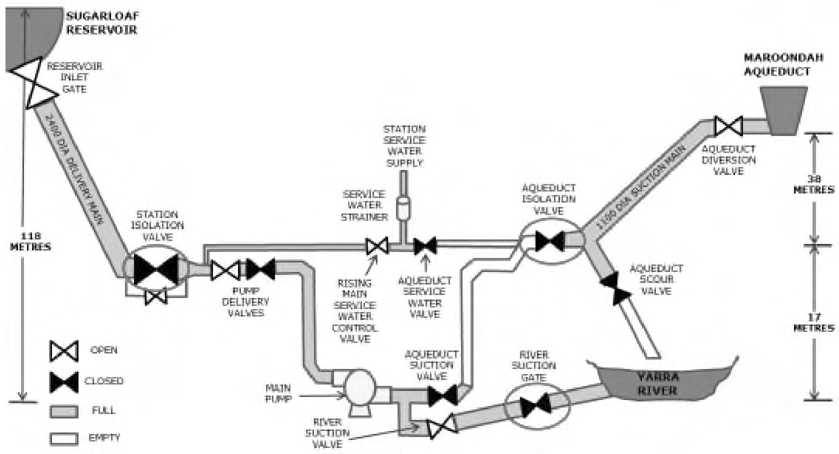
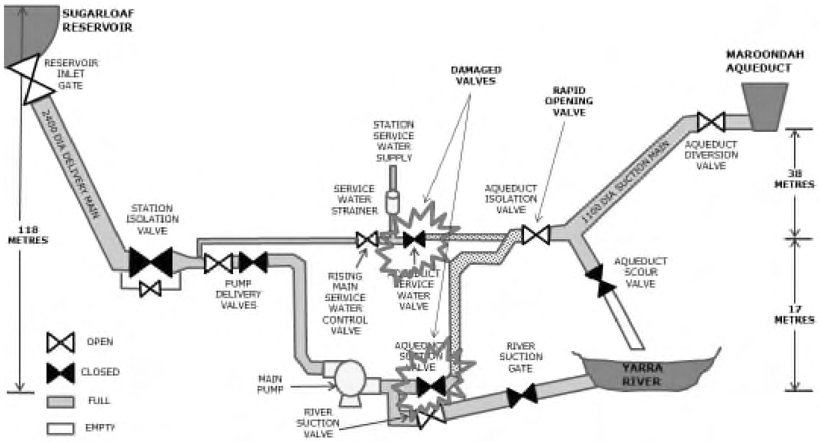


Figure 3: ***Aqueduct main recharged***

2.6 Event 4: May 22

The Operator attends site to prepare the station to resume pumping from the now recharged, aqueduct supply. He initiates a ***"Station Reset"*** command. This control function returns the Aqueduct Isolation Valve to its pre-shutdown condition, immediately opening the valve. The opening travel time of the 1100mm diameter butterfly valve is less than three seconds and the rapid opening of this valve allowed the 40 tonnes of stored water above the valve to drop rapidly into the empty void below. The resulting pressure shock split the housing of the 250mm service water valve causing water to flood from the ground floor into the station below showering the high voltage pump drives with water and causing an electrical fault turning off all the station lighting.

The shock also hits the two closed, 1100mm diameter, aqueduct pump suction valves tearing the butterfly's from their cast housings and punching a 300mm hole in the side of one of the valves (Figure 4 & 5). Water flowing from these valves knocked down a blockwork wall and flooded into the pump well at a much greater rate than the sump pumps could manage.



<u>Figure 4:</u> ***Location of damaged valves***

<u>Figure 5:</u> **D*amaged butterfly valves***

2.7 In the Line of Fire

The Operator Interface Unit used for station control is situated on "C" floor at the bottom of the pump well, one level above the main pumps. With water flooding over high voltage equipment from above, the pump well flooding from below and the station in total darkness, the operator was trapped in a precarious position. To add to the operator's predicament, an emergency escape ladder adjacent to the operator interface had been recently deemed non-compliant and was barricaded pending further investigation. This left the operator with no choice but to remain in this location (Figure 6) until help arrived to safely isolate the electrical supply.

2.8 Saved from Flooding

One of the alarm conditions that initiate the ***"Station Shutdown"*** sequence is a 110V DC supply failure. The water flooding in from the failed service water valve above faulted the 110V system initiating a Station Shutdown which closed the Aqueduct Isolation Valve preventing any further flooding. With the station power supply now faulted leaving the sump pumps no longer operational, the safety measure that initially led to this incident was the same measure that ultimately protected the station from being totally flooded.

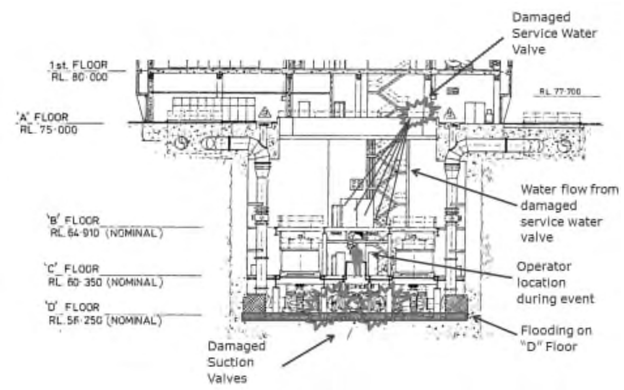


Figure 6: ***Operator location during the incident***

2.9 Recovery Works

With all personnel now safe and the station safely isolated, work began immediately to repair the station to an operational state. Transfer of water from the Maroondah Aqueduct was ceased and 10 Gigalitres of river water flowed past the station, unable to be pumped into Sugarloaf Reservoir. The Winneke Treatment Plant continued to supply water to Melbourne but, with no inflow, the level in Sugarloaf reservoir began to steadily decline.

A team of operations, asset management and project engineering representatives worked tirelessly together to implement the recovery project in as short a time as possible.

Orders were immediately placed for replacement valves. Meanwhile detailed isolation risk assessments and implementation plans were developed to allow the safe removal of the damaged valves and installation of blank flanges to enable the station to harvest from the Yarra River until the new valves arrived. A second shutdown was then conducted to remove the blank flanges and install the new valves returning the station to its full operating capacity. These restoration works were conducted over a period of eight months at a cost in excess of $1.2 million.

2.10 The Investigation

Following this incident a lengthy investigation was conducted using the "ICAM" investigation methodology. This investigation examined several key focus areas including:

- Organisational Factors
- Task / Environmental Factors
- Individual Actions
- Absent or Failed Defences

Whilst there were many key factors associated with this incident the root cause was ultimately determined as: ***"The hazard of the aqueduct suction pipe becoming dewatered was not identified in the design and subsequent operation of the pump station."***

2.11 Key Learnings

This incident involved hazards affecting the asset/technical integrity of the facility. The installed engineering controls did not effectively mitigate the process safety risks to asset integrity, which had the potential to affect personal safety.

In the facts and documentation considered during the investigation there was no evidence that the hazard of dewatering the lower section of the aqueduct suction pipe had been identified in the pump station design. The hazard was not identified in the relevant manuals, training or procedures, nor had it been observed in the operating experience of the pump station, and no mitigation measures were installed or implemented at the pump station. (Gall 2015)

The key learnings from this investigation include the importance of:

- Risk assessment processes during the design stage (HAZOP, CHAZOP & Safety in Design) to identify this type of hazard;
- Understanding hydraulic gradients and potential stored energy in pipes and pump stations;
- Monitoring and managing the differential pressure across control or reducing valves when de-isolating, recharging or resetting plant;
- Understanding how the loss of the control of stored energy can create process safety hazards, arising from the failure of asset/technical integrity, which have the potential to affect personal safety;
- Selecting the correct engineering controls to prevent the plant from operating in an unsafe condition e.g. bypass valves, control interlocks and permissive alarms;
- Ensuring asset risk assessment processes include consideration of process safety risks in evaluating the effectiveness of engineering controls and safe guards;
- Ensuring that risk assessments of operational or asset changes include a holistic (whole-of-system) review of the potential impact of the relevant change, and ensuring that those risk assessments are appropriately documented;
- Proactively reviewing local operations that may expose people to “line of fire” hazards in the event of an asset/technical integrity failure, including evaluating egress from these locations in the event of an emergency; and
- Ensuring core risks are identified for each operational site, and effective controls are in place and appropriately documented in procedures. (Gall 2015)

3.0 CONCLUSION

This incident was significant in identifying the need for renewed focus on process safety at Melbourne Water’s key high risk assets with potential to house large volumes of stored energy and high pressures. It also highlighted the potential for Operations and Maintenance staff to be in danger should a similar incident occur during routine plant operations. The ripple effect from this incident spread to all corners of Melbourne Water’s Service Delivery arm, as teams from both the water and sewer sides of the business took a fresh look at process safety at their keys assets and asked themselves the question, ***“Could something we don’t know be waiting to harm us on our site?”***

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- Aaron Ward: Process Engineer, Winneke Operations
- Peter Gall: Manager Eastern Treatment Plant

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RIVERINA WATER'S ENERGY EFFICIENCY AND COST MINIMISATION JOURNEY – THE STORY THUS FAR

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RIVERINA WATER'S ENERGY EFFICIENCY AND COST MINIMISATION JOURNEY – THE STORY THUS FAR

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ABSTRACT

No mistake, Riverina Water's journey did not begin easily… As many people would agree, it's difficult for any organisations to introduce energy cost minimisation programs if they don't understand the administrative, technical, economic and operational environments in which they operate.

Riverina Water's programmed commenced 3 years ago and Riverina Water is now benefitting from cost savings totalling $0.5M per year. It demonstrates that with a little understanding of energy pricing, tariff structures, and basic electrical theory, organisations can also obtain cost savings with good payback periods.

The implementation of various energy efficiency and cost minimisation programmes were based on obtaining the best returns on investments (ie. 'picking the low fruit from trees') and this presentation offer ways for others to begin this journey and implement some of these various programmes in the water/wastewater industry.

Programs include:

- Time of Use management
- Power Factor correction
- Energy data management
- Tariff management
- Collective energy procurement contracts
- Energy invoice data management and reporting
- Financial accounts verification and management
- Energy Audits

1.0 INTRODUCTION

Managing energy efficiency and electricity costs is very complex. Riverina Water, as with many similar local government water utilities, is under immense pressure to reduce operational costs and electricity cost is a significant component.

Riverina Water has 79 electricity sites comprising of 55 small (collective) sites and 24 large contestable sites. The 24 large contestable sites consume up to 93% of council's total electricity supplied, and make up approximately 89% of total electricity costs.

All these sites are under a single retail supply contract totalling approximately 11.5GWh per year at a total cost of approximately $1.8M (2015/16). Riverina Water, Goldenfields County Council and Wagga Wagga City Council also elected to undertake a joint retail contract totalling up to 31GWh per year.

Riverina Water began its energy efficiency and cost minimisation programme 3 years ago, and has quickly generated savings over $0.5M annually whilst only concentrating so far on 'picking the low fruits'.

Costs savings over the 3 years is illustrated in the graph below where water supplied to customers and energy consumed have been relatively consistent over the 3 years, whereas, the total energy costs have reduced from $2.5M to $1.8M. The total unit energy cost of water supplied reduced from $183/ML to $134/ML.

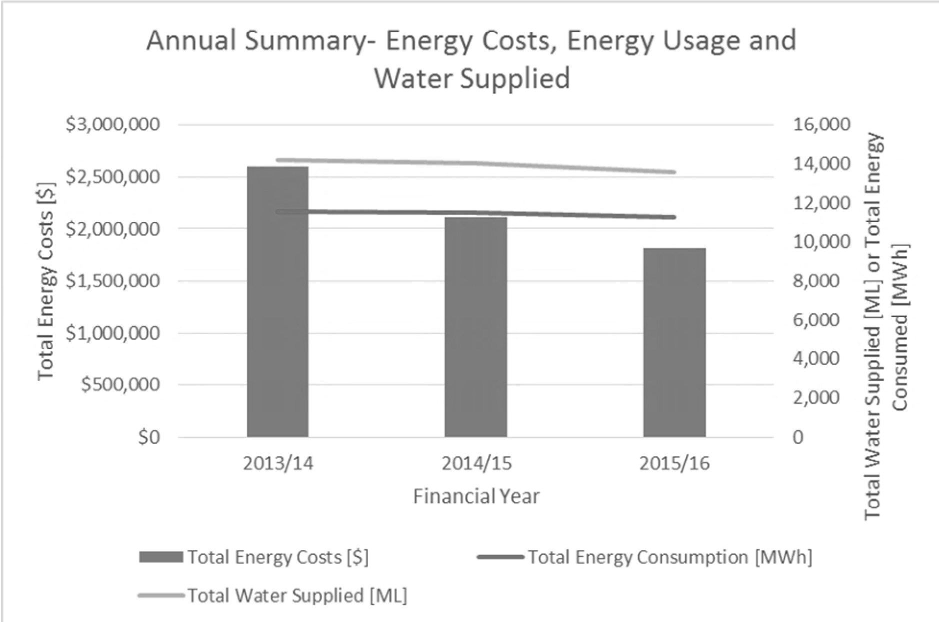

Figure 1: ***Cost savings over the 3 years***

The following is Riverina Water's experience in implementing these various energy and cost minimisation programmes over the last three years.

2.0 PICKING THE LOWEST HANGING FRUIT

Given that the 24 large contestable sites comprises 89% of Riverina Water's total energy costs, the following actions were performed that focussed on costs associated with these large contestable sites, namely 1) network charges and 2) retail energy costs.

2.1 Large Contestable Network Costs:

Over the 3 years, Riverina Water's network/service charges reduced from over 80% to 62% of total invoiced costs. This is the area to which Riverina Water obtained its greatest cost saving results.

The following programmes were used reduce these network costs:

- Network Tariff Analysis:

  Do not assume that the energy retailer or network provider is going to ensure that your large contestable sites are on the appropriate or the cheapest network tariff. It is recommended to perform your own network tariff review to:

  - ⇨ Check whether it's worthwhile for sites on obsolete network tariffs to remain on those tariffs, or change to the current equivalent tariff.

- ⇨ Identify which sites are affected by KVA charges. It's recommended to then undertake power factor analysis for these sites as described below.

- Power Factor Analysis for sites affected by kVA network charges:

  Power Factor is a way of measuring how efficiently power is being used to perform work. Poor Power Factor (ie. less than 0.95-0.98) will increase the Apparent Power [kVA] and therefore increase the energy network KVA charges for each tariff period based on the following relationship:

  Apparent Power [kVA] = Real Power [kW] / Power Factor

  Power Factor Correction units are used to increase poor power factor by use of capacitors, and these should be correctly sized for the range of power [kW] used throughout the year, and not just sized for the maximum power used.

  Power Factor values may be obtained from monthly invoices, or preferably from actual meter data (obtained from the retailer) where sufficient data is available to accurately determine the range of power factor corrections required over different power demands.

  - ⇨ For example, based on Riverina Water's experience, $61k savings in KVA charges was achieved with payback periods of less than 0.5-1 year for 3 sites after installing power factor correction units.

- Time of Use (ToU) Management:

  Similarly to Retail Energy Time of Use management, significant reduction of network costs is possible by managing when and how much energy is consumed during each tariff period.

  Each tariff period is described below:

  - Off Peak Tariff Period: 10pm-7am: 9 hours + Weekends
  - Shoulder Peak Tariff Period: 9am-5pm, 8pm-10pm: 10 hours
  - Peak Tariff Period: 7am-9am, 5pm-8pm: 5 hours

  Time of Use network costs may be reduced by:

  i. Load shift production to Off Peak Tariff periods (providing there is latitude to shift timing of production) and balance further production requirements by utilizing shoulder, and then lastly, peak tariff periods eg. Refilling reservoirs overnight and/or over the weekend.

     Note: Shoulder Tariff Period is preferred over Peak Tariff period as it has more continuous hours ie. 10 hours compared to 5 hours.

  ii. Limiting the tariff periods that are activated for each month: For example, KVA charges are based on $/max KVA/Month for each tariff period. There are immediate savings by avoiding activation of tariff periods.

For example, if a pump with a resulting 344kVA is operated for 1 hour from 8:30am to 9:30am, both Peak Tariff and Shoulder Tariff periods are activated and both incur these kVA charges for the month (ie. $5.5k + $5.5k).

Riverina Water installed ToU control systems at various facilities to inhibit pump operations for certain tariff periods for each month. Assignments of what treatment facilities and pump stations are available to operate for each tariff period are determined based on estimated water supply demands.

3.0 LARGE CONTESTABLE ENERGY USAGE COSTS

Energy usage costs typically make up 20-40% of the total bill compared to network costs. Several of cost saving measures used for managing network costs can also assist reducing energy usage costs. The following programmes were used to specifically reduce energy usage costs:

- Identification of sites that qualify to be included on a large retail contestable supply contract:

  The typical difference between the general business retail usage and large contestable supply contract retail charges can be very significant and it’s worthwhile to ensure sites that do qualify are included in the large contestable supply contract. Don’t necessarily rely on being informed by the retailer when sites qualify over 100Mwh per year.

- Re-negotiation of council’s large retail market contestable supply contract:

  Riverina Water County Council, Wagga Wagga City Council and Goldenfields County Council have a combined annual energy consumption of approximately 31GWh.

  There are financial benefits gained by collectively purchasing power with other organisations as well as stipulating levels of service expected from the electricity retail company ie. Provision of energy data, invoices, dedicated account manager(s), etc.

- Time of Use (ToU) Management:

  Typically, the energy usage cost per kWh during peak tariff and shoulder periods are the same, and depending on the retail supply contract, cost per kWh during off-peak tariff periods are typically 30-40% cheaper. Therefore, similarly principles used to manage ToU network costs can be used to reduce energy usage costs by shifting production times to utilise off-peak tariff periods in preference to shoulder and peak tariff periods.

- Introduction and upgrading to energy efficient motors and appliances:

  - ⇨ Identify where existing pumps are no longer performing efficiently ie. worn impellers

  - ⇨ Install variable speed drives to existing motors (ie. retro fit programme) or install them as part of asset replacement/upgrade programmes. These systems allow the control of flowrates that better suit lower demand periods, therefore use less energy per ML pumped due to lower friction head loss.

  - ⇨ LED lighting replacement programmes. Riverina Water's engineering and administration offices was completed with a return of investment of approximately 4.5years.

- Changes to combined/simultaneous pump operations:

  When multiple pumps are operating together, additional energy is required to compensate for higher pipe friction head loss associated with increased flows in rising mains, resulting in higher cost per ML. Therefore:

  - ⇨ Avoid multiple pumps from pumping into a shared rising main unless it's actually required to meet demands eg. peak demand times.

  - ⇨ In terms of multiple bore operations into a treatment facility, it's also preferred to operate the closest bore(s) to the treatment plant as it requires less energy to pump due to shorter distances.

4.0 NEXT LEVEL OF HANGING FRUIT

Riverina Water has 79 sites where 24 sites are billed monthly, and the remaining 55 sites are billed quarterly at various times during each quarter. That's over 500 invoices per year that were originally being sent directly to the finance department and paid with only basic verification and vetting from finance and facility managers.

The bundling of both large and small sites into a collective billing arrangement greatly improved the invoice and energy use data management.

The following programmes were introduced to address some of these issues:

4.1 Electricity Data Management System:

To help collate and prepare reports on energy usage and costs, Riverina Water, Goldenfields County Council and Wagga Wagga City Council specified how data was to be provided as part of the joint retail supply contract. This was emphasised to each prospective energy retailer.

In addition, Riverina Water decided to utilise a third party (ie. Planet Footprint) to help manage the invoice and electricity data sourced directly from the energy retailer.

This process required the assignment of electricity invoices to council facilities allowing energy usage and cost reports to be readily produced for further analysis eg. Power factor, tariff optimisation, quarterly/annual usage and costing reports.

4.2 Account and Invoice Management System:

Until August 2016, there was minimal verification and vetting of energy invoices before payment to ensure their accuracy, and no formal means of tracking or resolving account and invoicing issues. Given that Riverina Water's total energy costs are $1.8M (2015/16), there was adequate financial justification to introduce a third party account management system (ie. Finance Footprint by Planet Footprint) to perform the minimal functions that any prudent organisation should do.

Some of the advantages identified from this system include:

- Verify all energy accounts are correct in consistent with contract rates
- Provide a single reporting platform that consolidates financial invoice and energy consumption data from multiple systems into one system.
- Create a channel for better communication between the operational managers and finance department
- Able to generate useful reports and improve tracking of invoice adjustments and reduce of number of apparent estimated reads

Some of the validation rules used to verify invoices, include:

- Bill does not match with a current account, asset (site) or organisation unit in our system.
- Overall consumption, cost or cost/unit is more than 20% higher than for the same time previous year.
- Bill overlaps a previously received bill for the same meter and time period, including partially overlapping periods.
- Meter read is estimated by the utility
- Billed usage does not match usage read from meter
- Energy account is not on the correct contract
- Charges are not as per the rates in the contract
- Large market electricity account is not on the most cost-effective network tariff.
- Water utility is charging for wastewater or other services that don't apply to that facility. For example, where water is used only for irrigation.
- Metered accounts that aren't consuming any energy/water that could possibly be disconnected to save on service charges.

5.0 CONCLUSION

The journey to reduce energy and costs can be very daunting for a newcomer. It's a long road to understand retail and network pricing structures, how different tariffs apply within a day/week, technical energy terms and theory (eg. Power factor, KVA, kW), complexity of understanding electricity invoices, relationships between the energy retailer and network provider and how electricity data is being recorded and its availability.

Based on Riverina Water's experience, it's hoped others to start or continue their journey to reduce energy and costs by implementing some of the above-mentioned programs.