WATER

Issue 178. March 2013

Benefits of Pilot Planting New Wastewater Treatment Technologies

Impact of Domestic Greywater Diversion on a Septic Tank System and Potential Health Considerations

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The New Zealand Water & Wastes Association Waiora Aotearoa


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The next issue of *WATER* will be published in May 2013.

WATER

On the Cover

Water New Zealand News

Features and Articles

Cover photo: istock.com

The official journal of *Water New Zealand* – New Zealand's only water environment periodical. Established in 1958, *Water New Zealand* is a non-profit organisation.

Steve Couper

Reform and Rationalisation

There has been considerable discussion on reform and rationalisation of our water service providers, but what about our regulators? Key arguments that are often put forward when justifying rationalisation of water services into larger water utilities are:

- Economies of scale
- Specialisation of staff
- Separation of policy and politics from the infrastructure planning and provision of utility services

While these arguments are valid and indeed this philosophy has been adopted in many jurisdictions throughout the developed world, what about regulation? How will a rationalised water sector fare under the current environmental regulatory regime? And is it not just as important to consider the structure and governance of the regulators as this will essentially drive the behaviour of the sector.

In New Zealand, we have a special act called the Resource Management Act 1991 (the Act) – this legislation, introduced as a bill by the third Labour Government in 1990 and enacted by National in 1991 was an attempt by our learned lawyer colleagues to pull together planning (Town and Country Planning Act) and environmental (Water & Soil Conservation Act) considerations along with a number of other statutes into a single Act. The implementation of the legislation, hailed as a great success by those who implemented it, has been observed by many water practitioners as having some practical difficulties.

Applying the effects based philosophy on a case by case basis that considers social, cultural and economic factors alongside environmental considerations often creates conflicting views and inconsistencies across catchments and regions. While this approach may be appropriate for urban developments is it really appropriate for water management where environmental protection conditions are essentially science driven? Many of us have witnessed the frustrations on both sides of the fence with obtaining or renewing consents and the inevitable appeasement effort or litigation often not driven by the sustainable use of resources that goes with securing consent conditions for this critical infrastructure.

So where has all this left the protection of our environment? And does this regionally based regulation provide the best platform for our water service providers and water hungry industries to protect our environment? Or would a centralised agency, independent of local politics and a focus on the "bigger picture" be more effective?

When discussing these issues with those who treat and discharge significant quantities of wastewater often one word leaps out and that is inconsistency. For example:

- Inconsistency in the way the Act and associated policies are developed and applied geographically
- Inconsistency with consent conditions and water quality limits
- Inconsistencies with policing and regulating those who breach limits

Recent attempts to provide better consistency through, for example, the release of the new fresh water quality guidelines are long overdue and will go some way to improve our understanding as to what is expected to protect the environment. But do the regulators really enforce compliance when breaches are made or will it take a centralised agency to do this as is typically the case elsewhere?

As part of the Auckland Council amalgamation, Watercare has integrated the centralised management of 20 wastewater treatment plants into their organisation. Watercare has provided in their Asset Management Plan for 2012 – 2022 key performance targets for compliance of the smaller non-metropolitan wastewater schemes, the target being "65% of non-metropolitan plants compliant with wastewater treatment plant discharge consents by 2015, 100% by 2020". This implies that greater than 35% of these plants were non-compliant prior to the amalgamation, yet how many prosecutions can you remember being taken against non-compliant wastewater plants in the Auckland region in the years leading up to amalgamation?

While encouraging affordable water infrastructure is a good thing, surely there should be adherence to agreed consistent science based consent parameters. We all understand that there needs to be a balance between affordability and environmental protection. If this was not the case then every discharge would be pure water but what is the point of setting standards if they cannot be met with the technology in place? And what is the point of setting standards that really are required to protect the environment if our regulators are not willing or able to police the standard? What message does this send to our water service providers and wet industries?

The dairy sector is increasingly vocal about standards of compliance and enforcement for their sector when compared to the municipal water service providers.

Can we as a nation lift our game at providing essential water and wastewater services that protect New Zealand's environment when the derivation of many consent limits are based on appeasement and then, if exceeded, depending on who you are, often minimal recourse.

The Government is currently considering phase 2 of the RMA reforms along with the recommendations of the Land and Water Forum. The challenge for them will be ensuring that national objectives and limit setting, along with compliance, will in the future be consistent.

"Recent attempts to provide better consistency through, for example, the release of the new fresh water quality guidelines are long overdue and will go some way to improve our understanding as to what is expected to protect the environment." ■

Steve Couper
President, Water New Zealand

new members

Water New Zealand welcomes the following new members:

CORRINA JULIAN	VAUGHAN MCEWEN	OWEN SOUTHERN
YASENKO KRPO	MARTY SIMPSON	ZEFANJA POTIGETER
SIMON JURY	LOGEN LOGESWARAN	JOHN MOORE
DAVE ROUSE	MARK THOMPSON	DON GRACIA
DONNICK MUGUSTO	DR DEBORAH LIND	GENE OLLERENSHAW
KEVIN WILLERS	MARK CHRISTISON	MOHAMED IMTIAZ

Murray Gibb

“Many governments across the globe are under pressure to deleverage their balance sheets and reduce public debt. They also face competing pressure to fund education, health and social services.”

Meeting the Global Infrastructure Challenge

Two recent reports highlight the growing gap between the investment required in global water infrastructure, and actual delivery. Both suggest that the size of the infrastructure gap is now so large, even in some developed countries such as the USA, that it poses a threat to future economic growth. Can this challenge be averted?

The first report entitled *'Failure to act: the economic impact of current investment trends in water and wastewater infrastructure*,' quantifies the investment needed to upgrade water infrastructure in the United States. Commissioned by the American Society of Civil Engineers, it also describes the consequences of insufficient investment for both domestic and commercial users.

98% owned by municipalities, much of the urban water infrastructure in older cities in the USA is old and aging. The assets are not being properly maintained, with the gap between required annual capital expenditure and forecast spending, widening from $54.8 billion in 2010 to $84.4 billion in 2020.

The American report suggests that unless this infrastructure deficit is addressed, unreliable water services will detrimentally affect the national economy. In the worst case scenario, by the year 2020, 700,000 jobs could be lost, and the cumulative loss to the nation's GDP could be as high as $252 billion.

The second report, *'Infrastructure productivity: how to save $1 trillion a year*,' looks at the global investment requirements for transport, power, communications and water infrastructure over the next 18 years. Produced by McKinsey and Company, it sizes the extent of the infrastructure challenge, offers suggestions to boost productivity, and makes the case for governance reform.

The McKinsey report echoes the American one, but extends its reach, suggesting that across the world, in-adequate or poorly performing infra-structure presents major economic challenges. Failure to invest is not an option since it would 'stifle growth in GDP and employment, and compromise a range of human development initiatives in less well developed countries.'

The size of the investment required over the next two decades is almost beyond comprehension.

For the four asset classes analysed, simply to support projected economic growth between 2013 and 2030, the global infrastructure investment will have to increase (from the US$36 trillion spent in total over the last 18 years), by 60% to $57 trillion in total over the next 18 years. That works out at US$3.2 trillion annually, or 3.8% of global GDP. Water infrastructure's share of the estimated $57 trillion total require-ment is over US$10 trillion.

These figures are derived from the most conservative of three different methods used to calculate global infrastructure investment needs. They do not include the cost of addressing 'the large maintenance and renewals backlog and infrastructure deficiencies in many economies'. Neither does it include the cost of raising the standard of infrastructure in emerging economies, or building in more resilience to cope with, for example, climate change.

Finding the money to fund this investment is problematic for both governments and the finance industry.

Many governments across the globe are under pressure to deleverage their balance sheets and reduce public debt. They also face competing pressure to fund education, health and social services.

The global financial crisis has 'hit the lending capacity of the banking sector both in terms of volume and price.' The effect is constrained lending capacity.

So much for the challenges – what about the solutions?

The McKinsey report suggests that two solutions, namely improving productivity and better governance, would, if applied allow these challenges to be met.

Based on their extensive work with governments McKinsey suggested that, “if owners around the world were to adopt proven best practice, they could increase the productivity of infrastructure to achieve savings of 40 per cent”. This equates to US $1 trillion in savings per year over the next 18 years. Best practice includes 'making better choices about which projects to execute, streamlining delivery of projects and mak-ing the most of existing infrastructure.'

On better governance the McKinsey report suggests that 'the effective delivery of services in many areas of economic and public life happens within a framework of well – defined systems. An effective system requires …clear division of labour between policy and execution, and effective coordination between critical players within it. When such systems lack these characteristics, they become dysfunctional and unproductive.'

'In the case of infrastructure, the system often functions poorly. Indeed too few people in the public and private sectors regard infrastructure as a system at all, but rather, think in terms of single projects. Until sound infrastructure systems are in place, countries will continue to fund the wrong projects, place priorities in the wrong area and fail to meet the needs of their people.'

McKinsey suggests that effective infra-structure governance systems share six common traits:

- Close coordination between infrastructure institutions
- Clear separation of political and technical responsibilities
- Effective engagement between the public and private sectors
- Trust based stakeholder engagement
- Robust information upon which to base decision making
- Strong capabilities across the infrastructure value chain

In other words if the global infrastructure system is to meet the challenges outlined in the report, significant governance reform will be required. Arguably the water sector is fortunate in that well performing governance systems have been put in place in some jurisdictions. These can be emulated. ■

Murray Gibb
Chief Executive, Water New Zealand

CHANGING CURRENTS

2013 WATER NEW ZEALAND'S ANNUAL CONFERENCE & EXPO

Claudelands Event Centre, Hamilton 16–18 October

Water New Zealand's Annual Conference & Expo 2013

The Annual Conference & Expo will again be an industry gathering not to be missed. It remains the largest and broadest conference of its kind held in New Zealand.

The annual conference provides the water industry and in particular association members a chance to gather together for three days to catch up with old friends and colleagues, discuss the latest developments, technologies and debate the issues at the forefront of our sector. It is also a chance to meet new members of the industry and view the new tools and technology in the largest water and wastewater trade exhibition in New Zealand.

We look forward to seeing you in Hamilton 16–18 October. Mark the following key dates in your diary!

Key Dates

Exhibition sales open	**Wednesday 27 March**
Call for Abstracts Close	**Wednesday 24 April**
Authors notified of selection	**Monday 10 June**
Registration Open	**Wednesday 26 June**
Poster Summaries Close	**Monday 19 August**
Final Paper Due	**Thursday 22 August**
Earlybird Registration Closes	**Friday 23 August**
Presentations Due	**Friday 4 October**

Conference Theme

The 2013 conference will have a core theme of ***'Changing Currents'***.

Exhibition

Held for the duration of the conference, the exhibition gives delegates and trade visitors the opportunity to meet with leading equipment manufacturers and service providers and see state-of-the-art equipment, technology and services. Over 100 companies take part and the exhibition sites at this event are extremely popular.

Awards 2013

A number of awards are available at each Annual Conference. In 2013 these are:

- Young Water Professional of the Year Award
- Trainee of the Year
- Operations Prize
- Ronald Hicks Memorial Award
- Hynds Paper of the Year: Gold, Silver, Bronze
- Poster of the Year: Best Poster and 2 x Highly Commended
- Exhibition Awards: Best Expo Stand and 2 x Highly Commended

For more information about the awards and for criteria visit **www.waternz.org.nz**

Call for Abstracts

The call for abstracts opened on 7 March and will be of interest to the full spectrum of the water industry and can cover a range of topics. The call for abstracts closes on Wednesday 24 April. To submit a paper visit **www.waternz.org.nz**

Poster Summaries

Poster presentations are always a popular component of the Annual Conference. Submissions are open until Monday 19 August. Visit **www.waternz.org.nz** for more information and to submit your poster summary online.

Welcome to the First issue of *WATER* for 2013

WATER is published five times a year, and we welcome contributions of technical and general news items across the spectrum of the water and wastes industry on the following areas:

- Policy and legislation
- Water quality
- Demand management
- Wastewater
- Project news
- Modelling
- Stormwater
- International
- Training
- Trade waste
- Industry news
- Technical topics/paper

The next issue of *WATER* will be published in May, the themes are Water Reform Announements, Infractructure Resilence, Rainwater Harvesting, and Water Storage.

Please contact the Editor, Robert Brewer, on +64 4738054 or email robert@avenues.co.nz if you have any story ideas, contributions, or photos. The deadline for the May issue is Monday 8 April.

To view the themes for 2013 visit www.waternz.org.nz/journal

Pacific Water Conference 2012 and Beyond

The 5th annual Pacific Water Conference and Expo (PWC'12) by the Pacific Water and Wastes Association (PWWA) was held for the first time in Auckland from 31 October – 2 November 2012. This event was hosted by Woods Pacific with a preceding Sanitation Seminar which was supported by GHD NZ.

The PWWA is similar to *Water New Zealand* in that it is a not for profit industry membership organisation for the Pacific region. The Association is founded on 21 countries with members such as utilities, product suppliers and consultancies and supported by a voluntary secretariat from KEW Consult team in Apia, Samoa.

Over the last five years, the Association has developed significantly with a new logo and website, the initiation of new funded projects such as Benchmarking and Twinning, forming international linkages and solid growth of the membership base and the conference.

A relevant international linkage of note to the New Zealand water sector is the recent signing of a Memorandum of Understanding between PWWA and *Water New Zealand*. On 28 October 2012, Murray Gibb, CEO, *Water New Zealand* presented the opening address at PWC'12 followed by the signing of the agreement formalising the Associations' partnership. It is anticipated that the MoU will facilitate new opportunities for the Associations and their members to work together.

The PWWA and PWC have grown significantly over the last few years and we welcome the participation of our New Zealand neighbours. There are four ways to liaise with PWWA and its members:

1) Become a PWWA member
2) Share expertise and resources
3) Forge a Pacific twinning partnership
4) Attend the Pacific Water Conference (PWC'13) in the Cook Islands

If you would like more information you can either visit PWWA in Samoa, or go to PWWA's new website: www.pwwa.ws or contact Fiona Mackenzie: fiona@pwwa.ws or ph: +685 30326. Alternatively you can contact local PWWA members: Jack Out on +64 27 665 2097 or Steve Carne on +64 27 280 2273. ■

WATER NEW ZEALAND'S 8TH SOUTH PACIFIC STORMWATER CONFERENCE

STORMWATER 2013

8–10 MAY AUCKLAND

REGISTRATION IS NOW OPEN!

TO REGISTER VISIT
www.waternz.org.nz

Sponsorship and Trade Exhibition Opportunities

The Stormwater Conference is a prime opportunity to promote your organisation through sponsorship and the trade exhibition.

We are seeking to partner with organisations to create an exhibition area to contribute to an even more exciting and valuable event for all participants.

The exhibition area will provide an opportunity for your organisation to reach a wide range of participants with morning tea, lunch and afternoon tea all held in the exihibition area.

For details on the sponsorship and exhibition opportunities available visit www.waternz.org.nz or email waternz@avenues.co.nz

"The 2013 conference will feature three streams over three days and will include the introduction of short poster presentations, field trips and work-shops along with stimulating keynote addresses from leading industry commentors."

The Water New Zealand Stormwater Special Interest Group, in conjunction with the Water New Zealand Modelling Special Interest Group and the Rivers Group invites you to its 8th South Pacific Stormwater Conference 2013 being held at the Rendezvous Hotel, Auckland, New Zealand from 8–10 May 2013.

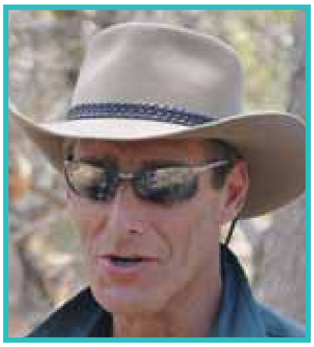
The conference is an annual event and includes a more significant international component every two years, which will be the case for 2013.

The 2013 conference will feature three streams over three days and will include the introduction of short poster presentations, field trips and work-shops along with stimulating keynote addresses from leading industry commentors.

Visit www.waternz.org.nz to view the preliminary programme and to register.

Keynote Speakers

An exciting and innovative programme has been developed with keynote addresses from several industry leaders, including Andrew Simon, featured below.



Dr. Andrew Simon

Andrew Simon is a Senior Consultant at Cardno ENTRIX in Portland, Oregon. He received his PhD from Colorado State University under the direction of Professor Stanley Schumm. He has 32 years of federal research experience, 16 years with the USGS and 16 years at the USDA-ARS, National Sedimentation Laboratory. His research has been in channel response of unstable channels, streambank processes and modeling, and quantifying the role of vegetation on fluvial processes. He is the author of more than 100 technical publications, has edited several books and journals and is the senior developer of the Bank-Stability and Toe-Erosion Model (BSTEM). Dr. Simon is an adjunct Professor at the University of Mississippi and Special Professor in the School of Geography, University of Nottingham, UK.

A New Zealand Inventory of Waste Water Treatment Plants (WWTPs)

Background

The NZ WWTP Inventory replaces WINFO, which was established in 2005 as a joint venture between *Water New Zealand* and the Ministry for the Environment to record data about New Zealand's publicly owned wastewater treatment plants (WWTPs). The NZ WWTP Inventory is a spreadsheet based data collection system for wastewater treatment plant data that has greater flexibility than the WINFO database, making manipulation of the data easier and enabling changes to be more readily introduced.

Benefits in Having a National Inventory of WWTPs

The greatest benefit from having a complete inventory of wastewater treatment plants is at a regional or national level. For example, aggregation of the data would enable investment in WWTPs to be put into perspective with investment in other publicly owned infrastructure. The data would also enable an assessment to be made of the impact of wastewater treatment on our waterways, lakes and coast.

Having data on the country's water infrastructure has been reinforced by comment in Treasury's Infrastructure Unit's 2011 National Infrastructure Plan. Amongst other things, it was stated, "There is insufficient good information available at local or national level to develop a consistent and credible understanding of the current state of urban water assets".

Individual WWTP operators can benefit from improvement achieved through benchmarking, but as each wastewater treatment plant is different (different input load, different configuration and type of treatment elements, different resource consent conditions for discharge) the benefits from benchmarking are not that straightforward. The challenge is to emphasis the local benefit for benchmarking purposes by having a complete national inventory to the extent that individual WWTP operators voluntarily provide the data needed to put that national picture together.

How the NZ WWTP Inventory will be Operated

A downloadable spreadsheet (*Combined WWTP Data.xls*) containing the combined data from each WWTP as it becomes available will be maintained on the *Water New Zealand* website. Data from the downloaded spreadsheet can then be sorted in any way that is needed.

To update information on your plant(s), download the spreadsheet *Individual WWTP Data.xls* from the *Water New Zealand* website, add a column(s) and populate it with each plant's updated information then email the file to David Edmonds – david.edmonds@waternz.org.nz and Cherish Low – cherish.low@waternz.org.nz at *Water New Zealand*. After a general check on the data provided the information will be added to the combined WWTP data file.

It is not intended that historic information is held in the WWTP Inventory. That is, the spreadsheet will contain the most recent updates only, and the date at which the updated information was provided.

Data Sought on WWTPs

The categories of data sought on each WWTP cover:

- General (population served, design capacities and average daily flow)
- Influent (typical properties – listing of data normally being recorded at the plant)

- Preliminary treatment (removal of gross solids and grit)
- Primary treatment (physical settlement of suspended solids)
- Secondary treatment (biological treatment)
- Tertiary treatment (polishing and/or disinfection)
- Receiving environment for the effluent discharge (i.e. land-based, stream or river, ocean outfall, etc.)
- Effluent (typical properties – listing of data normally being recorded)
- Sludge treatment
- Disposal/usage of sludge
- Sludge (quantities produced and % dry solids)
- Energy consumption
- Resource consent expiry dates
- Financial data (capital value, operating cost, planned investment)

Because of the flexibility of the spreadsheet format, changes can be readily made. For example if there is a treatment process that has not been already included in the listing, it can be requested and in all likelihood can be incorporated in an update of the spreadsheet. Comment can also be made on the spreadsheet to provide additional information if required, and if process diagrams are available these can be added.

Timeframe

We hope to have the basic information for all of New Zealand's approximately 330 WWTPs available by mid-2013. To get things started each local authority has already been provided with the data in spreadsheet format that was previously recorded in WINFO. Providing the data is of course voluntary, but even partial data, e.g. population served, basic processes employed at the plant and receiving environment would be of some value in establishing a national picture and all WWTP operators are encouraged to participate.

Location of WWTPs – *Water New Zealand's* website provides a link to a Google Earth showing the plants on an aerial map of the country

School Design to End Water Wars

Jane Harrison, Executive Director, PITCHAfrica

An innovative school designed to ease water shortages in a semi-arid region of East Africa is to open later this month. The WATERBANK™ School, conceived and designed by US based non-profit PITCHAfrica, demonstrates the dramatic potential of rainwater harvesting in semi-arid regions and aims to put an end to Water Wars.

> "Enabling schools to harvest, store and filter water in large quantities as part of a community-integrated approach to rainwater harvesting is a powerful concept…"

"Enabling schools to harvest, store and filter water in large quantities as part of a community-integrated approach to rainwater harvesting is a powerful concept, particularly in regions where ground and surface water resources are already under stress," says PITCHAfrica's Founder and Director, Jane Harrison.

This first School is being built by PITCHAfrica in collaboration with The Zeitz Foundation, a locally based NGO with funding from Guernsey Overseas Aid. In a region with an annual rainfall of 600mm, the WATERBANK™ School's 600m^2 roof catchment area can harvest more than 350,000 litres annually and will mean that the 200 plus students who will attend the school will receive 5 litres a day year round.

"This access to clean water will mean a reduction in illness and malnutrition, fewer school absences, improved study results, encourage development and thus lead to a reduction in youth unemployment in the future. But most importantly the school will achieve greater gender equality as the girls in the community who typically spend hours collecting water will be able to attend school and do homework instead," says Jane.

"Every child will be able to learn about economically and environmentally sustainable rainwater harvesting, water filtration, sanitation and agricultural practices while at school."

In addition to four full-sized indoor/outdoor classrooms the WATERBANK™ School includes protected vegetable gardens for the children, four teachers' rooms, community spaces and workshop, a courtyard theatre and a 150,000 litre water reservoir with integrated water filtration. The workshop spaces can be used for health projects and other local initiatives that strengthen the school and local community.

> "Access to clean water will mean a reduction in illness and malnutrition, fewer school absences, improved study results, encourage development and thus lead to a reduction in youth unemployment in the future."

This is a breakthrough in school and institutional design that could have major ramifications for construction in semi-arid environments. A vast proportion of the 420,000 million people on

the African continent who are trying to survive without access to safe water, live in regions where the rainfall is in excess of 600mm.

The WATERBANK™ School is one of a wide range of WATERBANK™ designs produced by PITCHAfrica which include variants for a WATERBANK™ Dormitory and Sanitation Center.

PITCHAfrica WATERBANK™ School "Harambee": Above left – The Community pools resources to dig foundations for the perimeter wall; Above centre – Indoor-Outdoor Classroom under construction being visited by students; Top right – School entrance under construction; Bottom right – 600m^2 roof and rainwater catchment surface under construction (All photos courtesy of: Njenga Kahiro, Zeitz Foundation)

Left – Graduation of Fiona Macdonald, AECOM – Matt Bond, WEF President 2011–2012 presenting; Right – Macdonald clan celebrate Fiona's graduation

First Kiwi Graduate from WEF's Water Leadership Institute

Garry MacDonald – WEF Board of Trustees

The Water Leadership Institute (WLI), a programme of the Water Environment Federation (WEF) that is designed to encourage innovation, entrepreneurship, and professional commitment from future leaders of the water quality sector, was launched in January 2012. The WLI provides education, training, and networking to enable participants to build lasting relationships and develop the skills and knowledge needed to affect change in their organisations. A blended learning approach includes examination of complex water challenges, management training, and leadership development.

A competitive application process determined programme participation and 29 water, wastewater, and stormwater professionals were selected from 75 applicants to participate in the augural course. One of the 2012 graduating class was Fiona Macdonald from Auckland, New Zealand – a former member of Water New Zealand – who was spending two years OE with AECOM in Toronto, Canada. As part of the programme, small groups had to undertake a project and present their report to the rest of the class during WEFTEC 2012 in New Orleans. Fiona's group included future leaders from North America and looked at future issues facing the industry from a utility's viewpoint.

"The WLI provides education, training, and networking to enable participants to build lasting relationships and develop the skills and knowledge needed to affect change in their organisations. A blended learning approach includes examination of complex water challenges, management training, and leadership development."

Fiona and her fellow classmates received their WLI graduation certificates from WEF President, Matt Bond, after all their project reports had been presented. She was lucky to have some of her family present to help her celebrate this unique occasion – and to sample the sights and delights of New Orleans afterwards!

Water Resources Utility of the Future

Ken Kirk – Executive Director, NACWA

The National Association of Clean Water Agencies (NACWA), the Water Environment Research Foundation (WERF), and the Water Environment Federation (WEF) have mutually released a pioneering document that defines the evolving environmental, economic, and social roles that clean water utilities are playing in their communities.

As outlined in *Water Resources Utility of the Future – Blueprint for Action*, this new "Water Resources Utility of the Future" (UOTF) will transform the way traditional wastewater utilities view themselves and manage their operations. The document explores how traditional publicly owned treatment works have mastered their core wastewater treatment function and are now redefining themselves as resource recovery agencies and vital community enterprises. The blueprint opens the door to re-imagining the Clean Water Act in the wake of unprecedented progress and evolution over the 40 years since the Act's passage.

"This Blueprint will help us realise a sustainable future that minimises waste, maximises resources, protects the ratepayer, improves the community, and embraces innovation in an unprecedented manner," said NACWA Executive Director Ken Kirk.

"It also will help ensure that UOTF issues are front and centre as the 113th Congress and incoming Administration develop their environmental priorities."

Career Changers Tap into a Watery Career

Anna Lindsay – Communications Adviser, Primary Industry Training Organisation

Palmerston North City Council Modern Apprentices Elysia Butler and Joshua McIndoe are the proud owners of not one, but two, Water Industry Training (Water IT) qualifications. Colleagues at the council, Elysia and Joshua have both successfully completed the National Certificate in Water Treatment (Level 4) and the National Certificate in Wastewater Treatment (Level 4).

Elysia and Joshua are career changers. Elysia swapped corporate life as a legal secretary for a 'get your hands dirty' job in the water industry, while Joshua gave up a life on the road as a truck driver to tap into a water career.

Water IT offers nationally recognised qualifications in water treatment, wastewater treatment, reticulation and irrigation. A Water IT qualification can help you learn the skills you need to succeed and accelerate your career.

The pair's supervisor, Mike Monaghan, describes Elysia and Joshua as committed, dependable employees who have embraced the training available and have a bright future ahead of them. "Taking on apprentices at the council is progression planning for us, as it ensures we secure employees that are well-trained in our systems and protocol and are ready to take on key roles when staff move on or retire," Mike believes.

Rebecca Fox, Water IT Training Consultant adds "Elysia and Joshua are vibrant, keen trainees who are motivated to improve their learning. In fact, Elysia is one of only two women in New Zealand who holds National Certificates in both Water, and Wastewater Treatment. She's really paving the way for women in the industry."

Water IT qualifications involve a mixture of practical and theory based study. "A benefit of our training is that you learn the ropes from the people you work with – employers and supervisors with years of experience in the industry. Support from a mentor helps keep trainees focused and supports them throughout their journey, really giving them a step up," Rebecca says.

Pictures above left and right and below – Palmerston North City Council colleagues, Elysia Butler and Joshua McIndoe have both just completed two Water Industry Training qualifications

"Elysia and Joshua are career changers. Elysia swapped corporate life as a legal secretary for a 'get your hands dirty' job in the water industry, while Joshua gave up a life on the road as a truck driver to tap into a water career."

For Elysia, one of the highlights of her Water IT training was the block courses because "it gives you the opportunity to really concentrate on your learning. You meet people who are doing the same thing as you, so you can share ideas." Block courses involved going away for a solid two week block to focus solely on learning, while also meeting people in the industry from different parts of the country.

Joshua believes having a qualification to your name is vital in the industry today.

"I think it's crucial to have a qualification under your belt. It's a necessity to have a qualification behind you and makes it much easier to move up the ladder" he says.

Joshua enjoys his job. "I take real pride in my work. People just turn on the tap and expect clean water to come out! While I know there's a bit more to it than that. It's satisfying to see what you are achieving on a daily basis – fresh, clean water for everyone in the community."

He also says that flexible hours are a perk of working the in sector.

In terms of the future, Elysia is enrolled in the National Diploma in Wastewater Treatment (Level 5) while Joshua is set to get stuck into the National Diploma in Water Treatment (Level 5) starting mid-2013. The Diploma courses are the highest national recognised qualification for people working with local Government or industrial water supply systems.

If you are interested in taking on a Modern Apprentice like Elysia and Joshua, it's important to note some changes are about to be made to the apprenticeship schemes in New Zealand.

Recently announced Government changes mean that Modern Apprenticeships and other apprenticeship-type training will come under an expanded and improved scheme called New Zealand Apprenticeships.

The apprenticeships re-boot initiative will commence from 1 April this year. The legislative changes and remaining funding changes are scheduled to commence from 1 January 2014.

If you're keen to find out more about Water IT qualifications and apprenticeships, call 0800 WaterIT (0800 928 374) or visit www.waterit.ac.nz today.

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Reform, Reform, Reform The Changing Legislative Landscape

Helen Atkins – Partner and Vicki Morrison – Senior Associate, Atkins Holm Majurey

Introduction

It has been full steam ahead on the legislative front in recent times with amendments proposed to both the Resource Management Act and the Local Government Act with further reforms on the way. This article will outline the changes proposed by the Resource Management Reform Bill and the process going forward. Due to space constraints we will provide a detailed review of the changes made in the Local Government Amendment Act and the further amendments suggested by the Local Government Efficiency Taskforce in our next article. We do however provide a brief note of these changes as well as other recent developments of relevance to the water sector – namely the Third Land and Water Forum Report, the Local Government Reporting consultation, and the Water Infrastructure Development Fund – at the end of this article.

Resource Management Reforms

Resource Management Reform Bill

The Resource Management Reform Bill ("*RM Bill*") was introduced in early December 2012 to further advance the Government's aims to reform the area of resource management[1].

The RM Bill aims to improve the consenting regime; streamline the delivery of the first combined plan for Auckland (the so-called "*Auckland Unitary Plan*"); improve local government decision making; and improve the workability of the RMA[2].

The Bill aims to do this through making a number of substantive, technical and operational changes to the Resource Management Act 1991 ("*RMA*") which are proposed to come into force at various times[3], and through making some consequential amendments to the Auckland Local Government Act and the Local Government Official Information and Meetings Act.

Due to space constraints we are not able to outline all of the changes proposed in the RM Bill. However, some of the key changes include[4]:

- The imposition of a six month consent time frame for "medium-sized" projects
- A requirement for a local authority to agree to direct referral of a consent application if the application meets certain investment thresholds (as may be specified in regulations) and provided there are no exceptional circumstances
- Enabling all lifeline utilities to take emergency action to save lives and prevent injury / damage to property without obtaining a resource consent
- Extending certain consenting timeframes[5] including:
  - » Filing a notice of motion for direct referral (from 10 to 15 working days)
  - » Deciding whether a consent application is complete (from 5 to 10 working days)
  - » Deciding whether to notify an application (from 10 to 20 working days)

"Further more substantive RMA reforms are also in train and these are designed to 'deliver more substantive, system-wide improvements to increase the long-term resilience of the resource management system' including freshwater management."

- » Commencing a hearing for a non-notified application (from 25 to 35 days) and removing the time limit for notified applications
- » Correcting minor mistakes or defects in a consent (from 15 to 20 working days)
- Replacing section 32 (which relates to assessment of the appropriateness of proposals) with new sections 32 and 32AA which outline more detailed requirements for preparing and publishing evaluation (and further evaluation) reports of the costs and benefits of proposals
- The establishment of a separate and distinct process for the delivery of the Auckland Unitary Plan
- Amending the tree protection rules so that:
  - » They only apply to trees "specifically identified in a schedule to a plan by street address or legal description"
  - » The meaning of "group of trees" is limited to a cluster, line or grove of trees on the same or adjacent lots in a precise location
- Amending the provisions which relate to Boards of Inquiry to clarify that:
  - » The prohibition on cross examination does not apply to Boards appointed by the Minister under s 149J (ie proposals of national significance or ones referred on by the Environmental Protection Authority)
  - » Boards hearing nationally significant proposals and applications for water conservation orders do not have to comply with the meeting requirements set out in the Local Government Official Information and Meetings Act 1987
- Providing a power to make regulations which require local authorities to monitor the environment in a certain way and for certain specified priorities

Of particular interest are the changes relating to the Auckland Unitary Plan. Essentially what is proposed is an independent hearings process where the Hearings Panel (comprising between 3 and 7 members) is appointed by the Minister for the Environment and Minister for Conservation after consulting with the Council and the Independent Maori Statutory Board. The Hearings Panel has three years and two and a half months from the date of notification of the plan to provide its report to the Council. This deadline can only be extended by the Minister for the Environment and then any such extension is limited to a period of one year. The Council is required to meet any costs associated with the Hearings Panel.

In terms of process, the Hearings Panel is able to regulate its own process (within certain parameters) and has some additional rights and powers which are similar in some respects to those of the Environment Court. These include (but are not limited to):

- The right to refer certain submitters (with their consent) and the Council to mediation or other alternative dispute resolution processes
- The right to permit parties to question other parties and to allow cross examination of witnesses

- An ability for the Hearings Panel to itself call witnesses and a requirement for the Council to meet the costs of any such witnesses
- The power to strike out part or all of a submission (although submitters do have a right of objection against any such strike out action)
- The power to make recommendations which go beyond the scope of submissions to include any matters identified by the Panel or any other person during the hearing process.

Perhaps most controversially, the Hearings Panel only has the power to make recommendations. The Council is not obliged to accept the recommendations but if it decides to reject a recommendation then the Council must determine an alternative solution which cannot go beyond the scope of submissions. In coming up with an alternative solution the Council is not required to consult anyone and nor is the Council required to consider submissions or evidence. While the intention is obviously to ensure that there is a defined end point (so that the Council does not get bogged down in an endless cycle of consultation and further hearings) the power given to the Council to make such a decision without having heard the evidence is quite unprecedented. Even the Environment Court is required to make its decision based on the evidence before it. This is one aspect of the Bill that we consider is likely to be subject to revision in the Select Committee process.

The power to propose alternative solutions may however be tempered somewhat by the requirement for the Council to issue its decisions on the recommendations within 20 working days of receiving the Hearings Panel report. Realistically that does not leave a lot of time to develop completely new solutions. So the most likely outcome is the adoption of a solution previously suggested by the Council or another submitter – with or without further changes. As there are relatively few constraints on what the alternative solutions may be (ie just limited to the scope of submissions) there is however nothing to stop the Council proposing and adopting a solution even where the pros and cons of such a solution are not fully known or appreciated. Such a decision could only be appealed by a submitter if the submitter had addressed the subject matter of the rejected recommendation in their submission. Appeals of such decisions are to the Environment Court and are not constrained to only being on points of law.

> "Appeal rights are also further constrained in that there are no merit appeals on recommendations accepted by the Council."

Appeal rights are also further constrained in that there are no merit appeals on recommendations accepted by the Council. Decisions on accepted recommendations can only be appealed on a question of law and such appeals must be heard by the High Court.

While the Bill is not proposing to limit the right to judicial review (beyond that in section 296 of the Act which requires that any appeal right to the Environment Court be exercised first), judicial review actions are limited to procedural fairness type considerations and do not (at least strictly speaking) address merits. This means that provided the process followed by the Council was lawful and fair the decision will stand even where another alternative may have had greater benefits and less costs.

Process Going Forward

The RM Bill has been referred to the Local Government and Environment Select Committee for consideration. The Bill is open for submission until 28 February 2013 with the ability for submitters to speak to their submissions following that date. The Select Committee report on the RM Bill is due by 11 June 2013. Given the controversial nature of some of the provisions we suggest that the Select Committee Report will be a must read for those with an interest in resource management and also more particularly for those likely to be affected by the Auckland Unitary Plan.

Further more substantive RMA reforms are also in train and these are designed to "deliver more substantive, system-wide improvements to increase the long-term resilience of the resource management system" including freshwater management. We will ensure that we keep you informed of any such reform proposals in future articles.

Local Government Reforms

Like the area of resource management, the Local Government reforms have been continuing apace, most recently with the passing of the Local Government Amendment Act[6], which was passed in early December 2012. This Act amends the purpose of local government to remove the reference to the four well beings, it streamlines the provisions relating to reorganisation proposals and it provides the Minister with greater powers of oversight and rights to intervene in local government.

Further reforms are also likely once the Government has had time to consider and respond to the Local Government Efficiency Taskforce's report. The report, which was issued in late November 2012, found that there were a number of areas in which the functioning and processes of local government could be improved, and included a series of recommendations (32 in total) for how this could occur.

We will include more detailed comment on the Local Government reforms in our next article.

Other Recent Developments

There have also been a number of other recent developments of note in the water sector. Briefly these include:

- **Third Land and Water Forum Report** – In November 2012 the Third (and final) Report of the Land and Water Forum – "Managing Water Quality and Allocating Water" – was released[7]. This report contains a series of recommendations (67 in total) regarding managing water quality, allocating water, enabling change and the national strategy. The recommendations build on and provide more detail on how to implement a collaborative, transparent fair and efficient approach to managing water (ie the approach that was called for in the previous two reports). Of particular interest in this report are the differing views on the duration and treatment of water consents on expiry[8] and on the issue of merit appeals to the Environment Court[9]. While the formal work of the Forum is at an end, the Forum has indicated that it intends to reconvene in July 2013 to consider an ongoing role for the Forum in the freshwater management regime.
- **Local Government Reporting of Water** – The Department of Internal Affairs has completed a consultation round on proposed mandatory performance measures for five local government activities including water supply[10], which will come into effect in 2015. These measures are proposed to allow 'like for like' comparisons between local authorities so that people are able to contribute in an informed way to discussions on appropriate levels of service for their communities.
- **Water infrastructure development fund** – In 2011 the Government indicated that it would establish a water infrastructure development fund to assist regional water schemes to get off the ground and encourage third party investment in the schemes. In December 2012 the Government confirmed how the fund will be run and the amount allocated for the first year. In short, the Government has indicated that the fund will be run by a Crown owned company and that $80m will be set aside for the 2013 year. We will advise further details as and when they become available. ■

Footnotes

[1]See link www.legislation.govt.nz/bill/government/2012/0093/latest/versions.aspx.

[2]Refer Explanatory Note to the Resource Management Bill, page 2.

[3]Generally either following royal assent, or three or 18 months after that date.

[4]Refer Explanatory Note to the Resource Management Bill pages 4 – 29 for a clause by clause analysis of all of the proposed changes.

[5]Note the time extensions do not apply to all consents with time limits staying the same for certain parts of the processes for notices of requirement for designations and heritage orders.

[6]The full name of the Amendment Act is the "Local Government Act 2002 Amendment Act 2012".

[7]A copy of the report is available from www.landandwater.org.nz.

[8]Refer pages 47 to 49 of the report and recommendations 43, 44a and 44b.

[9]Refer to page 74 of the report.

[10]The other areas are stormwater drainage, sewage and the treatment and disposal of sewage, flood protection and control works, and the provision of roads and footpaths.

In the November issue of WATER we published the winner of the Hynds Paper of the Year 2012. In this issue of WATER, as promised, here is Hynds Paper of Year 2012 runner-up – Ed.

Passive Treatment of Acid Mine Drainage Using Waste Mussel Shell, Stockton Coal Mine, New Zealand

F.M. Crombie[A], P.A. Weber[A], W. Olds, D.G. Thomas[A], G.A. Rutter[A], and M.H. Pizey[A] – [A]Solid Energy New Zealand Limited

Abstract

Acid Mine Drainage (AMD), a result of historical and current coal mining, and the associated oxidation of pyrite within the coal measures, is a significant environmental liability for Stockton Opencast Mine, located on the West Coast of the South Island, New Zealand. This liability is likely to persist for at least 100 years. With up to 6,000mm of rainfall per year, often in intensive events (some up to 100mm/hr), water management is critical for the control of adverse effects that include low pH, dissolved metals (including aluminium), and high suspended solids in drainage waterways. Traditionally, neutralisation of AMD at Stockton coal mine has been carried out by direct dosing of ultra-fine limestone (UFL) to affected waterways.

An alternative passive treatment system utilising mussel shell, generally considered a waste stream and dumped at landfill, offers a cheaper, less labour-intensive method of reducing the acid load reporting to the primary waterways on site.

An operational field trial was conducted on the Manchester Street Seep and indicated a payback period of 1,027 days (up to March 2012) when compared to the cost of UFL treatment. The bioreactor has been treating water with an initial pH of <3 to a pH >7; and achieving a metal removal efficiency of 96–99% for Al, Fe, Ni, Tl, and Zn. Low DO and initial high concentrations of CBOD5 and ammonia nitrogen in the discharge due to remnant mussel flesh had negligible effect on the receiving waterway. The removal of sediment and sludge build-up on the surface of the system is required approximately every two years to increase the system's porosity and treatment capacity.

Keywords

Acid mine drainage, Stockton coal mine, mussel shell, passive treatment system, Perna Canaliculus, water treatment.

1. Introduction

Stockton Opencast Mine, owned by Solid Energy New Zealand Ltd, and located on the West Coast of the South Island, 35km north of Westport and 700 – 1,100 m above sea level (Fig. 1 inset), is the largest opencast coal mine in New Zealand, with an active mining area of ~900 ha; ~200 ha of which is rehabilitated. Annual precipitation at the coast near Stockton mine is ~3,000mm/a, increasing to ~6,000mm/a at the mine site (Davies et al., 2011). Frequent rain events with daily rainfall exceeding 200mm can occur at any time throughout the year; mean annual temperature is ~9°C

(Davies et al., 2011). Coal mining has been a feature at Stockton since 1896, within the Eocene Brunner Coal Measures (BCM) that formed in a marginal marine setting. The BCM are overlain by marine sediments, mainly mudstones, with some marginal marine sandstone near the contact with the coal measures. Pyrite is abundant (up to 5 wt.%) in the upper portions of the coal measures and the lower parts of the overlying marine sediments. The Brunner Coal Measures have very unreactive alumino-silicate minerals (K-feldspar, kaolinite, muscovite) that provide little silicate neutralisation of acidity such that the oxidation of pyrite typically leads to the formation of acid mine drainage (AMD).

Pyrite is the most common sulfide mineral in the BCM and when it is exposed to water and atmospheric oxygen during the mining process, acidity is generated resulting in AMD, a significant environmental liability for the mine, which is likely to persist for at least 100 years. The low pH associated with AMD leads to the acid dissolution from the surrounding rock of metals such as aluminium from the alumino-silicate minerals present. Traditionally, acid neutralisation of waterways at the mine has been carried out by direct dosing of ultra-fine limestone (UFL) to affected waterways which raises the pH and precipitates out metals such as Fe and Al. Further details on AMD at Stockton are provided in Elder et al. (2011).

Mussel shell, primarily made up of calcium carbonate ($CaCO_3$), protein, chitin, and small amounts of lipid and phosphate, are increasingly being investigated as a means to treat contaminated water. The use of mussel shell to treat AMD has received limited attention in literature, although several comparable studies are available (e.g., Mackenzie 2010; McCauley 2010a,b). Biogenic aragonite has been investigated for Cd removal and other metals to the order of 0.5 μM, and mussel and oyster shell was used to treat waters containing Cd, Fe, Pb, and Zn (Kohler et al. 2007). Laboratory scale bioreactors containing organic materials and mussel shell have shown promising results in their ability to sequester metals, increase the pH, and decrease the acidity of AMD (McCauley et al., 2008; MacKenzie, 2010; McCauley et al., 2010b). >99.8% – 99.9% of Al, Fe, Cd, Cu, Ni, Pb, and Zn was removed from three laboratory bioreactors containing organic materials and mussel shell (McCauley 2008; McCauley, 2010b). Metal removal efficiencies of 47% for Cu, 80% for Zn, and 89% for Pb were seen in rain gardens that used mussel shell to treat storm water runoff (Good, 2011).

Seafood is New Zealand's fifth largest export by value. International sales have grown from $500 million to more than $1.35 billion over the past 20 years, and mussels have the greatest market share at approximately $202 million (32,724 tonnes in 2009) (NZTE, 2010). The major mussel-growing areas in New Zealand are the Coromandel, the Marlborough Sounds, and Stewart Island (FAO, 2012). Seasonal variation and subsequent harvest season means mussel shell is not available during part of the year (June to September). The South Island of New Zealand has close to 4,000 tonnes of mussel shell that could be used for AMD treatment and this paper looks at the opportunity that this presents.

This paper documents the improvement in quality of AMD through the use of 100% green lipped-mussel (Perna Canaliculus) shell (a waste stream generally dumped at landfill), and compares the cost of this water treatment strategy to dosing waterways with UFL.

2. Materials and Methods

2.1 Materials

Perna canaliculus shell, commonly known as the green lipped-mussel, was used in this field trial to treat AMD. Perna canaliculus shell is composed of a hard inner layer (nacreous layer) made of $CaCO_3$, a middle chalky layer (prismatic layer) composed of inorganic $CaCO_3$ (90%) in a crystalline structure of either calcite and/

"Shell for this operational trial was obtained after the mussel flesh had been removed as part of the food processing. The shell was crushed to approximately 30mm to compact its volume for transport, volume being the limiting factor to bulk transport rather than weight in a truck."

or aragonite, mixed with a small amount of protein (conchiolin), and a thin outer protective layer composed predominantly of organic protein (SITO, 2006; Kohler et al., 2007).

Shell for this operational trial was obtained after the mussel flesh had been removed as part of the food processing. The shell was crushed to approximately 30mm to compact its volume for transport, volume being the limiting factor to bulk transport rather than weight in a truck. Crushing also provides a large reactive surface area for neutralisation reactions to occur on, and significant porosity in the bioreactor due to poor packing of crushed shells. Mussel shell supplied for this trial typically contained between 5 and 12wt.% meat (determined by scraping the meat from samples of the supplied shell and weighing the two components). The acid neutralisation capacity (ANC) of the shell (containing meat) ranged from 786 – 894kg $CaCO_3$/t equivalent (mean 850kg $CaCO_3$/t) as determined by the ANC test (Smart et al., 2002).

2.2 Mussel Shell Bioreactor

The mussel shell bioreactor was designed as a passive treatment system for the neutralisation of acidity and the removal of dissolved metals contained in the AMD. From a cost-benefit perspective, a simple system was required, to make the process less expensive compared to conventional treatment by UFL. A seep day lighting below Manchester Street (Fig. 1) and next to the main 2–5 Haul Road at Stockton coal mine was selected to be treated.

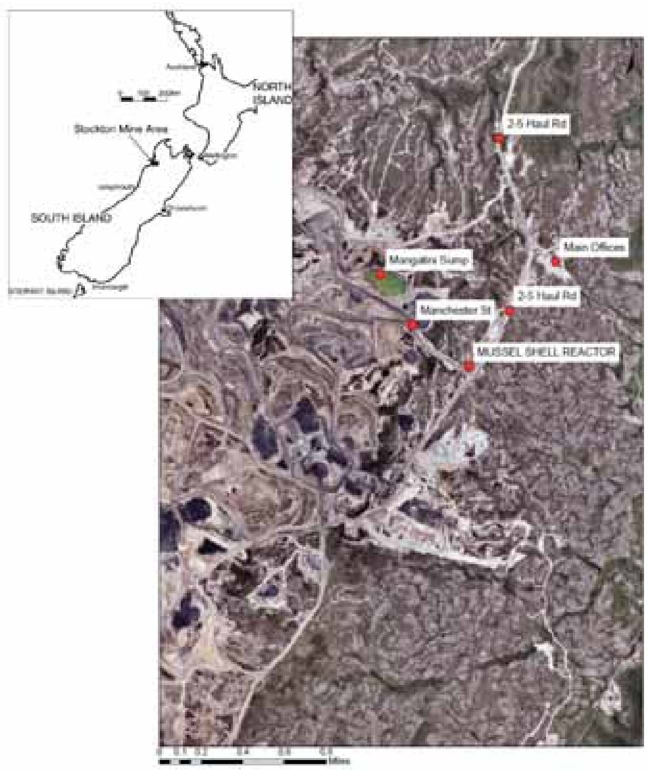


Figure 1 – Location of Stockton coal mine on the West Coast of the South Island of New Zealand (inset) and location of the Manchester Street seep mussel shell bioreactor at Stockton coal mine. The mussel shell bioreactor is located below Manchester Street and next to the 2–5 Haul Rd.

A sedimentation pond located beneath the AMD seep was excavated to form a bioreactor 2m deep, 35m long, and between 2.7m and 10.2m wide. The bioreactor, with 60° angle sides, had perforated novaflow pipe (two lengths of 25mm x 50m) placed in the bottom. Each length of this permeable pipe was then attached to a length of alkathene pipe (25mm diameter) which was feed through the culvert (sealed with bentonite) down to the discharge channel where the treated water would be released onto rocks before being discharged into the receiving waterway. The alkathene pipe was used as a riser to control the pond height and 100–200mm of water was kept above the shells to control odour and oxygen ingress into the bioreactor (to maintain anaerobic conditions). 160 tonnes of shells were loaded into the bioreactor on top of the novaflow pipe (Fig. 2). This set-up allowed the influent to flow horizontally across the pond before moving vertically through the shells into the novaflow and out through the alkathene pipe.

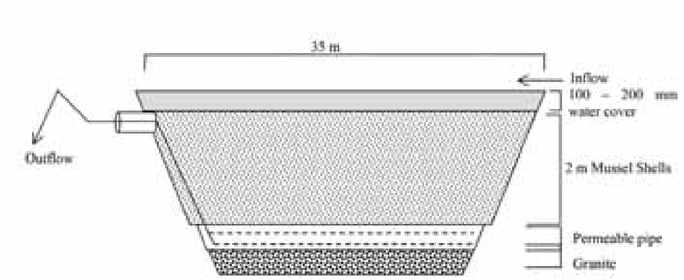


Figure 2 – Schematic of the Manchester Street mussel shell bioreactor installed at Stockton coal mine

2.3 Water Sampling and Analysis

Daily water samples from the influent and effluent were collected from June 2009 for 28 days and, thereafter weekly in accordance with the Australian/New Zealand Standard for Water Quality – Sampling (AS/NZS 5667.1:1998). Routine in-situ analysis included temperature, pH, EC, odour, and flow.

Water samples were analysed in the field for DO in accordance with the 4500-OG Dissolved Oxygen Membrane Electrode Method, while the pH, EC, and temperature were determined using a TPS WP 81 pH, Cond, Salinity meter using a TPS pH and conductivity probe, pH electrode double junction with porous Teflon BNC Plug. The meter was calibrated at pH 4, and 7 using TPS or BDH branded buffers weekly. Odour was recorded by staff using a basic assessment scale – no odour, odour, strong odour, and persistent odour (>50m away).

Acidity (mg L^{-1} $CaCO_3$) was measured by back-titration of a 50mL aliquot to pH 4, 5, and 7 with 0.1 M NaOH; acidity was then calculated as per the American Public Health Association (APHA 2005). An unacidified sample was filtered through a 0.45μm membrane filter to remove suspended particulate matter and then sent to R J Hill Laboratory for ammonia nitrogen (phenol/hypochlorite colorimetry using a discrete analyser APHA 4500-NH3 F (modified from manual analysis) 21st ed. 2005); $CBOD_5$ (APHA 5 Day BOD Test, 5210 B, 21st edition 2005); and dissolved Al, Fe, Ni, and Zn by ICP-MS using the APHA 3125 B 21st ed. 2005 standard method.

Three inflow and outflow water samples were collected (11/12/09, 15/01/10, 29/01/10) for complete water analysis and subsequent geochemical modelling using PHREEQC. The full mass balance was carried out by R J Hill Laboratory and involved nitric acid digestion as a pre-treatment prior to analysis (APHA 3030 E 21st ed. 2005). Mean pH for the three samples was determined from the –log(H+).

A Sensus flow meter was used to monitor the effluent flow and determine the quantity of water treated by the system. The meter was cleaned every six weeks to prevent build-up of a grey-white precipitate which would block the impeller and consequently not record the flow. The influent flow was recorded when possible using a 150–300mL container and a stopwatch. At times during high flow the bioreactor capacity was exceeded, resulting in untreated water overflowing and running directly into the receiving waterway. Water passing through the bioreactor, however, was still treated to a comparable standard to that during low-flow periods. The residence time for the mussel shell bioreactor was calculated as per Equation 1.

Residence Time:
(Void volume (m^3)/Flow rate (L/s)) X (1,000 L/1 m^3) X (60s/1 min) X (60 min/hr) X (24 hr/1 day) (1)

Where:
Void volume = mussel shell volume (m^3)/void space (m^3/m^3 mussel shell)
Void space = saturated mussel shell bulk density (kg/m^3) – dry mussel shell bulk density (kg/m^3)
Mussel shell volume = mussel shell weight (kg)/dry mussel shell bulk density (kg/m^3)
Void space = mussel shell volume – (mass of mussel shells (kg)/dry mussel shell bulk density (kg/m^3))
Mussel shell volume = mass mussel shells (kg)/dry mussel shell bulk density (kg/m^3)

2.4 Leach Test

After 320 days an autopsy of the shells was undertaken and a test pit was dug identifying several distinct zones. Three samples of 1kg of both the white sludge layer (Zone 3) and the underlying black precipitate zone (Zone 4) were collected in 1L containers and flooded with influent AMD to create zero headspace, and thence transported back to the laboratory where the samples were stored in a fridge until test work was undertaken. The AMD was removed from the containers in the laboratory using a pipette and then the remaining sample was weighed. 500ml of fresh influent AMD was poured into the container and then a pH meter connected to a data logger was placed into the container and the pH recorded over 4 days to look at neutralisation profiles.

A pipette was used to collect the white precipitate that had loosely adhered to the shells in the Zone 3 layer. The precipitate was filtered through 11µm filter paper and the retentates sent to R J Hill's Laboratories where the sample was placed through a modified aqua regia digestion procedure followed by ICP-MS (in-house method 7303 based on NIOSH, issue 1 (modified)) to obtain results for total and dissolved metals.

2.5 Precipitate Analysis

A black and grey-white precipitate was observed forming below the discharge point of the mussel shell bioreactor (Photograph 1.). Several rock samples coated in the precipitates were sent to CRL Energy Limited and R J Hills Laboratory for XRD and ICP-MS analysis of an acid digestate (APHA 3125 B 21st ed. 2005, US EPA 200.8).

After 320 days the mussel shell bioreactor was drained several test pits were dug through the top sludge and sediment layers into the layers of shell. A number of distinct zones were identified, including an upper sediment sludge layer (Zone 1) above the mussel shell; an orange $Fe(OH)_3$ precipitate zone (Zone 2); a white $Al(OH)_3$ precipitate zone (Zone 3); and a black precipitate zone beneath these layers (Zone 4) to depth (Photograph 2). A white precipitate accumulating on the outside of the Zone 3 shell was extracted during the leach test and sent to CRL Energy for XRD analysis, while a black precipitate within Zone 4 was also extracted during the leach tests and sent to CRL Energy for XRD and XRF analysis. PHREEQC, a computer programme for speciation, batch-reaction, one-dimensional transport, and inverse geochemical calculations, was also used to predict potential precipitates that were likely to be forming in the biocreactor.

Photograph 1 – Black precipitate at the effluent discharge point for the Manchester Street seep mussel shell bioreactor at Stockton coal mine

Photograph 2 – Cross section through the Manchester Street seep mussel shell bioreactor at Stockton coal mine on day 933. Four distinct zones are shown (sediment layer, iron oxide layer, mussel shell with aluminium oxide layer, and unreacted mussel shell) and the depth of each layer.

2.6 Cost Determination

The cost to neutralise one tonne of acidity by means of the mussel shell bioreactor was compared to the cost to neutralise one tonne of acidity using UFL. The amount of acid neutralised per day by the mussel shell bioreactor was determined from the flow of water discharged over 23 days multiplied by the tonnes of acidity per m^3 of water treated converted to a daily acidity neutralisation rate. ~0.035 tonnes of acidity was neutralised by the mussel shell bioreactor per day.

The current cost of direct dosing UFL at Stockton coal mine is ~$320 per tonne of acidity (based on 60% efficiency). The cost of installing the mussel shell bioreactor was approximately $11,000, including equipment, on-site labour and machinery Thus, payback of the capital cost of construction is achieved if ~36 tonnes of acidity is neutralised by the mussel shell bioreactor. Based on a neutralisation rate of 0.035 tonnes of acidity per day, payback therefore occurs after 1,027 days. This is equivalent to ~36 tonnes of acidity. The calculation does not include the savings to suppliers of shell that do not have to pay to dispose of the waste shell in the likes of landfills, which are constantly increasing their disposal fees.

3. Results

3.1 Water Chemistry

The mean pH (as determined from the hydrogen ion concentration) of the seep increased from pH 2.8 (initial) to pH 6.9, while for 59 out of 84 days the effluent pH was ≥7 (Fig. 3). The mean level of acidity recorded in the mussel shell bioreactor influent was 422 mg $CaCO_3L^{-1}$ eq., which is significantly higher than the mean effluent acidity of 0.3mg $CaCO_3L^{-1}$ eq. (Fig. 4). The temperature of the influent and effluent was relatively constant with a mean influent and effluent temperature of 11°C. The flow rate for the discharge effluent varied dependant on pond head (which would rise during storm events as discharge capacity from the alkathene pipe was exceeded) and ranged from 0.04Ls^{-1} to 0.59Ls^{-1}. The latest results indicate a mean flow from the mussel shell bioreactor of 0.3Ls^{-1}. The residence time was calculated as ~6 days.

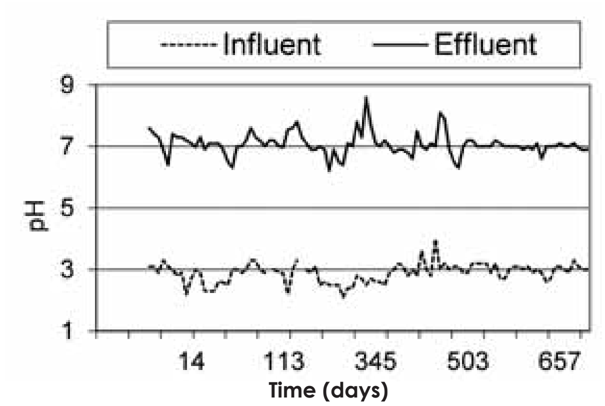


Figure 3 – pH results. pH of effluent (_____) and influent (- - -) for the Manchester Street seep mussel shell bioreactor installed at Stockton coal mine

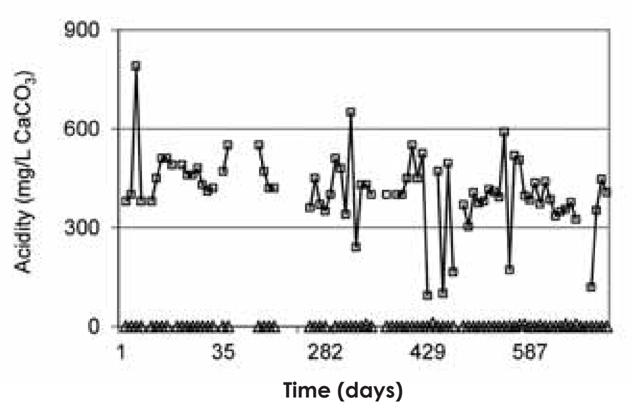


Figure 4 – Acidity results. Concentration of acidity (mg/L $CaCO_3$) in the influent (□ squares) prior to passing through the Manchester Street seep mussel shell bioreactor and after (Δ triangles) passing through the bioreactor

Ammonia nitrogen and carbonaceous biochemical oxygen demand ($CBOD_5$) were initially elevated (Fig. 5) peaking at 46 mg L^{-1} and 200 g.O_2 m^{-3} respectively on day 16 before, decreasing steadily to a mean of 3.4 mg L^{-1} for the last 20 (out of 25) samples for ammonia nitrogen and, to a mean of 58.44 g.O_2 m^{-3} over the last six samples for $CBOD_5$. Downstream monitoring in the receiving waterway (Ford Creek) indicated that DO, $CBOD_5$, and ammonia nitrogen were comparable to baseline values, indicating discharging the effluent into the creek did not have a negative effect on the creek's water quality.

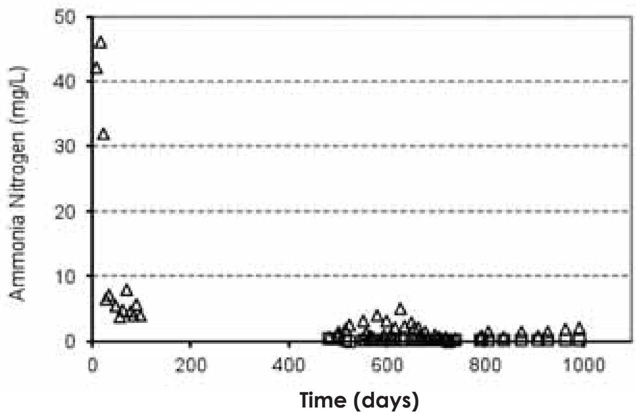


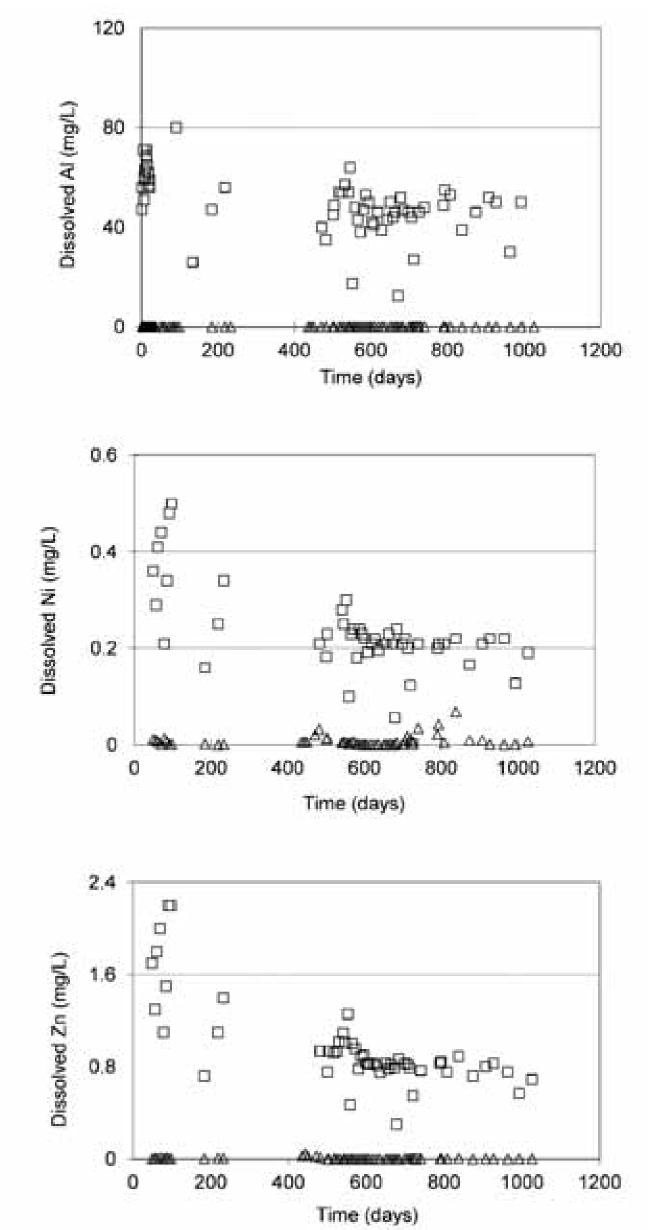
Figure 5 – Ammonia nitrogen. Concentration of ammonia nitrogen (mg/L) in the influent (□ squares) prior to passing through the Manchester Street seep mussel shell bioreactor and after (Δ triangles) passing through the mussel shell reactor over time (days)

3.2 Metal Removal Efficiency

Metal removal efficiency was 96–99% for Al, Fe, Ni, Tl, and Zn (Fig. 6a-e and Table 1). Fe was two to three orders of magnitude lower (99% reduction) post treatment. Dissolved Al in the effluent from the mussel shell reactor was reduced to below the detection limit >50% of the time, whereas the influent was typically four orders of magnitude higher. The mean Ni in the influent and effluent results decreased one order of magnitude. The mean metal load of Zn was reduced four orders of magnitude in the effluent. The concentration of dissolved Zn in the influent fluctuated directly with the concentration of dissolved Fe. Similar trends of Zn removal coincident with Fe removal from solution have previously been identified at Stockton for the Mangatini Stream following UFL treatment of AMD (Davies et al. in prep). Three sampling runs were analysed for total anions and cations (days 184, 219, and 233) with results indicating that B, Br, Ca, Cs, Mg, Na, and Sr increased in concentration, a supposed result from the dissolution of the shells, although they were not at significant levels.

Table 1 – Influent and effluent water chemistry (Al, Fe, Ni, Zn, pH, EC, acidity, DO and ammonia nitrogen) for the mussel shell reactor installed at Stockton coal mine after operating for 1040 days. Mean pH determined from hydrogen ion concentration.

	Al (mg L^{-1})	Fe (mg L^{-1})	Ni (mg L^{-1})	Zn (mg L^{-1})	pH	EC (µS cm^{-1})	Acidity (mg L^{-1} $CaCO_3$ eq.)	DO (mg L^{-1})	Ammonia Nitrogen (mg L^{-1})
Influent									
Min	<0.003	0.81	0.10	0.5	2.1	332	240	2.1	0.037
Mean	51	29	0.27	1.18	2.8	1246	422	8.5	0.15
Max	80	140	0.5	2.2	4.0	1621	790	10.2	0.32
Effluent									
Min	<0.003	<0.02	<0.0005	<0.001	6.2	943	0	0.5	0.06
Mean	0.013	0.17	0.028	0.008	6.9	1445	0.3	2.8	7.81
Max	0.21	0.92	0.038	0.045	8.6	2110	9.9	6.1	46



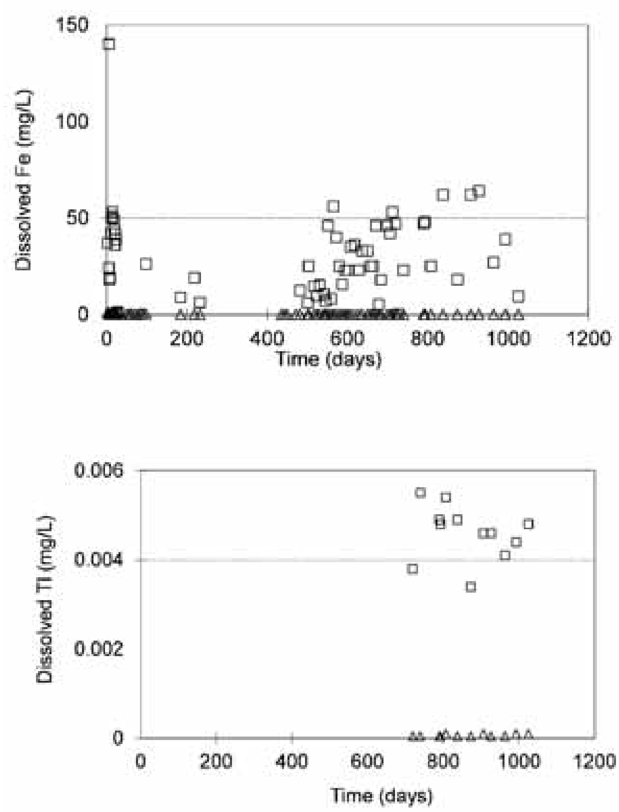


Figure 6(a – e) – Dissolved metals results. Concentration of dissolved Al (a), Fe (b), Ni (c), Tl (d), and Zn (e) (mg/L) in the influent (□ squares) prior to passing through the Manchester Street seep mussel shell bioreactor and after (Δ triangles) passing through the mussel shell reactor.

3.3 Precipitate Characterisation

A number of distinct zones were identified upon conducting the autopsy including an upper sediment sludge layer (Zone 1) above the mussel shell; an orange $Fe(OH)_3$ precipitate zone (Zone 2) immediately at the top of the mussel shell; a white $Al(OH)_3$ precipitate zone (Zone 3) beneath the orange layer; and a black precipitate zone beneath these layers (Zone 4) to depth (Photograph 2).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> "The bacterial decomposition of remnant mussel flesh and degradation of protein from the shell initially causes low DO and high ammonia nitrogen and $CBOD_5$ levels in the effluent."

The sediment layer (Zone 1) on top of the mussel shell reactor was likely to be a combination of road dust and sediment (TSS) transported into the reactor from the seep. The median TSS for the seep which drains into the reactor was reported to be $18.8 mgL^{-1}$, although intensive events can range up to $2,960 mgL^{-1}$ (McCauley et al., 2009). Using a mean flow rate of $0.3 Ls^{-1}$ and a mean TSS of $18.8 mgL^{-1}$ ~500kg of sediment could have been deposited in the pond over 1,040 days, although frequent high-flow events (~10–20 per year) could also deposit up to ~70kg each event over a 24-hour period. Thus, it is reasonable to assume up to one tonne of sediment could be deposited on top of the system annually. Zone 2 is likely to be a mineral precipitate derived from the AMD of Fe origin ($24,000 mgkg^{-1}$), with minor Al ($1,620 mgkg^{-1}$) and less Si ($32 mgkg^{-1}$). Based on the flow rate ($0.3 Ls^{-1}$) and the mean concentration of Fe in the influent ($29 mgL^{-1}$), 0.55 tonnes of Fe would be deposited over two years. Converted to $Fe(OH)_3$ this would represent approximately one tonne of Fe hydroxide deposited on top of the mussel shells. Based on the depth of Zone 1 and 2 (~200mm deep) and pond dimensions ~$5m^3$ of sludge and sediment accumulated over one year.

In the subsequent two zones (Zone 3 and 4) the system becomes anaerobic. A white precipitate accumulates on the mussel shell in Zone 3. ICP-MS analysis of the white precipitate confirmed it was high in Al (~70% of the sample or 14,000–28,000 mg kg^{-1}). PHREEQC analysis indicated that this could be in the form of the hydrated mineral alunite (aluminium potassium sulfate, $KAl_3(SO_4)_2(OH)_6$) or gibbsite ($Al(OH)_3$). To date the concentration of metals in the effluent has been consistently 96–100% lower than the influent, suggesting no re-dissolution of the metals (Al, Fe, Ni, Tl, and Zn) has occurred. Analysis of the black precipitate in Zone 4 by XRD and XRF indicates sulphur was the major mineral element detected respectively (92.5% S by XRF). Magnetite (Fe_3O_4) was also picked up as a trace mineral on the XRD, while XRF reported Fe as 3.48%. This indicates that most Fe was precipitated in Zone 1 as a $Fe(OH)_3$ compound, most likely a direct result of increasing pH due to carbonate neutralisation.

Leach test results for Zone 3 and 4 (Fig. 7) indicate Zone 3 is significantly slower at neutralising acidity than Zone 4. Zone 4 samples neutralised (pH 7) AMD within 1 day, whereas Zone 3 required 3–4 days, suggesting the presence of the aluminium coating caused decreased neutralisation rates. For both layers the increase to ~pH 4 was rapid, however, buffering then occurs as Lewis acidity associated with Al is slowly neutralised between pH 4–5. The period of buffering is longer for Zone 3 at 49 hours compared to 14 hours for Zone 4, due to a combination of the Al coating and possibly equilibrium reactions (Al starts to dissolve below ~pH 4.5). The ability of $CaCO_3$ in the shells to rapidly neutralise AMD to pH 4 suggests why $Fe(OH)_3$ precipitates out immediately upon contact with the Zone 3 shells and is not seen lower down in Zone 4. If, as detected in the leach test, the neutralisation capacity of shells in Zone 3 is mostly exhausted and therefore limits the performance of the mussel shell reactor, then the forecast life of the mussel shell reactor determined from the growth rate of Zone 3 (150–200mm over 320 days), depth of the reactor (2,000mm) and exhausting the full depth of the reactor at is 8–10 years, at which point the mussel shell would need to be replaced. Acid neutralisation capacity (ANC) of the shell in each layer is currently being determined.

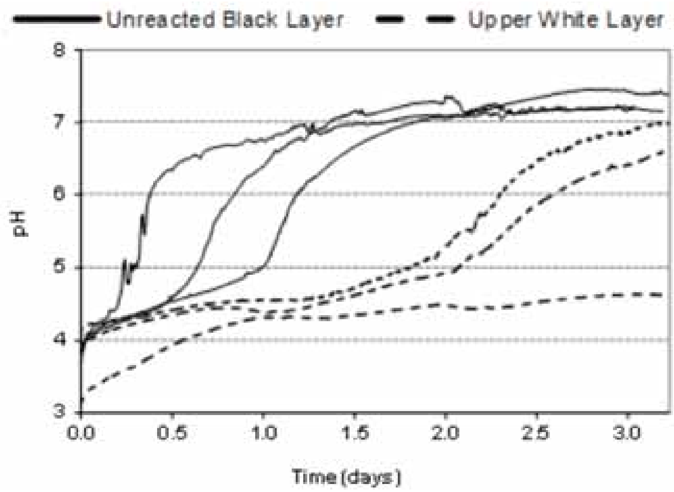

Figure 7 – Leach test results. pH against time for the unreacted black layer and the upper white aluminium precipitate layer. The buffering zone between pH 4 and 5 is extended for the shells with the white precipitate layer compared to shells without a layer of armouring, extending the required residence time from 1–2 days to 3–4 days.

3.4 Discharge Precipitates Characterisation

Two precipitates observed at the effluent discharge (Photograph 1), one black and the other grey-white. XRD detected gypsum as the major mineral in the grey-white precipitate; minor quantities of quartz, sulphur, and potassium magnesium aluminium fluoride silicate were also detected. ICP-MS analysis detected iron (92,000mg/kg dry wt.) to be the largest component of the black precipitate as per ICP-MS analysis, followed by sulphate (4,500mg/kg dry wt.) and aluminium (1,330 mg/kg dry wt.). It was also high in trace elements Mg (510mg/kg dry wt.), Ni (260mg/kg dry wt.), and Zn (530mg/kg dry wt.). A slight sulphur smell (H_2S) could be detected within five metres of the bioreactor effluent discharge point. 50m down-gradient in the rock drain the black precipitate was absent and the only observable effect was iron staining, which is likely to be a function of Fe(II) oxidation and subsequent precipitation. No significant environmental effects other than aesthetic are expected from this precipitate.

Discussion

The bioreactor has been operating for 1,027 days and, at March 2012, remains in operation. The results presented show significant improvement in water chemistry of the seep. pH increased to >7, and ~36 tonnes of acidity was neutralised by the bioreactor during this time (based on recorded effluent flow and influent acidity). 96–100% of Al, Fe, Ni, Tl, and Zn were removed from the influent. Based on a mean flow and metal load for dissolved Al, Fe, Ni, and Zn, 432kg of metals are estimated to be removed from the AMD seep per year by the bioreactor. Effluent metal concentrations from the bioreactor for Al, Fe, Ni, and Zn are in accordance with the 99% protection level recommended in the ANZECC guidelines (2000). The presence of DO in the influent likely promotes the oxidation of Fe^{2+} to Fe^{3+} where it is precipitated as $Fe(OH)_3$ following an increase in pH derived by neutralisation of the acid load by the $CaCO_3$ present in the mussel shells.

The mussel shell bioreactor has greater metal removal efficiency in AMD-impacted waterways than active ultra-fine limestone (UFL) (90% < 100μm). Direct dosing of UFL to an AMD-impacted waterway at Stockton mine lead to metal removal efficiencies of 96%, 99%, 45%, and 71% for Al, Fe, Ni, and Zn respectively, which is significantly less than the mussel shell bioreactor. The field-based mussel shell reactor also outperformed limestone and mixtures of limestone and mussel shell in laboratory based bioreactors (McCauley et al., 2009). The residence time was calculated as ~6 days, however, as the reactor is not lined water is likely to be leaking out the base of the bioreactor thus the reported flow may be lower than the actual flow. Nevertheless, water seeping out the base will have been treated and its quality improved.

A decrease in SO_4^{2-} between the influent and effluent, presence of H_2S at the discharge point, anaerobic conditions (low DO), degradation of mussel shell meat, supply of organic carbon (mussel shells), consistent supply of sulphate in the influent and circum-neutral pH between 5–8 indicates the presence of sulphate-reducing bacteria. Gas bubbles released during the autopsy of the bioreactor had no noticeable odour and could be CH_4, CO_2 or a combination of both and derived from anaerobic conditions and the dissolution of carbonate. This gas was likely to be captured in pockets created by shells and also retained by the lower permeability sediment and sludge layers (Zone 1 and 2 respectively).

The bacterial decomposition of remnant mussel flesh and degradation of protein from the shell initially causes low DO and high ammonia nitrogen and $CBOD_5$ levels in the effluent. However, as DO continues to be low after day 16 when reactive organic material appears to be exhausted (decreased ammonia nitrogen and $CBOD_5$ levels), SRB are likely to be established and retaining the bioreactor in an anaerobic-reductive state. Low DO and high $CBOD_5$ and ammonia nitrogen in the effluent had no effect on the receiving waterway.

> "If, as detected in the leach test, the neutralisation capacity of shells in Zone 3 is mostly exhausted and therefore limits the performance of the mussel shell reactor, then the forecast life of the mussel shell reactor determined from the growth rate of Zone 3 (150–200mm over 320 days), depth of the reactor (2,000mm) and exhausting the full depth of the reactor at is 8–10 years, at which point the mussel shell would need to be replaced."

The Zone 2 $Fe(OH)_3$ sludge could affect the longevity of the bioreactor by creating a low permeability layer, thus preventing the ingress of influent AMD and potentially reducing treatment capacity. As part of the autopsy the bioreactor was drained and test pits dug to expose the Zone 4 black unreacted shell (Photograph 2). Upon digging the holes the remaining pooled surface water on the surface of the bioreactor quickly drained and flow rates increased, suggesting water infiltration is being inhibited by Zone 1 and Zone 2 (sediment sludge layer). Therefore, to prevent the system from losing its efficiency, Zone 1 and 2 may need to be removed periodically as part of any maintenance programme.

A second bioreactor to be built at Stockton coal mine using 500 tonnes of weathered mussel shell, to eliminate any associated odour, has been designed to include a sedimentation pond in front of the mussel shell bioreactor to significantly reduce the mean TSS of 12.7mg/L. The second bioreactor will treat a slightly higher flow

"The use of mussel shell in a field-scale bioreactor to treat AMD in New Zealand is not only a first in New Zealand, but in the world. The mussel shell bioreactor successfully treated an AMD seep high in acidity and removed 96–99% of Al, Fe, Ni, Tl, and Zn."

(0.62 L/s), lower mean acidity (165mg $CaCO_3$/L eq.) and a lower total acid load (8.78 kg $CaCO_3$/day eq.).

The only other maintenance required would be if remobilisation of metals is observed due to the pH in the mussel bioreactor dropping; Ni and Zn would be released first, followed by Al (Kohler et al., 2007) and thence Fe, as has been demonstrated by laboratory based sludge stability trials (McDonald and Webb, 2006). The black and grey-white precipitates discharged from the bioreactor were the only downstream issues, and those only aesthetic. Stockpiling of mussel shell generated a small number of odour complaints, however, once flooded by AMD there were no odour issues except within 5m of the discharge point.

The system has been operating for 1,027 days and has treated a calculated 36 tonnes of acidity and remains in operation. Payback of the mussel shell bioreactor occurs after 1,027 days and thus provides a good argument for installing further systems.

Conclusions

The use of mussel shell in a field-scale bioreactor to treat AMD in New Zealand is not only a first in New Zealand, but in the world. The mussel shell bioreactor successfully treated an AMD seep high in acidity and removed 96–99% of Al, Fe, Ni, Tl, and Zn. pH increased to ~7, and acidity reduced to 0.5mg/L $CaCO_3$. The bioreactor has operated for over 1,027 days thereby achieving payback compared to treating with UFL. A low-permeable sludge composed predominantly of an acid mine drainage precipitate $Fe(OH)_3$ accumulated on top of the shells reducing the infiltration of water into the bioreactor. As AMD progressed down through the mussel shell reactor aluminium was precipitated out onto the outer layer of Zone 3 shells, which reduced the performance of these shells and therefore the system. Based on the rate of growth of this layer the mussel shell bioreactor is expected to continue to provide treatment for another 8–10 years. Passive on-site treatment of AMD using mussel shells is simple and cost-effective, and has been shown to successfully treat AMD. ■

Acknowledgements

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WEDECO

Benefits of Pilot Planting New Wastewater Treatment Technologies

Dr Matt Savage – Apex Environmental Limited

With ever tightening compliance requirements more and more wastewater producers in New Zealand are turning to advanced and novel wastewater treatment technologies that do not have a long track record of performance in their industry.

Whilst there is a large body of data regarding the performance of wastewater treatment technologies on domestic sewage, for industrial producers there is often little data relevant to their specific application. The variation inherent between industrial processes and feedstock often also means that there is a wide variation in wastewater quantity and quality produced from different sites within the same industry. For example, even in wineries the nature of wastewater depends on such factors as solids handling practices, the presence of diatomaceous earth and other fining agents, and water conservation measures.

This can make the task of selecting and designing appropriate treatment technologies a high-risk exercise particularly in industries where extremely high quality discharges are required, such as those discharging to surface waters.

Depending on the nature of contract entered into, it is often possible to pass this risk on to a design and build contractor, but despite the accountability for the risk shifting, the risk of a new technology not performing to the required level still exists.

"The use of pilot plants is not new as it offers a robust means of managing this risk in the design process by proving a novel process under real conditions on the actual site that the treatment technology is being evaluated for."

With a marked increase over the last five years in the number of industrial sites being required to meet extremely tight discharge limits (such as BOD_5 < 10mg/L), or achieve extremely high levels of treatment (such as > 99.9% reduction of COD) there has been a corresponding increase in the need for a robust means de-risking the design process. This de-risking benefits both the end user, who any non-compliances will directly affect, and the design and build contractor who ultimately shoulders the responsibility for system performance.

The use of pilot plants is not new as it offers a robust means of managing this risk in the design process by proving a novel process under real conditions on the actual site that the treatment technology is being evaluated for.

By operating the pilot plant on site using a feed of the existing wastewater being produced, the impact of the normal day-to-day fluctuations in the industrial process on the level of treatment achieved can be evaluated. Generally a trial of six to 12 weeks duration is recommended to ensure that a representative sample of plant operating conditions is evaluated.

With a large proportion of New Zealand's industry being agriculture based, the seasonality of operations and subsequent wastewater production is a key factor that needs to be taken into account in the design process. It is therefore essential that any pilot plant trials provide a representative cross-section of the normal operating conditions of the plant throughout the year.

For many biological wastewater treatment systems operating under these conditions, the highest stress to system performance comes at the onset of the processing season. In extreme examples such as wineries processing predominantly a single variety of grape, harvest time can be a period as short as 11–14 days during which time the bulk of the year's wastewater is produced.

In these cases the pilot plant trials need to be designed both to determine the maximum ramp up rate of the treatment plant from dormant off-season conditions to full production and to determine the best treated wastewater quality that can be guaranteed at all times during this high stress period. Key design outcomes of this process are generally sizing of flow balancing and treatment tanks, and resource consent conditions/performance guarantees relating covering the quality of the treated wastewater.

Unfortunately the use of pilot plants has historically been limited largely to companies large enough to have dedicated R&D funding, or to industry bodies that obtain government or pooled industry funding to carry out such research and development work. This leaves smaller independent businesses with few options other than to accept a higher level of risk, or avoid the adoption of new technologies.

Apex Environmental has addressed this gap in the design process by developing a range of bench-top and pilot plant wastewater treatment plants able to reliably evaluate the effectiveness of a wide range of water treatment technologies technologies at a diverse range of industrial sites.

The technologies that such test plants have been built for include:

- Aerobic Biological Reactors
- Sequencing Batch Reactors
- Membrane Bioreactors
- Trickling Filters
- Crossflow Filtration
- Coagulation/Flocculation
- Dissolved Air Flotation
- Activated Carbon Adsorption

These have been successfully applied in the dairy, wine, beverage, textile, and timber industries.

The trial plants developed range from small bench-top jar testing rigs for evaluating the performance of different coagulants and flocculants in gravity separation, flotation or filtration processes, through to fully automated 3,000 litre bioreactors able to be operated in either activated sludge, sequencing batch reactor, or membrane bioreactor modes to evaluate the comparative performance of these technologies to a given application.

The use of these plants at a range of sites has repeatedly shown how actual conditions achieved on site differ from those modelled or predicted from theory. Common answers that the pilot plant can provide are:

- Actual membrane flux in an MBR versus manufacturers nominal rating
- Actual BOD_5 removal allowing for any nutrient deficiencies and real process conditions
- Nutrient removal limitations
- Actual aeration requirements allowing for oxygen transfer rate of the wastewater in question

Case Study

A typical example of a small industrial site where a pilot plant has been used to de-risk a treatment technology not commonly used in the industry is a small cidery that produces a high strength wastewater with up to 9,000mg/L BOD_5 that needs to be treated to a target BOD_5 of <5mg/L prior to discharge to surface water.

In this instance a pilot plant membrane bioreactor was installed in addition to the plant's existing wastewater treatment infrastructure. The performance of the combined systems were then evaluated under the diverse range of operating conditions of the factory by feeding the site's existing wastewater to the pilot plant over a period of twelve weeks.

Feed to the pilot plant was drawn off from different points within the existing treatment plant during the trial in order to evaluate what existing processes should be retained in order to achieve the desired level of treatment and which could be replaced by a new membrane bioreactor.

The results of this trial, were a detailed design for a new treatment plant that both the client and the design and build contractor can have confidence in, and proposed new resource consent conditions that are able to be reliably met whilst ensuring that the activity has less than minor impact on the receiving environment.

By testing the new process in conjunction with different combinations of the site's existing wastewater treatment plant, a fully integrated design that makes optimum use of the site's existing infrastructure was developed.

Because industrial sites seldom have detailed component analysis of their wastewater a pilot plant trial must be run for sufficient time, and reflect the full scale process with sufficient accuracy to detect any accumulative issues that may occur in the process due to

Top Left to right – Benchtop testing of aerobic biological treatment process; Membrane Bioreactor trial plant module; MBR Pilot Plant in operation; Above Left to right – MBR Pilot Plant; Biological plant able to operate as MBR or SBR; Jar testing of coagulants and flocculants

> "It must however be recognised that there are limits on the application of small-scale trial results to full scale operation."

known or unknown wastewater characteristics. A common example of this is the gradual reversible fouling of a membrane or filter that restricts the flow through the plant over a period of weeks or months, therefore impacting the design capacity required of the plant.

It must however be recognised that there are limits on the application of small-scale trial results to full scale operation. One site in Western Australia for instance was required to achieve 100% recycle of wastewater from their wastewater treatment process back to their factory by evaporating their entire wastewater stream and then further treating the distillate by reverse osmosis (RO). Over a period of months of complete recycle, one wastewater component, a phenolic compound that was present in the plant feed in the parts per billion range and was not therefore identified as significant in the process design, was found to pass through both the evaporator and the reverse osmosis plant in sufficient quantity to continuously accumulate to the point where it as present in the recycle loop in sufficient concentration to irreversibly poison the RO membranes to the extent that they needed to be replaced.

Without operating the full treatment system at full scale in conjunction with the full flow from the processing plant, any purge of wastewater that resulted from operating a pilot plant on a part flow of the wastewater stream would have been unable to detect this key design issue.

By producing a range of versatile test plants, the cost of which can be spread across multiple sites in a wide range of industries, the average cost of running a comprehensive pilot plant trial can be reduced to 2–5% of the cost of a new treatment plant. Most of this cost then becomes the direct cost of labour and sample analysis required to run a long term, robust trial without the capital cost of building a one-off pilot plant.

In the light of the contingencies and overdesign that are otherwise required to de-risk the project at full scale, and the potential impact on the business of environmental non-compliance, this is a small price to pay for surety that a process that has not previously been proven in the proposed application will meet the design requirements. ■

Dr. Matt Savage

Dr. Matt Savage is a chartered chemical engineer with a Ph.D. in industrial wastewater treatment plant design and over a decade's experience designing and installing a wide range of wastewater treatment plants around the world. He is a founding director of Apex Environmental which specialises in the design and build of turnkey industrial wastewater treatment systems.

Onsite Wastewater Workshop – Do We Need Change?

Hamish Lowe – Lowe Environmental Impact and Virginia Baker – ESR

On 14 November last year 102 people attended the New Zealand Land Treatment Collective one day workshop at Scion in Rotorua to discuss the status of onsite wastewater management in New Zealand. Onsite wastewater management in New Zealand and internationally was presented, discussed and a series of issues that need further attention were identified. Participant breakdown was 27% regulators, 40% technical advisors and 32% suppliers and installers.

National and International Status

Ian Gun – OnSiteNZ: set the New Zealand scene and provided an overview of the OSET testing facility. Ian presented a forward view which requires the need to consider more than treatment plants, and highlighted the importance of training.

Sarah West – Victorian EPA: summarised the Australian testing facilities, including the duplication that is occurring as a result of individual state testing programmes. This is adding costs to manufacturers. A number of limitations with NZ/AS 1546 and the opportunity for adopting the European Standards (ES) were discussed. A comparison of the OSET, 1546 and ES evaluation systems was made.

Nick Nobile – Orenco, USA: described the National Sanitary Foundation (NSF) testing processes for onsite wastewater systems. A key aspect of the US testing is systems get a pass or fail, with no grade being provided. Nick highlighted a key industry frustration was despite passing NSF testing there was also a need to have systems approved by individual states.

Issues of particular note from this plenary session included:

- There is currently duplication between councils (within NZ) and states (within both US and Australia) and there is scope for greater collaboration/coordination within the same country

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- The OSET facility has a programme which is comparable with other international programmes, including NSF and the ES, and in some cases is superior
- New Zealand could look to adopt parts of existing standards to enhance the current testing facility in Rotorua
- There will be regional differences which may affect the validity of treatment site results, but this has to be accepted to avoid duplication of testing facilities

Regional Status

Keith Peacock – Hawke's Bay Regional Council: described the history of the region's monitoring and investigation programme and how this has been refined, now leading to a system, designer and installer accreditation system.

Judith Robinson – Gisborne District Council: presented the view of a unitary council and highlighted the benefit of health protection officers being actively involved in consent processing and setting regional rules. Local collaboration and participation was seen by Judith as being essential in the development of new rules and on-going management requirements.

Trisha Simonson – Waikato Regional Council: the actual number of failing systems are not as high as initially thought, and corrective action is usually undertaken with health officers without the need for enforcement action. Despite this considerable effort is going into risk assessment work to identify risk areas for future management.

Key Issues

The participants were divided into groups of 10 and Virginia Baker facilitated a series of discussions to identify key issues of interest to the industry. A ranking process was used to identify critical issues, which are summarised below.

Issue	Priority rating	Priority count
Regular servicing	1	19%
Accreditation – systems/designers/ inspectors/regulators	2	14%
System design – appropriate and complete	3	11%
Homeowner/customer education	4	11%
Training	5	10%
Robust testing	6	10%
Accreditation – installers/maintainers	7	7%
Place of low cost/simple systems	8	5%
Database	9	4%
Occupancy/Regulations	10	3%
Conflict of Interest	11	3%
Regulatory Collaboration	12	2%
Self-Governance	13	2%

The participants were also asked to identify the issues that they saw as being the easiest to address, being those that could be done easily, quickly and will minimal financial input.

Issue	Ease rating	Ease count
Regular servicing	1	21%
Accreditation – installers/maintainers	2	18%
System design – appropriate and complete	3	14%
Training	4	9%
Accreditation – systems/designers/ inspectors/regulators	5	8%
Robust testing	6	7%
Homeowner/customer education	7	7%
Place of low cost/simple systems	8	5%
Self-Governance	9	4%
Database	10	3%
Regulatory Collaboration	11	2%
Conflict of interest	12	1%
Occupancy/Regulations	13	1%

The top six priority issues were examined in further detail with groups asked to identify solutions to a number of questions, including:

- What is the change or improvement you are wanting? What different outcome do you want? Inputs/outputs?
- Who is impacted? Who will benefit from the change? Who might be adversely impacted?
- Who needs to be involved? Who do you need to work with to make the change?
- Who owns this issue? Who has the power to block or undo the change you are seeking?
- What sets of conditions need to exist or happen to make this change? What are your assumptions? What is your big picture?
- What are the givens (ie. regulations), the things that you need to work with or around? What are the constraints, uncertainties or unknowns?
- Is money needed for the change, and if so how much and who is going to pay for it?
- Who is best (person or group) to make the initial step for change?

A summary of the responses to questions for the top 5 issues is to be presented at the LTC Annual conference in Blenheim in April Next year.

The workshop exercise and how it was facilitated allowed a room of mixed opinions to be consolidated into common views. It was very clear that the views and priorities of regulators were different to the installers. Regulators wanted minimum designs and a clear demonstration of competence. Industry personal wanted a level playing field which was nationally consistent.

Amongst debating the priority issues there was interesting and constructive questions and answers. This allowed all to better understand the issues facing the industry. An example of a particular issue was the simple fact that while considerable effort is being placed on developing testing facilities and management of Advanced Wastewater Treatment (AWT) Systems, good old septic tanks were used in up to 75% of installations in some regions. This highlighted the need to ensure that focus is not side-tracked by AWT systems, which while important and have their place despite only making up a very small portion of onsite systems used nationally.

Another example is the difference in management, approval and regulation being adopted by both district and regional councils throughout the country. While the regional variations often reflected the requirements of that region, there was a frustration that neighbouring regions had different approaches to the same issue. The potential for national standardisation on some issues was seen as a key aspect of coordinating the industry going forward.

Considerable debate stemmed from views on an integrated national database to track the location and performance of systems. There were strong views on this with the very clear message that such a database, despite some logistical setup and financial constraints, was seen as a positive step forward for the industry. In the prioritisation exercise a national database scored relatively low (9^{th}) on the list of priorities, but it was noted that the much higher ranking 'Regular Servicing' priority needed a database to function adequately. Consequently by default a national database, or a database of some form, is considered important going forward.

A forward process was identified to make the workshop more than a talk fest. This consisted of taking several critical issues and developing them further with the help of a steering group made up of people from the day. This group would seek to develop a plan and secure funding to assist with implementing any changes. The highest priority was a consistent national plan for regular servicing. Details of this plan are to be developed and feedback will be sought from the steering group before it is discussed further with regional councils, with an agreed to plan presented at the LTC Annual conference in Blenheim in April Next year.

Marie Denis, the LTC Technical Manager, coordinated the day with Hamish Lowe (Lowe Environmental Impact) chairing the day and Virginia Baker (ESR) facilitating the workshop sessions.

First of Its Kind Full-Scale Implementation of a Biological and Chemically Enhanced High-Rate Clarification Solution for the Treatment of Wet Weather Flows at a Municipal Wastewater Treatment Facility

Julian Sandino – CH2M HILL

Like many New Zealand wastewater treatment plant operators facing steady service area growth and increased challenges of wet weather flow management, North Texas Municipal Water District (NTMWD), Texas, USA, evaluated several wastewater treatment upgrade alternatives to meet these challenges in one of their existing plants – Wilson Creek Regional Wastewater Treatment Plant (RWWTP). This article provides insights, results, and direction on their selected upgrade alternative that incorporated dual-purpose treatment components and reconfiguration of existing systems that provide both advanced treatment of dry weather flow increases, as well as treating wet weather flows to protect their nearby water supply source.

North Texas Municipal Water District (NTMWD) serves 1.7 million customers by operating one water treatment plant and four regional wastewater treatment plants including the Wilson Creek Regional Wastewater Treatment Plant (RWWTP). This facility discharges into Lake Lavon, which also serves as the District's water supply. With continued growth of the service area and the increased challenge of wet weather flow management, NTMWD evaluated several alternatives and selected to upgrade and expand the Wilson Creek RWWTP. One key characteristic of the selected alternative is the incorporation of dual-purpose components to provide both advanced treatment of dry weather flows as well as treatment of wet weather flows components aimed at further protecting Lake Lavon as a water supply source.

Upgraded Process Configuration

The proposed treatment approach uses high rate clarification (HRC) in a dual-function mode to achieve both tertiary treatment during dry weather conditions while also providing additional secondary clarification capacity to a reconfigured activated sludge process during wet weather events. A high-rate ballasted flocculation system (Actiflo) is used for the tertiary application, and is converted to a secondary clarifier configuration (BioActiflo) during wet weather events to provide additional biomass separation capacity for the activated sludge process during the high flow conditions (see Figure 1). During wet weather events, the plant's biological nutrient removal (BNR) activated sludge process is re-configured to a step feed mode to treat part of the diluted excess flows that are being diverted around the primary clarifiers. In the BioActiflo mode, return activated sludge (RAS) from the plant's secondary treatment process is routed to a short contact time aerated basin where it blends with excess wet weather flows.

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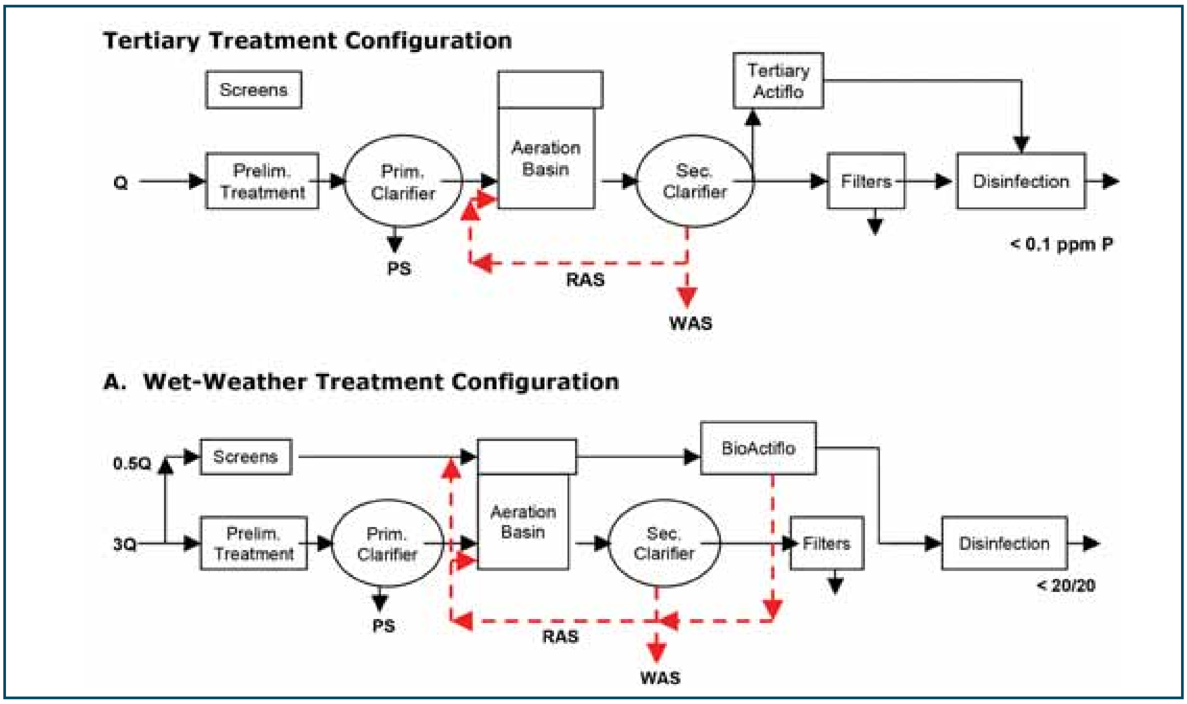

Figure 1 – Reconfiguring a High-Rate Clarification System from Tertiary Treatment to a Biological and Chemically Enhanced High Rate Process for Wet Weather Flow Management

This mixture of biomass and influent wastewater is then treated through the high-rate chemically enhanced clarification facilities (using ferric chloride as coagulant and polymer as a flocculation aid) working in parallel to the plant's conventional secondary clarifiers. This innovative approach increased Wilson Creek's dry weather treatment capacity from 48 mgd to 64 mgd and meets a future anticipated P effluent limit of 0.1 mg/l and reduced TOC levels, while providing biological treatment for wet weather flows up to 168 mgd.

Table 1 – Summary of High-Rate Clarification Facilities – Wilson Creek Regional WWTP

Biological Contact Reactor	
HRT, hours	0.42
MLSS, mg/L	700–1500
Maximum Airflow, (scfm)	(2500)
Number of Trains	1
Volume, (Mgal)	(0.67)
Side Water Depth, m (ft)	(18)
Number of 9"diam. Fine Bubble Diffusers	1200
High Rate Clarifier	
Number of Trains	1
Coagulation Tank HRT, min	1.5
Coagulation Tank Dimensions, L x W x SWD, m (ft)	(14.3x15x24)
Injection Tank HRT, min	1.5
Injection Tank Dimensions, L x W x SWD, m (ft)	(14.3x15x24)
Maturation Tank HRT, min	5
Maturation Tank Dimensions, L x W x SWD, m (ft)	(23x31.3x24)
Settling Tank SOR, $m^3/m^2/h$ (gpm/ft^2)	(30)
Settling Tank Dimensions, L x W x SWD, m (ft)	31.3x31.3x24
Number of Sand Recirculation Pumps	4
Sand Recirculation Pump Capacity, (gpm)	2 @ (750); 2 @ (1130)
Number of Hydrocyclones per Pump	2
Estimated Sludge Concentration, % TS	0.5 – 0.8
Sludge Discharge at Design Flow, (gpm)	(3008)

Bench-scale testing of the biological and chemically enhanced HRC process was conducted as part of the design of the recommended facilities. Test results suggested that the system could be designed to provide the 85% BOD5 minimum removal efficiencies as required in the plant's NPDES permit by providing aerated contact times in excess of 15 minutes for the wet weather flows and the biomass in the RAS flow. Tests also indicated that the chemical dosages required were similar to those typically observed in other more conventional wet weather flow applications of Actiflo, even though the influent solids concentration was now considerably larger due to the addition of biomass. A summary of the high rate clarification upgraded facilities is presented in Table 1.

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Dynamic Simulation of Wet Weather Operations

Dynamic simulation of the proposed configuration using Biowin (Envirosim version 3.1.0.833) was also undertaken as part of the design effort in order to quantify the impact of removing wet weather loads in the BioActiflo process, which would primarily be the increase in mixed liquor suspended solids (MLSS) in the plant's biological reactors that could potentially overload the existing conventional secondary clarifiers. The simulation was performed using an assumed peak storm event hydrograph derived from modeling of the plant's contributing collection system.

Simulation results indicated that the MLSS may increase by 10 – 20% (e.g. from 3400mg/L to 3700–4000mg/L) for the design peak storm event depending when the wet weather loading "flush" occurs: if the flush occurs before change-over to wet weather mode, the MLSS increase will be less due to capture in the primary clarifiers. For most storms, which will be less intense than the design storm and consequently BioActiflo mode will operate for less time, the increase in MLSS will be less. Figure 1 shows the result of the simulation assuming the first-flush occurring before the changing over from the tertiary configuration to the wet wet-weather mode.

The simulation effort also allowed for the establishment of a daily incremental increase in wasting (approximately 10% per day) to determine the length of time it may be necessary to recover the original MLSS concentration. For the design peak storm event, where the MLSS increases by up to 10–20%, increased wasting may be necessary for 7–10 days. For most storms, which will be less intense than the design storm, the length of time to recover will be shorter, i.e. 1–7 days.

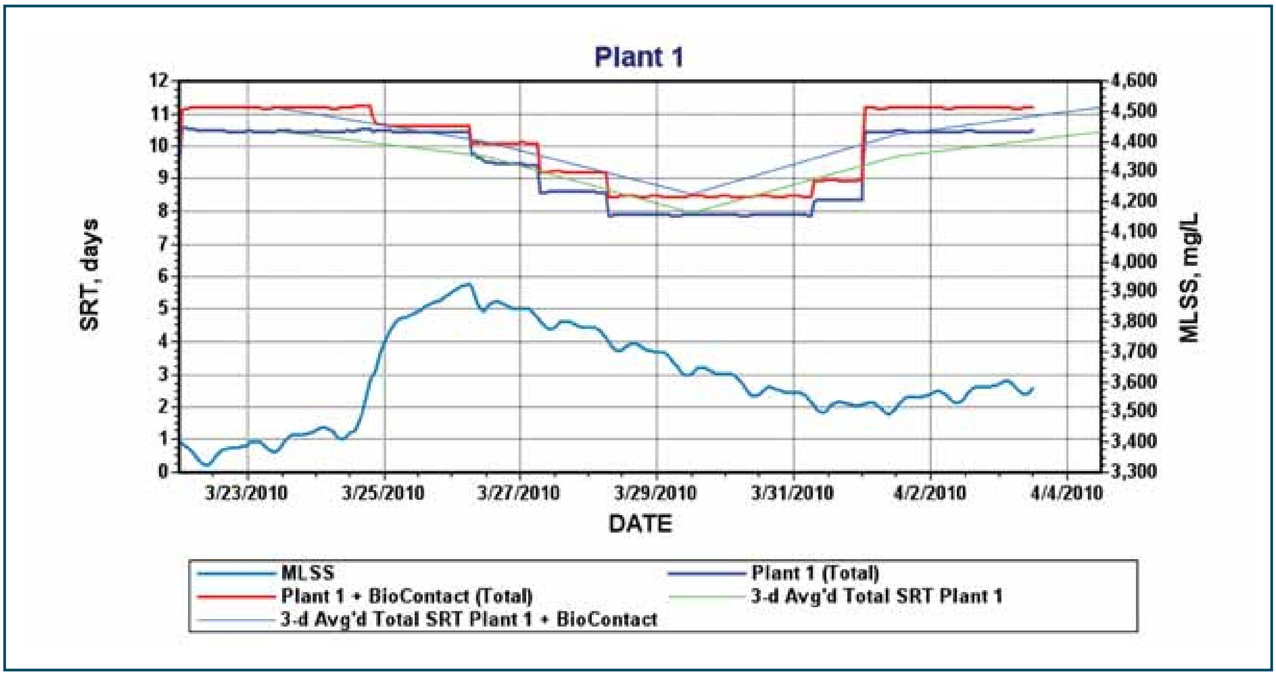

Figure 2 – SRT and MLSS for Scenario 1 (Wet weather flush arrives before change-over to BioActiflo mode)

This wet weather approach provides secondary treatment by providing biological treatment of all flows and will be the first full-scale facility in the world being permitted for the BioActiflo process. The No Feasible Alternatives Evaluation described in USEPA's 2005 Draft Policy on Peak Wet Weather Flow Diversions and the 2009 Draft Guidance on Preparing a Utility Analysis should not be triggered with this treatment approach because secondary treatment is being provided for all flows entering the facility. This project will set precedence on how regulators approach wet weather treatment requirements at wastewater treatment facilities nationwide. They are doing startup of these facility improvements as this article is being published. This is a first of its kind in the world! ■

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Impact of Domestic Greywater Diversion on a Septic Tank System and Potential Health Considerations

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The Problem

In rural New Zealand, domestic wastewater is typically treated on-site. Many new property developments are investing in advanced wastewater treatment systems although an estimated 270,000 existing properties still operate a traditional primary treatment septic tank. Failure rates of these systems are high (15–50%) and it is generally accepted that many older septic tanks do not have sufficient capacity to process and dispose of the volumes of domestic wastewater produced by modern lifestyles. Also, many rural properties experience extreme changes in occupancy, which may be sporadic and seasonal e.g. the family holiday home. Both on-going and temporarily elevated loading rates result in a decreased hydraulic retention time of wastewater in a septic tank system and poorer settling of suspended solids. This leads to clogging of the soakage area, increased discharge of microbial and chemical contaminants to groundwater and potential surface ponding of poorly treated wastewater, which has environmental and public health risk implications.

A Potential Solution

There are two main options to remedy this failing situation: (1) replace/modify the existing septic tank to meet the new hydraulic requirements of the property or (2) reduce the volume of wastewater requiring treatment by the septic tank system. The costs associated with re-designing or replacing existing septic tanks is dependent on the regional requirements, but could be up to NZ$18,000 per unit and would need to be financed by the homeowner. Many homeowners are unwilling or unable to finance a system upgrade, particularly for rural holiday homes that are not a primary residence and have intermittent use. Consequently, unregulated greywater diversion is practiced extensively in rural New Zealand as a means of relieving the hydraulic burden on failing septic tanks and the receiving environment. Greywater (domestic wastewater originating from laundry, shower, bath and bathroom sink) can account for 50–75% of the wastewater produced by a household (according to AS/NZS 1547: 2012). As such, its separation and diversion should increase the septic tank hydraulic retention time and theoretically improve the quality of the septic system effluent, thereby prolonging the life-span of the soakage area, lessen the impact on the receiving environment and reduce the public health risks.

However, greywater itself is a potentially hazardous wastewater stream, reported to contain a high microbial (bacterial and viral) and chemical (pharmaceuticals and household cleaning products) load. If greywater does not actually improve the treatment efficiency of a domestic septic system, then the unregulated use of a diversion/disposal system may in fact increase the exposure of the residents to potential public health risks, and further increase risks to the receiving environment.

Although the use of a greywater system for the purpose of relieving the hydraulic burden on a septic tank has not been previously investigated, many rural homeowners are nonetheless practising greywater diversion for this purpose. There are anecdotal reports that a growing number of households are using some form of unregulated and unreported greywater disposal system. This was confirmed by a recent survey of a small coastal settlement (to be published shortly), which identified a high proportion (ca. 44%) of properties that were undertaking greywater disposal measures. These disposal methods are typically basic, with no flow regulation, and may be as simple as pipes from washing machines going through a window and directly onto a lawn area. This in itself has implications for public health as well as environmental contamination concerns.

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The Research

The Centre for Integrated Biowaste Research (CIBR)* set out to fill this knowledge gap by carrying out a study that investigated the use of greywater diversion as a means of reducing the volume of wastewater directed to a domestic septic tank, and to determine if there were any associated environmental and public health risks from such a practice. Two domestic properties kindly agreed to participate in an eight week study; site-1 is located in Paekakariki on the Kapiti Coast, and site-2 is located in West Melton, Christchurch. Both properties had two permanent residents, were served by a reticulated water supply, and operated a single chamber septic tank and a Watersmart® greywater system, which diverts untreated greywater for irrigation, with no storage capacity. It should be noted that septic tank at site-1 was overdue for regular maintenance and a pump-out of the accumulated solids, which were clearly visible, and was therefore considered to be a "worst case" scenario. Site-2 had a larger tank that was well maintained and was operating more efficiently. This configuration enabled us to ascertain if, in addition to improving the functioning of an underperforming septic tank, greywater diversion would not be detrimental to the operation of a well-functioning system.

From weeks 1 to 4, all domestic wastewater was directed to the septic tank and triplicate samples were taken weekly from the septic tank effluent discharge pipe. From weeks 5 to 8, the greywater stream was diverted to irrigation, and the greywater was sampled in triplicate in addition to the on-going septic tank effluent sampling. Sub-samples were analysed by ESR for pH, total suspended solids, human polyomavirus and adenovirus, while Environmental Laboratory Services (ELS, Lower Hutt, Wellington) carried out analysis for BOD_5, alkalinity, Escherichia. coli (*E. coli*), Total Kjeldahl Nitrogen

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(TKN), ammonia, nitrate, nitrite, total phosphorus, dissolved reactive phosphorus (DRP), sodium, calcium and magnesium.

Loading rates applied to the septic soakage field before and after greywater diversion, and the loading rate of the greywater stream, were determined. These calculations were based on averages of the weekly triplicate samples taken over four weeks, and the volume of wastewater was estimated by an expected two person household water consumption of $0.4m^3d^{-1}$, with greywater diversion accounting for 50% ($0.2m^3d^{-1}$) of the total wastewater stream, according to AS/NZS 1547.

Physical Indicator of Effluent Quality

Total suspended solids (TSS) are one of the key factors to determine if a septic tank is operating beyond its hydraulic capacity. Insufficient settling time increases the level of solids expelled from the septic tank, and decreases the lifespan of the soakage field and/or impact on the receiving environment. There was a significant difference in the TSS levels of the septic tank effluent between both sites during the first 3 weeks ($p < 0.05$), with TSS of up to $190gm^{-3}$ observed at site-1 (Figure 1). This clearly shows that the septic tank at site-2 is operating more efficiently than that at site-1. Following diversion of the greywater stream, and for the remainder of the study, the TSS values of both sites were consistently between $120–140gm^{-3}$ (Figure 1). It appears that rather than causing a decrease in TSS as a rule, the diversion of greywater stabilises the TSS levels of the septic tank effluent. Also, at both sites we observed an overall decrease in the average daily TSS levels applied to the septic tank soakage area following greywater diversion, from 57 to 25g/day at site-1 and from 30 to 26g/day at site-2 (Table 1).

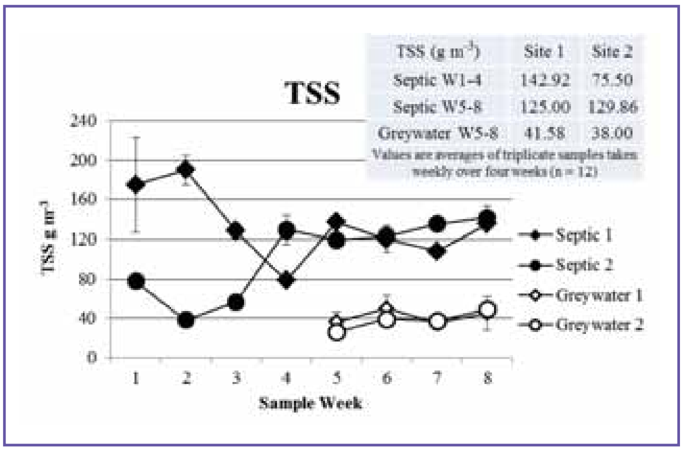


Figure 1 – Graph: Measured TSS (g m^{-3}) of septic tank effluent and greywater at sites 1 and 2; Table: average TSS values of septic tank effluent pre-diversion (Weeks 1–4) and post diversion (Weeks 5–8) and average TSS values of greywater (Weeks 5–8)

		TSS (g/day)	Alkalinity (g/day)	BOD_5 (g/day)	TKN (g/day)	Total P (g/day)	*E. coli* (MPN/day)
Site-1	Septic W1–4	57	229	119	56	6.5	3.1×10^9
	Septic W5–8	25*	170*	48*	42*	4.6*	5.6×10^{8}*
	Greywater W5–8	8	46	13	1	0.4	7.3×10^6
Site-2	Septic W1–4	30	127	175	27	4.5	4.8×10^9
	Septic W5–8	26	105*	62	23*	3.8	3.4×10^9
	Greywater W5–8	8	12	14	1	0.3	6.8×10^7

Table 1 – Average daily loading rates applied to septic tank soakage area. Calculated on the assumption that a two-person household produces approximately $0.4m^{-3}$ wastewater/ day, of which, greywater should account for approximately 50%, according to AS/NZS 1547. (*) denotes significant difference in the septic tank effluent between W1–4 and W5–8 ($p < 0.05$)

Chemical Indicators of Effluent Quality

The pH values demonstrated the variability of the greywater stream, which is believed to be dependent on the personal habits of the homeowners and the activities carried out in the property at the time of sampling. As an example, although the greywater sampled from both properties was generally slightly acidic (6.1–6.7), an average value of 8.2 was recorded at site-1 on week 7 (Figure 2). Septic tank effluent values were typically in the range of 6.3–7.6 (Figure 2).

The remaining chemical indicators monitored included alkalinity (Figure 2; a measure of the acid neutralizing ability, or buffering capacity, of a sample, which can be the result of several ions in solution), BOD_5 (Figure 3; a measurement of the dissolved oxygen used by microorganisms in the oxidation of organic matter in sewage in five days), the cations sodium, magnesium and calcium, which are used to determine the sodium adsorption ratio (SAR; Figure 3) and various forms of nitrogen and phosphorus (Figure 4).

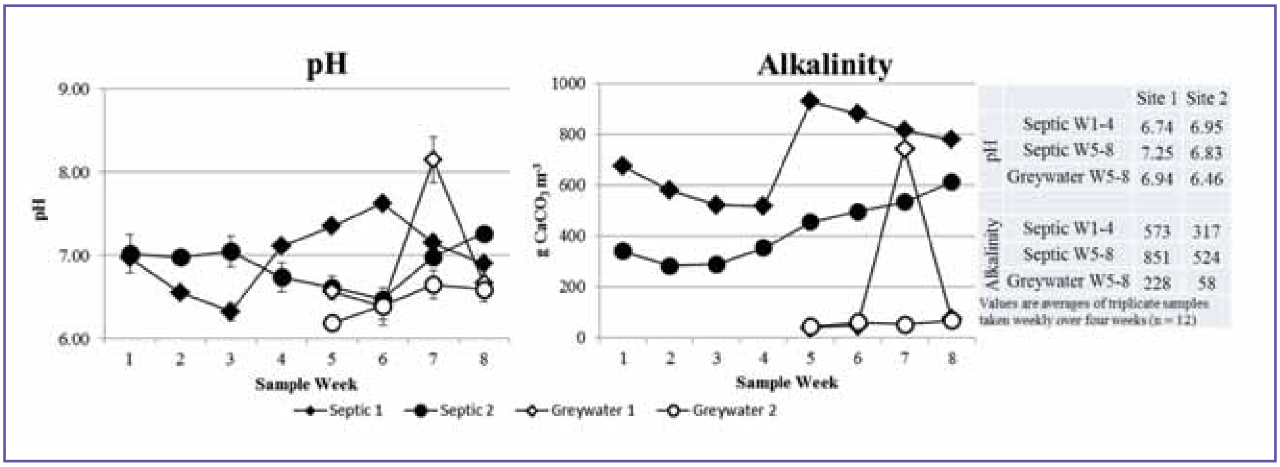


Figure 2 – Graph: pH and alkalinity of septic tank effluent and greywater at sites 1 and 2; Table: average pH and alkalinity values of septic tank effluent pre-diversion (Weeks 1–4) and post diversion (Weeks 5–8) and average pH and alkalinity values of greywater (Weeks 5–8)

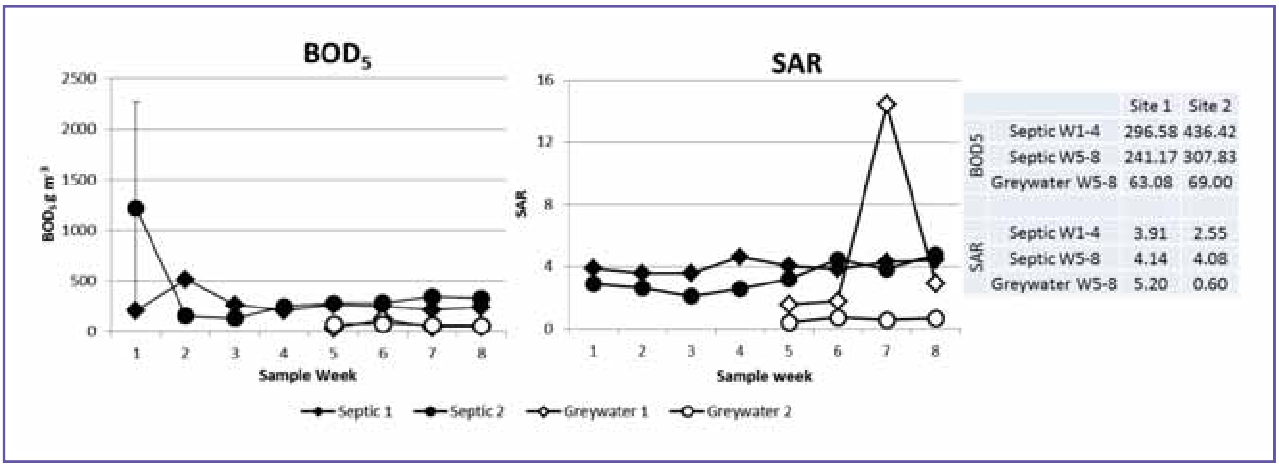
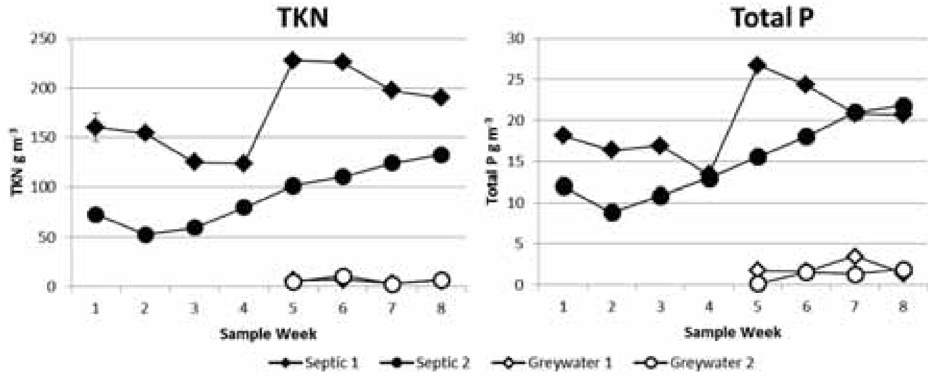


Figure 3 – Graph: BOD5 and Sodium Adsorption Ratio of septic tank effluent and greywater at sites 1 and 2; Table: average BOD_5 and SAR values of septic tank effluent pre-diversion (Weeks 1–4) and post diversion (Weeks 5–8) and average BOD5 and SAR values of greywater (Weeks 5–8)

For all parameters, except BOD_5 and pH, the diversion of grey-water corresponded to an increase in the average concentration of each chemical indicator in the septic tank effluent at both sites (Figs. 2–4). However, the lower volume of septic tank effluent produced as a result of greywater diversion means that overall there was a reduction in the mass load discharge of chemical components such as nitrogen and phosphorus entering the soakage area (Table 1).



		Site 1	Site 2
TKN	Septic W1-4	140.67	66.34
	Septic W5-8	210.25	117.08
	Greywater W5-8	5.70	6.32
Total P	Septic W1-4	16.18	11.19
	Septic W5-8	23.13	19.08
	Greywater W5-8	2.08	1.26

Figure 4 – Graph: Total Kjeldahl Nitrogen and Total Phosphorus of septic tank effluent and greywater at sites 1 and 2; Table: average Total Kjeldahl Nitrogen and Total Phosphorus values of septic tank effluent pre-diversion (Weeks 1–4) and post diversion (Weeks 5–8) and average TKN and TP values of greywater (Weeks 5–8)

Biological Indicators of Effluent Quality

Organisms, such as total and faecal coliforms and *E. coli*, are commonly used to indicate the density and reduction of pathogenic bacteria and viruses in wastewater. In this study *E. coli* levels at both sites were monitored and remained at approximately 10^6 MPN/100ml throughout our study (Figure 5). Greywater diversion did not appear to impact the concentration of *E. coli* in the septic tank effluent, and the levels of *E. coli* in the greywater stream were typically two orders of magnitude lower than the septic tank effluent. Again, the lower volume of septic tank effluent being produced following greywater diversion resulted in a reduced numbers of *E. coli* entering the septic tank soakage area on a daily basis (Table 1).

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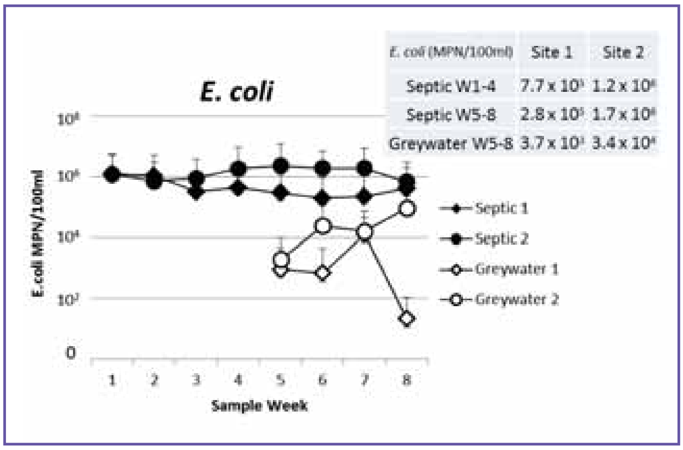

Figure 5 – Graph. *E. coli* levels of septic tank effluent and greywater at sites 1 and 2; Table: average *E. coli* values of septic tank effluent pre-diversion (Weeks 1–4) and post diversion (Weeks 5–8) and average *E. coli* values of greywater (Weeks 5–8)

Pathogens from poorly functioning septic tank systems have frequently been linked to outbreaks of human illnesses when these pathogens are transferred to nearby groundwater or drinking water supply sources. Therefore, a reduction in the numbers of *E. coli* entering the environment may be indicative of reductions in the numbers of pathogens, which would in turn indicate a reduction in the public health risks associated with the discharge of pathogens from septic tank systems. However, it has been widely demonstrated that coliform bacteria do not adequately reflect the occurrence and survival of pathogens in treated sewage and wastewater, and it is thus important to monitor a suite of organisms including a subset of pathogens). For this reason virology analysis was carried out at the Environmental and Food Virology Laboratory, ESR for human polyomavirus (HPyV) and adenovirus (HAdV). These viruses have been suggested as suitable human pollution indicators (faecal and urine) because of their prevalence in influent wastewater.

Table 2 – Virology analysis of samples collected throughout the study. Human polyomavirus (HPyV) and adenovirus (HAdV) were targeted. (-) denotes weeks where samples were not collected for virology analysis. +(F) indicates the species of HAdV detected in the sample. Values given are genomes copies/L

Week		Site 1		Site 2	
		HPyV	HAdV	HPyV	HAdV
Septic tank	1	5.6×10^5	Neg	2.4×10^4	Neg
	2	7.3×10^3	Neg	2.0×10^4	Neg
	3	-	-	-	-
	4	1.9×10^4	+ (F)	Neg	Neg
	5	5.2×10^3	+ (F)	1.5×10^5	Neg
	6	3.3×10^8	+ (F)	Neg	Neg
	7	1.6×10^9	+ (F)	-	-
	8	Neg	Neg	Neg	Neg
Greywater	5	Neg	Neg	Neg	Neg
	6	Neg	Neg	3.9×10^3	Neg
	7	-	-	-	-
	8	6.0×10^3	Neg	Neg	Neg

HPyV was detected in 6 out of 7 septic tank effluent samples collected from site-1, and in 3 out of 6 septic tank effluent samples collected from site-2. It was also detected sporadically in the greywater stream from both sites. HAdV was detected less frequently – in 4 out of 7 septic tank effluent samples collected from site-1, but was not detected in the septic tank effluent of site-2 or in the greywater stream from either site.

So What Does it All Mean?

The septic tank at site-one would not be described as "failing" as there were no visible signs of system failure at the property, e.g. surface ponding of partially treated effluent. However, prior to sampling at the property, the homeowner informed us that he was aware that the tank was overdue for a scheduled pump-out. This was apparent on visual inspection of the septic tank, and the homeowner agreed to delay his regular maintenance until sampling was complete. This tank, in effect, acted as a poorly performing system for the purposes of this study, and this was also evident in the elevated TSS, alkalinity and ammonia levels detected during the initial weeks of sampling. This site strongly benefited from the reduced hydraulic loading that resulted from greywater diversion. TSS, alkalinity, BOD_5, N, P and *E. coli* mass loading applied to the septic tank soakage area were all significantly lower in weeks 5–8 than in weeks 1–4 ($p < 0.05$). This should have a strongly positive impact on the life-span of the soakage area, thereby reducing the potential environmental and public health risks associated with the failure of an on-site septic tank system.

In contrast, the septic tank at site-2 had been pumped out more recently and there was no visible accumulation of solids in the tank. This tank was included in the study to determine if the reduced hydraulic loading to the septic tank as a result of greywater diversion would have a detrimental impact on a well functioning system. This did not appear to be the case – concentrations of TSS, BOD_5, total P and *E. coli* applied daily to the soakage area were not significantly affected by the commencement of greywater diversion ($p > 0.05$), although TKN and alkalinity levels were reduced.

This study suggests that the use of a greywater diversion system may be a suitable cost effective way to extend the life-span of a septic tank soakage area and thereby improve the function of an under-performing system; being older systems with reduced hydraulic retention capacities. Additionally, greywater diversion resulted in a decreased loading of factors such as *E. coli* and specific viruses to the environment, and does not appear to result in an increased risk to public health.

It should be noted that our research emphasises the necessity for certain precautions to be implemented with regard to the on-site use of untreated greywater. We can observe from our data that levels of *E. coli* in greywater were typically less than two orders of magnitude lower than that of the septic tank effluent, and were frequently $>10^4$ MPN/100ml. Also, we detected the intermittent presence of the HPyV virus in the greywater streams of both sites, which is emerging as a potential indicator of contamination by human biowastes. As such, despite the benefits on the performance of septic tanks, greywater in itself may be considered to be a public health risk and its use should be carefully considered with design undertaken and matched to the site conditions and receiving environment. There are currently no nationally applicable guidelines for the safe reuse of untreated domestic greywater. Most Councils recommend that untreated greywater is used for sub-surface irrigation (≥ 10cm depth) of non-food chain plants, such as borders and shrubberies, and that its use should be restricted to areas where children are unlikely to come into contact with the soil. Greywater should not be applied in areas with a shallow depth to the groundwater table, or on soil susceptible to clogging or excessive leaching, to minimise the environmental risks associated with its dispersal. Some councils, such as Kapiti Coast District Council and Gisborne District Council, have developed specific guidelines for greywater use in their region. However there is typically extensive variation between different councils, causing confusion and tension between engineers, system suppliers, and local government.

> "This study suggests that the use of a greywater diversion system may be a suitable cost effective way to extend the life-span of a septic tank soakage area and thereby improve the function of an under-performing system; being older systems with reduced hydraulic retention capacities. Additionally, greywater diversion resulted in a decreased loading of factors such as E. coli and specific viruses to the environment, and does not appear to result in an increased risk to public health."

The requirement for national guidelines is increasing and will likely need to be addressed in the near future. There are increasing demands for greywater systems as the general public become more water conscious; particularly as water metering is introduced throughout New Zealand. The CIBR is working towards collating scientific information that may form the basis of a New Zealand specific Greywater Guideline that takes into account New Zealand's unique soils and climate.

If you have any queries about this study or on-going greywater research at the CIBR, or would like to be involved in any future greywater research, please contact alma.siggins@esr.cri.nz

**The Centre for Integrated Biowaste Research is a multidisciplinary collaboration between 10 New Zealand research institutes, universities and research partners dedicated to developing appropriate and sustainable solutions that maximise the benefits and minimise the risks of reusing biowastes (www.CIBR.co.nz)*

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An editorial oversight meant the following article did not run in the November 2012 issue of Water – Ed.

New Stormwater Management Product Aims to Prevent Plastic In Our Oceans

Mike Hannah – Managing Director, Stormwater 360

Introduction

There is an increasing awareness that plastic and gross pollutants are killing our oceans . Once viewed as unsightly yet non toxic, gross pollutants were considered more a nuisance rather than the major and growing environmental degrader that it is. Recent research has shown that the volume of gross pollutants in our ocean is killing millions. Further the persistent and buoyant nature of the man-made compounds such as plastics and Styrofoam contained in gross pollutants have a cumulative effect accumulating in the environment. Man-made compounds in marine pollution can also leach containments such as estrogen like chemicals and heavy metals contaminating marine bio and travelling up the food train into humans.

Environmental cleanup organizations are horrified by the amount of material on our islands beaches and coast lines but this is only a small percentage of of what is being discharged into our coast environment. Stormwater360 leaders in stormwater innovation have redeveloped its successful EnviroPod catchpit filter to target gross pollutants in an effective manner. . The new Enviropod LT (Litter Trap) has been developed to target plastics and gross pollutants. The Enviropod LT starts in addressing the problem at the source.

What We Do in New Zealand is Affecting Animals Across the Pacific

Over 80% of marine pollution comes from land-based activities. (WWF). With the majority of these being discharged through storm sewers and rain flushes and impermeable surfaces through catch pits into the reticulation system where it eventually reaches our oceans.

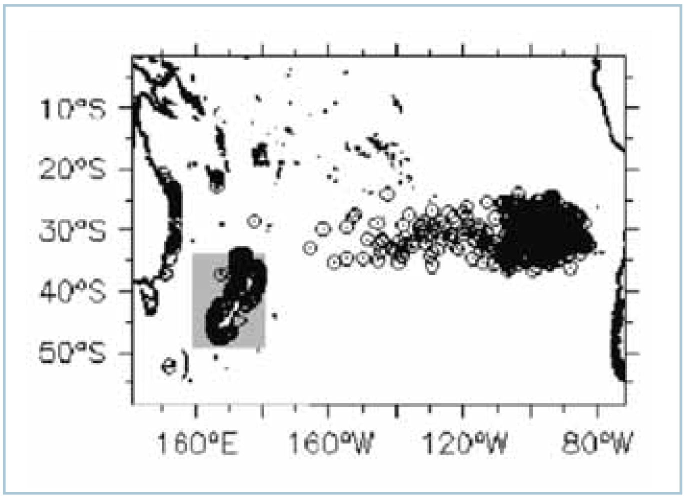
Once waterborne and in the ocean some gross pollutants settle to the ocean floor, some break down quickly (organic material), however a considerable amount can be blown by the wind, or follow the flow of ocean currents, and in time often ending up in the middle of oceanic gyres where currents are weakest. The Great Pacific Garbage Patch is one such example of this, comprising a vast region of the North Pacific Ocean rich with anthropogenic wastes. Estimated to be double the size of Texas, the area contains more than 3 million tonnes of plastic.

While the evidence of the North Pacific seems far away for New Zealand there is evidence that the same phenomena is occurring in the Southern ocean and New Zealand is a source. Young and Adams of Unitec undertook a study in 2008 where they trawled the parts of the Waitemata harbor and the inner gulf with plankton net. The plastic concentration was found to be as high as 16626 items/km^2 of ocean trawled. While this is not as high as the Great Pacific Garbage Patches 334,271 items/km^2, it is still a considerable and concerning amount.

This figure below is an extract from Martinez et al research paper "Floating marine debris surface drift: Convergence and accumulation toward the South Pacific subtropical gyre". Her modeling shows that Land based marine pollution originating from New Zealand (gray box) often ends back up on our own shores of a much large amount accumulates in the in the center of south pacific gyre.

Figure 1 – Sample of seawater from the great pacific garbage patch
Source: Scripps Oceanography

Figure 2 – Final destination of plastics originating from New Zealand
Source – Floating marine debris surface drift: Convergence, Martinez



The Size of the Problem

Gross pollutants are large pieces of litter, debris, and sediment. The litter component mainly comprises of paper, plastic and cigarette butts. The percentage of litter can vary greatly from location but on average is approximately 30% of the gross pollutant load.

While the discharge of total suspend solids is regulated in Auckland and in other regions of New Zealand – gross pollutant discharge is not and there has been little effort to control them. That is apart from the heroic efforts of some individuals and community groups such as Island Care Trust and Sustainable Coastlines which annually pick up tones of gross pollutants from our beaches

The volume of gross pollutants that discharge from urban areas into the marine environment is significant. In 1995 the Island Care Trust of New Zealand estimated 28,000 piece of litter a day were discharging from Auckland cities stormwater drain into the Waitemata Harbor.

Island Care study found industrial catchments contribute more plastics and commercial catchments contribute more paper.

Allison's research estimated the gross pollutant load for Melbourne to be 230,000 cubic meters per year. Which is almost the same as a super tanker (300,000m^3) of gross pollutants a year. Research by Hannah in 2005 on retained material from Enviropods in Auckland and Sydney estimated a loading rate of 1.6m^3 of particles over 1mm per heater where entering the stormwater drain in urban areas. Applying this to the urban area of Auckland (482km^2) would equate to over 75000m^3 or over 1100 40ft shipping containers being dumped into Auckland's marine environment every year. Another study in Hobart with the EnviroPod found that nearly 10,000 cigarette butts and over 500 pieces of plastic per hectare where being washed down Hobart stormwater drains and into the southern ocean.

The Effects of Gross Pollutants in the Marine Environment

Gross Pollutants in our waterways and on our beaches are unsightly and unattractive. Tourism is worth 23 billion dollars to the New Zealand economy

First the share volume of gross pollutants is a concern. This volume tends to settle out in our receiving water bodies smothering and clogging them. The organic component is also a considerable source of nutrients (phosphorous and nitrogen) into ours waterways. Excess nutrients effect dissolved oxygen levels in the water bodies and can lead to algal blooms.

The entanglement by and ingestion of, marine litter by organisms, are the most noticeable short-term impacts. Plastic litter in particular, is estimated to lead to the world wide mortality either directly or indirectly of one million seabirds, 100,000 marine mammals (including 30,000 seals) and 100,000 turtles globally every year either through entanglement or ingestion.

Figure 3 – Oystercatcher found with ingested plastic in Colville Harbour NZ. Source: Sustainable Coast Lines

Long-term impacts are usually associated with the fate and interaction of contaminants over a long period of time. Ecosystem deterioration can result from a combination of these impacts, such as habitat damage, reduced population size and biodiversity loss.

Gersberg even with a small amount of un-burnt tobacco clinging to it, a single cigarette butt soaked for a day is enough to turn a liter of water a sickly yellow brown and kill 50 percent of fish swimming in it. Without tobacco, it takes about 4 smoked filters to do the same job.

Research has shown photo-degradation of plastics causes estrogenic compounds to leach into the surrounding water. A study in Germany has shown that plastic packaging material was capable of leaching Estradiol into water and into the New Zealand mud snail. Estradiol is Estrogen like chemical – it has a critical impact on reproductive and sexual functioning. Estrogen mimics, like those released from the photo-degradation of plastics and magnified up the food chain into our seafood. In our bodies, they attach themselves to estrogen receptors in cells and mimic the action of the body's natural estrogen, or they may block the action of natural estrogen and are thus called estrogen antagonists.

Ministry of Science and Innovation Grant

With knowledge and understanding the effect plastic and gross pollutants are having on the world marine life, the team at Stormwater360 decided to do something about it.

Stormwater360 started in 1996 by developing the Enviropod Catchpit filter. In 2010 Stormwater360 successfully applied to the Ministry of Science and Innovation for a technology development grant to redevelop the EnviroPod filter. The MSI grant enabled extensive lab and field testing, engineering materials design, modeling and industrial design

The goal was to come up with a low cost solution for gross pollutants that could be applied anywhere, handle the volume of gross pollutants washing into our drain and be easy to maintain. The redesign objectives were as follows:

- Low Cost
- Dry Capture
- High Flow Capacity
- Hand Maintainable

The original Enviropod (the EnviroPod 200) was designed to target sediment as well as gross pollutants. It utilised a 200 micron screen with a galvanised or stainless steel frame. Suspended sediment is usually the contaminant of concern as heavy metals attached to sediments are transported into the marine environment with them. The Enviropod 200 was tested at Auckland University for Auckland Council and shown to remove more than 95% of particle above 100 micron (0.1mm). Since then over 7,000 Enviropods 200's have been installed throughout New Zealand. These Enviropods have been installed in city centres, shopping centres and commercial properties and when properly managed have removed significant amounts of sediment and gross pollutants. Stormwater 360 estimate 480 tonne of contaminants have been prevented from entering New Zealand waters by the Enviropod since its inception in 1996.

"With knowledge and understanding the effect plastic and gross pollutants are having on the world marine life, the team at Stormwater360 decided to do something about it. Stormwater360 started in 1996 by developing the Enviropod Catchpit filter."

By removing large volumes of sediment the EnviroPod 200 required cleaning by Induction Truck. Induction trucks are expensive to operate ($200 + hour). All waste removed from inductor trucks is required to be treated as special waste. Further by focusing on sediment the serviceability of the EnviroPod 200 was high i.e. the system needed to be maintained every 2–4 months.

The EnviroPod 200 is a very effective tool, however feedback from the market was that there needed to be a lower spec option The EnviroPod LT is modified to only focus on the gross pollutants, this increases the serviceability and allows the system to be hand maintained not dissimilar to emptying a curb-side rubbish bins therefore removing the need for the induction truck.

Figure 4 – EnviroPod LT

Figure 5 – Hand maintenance

The design of the Enviropod LT is based around a self supporting bag, removing the need for a support frame. As the system sets loaded with gross pollutants the bag gets heavier causing the sidewalls of the original bag to get stiffer. This feature allows the removal of the frame which was a costly yet essential element to the original design.

The effective bag design enables a large surface area bag to be constructed. The large surface area allows the device to convey a high amount of flow through the screen with low head loss. The photo below show the system being tested at the Auckland University hydraulics lab. The photo shows the small amount of head loss through the system as a flow of 12 l/sec passes through the bag. The photo also shows very little turbulence in the sump under the Enviropod LT as the bag dissipated the incoming flows energy. This energy dissipation enhances sediment settling in the sump of the catchpit.

The Allison study in Melbourne revealed that approximately 20% of gross pollutants were floating. There is also a large amount of gross pollutants that travel in the water column i.e. they are neutrally buoyant. The only way effective to capture floating or neutrally buoyant material is by screening it. A standard catchpit has no means to stop neutrally buoyant material. Some standard catch pits are installed with half siphons – this has only a limited effect on capturing truly floating material. By screening the flow the EnviroPod LT can effectively capture and retain all gross pollutants in the flow.

The EnviroPod LT uses a fiberglass burn proof fabric that captures all particles over 1mm that enter the catchpit The retained trash

Left to right: Figure 6 – Load Testing of Self Supporting Bag; Figure 7 – Head Loss and Energy Dissipation @ 12 l/sec; Figure 8 – Dry Capture

and debris are held dry in the system, preventing break down in the catchpit sump or in the receiving environment. Allowing excess water to drain from the retained material lowers the disposal costs.

> "The EnviroPod LT uses a fiberglass burn proof fabric that captures all particles over 1mm that enter the catchpit The retained trash and debris are held dry in the system, preventing break down in the catchpit sump or in the receiving environment. Allowing excess water to drain from the retained material lowers the disposal costs."

During the development process over 40 prototypes were manufactured and installed in various catch pits around Auckland and a few in Sydney. Trail locations where chosen specifically to test the functional aspects of the design, these included: concrete yard, steep streets and ultra urban catchments. Removal rate was between 550–1800kg/ha/or 2.3–7.5m^3/ha/yr.

The EnviroPod LT is now available. It intended to start mass production of the product in the New Year with a view to export the product to Australia, USA and abroad. Further information is available at www. stormwater360.co.nz

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Figure 9 – Example of gross pollutants caught in during development of the EnviroPod LT

Contributing to a Stronger Christchurch – A Personal Perspective

Chris Maguire – Water and waste water engineer, MWH Global

Making the Move

Upping sticks and moving your life to the other side of world is never an easy step to take. But for me, the move brought me face to face with challenges I couldn't have imagined: helping to rebuild an earthquake-torn city. This was far more than just a lifestyle change.

In 2009, I was working for MWH Global in Belfast, Ireland, designing the upgrade of wastewater treatment works for Northern Ireland Water. The country was at the height of the global financial crisis and with dwindling workloads it seemed the right time to take the leap and swap the engineering challenges of home for the opportunities and experience of overseas.

I started with MWH in New Zealand in March 2010, working as a water resources engineer and project manager in the Waikato, and joined the Institution of Professional Engineers New Zealand (IPENZ). I became both a member of the IPENZ Waikato Committee and the IPENZ Engenerate Waikato Representative, based in Hamilton.

I had started to settle into the Kiwi way of life and had no idea that bigger decisions were yet to come.

A Stronger Christchurch

Within a year of my arrival in New Zealand, Canterbury experienced two catastrophic earthquakes. The September 2010 earthquake required the repair of public infrastructure, but following the devastating 22 February 2011 quake, the situation became far more complex.

Following the initial disaster and emergency response phases there was a need to look at the long-term recovery of public infrastructure. The opportunity to help led me to pack up my life all over again and move to Christchurch. In July 2011, I was seconded from MWH to join the rebuild with the Stronger Christchurch Infrastructure Rebuild Team (SCIRT).

SCIRT is an alliance between owner participants Canterbury Earthquake Recovery Authority, Christchurch City Council and New Zealand Transport Agency, and five non-owner participants (Delivery Teams) City Care, Downer, Fletcher, Fulton Hogan and McConnell Dowell.

I found myself working as a full time design engineer for MWH which meant I had dropped my project management side and was now focusing on the design of wastewater and stormwater networks, including the design of pump stations. This was an exciting opportunity as I was totally focused on designing resilient infrastructure while others looked after the financial reporting.

Pressure Main 11

Over the next few months, along with my fellow designers at SCIRT, I ate, slept and breathed the Pressure Main 11 (PM11) project. The project was the design of a 3.6km long, 1.2m diameter Glass Reinforced Plastic (GRP) wastewater pressure main through the east of Christchurch, sitting in liquefiable ground. This was needed as the previous pressure mains failed during the earthquake and were damaged beyond repair. The opportunity to design one of the largest GRP wastewater pressure mains in the country and the ability to make a real difference, through engineering, fuelled me.

The original Pressure Main 11 consisted of two 600mm ductile iron pipes. These were paired with a concrete pressure main to allow for resilience in operation. With the iron pipes damaged in the earthquakes it meant there was only one line to carry 30% of Christchurch's wastewater from Pump Station 11 to the Christchurch Wastewater Treatment Plant. Therefore, there was a need for a quick delivery of the design for the new pressure main. Christchurch City Council requested the new pressure main be constructed from glass reinforced plastic (GRP), as this material had performed well in the earthquakes on other wastewater lines.

We found there were some challenges when designing the new pressure main especially around the ground conditions. Although there has been a considerable amount of study of earthquakes and seismic stability of buildings and vertical structures, there were surprisingly few examples in New Zealand of the tested performance of underground pipelines in seismic conditions. Geotechnical investigations undertaken in the area of the proposed pipeline indicated that it was prone to liquefaction. Although a relatively new concept, the black sleech (soft estuarine quasi-thixotropic deposits) in

Belfast can be comparable to liquefaction in poor soil strength and instability so the design could be transferable back home in Ireland.

Through extensive testing and using existing borehole logs we soon built up good information about the existing ground conditions which enabled us to understand the potential issues around resilience. Conventional design of flexible pipelines considers static ground conditions and soil strength, not liquefaction, where seismic events can mobilise the silts and sands.

The shortage of information about the effect of liquefaction on pipelines in New Zealand meant I found myself having to quickly upskill through research from others international experience. This meant I undertook extensive study into the soil strength and the native soil modulus (or "stiffness") and its relation to liquefaction in Canterbury. This research used MWH pipeline experts from around the world and I found myself being involved in many robust discussions about the design within SCIRT.

I was surprised how much I enjoyed this style of forensic research into the origins of engineering codes and the background data behind them.

It was eye opening to discover the majority of flexible pipeline codes used around the world are based on an American research paper called 'Modulus of soil reaction (E') Values for buried flexible pipe', Howard (1977). Also, research which looked at the strength of liquefaction

New pipes alongside old pipes

"We found there were some challenges when designing the new pressure main especially around the ground conditions. Although there has been a considerable amount of study of earthquakes and seismic stability of buildings and vertical structures, there were surprisingly few examples in New Zealand of the tested performance of underground pipelines in seismic conditions."

was mainly based on above ground 'unconfined' embankments and dams where the soil had more opportunity to move and relax. However, we were looking at underground pipelines which were confined giving a larger factor of safety and greater confidence in the design principals we had established.

Along with research, the senior engineers in SCIRT were essential mentors who actively challenged me in my designs and methodologies throughout all my projects.

As part of a knowledge sharing initiative at SCIRT, international experts with experience of seismic effects on public infrastructure were invited to discuss potential solutions. These discussions included representatives from the Los Angeles Department of Water & Power (LADWP), Kobe City, Kyoto University and the University of Canterbury.

The opportunity to talk about issues around seismic design and resilience with those who have first-hand global experience was invaluable to me. Open, honest and robust discussion around our design gave me confidence in the methodology and principals we were adhering too. It also opened my eyes to the challenges that had been faced elsewhere; something which would become the new reality of pipeline design in New Zealand.

After my discussions with numerous international experts it was decided that a method of keeping the ovality of the pipeline in such events was required. This meant using a geo-grid and textile wrapping, similar to a gabion basket that would resist horizontal and vertical deflection in the pipeline when the soil strength was reduced due to liquefaction. In order to prove that this would work we undertook a physical test of the methodology. For me, testing the design was essential to ensure it was understood.

Testing involved using three lengths of GRP pipe with different trench constructions. The first construction was using a geo-grid and geotextile wrapping, the second was with geotextile wrapping only and the third was with a standard backfilled trench without any geogrid or geotextile. We tested the most extreme case of liquefaction, simulating the complete loss of side support; by proving that the materials coped in this situation, we could be satisfied that any increase in side support would increase resilience.

Above – Wrapping pipes; Above right – Testing; Below right – GRP Ribs

Analysis of the testing results showed that the geogrid gabion type trench resisted changes in ovality and resulted in a reduction of 30 to 40% in vertical deflection when compared to the geotextile and standard trench details. However, testing also revealed that even after three days of complete loss of side support all three trench constructions showed less deflection than allowable limits. This gave me great satisfaction that the design we had spent time perfecting would better withstand any future quakes.

Our innovation also extended to the use of geo-grid thrust blocks which help to strengthen the trench and minimise differential settlement. Previous concrete thrust blocks had been seen to cause cracking and pipe fracture in other places from settlement.

Christchurch City Council had previously used geo-grid reinforced aggregate thrust blocks for GRP pipe outside Pump Station 11 and these had performed well in the quakes.

Using information from these previous thrust blocks and research gained from similar blocks used in Japan, a new design for geo-grid reinforced aggregate thrust blocks was developed. This was designed using static analysis and finite element

"Analysis of the testing results showed that the geogrid gabion type trench resisted changes in ovality and resulted in a reduction of 30 to 40% in vertical deflection when compared to the geotextile and standard trench details. However, testing also revealed that even after three days of complete loss of side support all three trench constructions showed less deflection than allowable limits. This gave me great satisfaction that the design we had spent time perfecting would better withstand any future quakes."

analysis. GRP ribs were also added to the bends to give added cohesion between the trench backfill and the geogrid thrust blocks. This provided extra safety against joint displacement due to thrust.

Team Effort

Working in SCIRT is like working for the United Nations; along with all the Kiwis, you have people from all over the world with years of combined knowledge from different projects, places, experiences and challenges. Each person brings a different flavour of their world to SCIRT, which was a real eye-opener.

Throughout the design and development of the new Pressure Main 11 there were more than 30 people from nearly 20 different consultancies, delivery teams and client organisations working as one team. Without a doubt, I put success down to the energy, commitment and determination of the people at SCIRT and their common goal of 'creating resilient infrastructure that gives people security and confidence in the future of Christchurch'.

Personally, SCIRT has challenged and stretched my understanding of wastewater network design, looking beyond code to first principles and combining this with a greater understanding of seismic risk; not something we consider when designing pipes in Northern Ireland. Working with so many stakeholders, designers and contractors has also meant a change in how I communicate. At home in Ireland, there is a stricter hierarchical approach to design and construction. When each stakeholder has their own silo, innovation can be restricted and challenging the status quo is sometimes seen as disturbing the peace. That's not the case here.

The high-performing team atmosphere created at SCIRT enables open and honest communication which leads to the delivery of projects like the new Pressure Main. If I take one thing away from this, it is that no two people communicate in the same way. To be great engineers we need to engage with all people, in their own way. In order to innovate we need to break down barriers to communication and challenge the norm. Always ask: why?

The Future

People often ask me if I have any regrets of swapping one beautiful country for another, or leaving my old life behind. The opportunities that have been given to me through working at SCIRT have led me to engage with the engineering fraternity and the public as IPENZ Canterbury Chair, serving a membership of over two thousand engineers to further innovation, sustainability and security through engineering.

Being involved in the heart of the rebuild continues to give me an incredible insight into the undeniable passion that engineers have to build a better world for the people of Christchurch. I am looking forward to the exciting challenges as the rebuild ramps up over the next year and the opportunities for all engineers to drive the industry forward.

So, I don't look back. I only look forward to the next challenge.

Chris Maguire – Waste and Water Engineer, MWH Global

Innovative Wastewater System for Rural Campus

Paul Riethmaier – Director, Reflection Treatment Systems Limited

Smart thinking and cost-effective solutions were top of the task list for Auckland-based Reflection Treatment Systems during the design, manufacture and installation of a new wastewater system at in Mangatawhiri.

Located at the base of the Hunua Ranges south of Auckland, the 15ha property had once been the site of the now liquidated Hotel du Vin. In 2009 the property was purchased by Dilworth Trust, the funding board for Auckland's Dilworth School, and today is home to the Dilworth Rural Campus. Also known as Te Haerenga, the campus currently provides an innovative rural and outdoor experience for 150 Dilworth resident students and staff, with the capacity to go up to 300.

When developing the campus, Dilworth Trust required a wastewater treatment and disposal system that would be more sophisticated, environmentally-friendly and cost-effective than the aeration wastewater plant the Trust had inherited upon ownership of the site.

The old system had provided secondary treatment for the former hotel and the adjacent winery; the new system had to cope with fluctuating usage and a wider range of flows. It also needed to address some of the old system's negative features – excessive noise, environmental risk to the Mangatawhiri River which runs through the site, and lower than optimum effluent quality given the higher and more variable and intermittent flow expected from the school. And odour levels had to be kept at an absolute minimum.

Reflection Treatment Systems won the tender for the design, manufacture and installation of the wastewater treatment plant and disposal hydraulic designs, and geotechnical engineering consultancy Soil & Rock Consultants undertook the design of the disposal area. The Trust appointed Thorburn Consultants (NZ) Ltd as the engineer for the overall contract, including design of services and resource consenting.

Commencing design work on the new wastewater system in September 2011, Reflection Treatment Systems was faced with some complexities that needed to be cleverly dealt with at the design stage.

Firstly, and of paramount importance, was Dilworth Trust's requirement for the new system to include as much of the partially degraded existing infrastructure as possible. Reflection Treatment Systems' design incorporated an existing grease trap, three wastewater tanks, five open-topped aeration tanks and two pump tanks from the old system. All required modifications, upgrades and/or additions.

Functioning of the existing grease trap was inadequate. Although in theory its volume was 4000 litres, drain inverts at half depth prevented it from operating at more than half its capacity. The solution was to retain the existing grease trap as the first chamber and, adjacent to it, add a second 5000 litre, three-chamber trap.

The solution has proved highly successful for the campus despite bringing a 'level of anxiety' for the wastewater team at the time of installation.

"The site for the new trap was in a narrow space between two of the school's buildings, one of which housed an expensive curved-glass reception area. It certainly called for a high level of skill and care from our excavator operator and installation team to reach the great outcome that was achieved in such a tight space," recalls Reflection Treatment Systems owner, Paul Riethmaier.

The three 22,000-litre mortar tanks previously used for the winery's wastewater had been partly eroded by the acidic nature of the wastewater. They were cleaned, sprayed with 40mm of concrete to line their interiors and each tank was fitted with a new inlet/outlet square function and Zoeller effluent solids filtration on the outlets.

The Reflection team cleaned out the five rectangular aeration tanks prior to interconnecting them at their bases to form one new recirculation tank. Concrete roofs, manufactured by Atlas Tilt Slab, sealed the open-tank tops and provided access for cleaning and for components such as the inlet, outlet, ultrasonic gauge and low-level control valve.

Two 2.1m diameter x 4.5m deep manholes had previously been used as pump tanks for feeding sewage to the aeration process and winery wastewater to tanks. In the new design, these were made into one pump station with double the capacity by interconnecting both at their bases.

> "The old system had provided secondary treatment for the former hotel and the adjacent winery; the new system had to cope with fluctuating usage and a wider range of flows."

To comfortably handle the wastewater when the school reaches full occupancy, the new system must cope with a throughput of 40,000 litres a day on weekdays, 6000 litres a day every other weekend, and between zero and 6000 litres a day for staff during student holidays. To best serve the school's fluctuating throughputs, Packed Bed Reactor technology was chosen to replace the old aeration system.

After considering both recirculating textile and sand filters, Dilworth Trust opted for the Reflection Sand Filter System, despite the technology being less contemporary than that of textile filters. Paul Riethmaier says, while some may see this as a surprising choice, it is the option he supported wholeheartedly.

"Although we supply and install both textile and sand filters, and provided the Trust with both options, we fully backed the Trust's decision: the sand filter is a more forgiving media. And what strongly influenced the Trust was the effectiveness of the Reflection Sand Filter System at the houses of the former St Stephen's College and how clearly it met the requirements for the Dilworth Rural Campus system."

To comply with resource consent, the disposal system needed to mitigate the risk of wastewater spilling into the historic and environmentally-sensitive Mangatawhiri River which dissects the site.

The former vineyards had been planted on both sides of the river in areas providing good drainage and optimum soil for grape growing. The poorer draining of the two vineyard areas 700 metres from the treatment plant was made available for wastewater disposal. Typically, this area had 100mm of topsoil over greyish brown silt. The vineyard had mole-ploughed 600mm-deep drains into open water table drains exposing the risk of wastewater short circuiting into the open drains and ultimately into the river.

Left – Completed sand filter sits passively alongside the school grounds; Right – Existing open top tanks converted to sealed recirculation and disposal tanks housing: pumps, control valves and ultrasonic depth gauge

Soil & Rock Consultants' design mitigated the risks by UV treatment of wastewater and by collapsing and compacting the moleplough drains under a bund constructed to prevent surface flows to the drains. To comply with resource consent, regular monitoring, sampling and analysis of the drain, ground water and river is undertaken.

Disposal was at 5mm/day via a 12 zone pressure compensating dripper into the bunded former vineyard area 200 metres away from the river. Additional mitigation of risk to the river was provided with plantings at 1m spacing to loosen the soil structure and provide significant evapotranspiration during the several years loading at 2.5mm/day before the school is at full capacity. The selected pump head provides l.l litres/s at 54m head.

Reflection's design resulted in an easy-to-manage, self-controlling plant with generous built-in capacity. The system has more than adequate septic capacity ($110m^3$) for long periods prior to pump-out, and six Zoeller commercial effluent solids filters minimise solids carry over, resulting in long periods between cleaning. Ultrasonic depth measurement of the recirculation tank self-adjusts throughputs, reducing the pump's down time as levels rise and, when recirculation tank levels are low, sand filter output is directed for recirculation by a low-level ballcock valve. The sand filter is designed at 133mm/day load versus 200mm/day 'allowed'.

Promag flow measurement is linked to telemetry which provides daily emails to report discharge volumes and allows remote text inquiries. Dilworth Trust's requirement for the system to minimise noise and odour was well and truly met.

"Keeping noise to the lowest possible level was critical. The blower room had housed a safe for previous owners, presumably because the noise from the blowers was considered so loud it would be a preventative to would-be thieves entering the room!

"The noise must have exceeded 100dB! Now the system's only moving parts are the intermittently operating pumps which are submerged inside concrete tanks and produce zero detectable noise," says Paul Riethmaier.

Minimising unpleasant odours was also key. Because flow levels of the old system had been low, there had not been a significant problem with unpleasant odours but, with the school's envisaged peak flow of $40m^3$/day, they were sealed for their role in the new system. Now, when liquid levels rise in the tanks, air is expelled through activated carbon filters keeping odour to an absolute minimum.

Dilworth Trust's Project Coordinator, Martin Thomson, says that the campus had just started its second year of operation and the system is working well for them. Reflections has shown to be responsive to the client's requirements in supplying a system that is both cost effective and meeting the operation needs.

ENVCO Global Now Official Service and Supply Agents for WTW Online Instrumentation Downunder

Australasian company ENVCO Global has been appointed official supplier, service and support agent for WTW Online Instrumentation, a world leading manufacturer of wastewater treatment technology.

WTW has had an international reputation for the design and production of quality water testing instrumentation world-wide for more than 55 years, and today provides some of the World's broadest and most highly accepted product Lines for wastewater and drinking water infrastructure.

ENVCO Global Director Richard Morrow said that from 1 January 2013 the company will provide all sales and support for WTW Online Instrumentation, including servicing and maintenance services like membrane cap replacement and sensors.

> "WTW has an international reputation for the design and production of quality water testing instrumentation world-wide..."

WTW offers a complete line of pH/ORP, D.O., Conductivity, Nitrogen, Carbon, Phosphate and unique self-cleaning Turbidity instrumentation, as well as comprehensive accessories for the measuring and control of wastewater.

The dependability, reliability, and versatility of WTW field proven Ammonia, Phosphate, Nitrite and Nitrate Analyzers, probes, and pH, ORP, D.O., and Conductivity systems and meters have established WTW products as industry standards world-wide.

To have the endorsement of WTW here Downunder is a tremendous endorsement for ENVCO Global's practice of making a comprehensive range of environmental equipment more accessible, and affordable.

"In this way we make a solid contribution towards helping to improve the sustainable management of our natural environment and create a strong legacy for future generations," said Mr Morrow. ■

Earthquake Liquefaction Damage Response

Hynds Limited has signed an historic partnership with Nippon Hume International Ltd in Tokyo allowing the introduction of a retrofitted Floatless Manhole system. The system dramatically reduces earthquake damage, subsequent infrastructure repair costs, and is easily fitted to any existing concrete manhole at risk of floating during a seismic event.

In January 2012, Hynds undertook a study tour of Japan looking at seismic resilient technologies with the intent to invest in products that prevent infrastructure destruction, and protect people from injury.

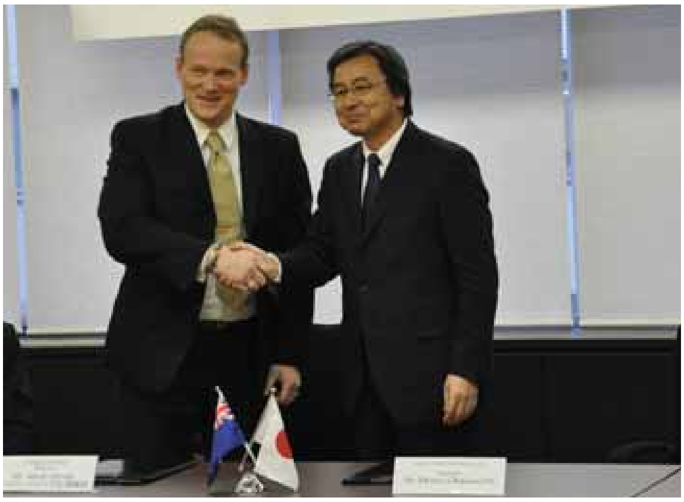
SCIRT was then consulted to determine their needs and ensure any product development was specifically suited to the effective rebuilding of Christchurch's infrastructure.

A relationship with Nippon Hume International developed throughout 2012 culminating in the formation of a Floatless Method Technical Assistance Agreement. The signing took place at the Tokyo Metropolitan Sewerage Service Corp on 10th December 2012.

Commencing this month, Hynds will be working with local councils and designated installers to progressively introduce this technology in to the NZ Market.

"We are very excited about our partnership with Nippon Hume International Ltd" says Hynds Limited Director, Aaron Hynds.

"They have many technologies able to minimise damage caused by seismic activity, and we look forward to introducing further products to prevent post-earthquake damage." ■



Top – Aaron Hynds shaking hands with Minoru Okawuchi, Director of Nippon Hume International Ltd; Above – Senior officials from other attending companies endorsing the Agreement

MWH Global Ensures the Future of Fiji's Roads

MWH Global is helping the Fiji Government improve its roading network.

Three new road maintenance contracts, with a combined value of $450 Million (FJD) have been signed with three experienced New Zealand Road Maintenance Contractors.

These appointments are the next step after MWH agreed a $25 million (NZD) contract with the Fiji Government to help them reform the country's road governance and operational practices. Since then, MWH has been assisting the Fijian Government to establish the new Fiji Roads Authority.

Under this contract, which began in January this year, MWH provides professional management services for the maintenance of the islands' road network which includes 5,000 kilometres of main roads (of which 4,000 kilometres are unsealed), 400 kilometres of urban roads,5,000 kilometres of 'other' roads (typically connecting sugar cane and forestry plantations), 900 bridges and 15 jetties. In addition to this MWH are also providing management and supervision services to approximately $600M (FJD) of new construction projects.

MWH Roading Network Manager Mike Rudge is overseeing the five-year contract.

"Since the start of this year MWH has been establishing the corporate structure and organisation of the Fiji Road Authority. We have worked hard reviewing how road maintenance and renewals are carried out. A key part of this review has been a move to outsource road maintenance contracts," says Mike.

"This will be the first time Fiji has committed to an ongoing program of maintenance and the renewal of its roads. One of the critical roles for the contractors will be to pass on their expertise to local workers and companies. We want these reforms to have a lasting effect rather than just being a Band Aid solution. So this also presents a great opportunity for local workers to upgrade their skills."

The three successful contractors are all New Zealand based companies and were selected after a thorough tender process that started in May this year. In total, proposals from 28 companies from around the Asia Pacific Region and Fiji were considered.

The contracts have a combined annual value of $120 Million (FJD) and have been awarded to Fulton Hogan, Blacktop Construction Limited and Higgins Group.

"This will be the first time Fiji has committed to an ongoing program of maintenance and the renewal of its roads. One of the critical roles for the contractors will be to pass on their expertise to local workers and companies. We want these reforms to have a lasting effect rather than just being a Band Aid solution. So this also presents a great opportunity for local workers to upgrade their skills," says Mike.

The contracts will start on 1 January 2013 and will be for four years with a right of extension for a further one or two years.

Waste, Water and Amenities Award

MWH and the Hastings District Council have been awarded for their project *Hastings Wastewater Treatment Plant: A Paradigm Shift in Wastewater Planning and Treatment.*

The successful completion and proven operation of the upgraded treatment plant commissioned in 2009 marked the end of a long journey described by the Coastal Permit/Resource Consent Hearings Committee in their decision as "a remarkable and probably historic accord between tangata whenua and local government." The journey has resulted in considerable engineering and planning innovation.

At the treatment plant a modified biological trickling filter without primary treatment or secondary clarifiers is used as an alternative to more traditional primary and secondary treatment of municipal waste. A low energy process treats the human waste into biomass, carbon dioxide and water which is then discharged through to the ocean through a rock lined channel.

"This project offers a simple low-tech solution that satisfies the many demands of the local community including the tangata whenua," says awards judge Andrew Read of Pedersen Read Consultants in Christchurch.

"Sometimes the best engineering is the simplest."

"I was very attracted to this project," says awards convenor, Bill Darnell. "It was a well worked through adaptation of proven methodologies to produce a very cost effective solution that recognised cultural sensitivities. A great solution for this local authority and one that has already been used by other Councils."

Hastings District Council, (HDC) group manager for asset management, David Fraser says, "In my experience very few engineering projects demonstrate both true innovation and excellence in delivery. On this project MWH, working closely with HDC staff, supported by excellent workmanship by DownerEDi as the main civil contractor unquestionably achieved that."

The wastewater treatment method has now been successfully implemented by the Gisborne District Council. Napier City Council and Grey District Council will soon follow suit.

The Water Waste and Amenities Award recognises recent activities associated with reliable supply of services to communities and/or their distribution networks in respect of any of water supply, water storage, wastewater, flood works and community amenities

Initiated in 2005, the New Zealand Engineering Excellence Awards are the premier awards for the engineering professionals of New Zealand.

Receiving the award left to right – Desmond Parkinson – MWH NZ, Hastings, Nick Smith – Awards presenter, Brett Chapman – Water Services Manager: Hastings District Council, David Fraser – Group Manager: Asset Management, Hastings District Council

The Next Generation in Sewer Leak Detection

City Care has brought a revolutionary leak-finding technology to New Zealand through its new licensing agreement with California technology company, Electro Scan.

Initially deployed in Christchurch as part of the infrastructure repair work following the earthquakes, the leak-finding technology works by passing an electric current through full pipes to discover leaks with pinpoint accuracy.

A pipe which leaks water will also leak electricity, so when an Electro Scan user sends a current through a full non-metal pipe (for example brick, cement, reinforced concrete, plastic, pipe-lining resins, etc), they are able to measure the variation of electricity passing through the defects. This allows the automatic location and quantification of cracks, fractures, defective joints or faulty service connections. This is used to measure the water infiltration and outflow exfiltration in wastewater and stormwater networks and pipes of various sizes.

Electro Scan measures potential leaks (litres/second) for any section of existing, newly installed or renovated pipes – including cracks, joint defects, poorly connected service laterals and manholes.

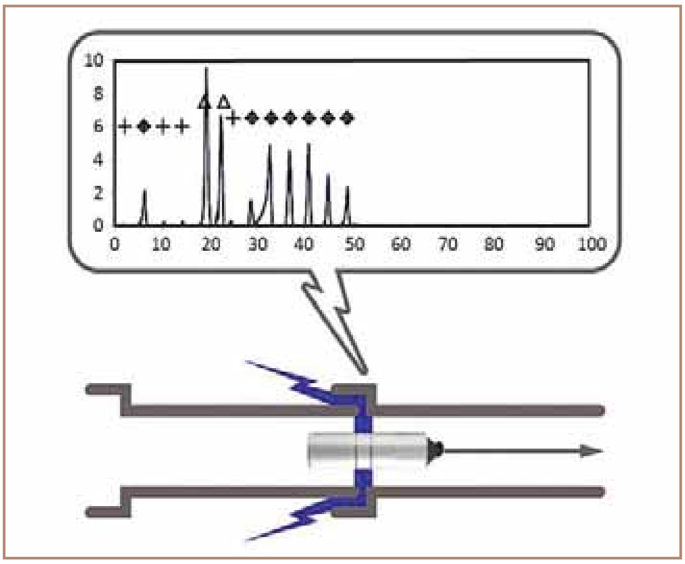


Figure 1– X-Axis = distance travelled, Y-Axis = conductivity

In addition to confirming the location of leaks, the technology also indicates the rate of leak. The bigger the electrical flow from the defect, the bigger the defect, and the bigger the leak potential. The type of defect as detailed in Figure 1 is shown by the pattern of the electric current in the graph.

Using saline water to surround its probe to transmit electricity to the pipe wall,

Electro Scan provides a 360-degree assessment of most sewer mains and stormwater and service drains. Due to its accuracy and sensitivity in locating defects, without relying on visual observations, Electro Scan is capable of establishing a condition assessment of each pipe joint, at an operating rate of up to 10 metres per minute.

Data is electronically captured by the probe, which is pulled manually or via a motorised CCTV tractor unit through the pipe. Immediate in-field analysis is available and the information is stored for more detailed analysis later off-site. Data is automatically sent to the Electro Scan Smartphone application and transmitted to a hosted cloud computing application, known as CriticalSewers.com.

"A pipe which leaks water will also leak electricity, so when an Electro Scan user sends a current through a full non-metal pipe (for example brick, cement, reinforced concrete, plastic, pipe-lining resins, etc), they are able to measure the variation of electricity passing through the defects."

City Care's Underground Contract Manager, Hugh Blake-Manson, believes this technology will deliver significant benefits for asset owners and managers. "Infiltration is a major concern for asset owners. The increased flow immediately costs more to pump, reduces their storage time during high flow periods, and reduces the effectiveness of treatment plant. The potential for pump station overflowing into natural watercourses is also increased. Infiltration is normally an issue with high ground water levels and during winter wet-weather events.

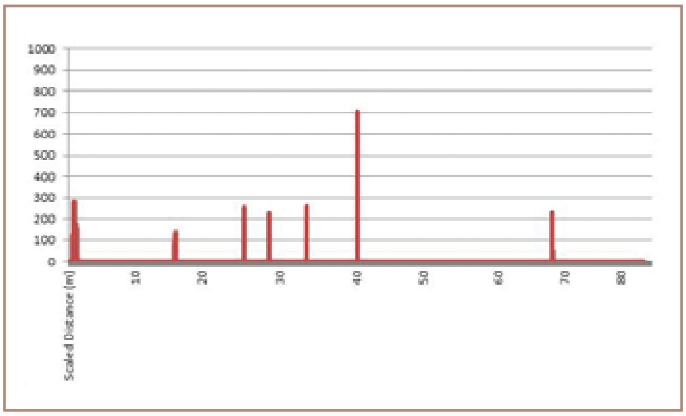
"Electro Scan will provide valuable pre- and post-rehabilitation diagnostics to local authorities, and therefore to ratepayers," he said.

According to Blake-Manson, Electro Scan will prove a valuable complement to CCTV analysis, and in particular situations will provide the only solution, especially where pipes are permanently submerged – for example siphons.

"CCTV takes much longer, due to the necessity to send the tractor down empty pipes. Operators need to stop and camera the defect, thereby reducing the inspection rate and the job productivity.

"Based on City Care's recent trials, Electro Scan is averaging over 10:1 leak identification compared to CCTV. That's an impressive

Figure 2 – A typical Electro Scan profile showing defects, with different levels of severity along the length of the pipe measured



Left – An Electro Scan unit set up next to a manhole on Beach Road in Akaroa; Below – CCTV image of sewer pipe – many leaks are not detected using standard video inspection methods; Bottom – The Electro Scan reading can be automatically sent to a Smartphone via Bluetooth

result, and we're very enthusiastic about the technology. We'll still use CCTV where visual identification is required, for instance in assessing pipe wall condition, but Electro Scan will provide additional powerful information to the asset owners. They can then use this information to deliver very effective, targeted repairs and renewal – a key part of their long-term planning."

Figure 2 shows a typical Electro Scan profile – from a run in a wastewater network. The asbestos cement pipe was jetted and cleaned, CCTV-ed against the NZ Pipe Inspection Manual, then filled with water and Electro Scanned. The line at 40 meters showed a major defect, which CCTV operators did not pick up.

About City Care

City Care is a major provider of construction, maintenance and management services across New Zealand's infrastructure assets; maintaining over 19,000 KMs of piping networks to 24% of properties throughout the country. As one of the five contractors comprising Stronger Christchurch Infrastructure Rebuild Team (SCIRT), City Care is heavily involved in reconstructing the region's catastrophically-damaged underground services. The company's earthquake-honed construction capability is being implemented into its contracts with existing and potential clients.

Mono Pumps (New Zealand) Appointed as Sulzer Pumps' Distributor in New Zealand and Pacific Islands

In November 2012 Mono Pumps (NZ) Company was appointed, the major distributor for Sulzer Pumps throughout New Zealand and the Pacific Islands, bringing together two respected names in engineered pump solutions.

Mono Pumps has been providing high pressure pumping solutions to the agricultural, industrial, food and beverage, and waste water sectors in New Zealand for more than 30 years, with pumps, solid waste grinders and screening systems designed and manufactured by Mono at its manufacturing and research facilities in Manchester and in Melbourne.

Mono Pumps (NZ) is part of the worldwide NOV Mono® Group, one of the world's leading providers of specialised water and waste water solutions and products with facilities in Australia, United Kingdom, United States of America, France, Argentina and China.

Sulzer Pumps is one of the world's leading pump manufacturers, recognised for state-of-the-art, energy efficient and high performance pumping solutions. The company provides a wide range of pumping products, services and related equipment for the oil and gas, hydrocarbon processing, power generation, pulp and paper, water and wastewater, and general industries. Sulzer Pumps has a network of 21 manufacturing facilities worldwide and sales offices and service centres in 150 locations globally.

General Manager of Mono Pumps (NZ), Shazad Ibnul, says the arrangement with Sulzer Pumps brings an exciting and additional capacity to the New Zealand organisation. "Together, we now have the ability to provide high volume pumping applications for farming, irrigation, mining, general industry, large scale water supply and power generation," he says.

Mono Pumps has been providing pumping, aeration, grinding and screening products to the wastewater sector in New Zealand for over three decades.

This includes the Seaview wastewater treatment plant upgrade in Wellington; the upgraded Army Bay wastewater treatment plant which is responsible for treating wastewater of the rapidly growing area north of Auckland, and the Thames Coromandel District Council's Eastern Seaboard wastewater treatment plant upgrades.

Mr Ibnul says that Mono Pumps also leads agricultural pumping solutions with its range of high performance dairy effluent pumps which are revolutionising dairy farming methods throughout the country.

"New Zealand dairy farmers in particular, recognise that Mono's progressing cavity (PC) pump systems are more powerful and cost effective than centrifugal pump systems. Mono's PC pumps are enabling farmers to beat rising energy and maintenance costs while also providing a far superior method of managing effluent irrigation management," he says.

For further information contact Shazad Ibnul, General Manager, Mono Pumps (NZ) Limited, NOVMono®, www.monopumps.com Ph: +64 9 829 0333, Mb: +64 27 496 0784 or shazad.Ibnul@nov.com

Beca – Celebrating 50 Years in Christchurch and 50 Years of Public Health and Environmental Engineering in New Zealand

Humphrey Archer – CH2M Beca Ltd

Not many New Zealand engineering consultancies can look back over half a century of unbroken service to our water and wastewater industry. Beca is one of these.

In 1989, Steven, Fitzmaurice and Partners merged with Beca Carter Hollings & Ferner (BCHF) Ltd to form Beca Steven which specialised in water, wastewater and environmental engineering projects. In 1996 CH2M Beca Ltd was formed to provide consulting engineering services and full project delivery to New Zealand's municipal water and wastewater industry. These companies can trace their legacy back a couple of decades to two of our water and wastewater engineering pioneers.

The fifty year Beca presence in Christchurch – and the start of national service to this important sector – can be traced to late 1962 when Leicester Steven founded his practice in his home city. Staff joined the practice during 1963.

In 1964 Leicester was joined by John Fitzmaurice who opened an office in Auckland. Together they practiced under the name of Steven and Fitzmaurice, providing specialist consulting services in public health engineering to local authorities, industry, and to other consultants.

Both partners had been senior engineers with large metropolitan drainage authorities in New Zealand, both had undertaken postgraduate study in public health engineering in the United States, and both gained further experience working in San Francisco for the consulting engineering practice of Brown and Caldwell.

The early sixties was a time when the pressing need for improved sewage treatment facilities was being widely recognised. The practice soon gained a reputation in this field and attracted commissions throughout New Zealand.

The original partners were joined by David Wilkie in 1971 and by Graeme Leggat in 1978, whereupon the name was changed to Steven, Fitzmaurice and Partners, Consulting Civil and Public Health Engineers. Humphrey Archer and Garry Macdonald joined these four partners in 1987, two years before the merger with BCHF Ltd to form "Beca Steven".

Major municipal projects delivered by Steven and Fitzmaurice, Beca Steven and CH2M Beca include wastewater treatment plants at Mangere (Auckland), North Shore, Hamilton, Tauranga, Gisborne, Napier, Hastings, New Plymouth, Palmerston North, Levin, Hutt Valley, Nelson, Blenheim, Christchurch, Timaru, Oamaru, Dunedin and Invercargill. Water supply projects include Project Waikato (supplying water to Auckland from the Waikato River), Joyce Road Microfiltration Plant, Whangamarino, New Plymouth, Kapuni (South Taranaki) and Blenheim.

Water New Zealand Conferences & Events

Water New Zealand Backflow Conference 2013

18 – 19 April 2013

Hotel Grand Chancellor, Auckland, New Zealand
For more information visit www.waternz.org.nz
or contact Amy Aldrich amy.aldrich@waternz.org.nz

Water New Zealand 8th South Pacific Stormwater Conference 2013

8 – 10 May 2013

Rendezvous Hotel, Auckland, New Zealand
For more information visit www.waternz.org.nz
or contact Amy Aldrich amy.aldrich@waternz.org.nz

Water New Zealand Annual Conference & Expo 2013 – Changing Currents

16 – 18 October 2013

Claudelands Event Centre, Hamilton, New Zealand
For more information visit www.waternz.org.nz
or contact Hannah Smith hannah.smith@waternz.org.nz

For more information on *Water New Zealand* conferences visit www.waternz.org.nz

Other Conferences

2013 NZ Land Treatment Collective Conference

10 – 12 April 2013

Marlborough Convention Centre, Blenheim, New Zealand
For more information contact Marie Dennis
nzltc@scionresearch.com

2013 Australian Water Association Conference – OZWATER'13

7 – 9 May 2013

Perth, Australia
For more information visit www.ozwater.org

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FrankPKS are specialists in the design and manufacture of long-life, strong, lightweight and flexible HDPE piping solutions that can be custom built to suit the nature of the environment.
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