WATER WORKS

OFFICIAL JOURNAL OF THE WATER INDUSTRY OPERATORS ASSOCIATION

W-I-O-A Australia EXCELLENCE IN OPERATIONS

JUNE 2007

WATERWORKS
OFFICIAL JOURNAL OF THE WATER INDUSTRY OPERATORS ASSOCIATION

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WaterWorks is the publication of the Water Industry Operators Association (WIOA). It is published twice yearly and distributed with *Water Journal.* Neither the WIOA nor the AWA assume responsibility for opinions or statements of facts expressed by contributors or advertisers.

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

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WHY?

I happened to be in a supermarket a few weeks ago, in the fruit juice and cordial aisle. This aisle also had the bottled water.

I had just finished a full day working at a Water Treatment Plant with two operators fully focused on trying to improve the water quality, to make it safer and more palatable. Muddy hard work scraping filters amongst other activities and lots of tests.

A woman and her daughter passed by. "We better get some water, "XYZ" brand will do!". What about this one, 5L for $4.75. or this one 10 L for $4.73. 47 cents a litre!

Good grief; from their tap they could have had around 400 L if price was the main issue. Why? Why did she feel the need to buy water in a box or a bottle or plastic container knowing nothing of where it came from? Why did she assume it was safer, or better, or tastier or whatever? And to look for the cheapest without even a hint that perhaps she should consider whether indeed it was safe and indeed why was it the cheapest.

I know nothing of the brand in question, I never drink the stuff, tap water is fine wherever I travel. But it really leaves you a bit deflated sometimes when you continually strive so hard to produce safe palatable drinking water. And one last thing, what happens to the containers. Water in pipes leaves no rubbish, the same cannot be said for containerised water. WHY???

Peter Mosse
Editor

Our Cover: Graeme Bartle-Smith inspects membranes at a pilot MBR plant.

ACRONYMS - WHAT THE???

Russell Mack

Acronyms are here to stay but I'm afraid that for me it is all a bit much! So I have listed a few of the acronyms that are use in the water industry, to see how many that you know. Answers on page 4.

1. ADWG
2. ANCID
3. AQF
4. AWA
5. COAG
6. DAF
7. GSA IAC
8. IAA
9. IWA
10. IWA (Vic)
11. KPI
12. NICS
13. NOM
14. PAC
15. ICEWaRM
16. WIOA
17. WICD
18. WIOG NZ
19. WTP
20. WSAA
21. WRF

LETTER TO THE EDITOR

Congratulations gentlemen on the quality of the December 2006 WaterWorks publication. I found the written papers particularly relevant and of the highest quality and I know they will be of significant interest to most operations personnel.

However my purpose in writing is to support your editorial position on the "Challenge of Training". I do this from my position as a Trainer of thirty years experience in the water industry and as one who has had to grapple with the Training Reform Agenda that has been with us since the early 1990s'. As we are all aware the underlying principles of this agenda is for Registered Providers to provide training and assessment leading to the achievement of Competencies which collectively can constitute a Qualification relevant to the occupational role of the student/trainee and their employer.

As a consequence the role of our National Industry Advisory Boards (Government Skills in our case) is critical in providing the "competence descriptors" for our ever changing industry and although the descriptors will never be perfect, the Training Package Developers have made a fair fist of this role. The real problem that I see is that whilst it is all very good for us to focus on the required outcomes of training, the achievement of these outcomes requires trainers to develop very sound educational pathways to the achievement of the competencies.

This problem is made more difficult because of a lack of consistent curricula and educationally valid training resources to support the Training Package outcomes and the more recent problem to which you have alluded i.e. the un-nesting of lower level qualifications as pre-requisites for a higher level qualifications. This can only make it more difficult for providers and students alike. The Providers' problem is that to adequately support the "knowledge component" of the skills development, some time is required for the understandings to develop. Time as we all know is money and therefore it requires adequate funding, which in our new system is generally fixed and tied to some predetermined number of hours for delivery rather than the educational requirements of the new competencies. Generally, I would suggest, that because of expanding Range statements the time required tends to increase. Readers should be aware that many of the issues that are requested in today's world didn't even exist ten years ago, yet no further time is allotted. This potentially can cause students to be "short changed" with respect to essential critical knowledge.

Further to this, as "outcomes" become more and more sophisticated, successful completion of any learning process becomes more reliant on the significant prior knowledge required in order to achieve the necessary understandings by the student. An analogy, and a very obvious prerequisite, would be a student successfully completing secondary school before embarking on a university course. It would never happen so we should ask therefore "Why should Vocational Education be any different?"

My concerns are aroused even more because of the current difficulties being experienced in drought afflicted Queensland where water reclamation plants will soon become the norm. Is it reasonable that the staff who are to be responsible for these plants only achieve "competencies" relevant to the "membrane process" they are working with directly, or should they be required to have served some "apprenticeship" and achieved a qualification in wastewater treatment plant operations first (an obvious prerequisite). Cost conscious HR managers in my experience will always err on the side of lower costs with little regard to the potential risks incurred by a limited knowledge by operational staff of both these processes. I have been personally contacted by leading Water/ Wastewater Treatment Managers who because of their obvious exposure to public liabilities in the case of failure of reclamation plant processes have expressed their desire for ensure their staff have more knowledge rather than less. The last thing anyone needs is a "dumbed down" industry. This is even more important in regional and remote locations where operational staff are often required to work with little support. At the same time I believe our community reasonably expects that these new generation plant staff should be significantly higher trained than in the past if only to meet these new expectations. Surely we haven't forgotten the lessons of Walkerton (Canada) yet!

I would have thought it is obvious that to meet the "Challenge of Training" in our industry we will need to focus as much on the practicalities of teaching, such as the knowledge pathways, as on the extrapolation of "outcomes". Such developmental pathways do require sequencing of the knowledge or "nested development". Together they will require not only significantly greater investment in the training but also funding for the essential educational resources to support the achievement of competence by our water industry personnel.

In closing, I am encouraged by the commitment of the Water Industry Operators Association to improving the level of knowledge, skill and effective performance of staff in the operational sector of the industry and I trust you will continue with your efforts in this regard in the future.

Don Mackay

Principal Teacher Water Programs

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Answers to ACRONYMS - What the???

1. ADWG - Australian Drinking Water Guidelines
2. ANCID - Australian National Committee on Irrigation and Drainage
3. AQF - Australian Qualification Framework
4. AWA - Australian Water Association
5. COAG - Council of Australian Governments
6. DAF - Dissolved Air Floatation
7. GSA IAC - Government Skills Australia, Industry Advisory Committee
8. IAA - Irrigation Association of Australia
9. IWA - International Water Association
10. IWA (Vic) - Institution of Water Administration
11. KPI - Key Performance Indicator
12. NICS - National Industry Careers Specialist
13. NOM - Natural Organic Matter
14. PAC - Powdered Activated Carbon
15. ICEWaRM - International Centre of Excellence in Water Resources Management
16. WIOA - Water Industry Operators Association
17. WICD - Water Industry Capacity Development
18. WIOG NZ - Water Industry Operators Group New Zealand
19. WTP Water Treatment Plant
20. WSAA - Water Services Association of Australia
21. WRF - Water Reclamation Facility

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FILTER ASSESSMENT AND OPTIMISATION SEMINAR

9th November, Melbourne

About sixty registrants turned up at the Sandown Park Hotel, Melbourne on a balmy November day to hear Peter Mosse and Bruce Murray present a seminar on *Filter Assessment and Optimisation*, which had also been held earlier in the year at Cairns.

Peter needs little introduction, being the editor of *WaterWorks* and now a Technical Advisor to WIOA. Bruce is an experienced Process Engineer, having worked for the former NSW Public Works Department before venturing out to set up his own very successful consultancy business, City Water Technology.

Firstly to set the scene, Peter explained the importance of the filtration process in the production of safe drinking water, followed by a brief explanation of risk management, Control Points and the notion of multiple-barriers. Filtration as a Control Point in the water treatment process was described, together with the concepts of process and verification monitoring. This is very relevant in the context of the ADWG and the Victorian *Safe Drinking Water Act,* as both use risk assessment as the framework in managing water quality.

Key processes in the treatment flow-sheet must be monitored in real-time, with Alert and Critical Limits defined to show satisfactory operation. In the case of filters, the parameter of interest is filtered water turbidity, with Alert and Critical Limits typically being set at 0.1 and 0.3 NTU respectively.

Peter concluded his first stanza with an overview of the WTP Operator's responsibilities in making all this work.

Bruce then gave a comprehensive outline of the principles of filtration and the different types of filters typically encountered in a WTP, followed by Peter returning to discuss filter operations and inspection.

This part of proceedings I found very informative. Peter demonstrated how important it is for Operators to observe all aspects of filter operation and to keep records as well as making relatively simple measurements that may help in diagnosing problems that may later emerge. Making simple trend graphs of filter run time is such an example. For dual-media filters, determining the filter bed expansion or degree of fluidisation during the high-rate backwash step is another.

Bruce discussed the importance of good coagulation to successful filter operation as well as the role of filter aids prior to seminar attendees then adjourning for a very enjoyable lunch and the opportunity to soak up some sunny Spring Melbourne weather!

The afternoon session comprised Bruce discussing different filter backwashing techniques, followed by Peter outlining OH&S requirements with regard to accessing filters to carry out assessment inspections.

Peter then continued with a very important presentation on how the WTP SCADA system can be used successfully to diagnose potential operational problems and to use trending data as a tool to monitor plant performance. Long-term trending data was shown to be helpful in recognising that some WTP problems may in fact be seasonal, possibly related to changes in raw water quality and treatability or maybe even temperature.

Bruce then countered with a captivating account of how filter failures can occur, complete with graphic photographic details. He then explained that an assortment of methods that can be used to rejuvenate problem filters.

The closing presentation by Peter concerned the Australian Water Treatment Alliance and the benefits of participating in this benchmarking coalition.

Apart from an extremely informative day, the other valuable benefit to be gained by attending was collecting a copy of what I'm sure will prove to be a Water Industry classic reference; Peter and Bruce's publication *Practical Guide to the Operation and Optimisation of Media Filters.*

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This very readable 76-page guide is now available from WIOA for the princely sum of $30 plus GST and handling. Peter, Bruce and the sponsoring organisations involved in its publication are to be congratulated! I thoroughly commend it to everyone involved in the management and operation of water and wastewater treatment facilities that incorporate this extremely important treatment barrier.

Finally, this has been one of a number of ongoing seminars and workshops that WIOA has organised over the past year and successfully held across Australia. They provide an excellent opportunity for those at the "coal-face" to learn first-hand valuable lessons and to network with fellow workers in the Water Industry. Again, I commend you to attend these as and when the opportunity rises. Congratulations and to George and the rest of the WIOA Committee, and keep up the excellent work!!

Peter Gebbie
Principal Engineer (Process Design)
Water Group
SMEC Australia Pty Ltd

LETTER TO THE EDITOR

Dear Peter

A short report on the Filter Workshop held in Cairns in September, 06.

It was a long day driving from Townsville to Cairns and return with an $8\frac{1}{2}$ hour workshop, but it was well worth the effort and I would encourage anyone to attend upcoming workshops on this subject.

The workshop highlighted just how limited our knowledge was on sand filters. We currently run an 8.0 Ml per day Dissolved Air Floatation Filtration on the back of a biological trickling filter wastewater treatment plant. This helps to clean up our final effluent as well as supply tertiary treated water to one of our major golf courses.

The very next day we implemented some changes gathered from the workshop. For example, we were running our air scour much too long and cut it back from 300 seconds to 120 seconds. Other problems were plainly obvious after attending the workshop such as possible holes in the plenum floor or broken nozzles. At the start of an air scour there are large eruptions of air indicating that something is amiss below causing disruptions to the support media – sand – filter coal with subsequent short-circuiting. This will mean a dig out of the filter media to find the cause. Another problem is that backwashes are not regularly observed.

The content of the workshop well and truly met our expectations and I found myself wishing that the workshop would run for another day.

This is the first WIOA workshop that I have attended and if this one is any thing to go by, more operators should be attending. There is heaps of information available and with another workshop coming up in Melbourne in the near future I would highly recommend this workshop to all operators. Make sure you get there if you can.

Yours faithfully,

Andrew Haden, Citiwater, Townsville

WHICH ONE IS IT?

Peter Mosse

All too often operators develop a suspicion that perhaps one of their filters (Water Treatment Plant or Sewage Treatment Plant) may be failing and that the small amounts of media in final turbidity meters or clear water storages may be coming from one of the filters. In some cases the first indication may be a decreasing service interval necessary for DAF recycle pumps or backwash pumps.

Most operators are aware that if the situation continues, filters may progressively fail and may in fact fail catastrophically resulting in blown under drains and nozzles or lifted plenum floors. While major problems can usually be seen during the air scour or backwash, in the early stages of the failure it may not be apparent during the backwash process.

In some cases filter nozzles have been found floating in backwash tanks or buried in sludge, a sure sign that something is wrong!!!!!

A simple method I tested recently involved setting up some sample taps on the individual filter outlet pipes and fitting fine, strong nylon filter bags to the taps and allowing the taps to run continuously during plant operation. The logic being that if there is media in the clear water storage it must be entrained in the water flowing out of the filter, therefore if that water can be filtered through a fine enough mesh then any entrained media will be captured.

Filter bag

The bags I used were from a local dairy factory and were supplied by Allied Screen Fabrics, Hornsby, NSW. There are likely to be other suppliers of similar filters but at least this is one source of the filter bags.

What happens after you prove that media is coming from a filter. Depending on the design of the filter it may be possible to inspect below the plenum floor by removing the filter outlet piping. In some plants there may be inspection plates that can be removed to look down into the filtered water chamber

Dead air scour

Media boil

Retained media

Violent air scour

Filter bags *in situ*

Sand below the plenum floor

leaving the filter. Visual inspection will allow the extent of the problem to be assessed.

In most situations where media is escaping in the filtered water a filter rebuild will be required at some time.

If only one filter is affected it is vitally important to prevent any media that may be in the treated water storage or filter backwash tank from "infecting" other filters. Diving teams can be mobilised to vacuum out any media and most importantly to erect baffles around the backwash pump suction to prevent media being taken into the pump.

By determining which filter is responsible for lost media it may be possible to prevent others failing and to take preventive action in a timely manner rather than at an inconvenient time in the middle of a high demand period.

From the WIOA Executive Officer George Wall

These photos, along with a wealth of knowledge and advice on how to get the most from your filter's operation, are contained in the publication *Practical Guide to the Operation and Optimisation of Media Filters*. This full colour, 76 page publication has been produced in Australia and is available from WIOA at the very affordable price of $30 + GST. This book is an essential part of the resource toolbox for any water or wastewater treatment operator responsible for the operation and maintenance of media filters. Order forms are available from the WIOA website – wioa.org.au

Look out for the next one in the series entitled Practical Guide to the Operation and Optimisation of Distribution Systems. These can be preordered at the same time.

Additional manuals on Catchment Management and Coagulation and Flocculation are due out later this year.

'A IS FOR ANTISCALANT...' AN A TO Z OF MEMBRANE TECHNOLOGY

Cameron Patrick

Membranes are increasingly finding application in water and wastewater treatment and are now being operated in many locations throughout Australia.

Membranes consist of thin plastic like sheets incorporating fine holes or pores. The size of the pores determines the type of water that can be treated using a particular membrane and the nature of the final product. Membrane filtration is a pressure- or vacuum-driven separation process where particles above a certain size are prevented from passing through the membrane pores. Membranes therefore act by a size-exclusion mechanism.

The key terms and definitions relating to membrane technologies that will be relevant to operators of membrane filtration systems are described below.

Anti-Scalant – proprietary (and generally expensive!) chemical agents that are added to feedwater to inhibit the precipitation or crystallisation of salts on the membranes. The optimal chemical is determined by feedwater analysis and pilot trials.

Autopsy – the dissection of a membrane element to investigate causes of unsatisfactory performance. The element casing is removed and samples of the membrane sheets analysed by methods such as x-ray diffraction to identify specific foulants.

Array – a term used in NF and RO membrane systems to describe the arrangement of membrane elements and reflect whether the elements are in series or in parallel.

Backwash (or Backpulse) – a cleaning operation that typically involves periodic reversal of flow to remove foulants accumulated at the membrane surface. The frequency of backwash cycles is generally from 15 minutes to 60 minutes, for durations from about 30 seconds to 3 minutes. A backwash cycle is usually triggered by an increase in transmembrane pressure beyond an acceptable level. Backwashing is associated with hollow-fibre MF and UF processes, whereas RO is cleaned using clean-in-place systems much less frequently (less than monthly).

Brine (see Concentrate)

Clean-In Place (CIP) – a cleaning system where the membrane system does not have to be disassembled in order to perform a thorough chemical cleaning. A chemical solution, or a series of solutions, is applied to a membrane unit to remove accumulated foulants. Generally, an alkaline solution (pH 10) is used to remove biological fouling, followed by an acidic solution (pH 3) to remove scaling.

Concentrate – the continuous waste stream of concentrated solids from a membrane process, exiting a membrane system after flowing over the membrane, not through it. This waste stream is much more concentrated than the feed with respect to suspended and dissolved constituents. As a result, concentrate disposal is a significant logistical and regulatory concern and is often a critical factor in the planning and design of membrane systems.

Concentration Polarisation - the increase in concentration of particles and salts that occur in the very thin layer at the feed side of the membrane surface. This increase in concentration near the membrane is due to the removal of the water through the membrane, leaving the particles and salts behind. The boundary layer contains the rejected contaminants from the filtrate flow in higher concentrations than the bulk feed. It can have an adverse effect on operation of the membrane.

Conductivity – the measure of the ability of water to conduct electricity. Related to the amount of total dissolved solids (TDS) and measured by a conductivity meter in units of microsiemens/cm.

Desalination – the process of removing dissolved salts from water.

Element – a term commonly used to describe an encased spiral-wound membrane module. It is the functional unit of a membrane system.

Feed Water – the influent stream to a membrane treatment process.

Filtrate – the water produced from a membrane filtration process

Flux – the amount of water produced by a membrane system expressed as flow per unit time per unit of membrane area (e.g. litres per hour per square meter (L/m^2/h). The flux is one of the most fundamental design considerations, since this parameter establishes the amount of membrane area necessary to achieve the desired system capacity, and thus the number of membrane modules required. Higher fluxes accelerate fouling; therefore backwashing and chemical cleaning must usually be conducted more frequently at higher fluxes.

Fouled MBR membranes.

Foulant – any substance that causes fouling.

Fouling – the gradual accumulation of contaminants on a membrane surface or within a porous membrane structure that inhibits the passage of water, thus decreasing productivity.

Hollow-Fibre Module – a configuration in which hollow-fibre membranes are bundled longitudinally and either encased in a pressure vessel or submerged in a basin; typically associated with MF and UF membrane processes. A typical commercially available hollow-fibre module may consist of several hundred to over 10,000 fibres. Hollow-fibre membrane modules may operate in either an "inside-out" mode meaning that feed water flows into the lumen of the fibre and the treated water passes through to the outside of the tube or "outside-in" mode where the feed water flows around the outside of the tube and the treated water passes to the lumen of the hollow fibre.

Interconnector – a device to connect adjacent membrane elements in series and to prevent leakage.

Integrity Testing – a means of determining whether or not a membrane system is free of any leaks, or defects that could result in the contamination of the filtrate with unfiltered feed water. The use of periodic or continuous integrity testing and monitoring methods allows ongoing operational verification that the membranes are performing as intended.

Irreversible Fouling – any membrane fouling that is permanent and cannot be removed by either backwashing or chemical cleaning. Not good news!

Leaf – a sandwich arrangement of flat sheet, semi-permeable membranes placed back-to-back and separated by a fabric spacer in a spiral-wound module.

Log Removal Value (LRV) – filtration removal efficiency for a target organism, particulate, or surrogate expressed as log10. e.g If a system removes 99.9% of bacteria this is referred to as 3 log removal, if only 99% are removed this is 2 log removal.

Lumen – the centre or bore of a hollow-fibre membrane

Membrane Bioreactor (MBR) – a system used in wastewater treatment combining the biological and membrane filtration steps of the treatment process. MBR's eliminate the need for secondary clarification, resulting in a compact plant with minimal footprint.

Membrane Materials – the substance from which the membrane itself is made. Each material has different properties with respect to surface charge, degree of hydrophobicity, pH and oxidant tolerance, strength and flexibility. MF and UF membranes may be constructed from a wide variety of materials, including cellulose acetate, polyvinylidene fluoride, polyacrylonitrile, polypropylene, polysulfone, polyethersulfone, or other polymers. NF and RO membranes are generally manufactured from cellulose acetate or polyamide materials.

Microfiltration (MF) – a pressure-driven membrane filtration process that typically employs hollow-fibre membranes with a pore size range of approximately 0.1 – 0.2 mm (nominally 0.1 mm). Ideally only suspended solids are rejected. Colour and salts pass through the membrane.

Molecular Weight Cutoff (MWCO) – a measure of the removal characteristic of a membrane in terms of atomic weight, as opposed to pore size. Typically measured in terms of Daltons (one Dalton is equivalent to the weight of one hydrogen atom) For example, RO membranes allow only water molecules and low molecular weight salt molecules to pass through the membrane; any molecule with a larger molecular weight is rejected.

Inspecting MBR membranes.

Nanofiltration (NF) – a pressure-driven membrane separation process that employs the principles of reverse osmosis to remove dissolved contaminants from water. Typically applied for membrane softening or the removal of dissolved organic contaminants. True NF rejects only ions with more than one negative charge, such as sulphate or phosphate, while passing single charged ions like sodium and chloride. NF also rejects uncharged, dissolved materials and positively charged ions according to the size and shape of the molecule in question. The rejection of sodium chloride with NF varies from 0% to 50% depending on the feed concentration.

Normalisation – since water temperature (and viscosity) can have a significant impact on flux, it is common practice to "normalise" the flux to a reference temperature (typically 20°C for MF and UF, 25°C for NF and RO).

Osmosis – the passage of water through a semi-permeable membrane from a solution of lower concentration to a solution of higher concentration so as to equalise the concentrations on either side of the membrane.

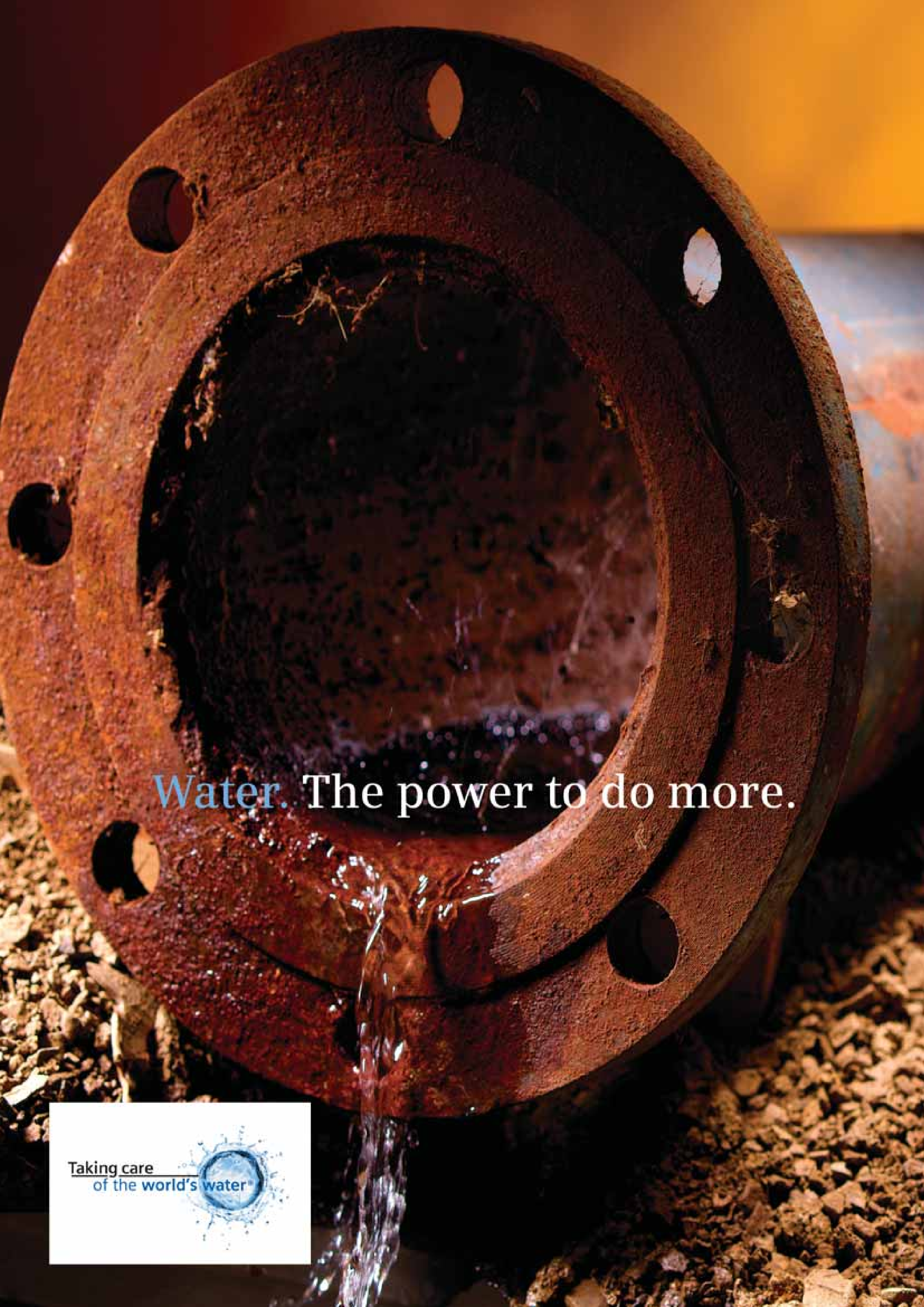
Osmotic Pressure – the amount of pressure that must be applied to stop the process of osmosis. The osmotic pressure is a function of the content of salt and other low molecular weight solutes.

Permeate – the water that passes through a membrane system; synonymous with the term filtrate.

Permeate Tube – the perforated tube in the centre of a spiral-wound module that collects permeate and transports it out of the membrane module.

Continued on page 16

Ouyen CMF membrane plant.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Removing end plates.

Stage 2 end plate removed.

Continued from page 13

Pore Size – the size of the openings in a porous membrane expressed either as nominal (average) or the absolute (maximum) size, typically in terms of microns.

Pressure Decay Test (PDT) - this test is the most common integrity test associated with MF and UF systems. In a pressure decay test, a positive pressure is applied to the membrane (test pressure is membrane specific) and the subsequent loss in pressure is monitored over several minutes. An integral membrane unit will maintain the initial test pressure or exhibit a very slow rate of decay.

Pretreatment – processes such as screening, filtration, chlorination, coagulation, clarification, or acidification may be used to treat feedwater prior to membrane filtration to improve quality, minimise scaling and corrosion potential, or control biological activity. Pretreatment is extremely important and often determines the overall plant performance.

Recovery – the percent of feed water that is converted to filtrate in the treatment process over the course of an uninterrupted operating cycle. Typical recovery rates range from 50% for RO of seawater to 90% for brackish water.

Reject – a continuous waste stream from a membrane system; used synonymously with the term concentrate.

Retentate (see Concentrate)

Reverse Osmosis (RO) – the reverse of the natural osmosis process – i.e., the passage of water through a membrane from a solution of higher concentration to a solution of lower concentration against the concentration gradient, achieved by applying pressure greater than the osmotic pressure to the more concentrated solution.

Reverse Osmosis (RO) Membranes – the pressure-driven membrane separation process that employs the principles of reverse osmosis to remove dissolved contaminants from water. RO is the tightest possible membrane process in liquid/liquid separation. Water is in principle the only material passing through the membrane; essentially all dissolved and suspended material is rejected.

Salinity – amount of salt in a solution; usually used in association with salt solutions in excess of 1,000 mg/L and synonymously with the term total dissolved solids (TDS).

Salt Passage – the transport of a salt through a semi-permeable membrane; typically expressed either as a percentage or as mass of salt per unit of membrane area per unit time.

Salt Rejection – the amount of salt in the feed water that is rejected by a semi-permeable membrane, expressed as a percentage; also referred to as “solids rejection”.

Scaling – the precipitation or formation of salt crystals on the feed side of a membrane

Silt Density Index (SDI) – a measure of the particulate matter in water. The SDI is calculated from the rate of plugging of a 0.45 μm membrane filter when water is passed through at a constant applied gauge pressure. For more details refer to ASTM D4189 /22. The SDI is generally useful as a rough gauge of the suitability of source water for efficient treatment using NF/RO processes. Water samples that contain greater quantities of particulate matter have higher SDI values. Spiral-wound NF and RO modules are generally not effective for treating water with a SDI of 5 or greater.

Sonic Testing - the principle underlying sonic testing is that water passing through broken fibres or other damaged system components will make a unique sound that can be detected using specialised equipment. Sonic testing is generally applicable to MF and UF systems when the direct integrity test (e.g. pressure decay test) indicates that there may be a problem in a membrane unit.

Spacer – the material that separates the semi-permeable membrane layers and creates flow passages in a spiral-wound module, providing a uniform channel for feed water to reach the membrane surface and promoting turbulence in order to minimise the formation of a boundary layer at the membrane surface.

Spiral-Wound Module – a configuration in which sheets of a semi-permeable membrane, a porous support matrix, and a spacer are wrapped around a central permeate collector tube; typically associated with NF and RO membrane processes. Spiral-wound membranes are commercially available in a variety of sizes. Modules that are either 4 or 8 inches in diameter and either 40 or 60 inches long are most common.

Stage – a group of membrane units operating in parallel.

Telescoping – the physical deformation of a spiral-wound membrane module due to high differential pressure in which the membrane, support, and spacer layers are displaced in the direction of the feed flow from the centre, causing membrane fracture and element failure.

Train – in a NF or RO spiral-wound membrane filtration system, a group of pressure vessels that share common valving and which can be isolated as a group for testing, cleaning, or repair.

Transmembrane Pressure (TMP) – the difference in pressure from the feed to the filtrate across a membrane barrier. Equivalent to head loss in a media filter

Operator adding Clean In Place (CIP) chemicals.

Membrane Post Mortem. Sampling membrane sheets.

Ultrafiltration (UF) – a pressure-driven membrane filtration process that typically employs hollow-fibre membranes with a pore size range of approximately 0.01 – 0.05 mm (nominally 0.01 mm). UF is a process where the high molecular weight compounds, and suspended solids are rejected, while all low molecular weight compounds pass through the membrane freely.

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The Author

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GOING DOWN?

Peter Norder

Not all water storages are located in paddocks, Water Treatment Plants or industrial estates. Have you ever thought how water is supplied to high rise buildings?? High-rise buildings also have a network of water systems to provide drinking water, ablutions and fire protection systems to the towering office complexes and the hundreds of people who work in them day by day. All these dedicated storages require periodic inspection and maintenance. Indeed Australian Standard AS 1851.3-1997 in reference to "Water storage tanks and associated equipment", states the following:

> "Inspect, internally and externally, for structural integrity, freedom from corrosion and accumulation of foreign matter",

and further states the requirement for this to be conducted every 3 years.

Nordical Diving has been approached on a number of occasions by facility managers and fire sprinkler maintenance companies to provide practical, safe solutions to assist in complying with these standards and statutory requirements.

So what are the issues associated with carrying out these requirements. The tanks and equipment are often in difficult to access areas, underneath car parks, at various heights in the high rise building, sometimes situated between floors and all too often with awkward and restricted access hatches. Traditional methods of emptying the tank are not acceptable where the tanks are necessary to provide water for fire fighting services. Emptying a tank means there may be no water for fire protection purposes for a significant period of time. Also in this time of increasing water shortages, water emptied from tanks is water wasted! We must all work to save as much water as we can.

Addressing all these issues can be complex and may result in difficult decisions being made, compromising some of the desirable outcomes. For example "Do I drain the tank, compromising water conservation and environmental impact, to internally inspect the fire tank, which is fundamental to the fire protection of the building?"

Practical solutions have now been developed for these logistical problems without compromising too many of the objectives. Of paramount importance is the safety of workers involved in the process. This cannot be compromised. Thorough Job Safety Analyses (JSA's) are undertaken in conjunction with the fire maintenance providers and facility management. Potential hazards are identified and safe control measures developed.

One of the best options is to use suitably qualified teams of divers to carry out the cleaning and inspections. The teams are trained in advanced commercial diving techniques but have also undergone training on water quality and hazards to water quality and how to prevent these. All equipment is dedicated to potable water diving and the diver does not come into direct contact with the water. Full dry suits and full face masks are used to prevent this.

Some specific control measures and solutions that have been developed to allow the work to be done without taking the tanks and storages off line include:

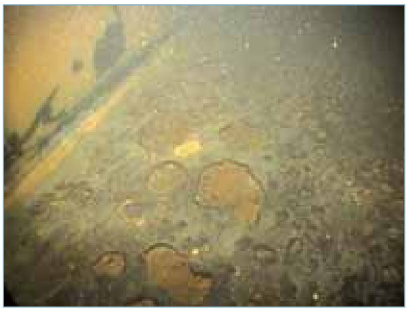
- Developing a dedicated vehicle that is low profile to fit into restricted under ground car parks.
- Developing trolley mounted diving and vacuum systems to fit into lifts and narrow stairways.
- Modifying tank hatches, in association with anchors points, safety harnesses and rescue winches to allow safe access and exit.

The tanks are isolated by the fire maintenance attendant who remains on site for the duration of the cleaning and inspection task. If a fire emergency occurs, the divers are quickly removed from the tank and the fire system can be quickly reinstated. The divers are in continuous communication to the diving team supervisor by radio communication systems.

Utilising divers means the storage stays full, even during the cleaning process and there is minimal wastage of water. Remotely operated cameras can also be used for basic inspections. Divers, however, have a better capability to assess findings, communicating via radio and even conduct simple repair or maintenance tasks during the initial dive. More difficult tasks can be programmed for later specialised dives using specialist equipment. Occasionally the nature of the repair does however require that the tank is emptied.

Sometimes inspections reveal some areas of concern, for example failing cement in the roof of a tank overlying an underground car park.

Imagine the surprise of parking your car and coming back to find it a submarine!!! Inspections have also revealed failed bituminous coatings in a fire fighting tank and rusted delivery pipes.



By using diver based cleaning and inspection programs water supply is maintained, fire safety is not compromised and the corporate compliance with relevant Standards, regulations is achieved thereby securing insurance compliance.

For the divers, this activity provides some unusual dive sites to enter into the log book, certainly a far cry from the exotic sites seen in holiday brochures.

For the building occupants, the vision of fully dressed divers in their lift lobby's and reception areas has brought some puzzling looks and interesting enquiries, something between the thought of a possible terrorist threat and Candid Camera set up.

The Author

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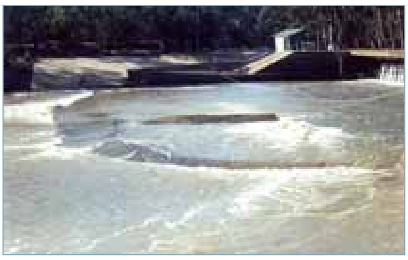
FISHWAYS AT TORRUMBARRY WEIR

Terry Holt

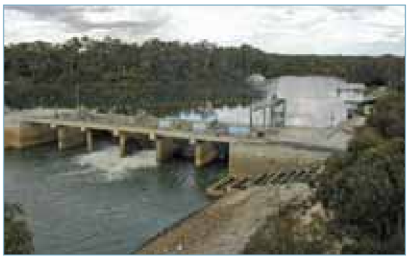
Torrumbarry Weir, on the River Murray, is about 80 kilometres by river downstream from Echuca and is the furthermost upstream weir and lock on the Murray. Designated as "Weir and Lock No 26 – Torrumbarry", it is one of a series of locks, with Lock No 1 at Blanchtown in South Australia continuing to Lock 11 at Mildura and Lock 15 at Euston. It was envisaged that in time all the locks and weirs would be built but due to various political changes and transport demographics the construction of Locks 12 to 14 and 16 to 25 never occurred.

The original trestle-style Torrumbarry Weir was constructed between 1919 and 1923 and operated quite effectively for 69 years. On the morning of 27th March 1992 there appeared to be a disturbance in the flow pattern on the spillway. Upon carrying out regulation of the structure to assist with an investigation of the flow irregularity and as a consequence of that regulation, the lightly reinforced, thin concrete foundations failed. Fortunately the irrigation season had just finished. The Weir level was lowered to assist with emergency repair works to the foundations in readiness for the following irrigation season due to start on the 15th August. After consideration of the structural integrity of the Weir an executive decision was made to completely replace the original Weir. The new Torrumbarry Weir, as it is now more commonly known, was built between 1994 and 1997.

Torrumbarry Weir Down Stream Apron Failure (circa 1992).



Torrumbarry Weir Failure Up Stream Vortex (Circa 1992).



The New Torrumbarry Weir (Circa 1997).

Since European settlement there has been a dramatic decline in the range and abundance of native freshwater fish in south-eastern Australia. On the Murray there are two high dams and 13 weirs that obstruct the passage of native fish. To improve fish passage, the Murray Darling Basin Commission are currently constructing fishways at all barriers on the river between the Hume Weir and the sea, a distance of 2,225 km. Fish populations are declining in the Murray Darling Basin River system and it is widely accepted that blockages to migratory pathways are a major cause of the decline.

Of the 15 man-made barriers, including Yarrawonga Weir and Hume Weir, only two fishways existed, one at Lock 15 in Euston and one at Lock 6 in Murtho. These fishways were not successful for native fish as they were based on designs from the northern hemisphere, only suitable for adult salmonids (trout and salmon). During the late 1980's the Murray Darling Basin Commission made a commitment to construct fishways on the Murray River 'as a first step in the responsible management of native fish stocks in the River Murray system'.

Based on research into the swimming ability of native Australian fish, a vertical

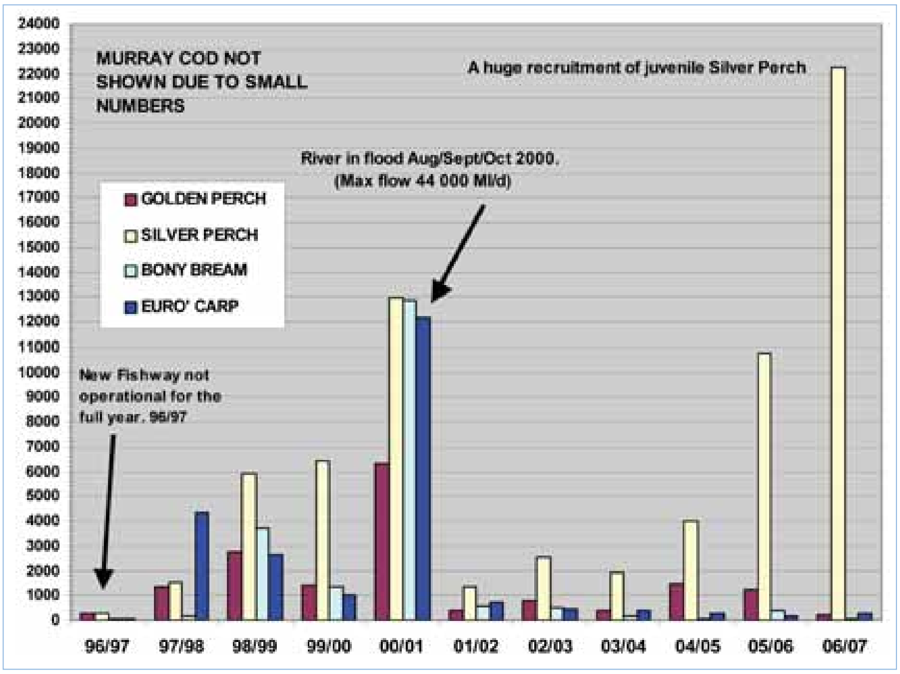


Figure 1. Fish movements through the fishway from 1996 to 2007.

slot fishway was built within the original Torrumbarry Weir in 1988. The construction of a fishway allows the migratory fish to negotiate the six metre high barrier presented by the weir. From the inception of the fishway and as a continuing study, all fish that negotiate it are counted, identified and classified into two categories being either juvenile or adult (juvenile under a hand span length, adults over a hand span). The European Carp are sorted from the native fish, stored in a separate cage then transported and processed as garden fertiliser or pet food. The remaining native species are released back into the river to continue their journey. The same design fishway was incorporated into the new Torrumbarry Weir with minor design changes involving resting pools at certain intervals throughout its length.

Torrumbarry Weir Fishway 1997 Version

Of the 162,845 fish that have traversed both fishways, since the completion of the original fishway in 1990 the statistics are broken down to:

- Silver Perch (76,695),
- European carp (40,242)
- Golden Perch (21,477)
- Bony Bream (23,453)
- Murray Cod (377) and
- other species including Redfin, Trout, Smelt, Crimson Spotted Rainbow fish and Catfish (601).

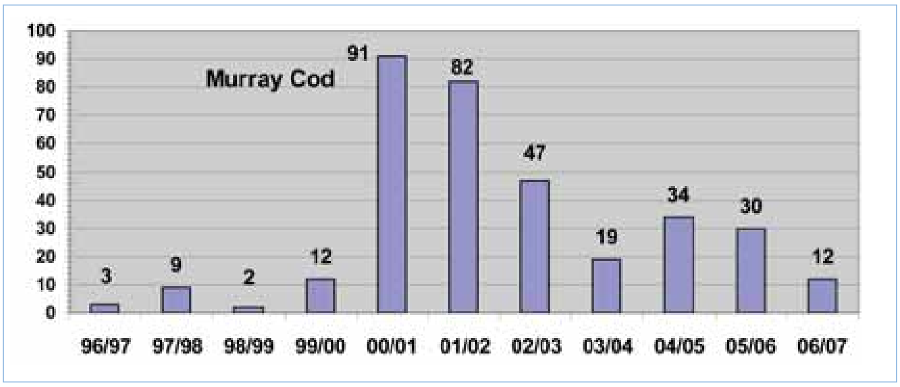


Figure 2. Movement of Murray Cod through the fishway from 1996 to 2007.

The largest fish to have negotiated the fishway to date is a Murray Cod weighing approximately 13 kg.

Figure 1 shows the number of fish traversing the fishway each year. The general low numbers of fish in recent years is thought to be due to the effects of the drought and the low river flows. Note that 2000/2001 was a 'normal' year with high winter flows. But out of context has been the rapid increase of juvenile Silver Perch in 05/06 & 06/07, the average size being approximately 50mm long.

Figure 2 shows a similar pattern for Murray Cod during high river conditions in the same years.

Borne out of the sheer necessity to improve a dirty, smelly and laborious task associated with removing the fish (particularly the carp) from the fishway was the creation of the Williams Carp Separation Cage (Figure 3). The invention of the cage is a classic example of a field operators desperate bid to make improvements to an extremely onerous task, by devising a system that would separate the carp from the native species. As with many new inventions the basic principle was simple. The design is based on the fact that Carp jump, native fish do not. Although the idea was simple, getting it to function was another matter, with a number of prototypes being built, trialed and fine tuned. With assistance from Ivor Stuart and John McKenzie from the Arthur Rylah Institute for Environmental Research and funding from the Murray Darling Basin Commission, the Williams Carp Separation Cage is now operating with an 80% to 90% success rate.

The second most prolific user of the fishway is the European carp. To indicate their abundance, the most captured and counted in an eight day period has been 5900 and for a twenty four hour period 1350.

It should be explained that all fish, up until the invention of the WCSC ended up in

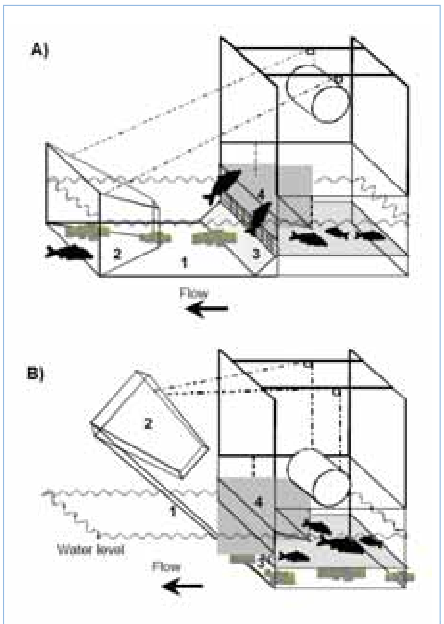


Figure 3. Diagrammatic Representation of the Williams Carp Separation Cage (WCSC). Details of the WSCS showing the (A) operating position to catch and separate jumping carp (black fish symbols) and non-jumping Australian native fish (grey fish symbols), and (B) the raised position, showing: 1 false lifting floor, 2 cone-trap, 3 native fish exit gate, and 4 non-return slide. For clarity, the mesh covering is excluded. Also your imagination is required as the whole arrangement fits into a concrete channel the width of the cage, thus forcing the fish to go through the funnel.

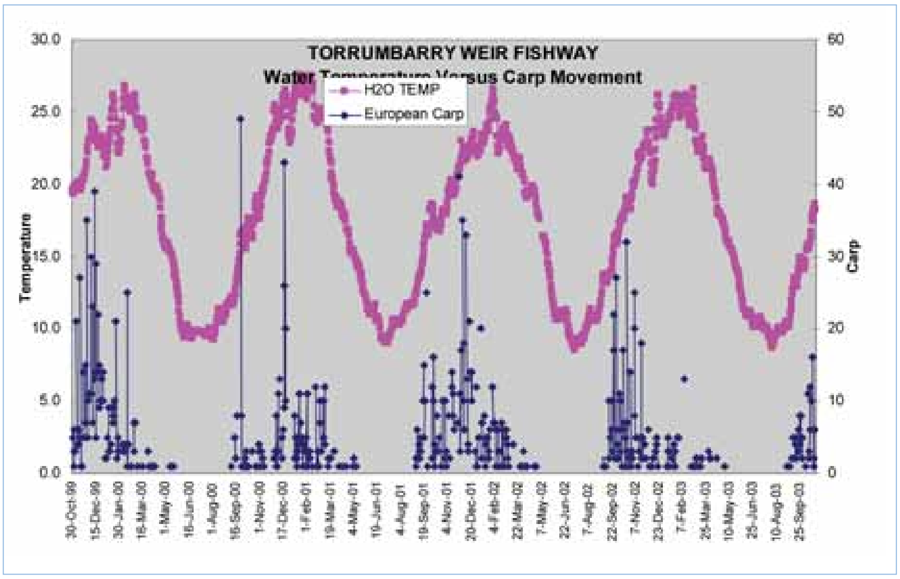


Figure 4. Relationship between water temperature and fish movement.

one cage, being a time consuming task to identify, count and categorise them as explained earlier. Amongst the1350 carp were 65 native species that had to be sorted from amongst all the carp. Fortunately we get a break during late May to late August as all fish decline to migrate through the fishway. This appears to be temperature dependant as the water temperature varies between 7.8°C (winter) and 28°C (summer) (Figure 4).

The automatic carp separation cage and the inventor Alan Williams.

Murray Cod.

The team were encouraged to nominate the Separation Cage in the Land and Water Australia Eureka Prize for Water Research and after the awards night returned home with the Grand Prize and a $10,000 cheque, proof that they were on the right track in assisting in removing European Carp from the waterways. They also took out the prize for the David Ashton Biodiversity and Ecosystem Award.

An extract from the nomination for this award reads as follows:

"The carp research program has developed several new and remarkable carp control tools using scientifically robust methods. This has included the development of the renowned "jumping cage" which is perhaps one of the most rapid cases of movement from an idea to proof of concept to implementation of any environmental solution in the Murray-Darling Basin. The jumping cage was a cooperative project with Goulburn Murray Water Weir Keeper Alan Williams and brought together river operators, community groups, commercial fisherman and scientists. It is a great example of a low cost solution - and will even contribute to the economy of regional centres! Information generated through this project was disseminated through more than 90 media and scientific outputs. The carp project, through its collaboration with river management agencies, stakeholders and the wider community, has successfully developed an on-ground management strategy and practical tool for carp control."

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MONITORING OF PRODUCT LOSS IN EFFLUENT DISCHARGED FROM DAIRY PROCESSING FACILITIES

Rob Dexter

Loss of valuable product to waste streams from industrial processes represents a direct financial loss, and also often an increased cost due to increased trade waste charges. While it is not possible to reduce these losses to zero, with appropriate targeted loss detection, simple reporting and high level operator training it is possible to minimise any losses.

In the dairy industry, the nature of milk and the practicalities of high volume processing make product loss an inevitable part of dairy processing operations. Until recently, the ability to continuously monitor the concentration of various components in the waste streams have been limited by the availability of suitable sensing technology. Recently a research project conducted at a number of dairy processing sites in Australia and New Zealand using a sensitive on line spectrophotometer, the s::can Spectrolyser, has shown that it is possible to measure the levels of fat and protein directly in the waste streams to a high level of accuracy. Absorbance data from the probe is analysed by software developed specifically to determine the levels of fat and protein using locally determined algorithms.

Figure 1 shows the results of the measurement of fat from a number of different sites. The values obtained by the Spectrolyser are compared with the values obtained by conventional laboratory methods. The correlation between Spectrolyser values and laboratory values is very strong (R^2 value of 0.97).

During the period of the trials there was no drift apparent in the instrument. The very nature of fat makes it difficult to measure using spectroscopic methods, however even at high fat concentrations the automatic pressure air cleaning system incorporated in the system kept the optical surfaces completely free of deposits.

Figure 2 shows the results of the measurement of proteins from a number of diary processing sites. The values obtained by the Spectrolyser are compared with the

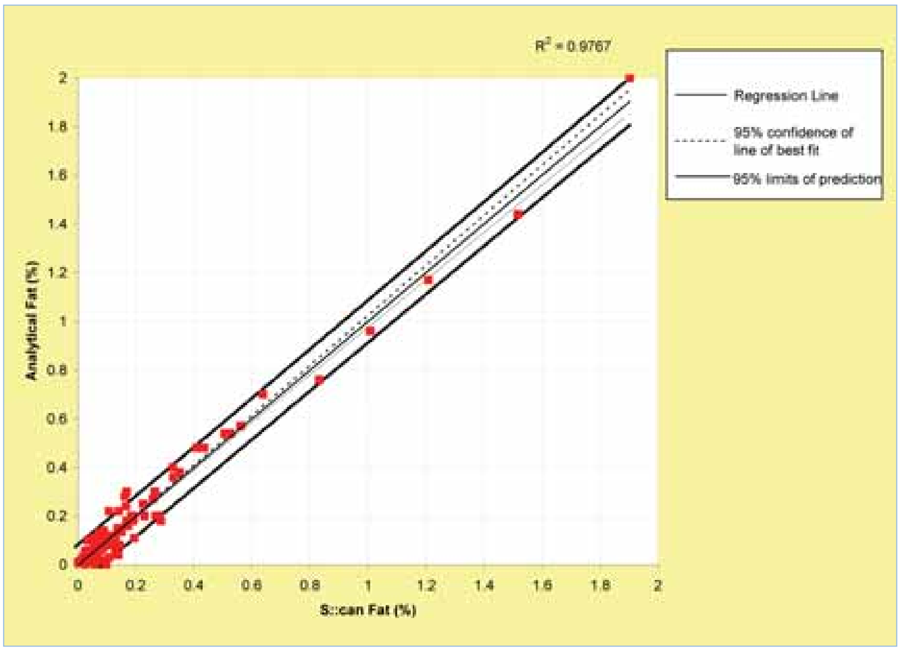

Figure 1. Comparison of fat levels determined by the Spectrolyser and laboratory methods.

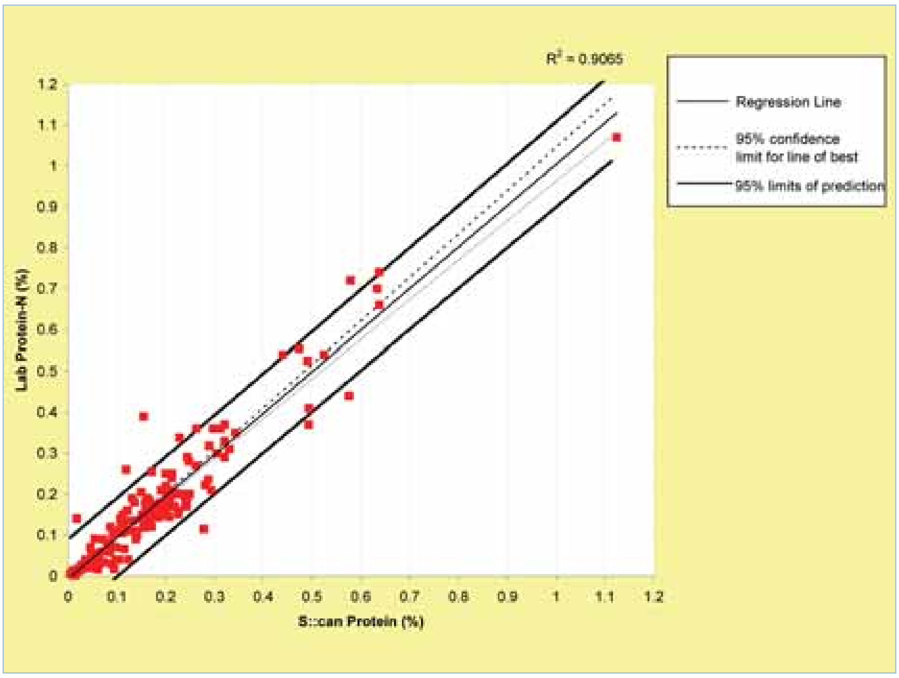

Figure 2. Comparison of protein levels determined by the Spectrolyser and laboratory methods.

values obtained by conventional laboratory methods. The Figure a shows a sound correlation between the two methods. ($R^2 = 0.90$)

This same system has been used widely in both Europe, Australia and New Zealand to measure standard wastewater parameters such as COD, BOD, nitrate and suspended solids. All these parameters including fat and protein can be determined concurrently giving a complete profile of the waste streams. An example is provided in Figure 3 where COD has been determined at a partially buffered dairy processing plant over a period of two weeks. Samples were analysed by the Spectrolyser at short intervals for the entire period. The figure shows a high variability in the COD concentration of the waste stream varying between 200 and 14000 g/L and a good agreement between instrument values and values determined using conventional methods. The correlation between the laboratory determinations and instrumental values was strong with an R^2 of 0.93.

The ability to measure COD, fats and proteins provides dairy factory operators and management with a powerful tool to monitor potential product losses and to manage the waste streams appropriately. On line information could control automatic diversion of any discharge that might cause a breach of compliance with a trade waste agreement. Even if diversion were not possible the data would allow notification of any breach to the downstream receiving network thereby providing early warning for the downstream treatment plants. But perhaps more importantly, the continuous on line information would allow the shutting down of poorly performing steps in a process thereby saving valuable product and preventing breaches in compliance and saving money.

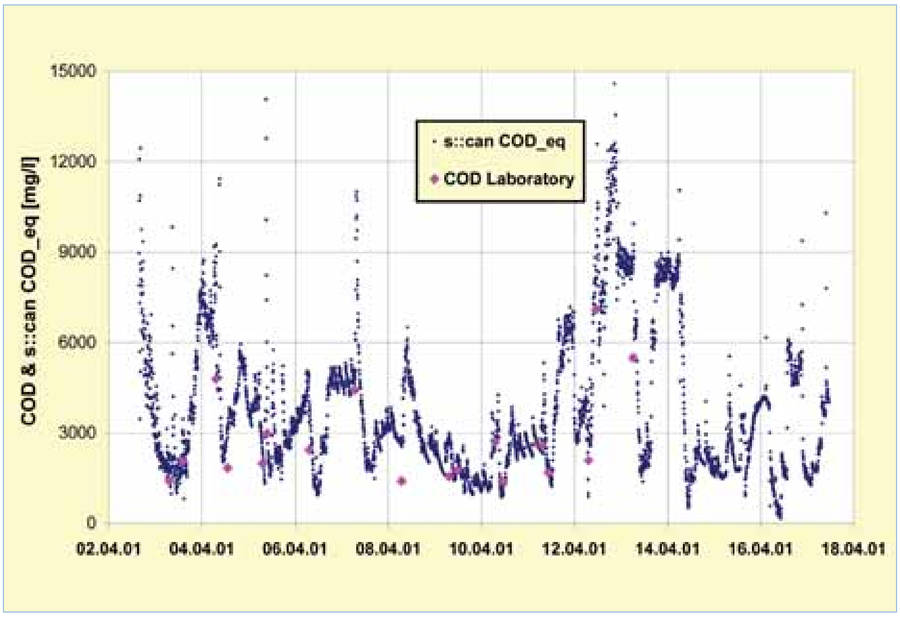

Figure 3. Continuous on line trend showing COD determined in a waste stream from a dairy processing plant.

The Author

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INNOVATIVE REUSE OF PAC PROCESS SLUDGE

Luke Zappia and Steve Capewell

Like many surface water sources in the South West and Great Southern regions of Western Australia, the Denmark water supply scheme is challenged by extremely high and variable levels of organic-based colour in the raw water. Dissolved organic carbon (DOC) concentrations in the order of 25-30 mg/L are common, with spikes beyond this upper limit seen for short periods following high rainfall events in the winter months. These extreme DOC concentrations present major challenges to the conventional coagulation-flocculation-sedimentation process at the Denmark Water Treatment Plant (WTP). To improve the process reliability, a powdered activated carbon (PAC) system was retrofitted to the 5.2ML/d treatment plant in late 2004. Since commissioning, this process has been extremely effective in removing THM precursors and improving chlorine residual penetration through the Denmark distribution system.

Whilst providing a water quality solution, it became clear soon after commissioning that the introduction of moderately high PAC doses presented a major challenge to sludge management at the Denmark plant. Being a compact site, the sludge drying beds were quickly overwhelmed by the PAC-enriched alum sludge. The combined annual output of untreated sludge from the plant is approximating 15,600 m^3. It was clear that a sustainable solids management solution was immediately required otherwise the continued operation of the PAC process was threatened.

Initially, the accumulated sludge was simply removed from the drying beds. This was complicated by a higher than expected water content of the sludge resulting from the local temperate climate. To deal with this, saw dust was broadly applied to the surface to adsorb water and improve "spadeability" (Figure 1) rendering it suitable for removal by backhoe and truck (Figure 2).

Geotextile bags (Geobags) were introduced to improve dewatering. The Geobags were placed on specially prepared soil drying beds. Due to the physical characteristics of the sediment however, the Geobags often blinded which prevented effective dewatering, and hence significantly reduced storage capacity between sludge thickener decants. Routinely filling the bag often resulted in Geobag pressure forcing the influent line to the bag to slip (Figure 3).

The process of managing the PAC sludge was time consuming which added significant operational costs to the already considerable disposal and bed preparation costs. Work conditions and environmental outcomes were also less than ideal. As a result the drying bed/Geobag combination was bypassed and trucks were used to transport sludge from the sludge thickener to the Albany tree farm for storage (Figure 4) until an acceptable sludge management process was found.

In close consultation with the water treatment plant operators at Denmark WTP, a number of waste management scenarios were proposed and tested. Of these, the use of Geobags combined with the dosing of specialised polymer flocculants was chosen as the preferred option (Figures 5 and 6). The results indicated that

Figure 1. Saw dust applied to the sludge to adsorb water and improve its "spadeability".

Figure 2. Backhoe and truck used to remove the saw dust modified PAC sludge from the Denmark WTP drying beds.

Figure 3. Denmark WTP operators John Adamson (left) and Willie MacDougal (right) attempting to re-seal the influent pipe to the Geobag. A "black" job!

Figure 4. PAC sludge wasted directly from the sludge thickener into a tanker truck.

polymer addition could increase the sludge solids content from 1.9±0.8 % (w/v) to 13±1.9 % (w/v), improve dewatering time from >30 minutes to < 1 minute and finally, modified the spadeable characteristics of the product to be suitable for use in either Geotextile bags or a mechanical dewatering system such as a belt press.

Based on the outcomes of the preliminary laboratory and field trials, full scale polymer dosing combined with Geobags has been successfully employed at the Denmark WTP since April 2006 (Figure 7). Operators at the site are extremely satisfied with the improvements made in the sludge management system at the plant.

In line with the Water Corporation's Environmental Management Systems and Sustainability Principles, a recent innovation to solve the problem of what to do with the dewatered sludge is the use of the final product as a support and energy medium for growth of "seed-stimulant" inoculant. Traditionally, peat-moss has been shown to be an excellent carrier material for a variety of Rhizome "seed-stimulant" inoculants. However, due to environmental regulations restricting future removal of this material from wetlands in the lower south west region of Western Australia, an alternative product is required. Bacterial growth studies conducted by researchers at the Agricultural Department of Western Australia have shown very promising preliminary data that the Denmark PAC/sludge material could potentially replace the current practice of using peat moss. Importantly, it was found that this material carries virtually no live micro-organisms that might compromise plant or animal health.

With further field trials currently in progress, it is expected that the entire annual PAC sludge production from Denmark can be used in this environmentally sustainable manner.

Figure 5. Results of the addition of anionic (Jar A) and cationic (Jar C) polymer to the sludge.

Figure 6. Bench-scale simulation of inline polymer dosing system demonstrating excellent "inline" water separation and solids retention using Geo-textile membranes.

Figure 7. Photograph of a Geobag taken during a sludge thickener "bleed" demonstrating how the polymer dramatically improved the dewatering of the PAC sludge after having already treated ca. 3600 m^3 of sediment.

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