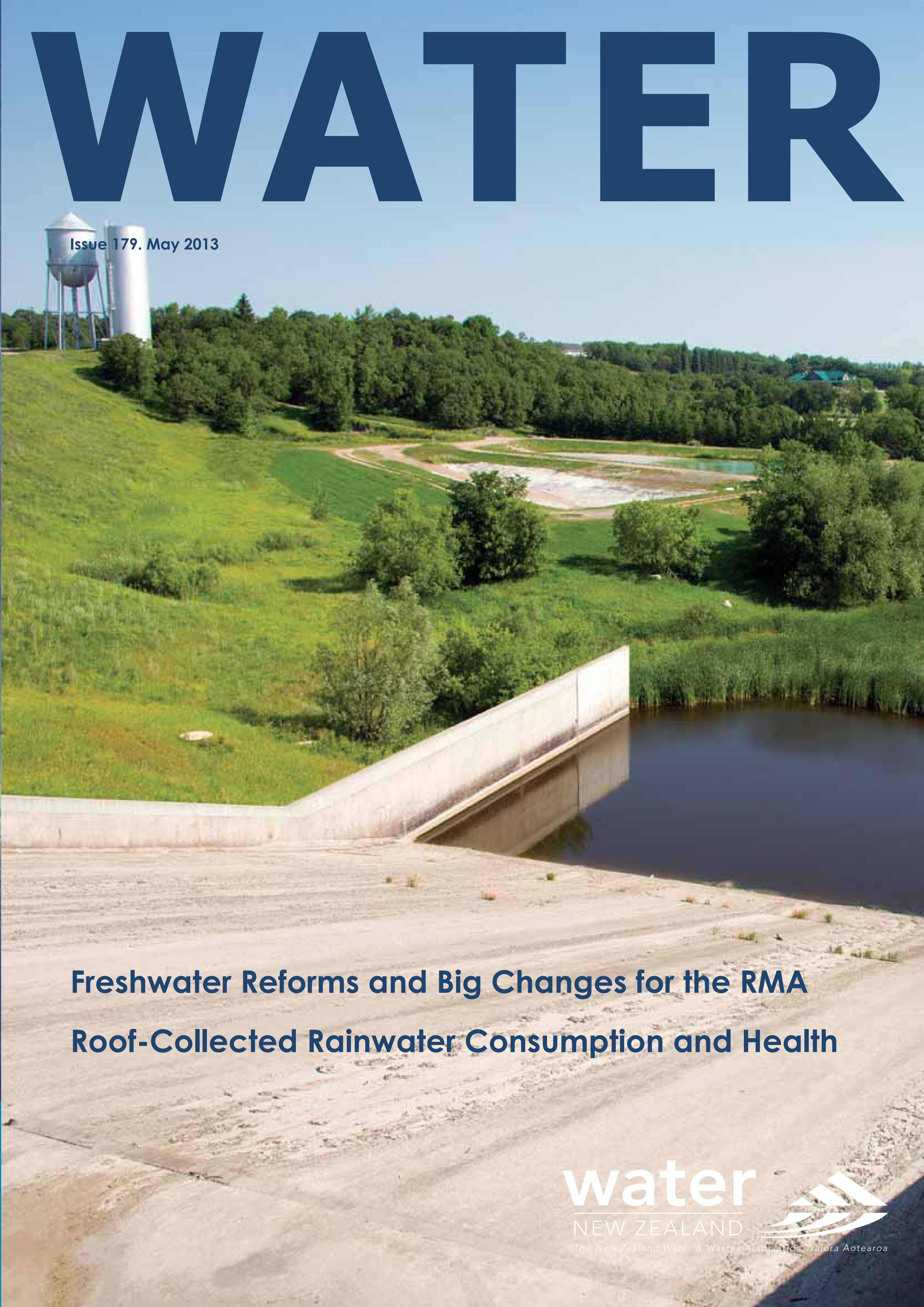
WATER

Issue 179. May 2013



Freshwater Reforms and Big Changes for the RMA

Roof-Collected Rainwater Consumption and Health

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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 July 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

Initiative Needed to Attract Younger Members

As with any member organisation it is important to know where your members are coming from, what they think of the organisation and the services provided. They need to derive value from their investment. Otherwise there would be little point in joining or remaining members.

"It was as a result of conversations among Water New Zealand board colleagues that we decided it is time to review our relevance to our younger members and evaluate the potential untapped membership that is out there."

Over the years the association has undertaken several surveys of member satisfaction and attempted to highlight where we are succeeding and where we can improve. One area of recent board discussion has been the demographics of our membership and how we might be able to make ourselves more attractive to younger professionals who are working in the water field.

I recently attended the IPENZ annual Engineering Leadership Forum and associated workshops where student members from the different tertiary institutions across New Zealand were invited to provide short presentations, answering questions on the relevance of IPENZ to them.

This was an excellent initiative as it provided untainted and honest feedback on the attractiveness and relevance of that organisation to our future engineering leaders. It will allow IPENZ to better understand their younger customers so that they can better plan for the future.

It was as a result of this and conversations among *Water New Zealand* board colleagues that we decided it is time to review our relevance to our younger members and evaluate the potential untapped membership that is out there. We agreed at the February board meeting that we would start with Auckland and look to establish a regional young person's group in order to provide feedback and to organise local events.

In April, board members Dukessa Blackburn-Huettner, Adrian Hynds and I each nominated a young person from our organisations and attended a meeting with them to discuss and set up this regional initiative. The meeting was attended by keen young professionals from Auckland Council – Anmar Taufeek and Phillip Johansen, Hynds – Jacob Lee, AWT Water – Emmanuel Rochais, and GHD – Simonne Elliot. Watercare are also looking to nominate someone to join the group in the near future. I congratulate this team and we are looking forward to working with them to increase the regional activity in Auckland along with the feedback dialogue it will hopefully create.

This group is open to any others who would like to get involved – so if you are a young member and interested in getting involved please contact Anmar – Anmar.Taufeek@aucklandcouncil.govt.nz and become part of this Auckland regional initiative.

WATER JULY 2013

The next issue of *WATER* will be published in July. The themes are Stormwater, Water Sensitive Design, Climate Change, and Flood Management.

Please contact the editor, Robert Brewer, robert@avenues.co.nz if you have any story ideas, contributions or photos. The deadline for the July issue is Monday 10 June.

To view the themes for 2013 visit www.waternz.org.nz under the Publication drop down box.

"I recently attended the IPENZ annual Engineering Leadership Forum and associated workshops where student members from the different tertiary institutions across New Zealand were invited to provide short presentations, answering questions on the relevance of IPENZ to them."

The challenge is to replicate this throughout New Zealand and our board will be discussing how we can catalyse this in the other areas. So if you live south of the Bombay's and would like to get involved please get in touch with Hannah Smith – hannah.smith@waternz.org.nz at the *Water New Zealand* national office.

The strength of our organisation is our people. We are unique in that we have a wide and diverse range of individuals from different backgrounds with a common interest in water and the water services sector. This is what brings us together. As the vehicle for this 'broad church', *Water New Zealand* is keen to ensure that along with providing advocacy and leadership for the sector, we also cater for the needs of the grass roots of our membership. ■

Steve Couper
President, Water New Zealand

new members

Water New Zealand welcomes the following new members:

RYAN PAK
TIM MCKENZIE
BRUCE FORBES
NICK WALMSLEY
DIANA KUHTZ
KAREN SANNAZZARO
EOGHAN O'NEILL
EMMANUEL ROCHAIS
CLIVE TOZER
BRIAN NORTON
WEN HOU
SIMON COLLIN
CRAIG MCCAULEY

Murray Gibb

To Irrigate or Not

The drought this summer demonstrated once again the vulnerability of the New Zealand's economy to climatic effects. The balmy months we've just had were good for holiday makers but not for farmers, and could knock economic growth by one per cent. This would repeat past experience. In 2008 as a result of drought and prior to the global financial crisis, New Zealand's economy was already in recession. The previous drought in 1998 had the same effect.

Climatic conditions affect our agricultural production. We are vulnerable because agriculture powers so much of New Zealand's economic base.

The figures speak for themselves. In dairying alone, last year's production provided a quarter of our merchandise export earnings.

Reliable water supply could drought proof some agricultural production and increase national wealth. Policy work undertaken by the NZIER suggests the economic benefit of irrigating the extra 347,000 hectares subject to current proposals, would generate an extra $4 billion in exports by 2026 in real 2010 prices. GDP would increase by 0.8 per cent by 2035.

The NZIER figures only calculate extra production from potentially irrigated land subject to investigation. Not included is any analysis of extra production from all of our potentially irrigable land.

Critics argue that the economics of irrigation proposals in the pipeline don't stack up, and point to potentially detrimental environmental impacts of intensification of land use.

Other points need to be brought to this debate. These include increased pressure on the world's land and water resource and New Zealand's relative abundance of both, the changing global food supply and demand nexus, climate change, and societal pressure.

Demand for food is expected to double over the next 40 years. More food is required to feed more people living in an increasingly urbanised world enjoying higher living standards.

But available agricultural land required to meet this demand is decreasing due to a number of factors, foremost of which are desertification and salinization of soils.

Desertification is widespread and advancing. The total affected land area is between 6 and 12 million square kilometres, out of the 48 million square kilometres of available agricultural land worldwide.

It is not generally known that nearly a third of the world's cropland has been abandoned in the past 40 years because erosion has made it unproductive.

Desertification leads to lowered food production, increased downstream flooding, lower water quality, and causes sedimentation of rivers, lakes and wetlands. It aggravates health problems and forces human migration.

The Food and Agricultural Organisation estimated 0.4 hectares of available agricultural land per person in 1965. The equivalent figure will be 0.17 hectares per person by 2030. That is less than half.

So land supply is decreasing, or, as some put it, we are past 'peak land.'

Freshwater supply is already under severe pressure in many countries through over-abstraction.

In an article published in Science in 1996 Postel[1] et al estimated human appropriation of freshwater at 54 per cent of runoff that was geographically and temporally accessible. Since then rates have increased. Through over abstraction groundwater levels are dropping in many countries, rivers are drying up and lakes are disappearing. These trends are simply not sustainable. Life itself depends on ecosystem services.

Add in the predicted effects of climate change and the picture gets worse. Modelling indicates drier areas will become even drier, and wetter areas will get wetter. Importantly, and in the context of this discussion, the drier irrigable eastern parts of New Zealand will get drier.

Earlier snow melt will reduce available water downstream for food production. That which falls on formerly productive land that has become desert or salinized is no longer immediately available.

So we are past 'peak water.' But much more will be required to be abstracted to meet future demand for food and urban reticulated systems.

The net effect is a global food supply system that is already under severe and increasing pressure, but will nonetheless require much more intensification to match demand going forward. Price signals will drive investment. Inevitably food prices will increase relative to household incomes. The upward trend began a decade ago, reversing a declining pattern that started with the agricultural revolution just prior to the beginning of the 19th century.

Where does this place New Zealand? We have a temperate climate, a skilled and entrepreneurial cadre of food producers, an economy based mainly round biological production, and relatively plentiful water. We have more land which could be irrigated.

Current price signals suggest there is no short term economic bonanza for investment in irrigation infrastructure. Recognising the value of water to New Zealand's economy, and taking the strategic overview outlined above, the government has stepped in, catalysing activity through the irrigation acceleration and equity funds.

Opponents suggest a poor rate of return on this investment. They ignore the global trends referenced above. When demand exceeds supply prices go up. In real terms food prices must rise, and will do so rapidly.

Opponents suggest further environmental degradation with intensification of land use. Again they ignore the big picture. The voting power base in New Zealand does not rest with irrigators, but rather the 86 per cent of electors who live in urban centres. Their number one environmental concern is declining water quality.

Successive governments have responded to their concerns.

These have already been given effect through the national policy statement on freshwater and the various clean up initiatives. The second round of Resource Management Act reforms will deliver the Land and Water Forum's vision of a national framework for water limits, given effect on a catchment by catchment basis through, if necessary, collaborative processes.

Taken as a whole these initiatives will provide wins for both the economy and the environment. ■

Murray Gibb
Chief Executive, Water New Zealand

Footnote

Postel,S., Daily,G.,& Erlich,P. Human Appropriation of Renewable Freshwater. Science, New Series , Vol 271, No. 5250 Feb.9 1996, 785-788. Retrieved 10 April 2013 from http://www.csrc.sr.unh.edu/~lammers/MacroscaleHydrology/Papers/PostelEtAl1996-HumanAppropriationOfRenewableFreshWater-Science.pdf

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 for your Diary

Registrations Open	**Monday 24 June**
Earlybird Registrations Close	**Friday 23 August**

Key Dates for your Diary

Authors advised of selection	**Monday 10 June**
Poster Summaries Close	**Monday 19 August**
Final Papers Due	**Thursday 22 August**
Powerpoint Presentations Due	**Friday 4 October**

Conference Theme

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

The programme will include general streams as well as specialist streams of Operations, Modelling, and IWA. The general technical streams will be divided into sub-streams.

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
- Young Author of the Year
- 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**

Registrations

Registrations will open via **www.waternz.org.nz** on Monday 24 June. An email and mailout flyer will be sent to *Water New Zealand* members and past attendees once registrations have opened.

Exhibition Sites

The Annual Conference Exhibition continues to be the largest trade exhibition for the sector with over 170 sites. Lunchtime demonstrations will also be held.

Poster Summaries – Submit Summaries Now

Poster presentations are always a popular component of the Annual Conference. Poster Summaries need to be submitted by Monday 19 August. Please visit **www.waternz.org.nz** for more information and to submit your poster summary online.

Premier Sponsors

The Annual Conference would not be possible without the valued support of our Premier Sponsors. *Water New Zealand* would like to thank and acknowledge the support of Applied Instruments; Citycare; Downer; Hynds; Veolia Water and Xylem Water Solutions.

Government to Invest An Additional $3 Million to Protect Lake Taupo Water Quality

Environment Minister Amy Adams has announced the Government will invest a further $3 million to ensure the long-term protection of Lake Taupo's water quality.

"Lake Taupo has significant economic, cultural and environmental value for New Zealanders. It is important that we continue to restore the lake's water quality so that people can make the most of this unique environment in the years to come," Ms Adams says.

The Lake Taupo work programme to date has been successful in getting land owners to change farming practices and significantly reduce the amount of nitrogen getting into the lake.

The extra funding will be used to achieve a 20 per cent reduction in nitrogen in the lake. High nitrogen levels in lakes and rivers can harm micro-organisms and cause algal blooms.

In total, the Government has committed $35.5 million to ensuring the long-term protection of Lake Taupo's water quality. Together with money provided by Environment Waikato and Taupo District Council, this forms a joint fund of $75.4 million.

"Improving freshwater quality and the way freshwater is managed is a priority for the Government, " says Ms Adams.

"Freshwater is one of New Zealand's most valuable assets and its importance – both to our economy and the environment – cannot be overstated.

"On an international scale, New Zealand's water quality is still among the very best, but we do not shy away from the fact that the quality has been declining in some of our lakes and rivers over many decades, and we must address this.

"That is why the Government has committed substantial funding towards cleaning up our most iconic waterways.

"The Government has already invested $101 million since taking office in 2008 into cleaning up historic pollution from our waterways." ■

Backflow Conference 2013 – Conference Report

The Backflow Conference 2013 was held 18–19 April 2013 at the Hotel Grand Chancellor, Auckland. The conference was opened by Labour's Spokesperson for the Environment, Maryan Street, who touched on some interesting points regarding water quality and the importance of backflow prevention throughout New Zealand.

Ms Street's presentation was not only informative for delegates but allowed the opportunity for delegates to provide feedback and further develop her knowledge of Backflow.

The conference also included two Australian presentations. The first, from Peter McLennan from the Backflow Association Australia, included an entertaining comparison of the Australian backflow industry and the American backflow industry and updated the delegates on what is going on in Australia. James Bowers from the Bidet Shop Australia opened the Friday morning with a presentation on bidets and backflow which is becoming a hot topic throughout New Zealand.

The programme also included:

- A presentation relating to backflow devices and problems encountered in the water/backflow industry as a result of the Christchurch earthquakes from Mike Baker
- A presentation from Jason Dyer on fire sprinkler systems
- an update on building compliance by Rose Mclaughlan from Auckland Council
- The development of online databases via smartphones and tablets by John Kan

The Backflow Committee rolled out the final version of the Code of Practice for delegates to provide feedback. Special thanks go to those who invested their time to develop the Code. This will be available on the Water New Zealand website shortly.

Nick Fleckney, Chair of the Backflow Committee, closed the conference with an update of the Committee's recent and planned future activities.

"The Backflow Committee rolled out the final version of the Code of Practice for delegates to provide feedback."

The Conference was followed by the Backflow Special Interest Group's Annual General Meeting which saw the election of the new Backflow Committee. The conference dinner was held at the Villa Maria Estate which included a wine tasting and vineyard tour.

Awards were presented to Tony Wellington for tester of the year, Diana Staveley for her efforts on the management committee and her contribution to the Code of Practice and Murray Ellis for his work in training testers.

Thanks to the delegates for their support of the event and the exhibitors; Hydroflow, Pentair, Reliance and Water Supply Products. Huge thanks to Water Supply Products, Hydroflow and Master Plumbers for their support with sponsorship. We look forward to seeing you at the next Backflow Conference.

The Stormwater Report will be included in the July issue of *WATER*.

Advisory Group Urges Big Shake-up of Local Government Water Services

Business Writer, Pattrick Smellie, reports that a Fran Wilde-chaired advisory group has released a report saying that all local councils should start charging ratepayers for both drinking and waste water by volume, while new water infrastructure should be delivered regionally because of its high cost for smaller communities.

The report was quietly released on the Department of Internal Affairs website, and is said by close observers to have been watered down to appease local government political sensitivities.

Among the most controversial recommendations is one that Councils should "consider moving delivery of potable water and wastewater to regional level, with the management and implementation of such delivery at arm's length from political decisions" by using a Council-owned corporate structure.

The original report recommended Councils be instructed to regionalise water services, rather than merely consider them.

Water New Zealand said in a statement it supported "rationalising water services and placing them at arms-length from local political control."

"However, the real concern *Water New Zealand* has is whether the reforms proposed by the expert group looking at local government infrastructure will be implemented," said Chief Executive, Murray Gibb.

"The need for reform has been known for a long time, but to date little progress has been made."

"Ratepayers and taxpayers will get improved services and better value for their money if the reforms are implemented. The proposals accord with industry best practice and should be supported," he said.

The EAG report also proposes creating a Minister of Water and ensuring that all water policy issues are led from one government agency.

"New Zealand has seven Ministries, eleven regionally based regulators and 67 suppliers with responsibilities for water, said Murray Gibb."

It also proposes that "where economically justified, metering and volumetric charging for water are implemented."

More broadly, the report recommends Councils should "consider amalgamation into unitary authorities with minimum populations of approximately 100,000." Figures in the report show some 75 percent of all local government entities are servicing populations of fewer than 50,000 people.

The report warns that New Zealand local government is currently not well arranged to handle the many hundreds of millions of dollars of new infrastructure which will be required over the next few years.

That's partly because Councils both small and large struggle to find infrastructure expertise, often fail to collaborate, and because of evidence that many New Zealand Councils don't plan or execute capital works projects efficiently, creating cost for ratepayers and the economy.

New Zealand has seven Ministries, eleven regionally based regulators and 67 suppliers with responsibilities for water, said Murray Gibb.

"Having 85 businesses providing water governance for a population of 4.4 million is plainly inefficient, and doesn't allow for a coordinated or strategic approach. By contrast, Scotland with a larger population has just four businesses doing the same job. Just one business delivers water services across the whole country," he said.

"Metering and volumetric charging has generally proven to be the most equitable way of funding water services, as has been found in Tauranga and Auckland" and still allowed water services to be publicly owned.

The report recommends the Local Government New Zealand umbrella group establish a "local government centre of excellence" service that could offer help across the country on looming major roading and water projects. ■

NEW ZEALAND ENGINEERING Excellence Awards
2013 Entries open

New Zealand Engineering Excellence Awards

Recognising Engineering Excellence

Initiated in 2005, the New Zealand Engineering Excellence Awards are the premier awards for the engineering professionals of New Zealand. The awards are presented in three major areas: Awards Recognising People, that recognise leadership, innovation, entrepreneurship and our young engineers; Project and Product Awards, that recognise achievement in the various industry areas, together with a Supreme Award for the best of the Project and Product winners; and Practice Awards that recognise a product, programme, project or a person demonstrating the application of engineering knowledge and skills to achieve excellence in safety, environmental protection or community engagement.

Entry and Judging Criteria for the 2013 Awards are now available. Entries close on 1 July 2013.

For more information about the awards on offer, entry and judging criteria, how to enter and key dates visit **www.nzeeawards.org.nz/2013/awards-2013.cfm**

WATER NEW ZEALAND Website

The new *Water New Zealand* website is up and running. It has been a huge task for the girls in the office, but it is working and we are very proud of our efforts. We welcome your feedback – email us via enquiries@waternz.org.nz

If you have not registered on-line, please do so by clicking on the link in the email sent to you on 26 March from *Water New Zealand*.

Water Meters "Worth a Look" – Tremain

Water meters and congestion charges are among proposals to cut local government costs.

Local Government Minister Chris Tremain says he is not ruling out recommendations made by a high-powered group tasked with finding ways to cut infrastructure costs.

The group, headed by Greater Wellington Regional Council chairwoman Fran Wilde, recommends water metering and changing the law to allow pricing on existing roads, opening the door to congestion charging.

It also proposes council-controlled organisations or corporate units to run water and transport infrastructure at arm's length from political decisions.

Mr Tremain said the proposals were not Government policy, but he was considering all but one of the recommendations – the one to create a Minister for Water.

"We are certainly going to take what they say seriously and have a good look at all the options they've got in there..."

"There is that argument that you can't manage what you don't measure. So there is a strong argument for measuring water consumption and other infrastructural components."

Labour's Hutt South MP Trevor Mallard said he was "very anxious" about the recommendations for water and transport council-controlled organisations which could be precursors for privatisation.

"The danger that I see in that approach is that it's not a big step from that to partial or full privatisation. The idea of selling off your roading and/or water systems is an anathema to the Labour Party."

Local Government New Zealand said last year it did not support the call for universal water meters.

"The assets providing water are owned by communities. Anyone moving to take control of them will have a fight on their hands," president Lawrence Yule said in August.

Ms Wilde said she was unable to comment on the report. It had been prepared for the minister, and it was up to him to speak.

> "Wellington Mayor Celia Wade-Brown said she had looked only briefly at the report, but water meters were completely unnecessary in the capital."

Wellington Mayor Celia Wade-Brown said she had looked only briefly at the report, but water meters were completely unnecessary in the capital.

Residents had already made it clear in a 2009 review that they did not want meters, and water use had trended down for the past five years, showing meters were not necessary to keep consumption down.

"To say we need water meters is not only unresponsive to what people have said but it's also unresponsive to what's actually happening."

Making Less Go Further in Featherston

Moving to a town with water meters has meant shorter showers and less hosing the garden for Maree McLeod. "It has definitely made us aware of our water use," she said.

> "Mr Tremain said the proposals were not Government policy, but he was considering all but one of the recommendations."

The McLeod family shifted a year ago from Wellington to Featherston, where most properties have water meters.

All South Wairarapa District Council residents pay an annual charge in their rates for 350 cubic meters of water per year per household. Any usage over that amount costs an extra $1.84 per cubic metre.

With two small children, 11-month-old Hannah and 2 1/2-year-old Alex, it was hard to keep water consumption under control, Mrs McLeod said. "But so far we haven't gone over the limit."

The family have bought a front-loading washing machine to save water. They cut back on hosing the garden, even before this year's outdoor watering ban.

"It was looking pretty droopy over summer, but so was everyone else's," Mrs McLeod said.

On the Kapiti Coast, plans to introduce water meters have encountered bitter opposition. Opponents presented a petition containing more than 7000 signatures to the council in November demanding a referendum. The council refused the request.

John Livesey, of Kapiti Concerned Citizens, said the group saw water meters as "just another tax".

"It's been very divisive for the community. We have got sufficient water – people don't go crazy." ■

Reform of the Management of Natural and Physical Resources Underway

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

"The Forum's core proposals – collaborative planning and a national objectives framework – are to be progressed immediately with others to follow in the months (and years) to come. What is signalled is that a number of matters require wider resource management and local government reforms which do not lend themselves to an immediate or quick response but require time to develop and implement."

Introduction

In our last article we covered the changes proposed in the Resource Management Reform Bill and signalled that this article would comment more fully on the Local Government Amendment Act and the Taskforce report. However, due to the recent release of two very important reform packages on resource management and freshwater management we have deferred commenting on the local government changes to our next article.

Freshwater Reform 2013 and Beyond

The Government has announced its proposed approach to reforming New Zealand's freshwater management system[1] and by the time this article goes to print the submission period (which was on a tight schedule) would have closed[2].

In general the freshwater reform package is based on and is (said to be) consistent with the Land and Water Forum's recommendations. The Forum's core proposals – collaborative planning and a national objectives framework – are to be progressed immediately with others to follow in the months (and years) to come. What is signalled is that a number of matters require wider resource management and local government reforms which do not lend themselves to an immediate or quick response but require time to develop and implement.

The key features signalled in the document are as follows:

Planning as a Community

Immediate Reforms	How
Include an optional collaborative planning process in the RMA, covering plan development, independent hearing panels, and limited appeal rights	Included in a Resource Management Reform Bill, to be introduced in 2013
Formalise a role for iwi in providing advice and formal recommendations, with a requirement for a council to consider that advice before making decisions on submissions, both for the new collaborative process and on Schedule 1 decisions relating to fresh water in a proposed plan	Included in Resource Management Reform Bill
Next Step Reforms	**How**
Provide national guidance and a support package on implementing the collaborative planning process	Guidance

A National Objectives Framework

Immediate Reforms	How
Make consequential changes to the National Policy Statement and/or other regulation making powers to facilitate a National Objectives Framework and consequential amendments to section 69 and schedule 3 of the RMA	Included in Resource Management Reform Bill
Develop regulation to implement the National Objectives Framework including national bottom lines	Regulation (national policy statement or other national instrument)
Next Step Reforms	**How**
Provide guidance and regulations to set clear national expectations and support limit setting under the National Objectives Framework, including managing outstanding water bodies and wetlands	Guidance and regulation

Managing within Quality and Quantity Limits

Immediate Reforms	How
Amend the RMA to ensure that councils can obtain information needed for accounting systems	Included in Resource Management Reform Bill
To account for all freshwater takes: make amendments to ensure the Government can require councils to collect data from all water users and share data with central government; use any standard accounting system developed; and adopt defined methods for estimating water takes	Included in Resource Management Reform Bill plus guidance
To account for all contaminants (for regional decision-making): make amendments to ensure the Government can require councils to collect data on all sources of contaminants and share data with central government; and adopt defined methods for estimating discharges	Included in Resource Management Reform Bill
Provide national guidance and direction on the setting of allocation limits covering all water takes	Regulation (national policy statement) and guidance
Develop sector good management practice toolkits	Guidance
Develop national guidance on implementing the national policy statement provisions on water efficiency	Guidance
Develop national guidance on the specification of water permits	Guidance
Review the Water Research Strategy	Refreshed Water Research Strategy
Provide national direction on accounting for sources of contaminants	Regulation
Provide national guidance on the use of models for managing freshwater quality	Guidance
Next Step Reforms	**How**
Provide national guidance on dealing with over-allocation	Guidance
Provide national guidance and/or direction on dealing with transition issues (quantity)	Guidance and/or regulation
Provide national guidance and/or direction on managing takes that do not need consents	Guidance and/or regulation
Provide national guidance and/or regulation on compliance and enforcement (quantity)	Guidance and/or regulation
Provide national guidance and/or direction on the choice of methods and tools to manage water quality	Guidance and/or regulation
Review the duration of permits	Policy to be developed

Next Step Reforms	How
Develop alternative tools for initial allocation of fresh water	Policy to be developed
Develop options for allocating permits on expiry	Policy to be developed
Facilitate transfer and trade for quantity	Policy to be developed
Develop new transfer or offsetting mechanisms for water quality	Policy to be developed
Develop incentives for efficient water use (both for quality and quantity): for example, pricing and standards	Policy to be developed

The immediate reforms will largely be included in the Resource Management Amendment Bill which is due to be introduced later this year (see below for more comment on these reforms) and in regulations (in relation to the National Objectives Framework). There will therefore be an opportunity for further input and comment on the specific proposals as they are developed.

Improving our Resource Management System

Similar to the freshwater reform package the resource management reforms signalled in the discussion document released in February[3] are said to be a 'reboot' of the system designed to result in:

...an easier to use, more predictable system with less duplication and cost, and that more effectively safeguards environmental, social and cultural outcomes. In short, the sustainable management purpose of the RMA would be met in a more effective and efficient manner[4].

At the time of writing this article submissions on the discussion document had closed[5] but as the proposals will be followed up by a Bill an opportunity to comment further will be provided when the legislation is introduced.

The reform highlights are:

- **Changes are proposed to sections 6 and 7 of the RMA in line with the recommendations in the TAG's June 2012 report.** A number of the current section 7 matters would be deleted, with the remainder moved to section 6.

> "While it is too early at this stage to say whether all of the proposed changes will survive the legislative process in their current form, what is clear is that there will be some changes and these changes will be designed to improve and streamline the functioning of the RMA."

"While most will agree that some change is required for the RMA to work effectively into the future, just what that change is, and how that change can be best be provided for is still the topic of much debate."

The existing section 6 matters are then either reworded or combined with a new matter. For example, in relation to the functioning of the built environment and land availability, natural hazards, and the provision of infrastructure have been added. A new section 7 would set out the methods for achieving the section 6 principles. These methods include requiring that persons exercising functions and powers under the RMA use best endeavours to ensure timely, efficient and cost-effective resource management processes, and achieve an appropriate balance between public and private interests in land use.

- **A number of measures seek to clarify and extend central government powers of intervention,** including:
  - » allowing for combined and/or locally targeted national environmental standards (NES) and national policy statements (NPS), to improve their flexibility and operation;
  - » streamlining of the NES/NPS process;
  - » the extension of central government powers to direct plan changes to allow the Minister to identify issues or outcomes to be addressed in a council plan, to direct a plan change and/or to directly amend an existing operative plan.
- **A new requirement is proposed for the provisions of regional policy statements, regional plans and district plans to be combined into a "single resource management plan", in line with a national template, within five years.** This would be at district level, or broader area by agreement. The national template would provide standardised terms and definitions, and possibly also specific standardised zones and rules for particular activities. The scope and status of the template and how it would be developed (including any opportunities for public input) are currently unclear.
- **A new optional plan-making process is proposed.** A collaborative track (as noted in the freshwater reform package) for the development of new single resource management plans would allow regional and district councils to prepare these jointly, and then take advantage of a streamlined process with an independent hearings panel and limited appeal rights. In particular, rights of appeal to the Environment Court on the merits would be limited to where the council deviated from the recommendations of the independent hearings panel. A right to appeal to the High Court on points of law would still be available where the Council accepted the hearings panel recommendations. The scope of the Environment Court's consideration of an appeal would also be narrowed. The appeal would be by way of "rehearing", rather than de novo.
- **A new requirement for councils to "plan positively for future needs" is proposed,**

"In general the freshwater reform package is based on and is (said to be) consistent with the Land and Water Forum's recommendations."

with an emphasis on ensuring adequate land supply to provide for at least 10 years of projected growth in demand for residential land.

- **A suite of changes intended to provide more efficient and effective consenting.** These include a 10 working day timeframe for straight-forward, non-notified consent applications and an "approved exemption" for activities that only narrowly miss out on permitted activity status.
- **A proposal to limit the scope of consent conditions by requiring conditions to be directly connected to the reason a consent is needed.**
- **Amendments to the process of obtaining written approval from neighbours who are affected by particular aspects of a development.** The proposed amendments would mean that if a neighbour does not give written approval, councils could limit the involvement of the neighbour to the particular aspect of the development that would affect the neighbour. At present, there is no such power to limit a neighbour's involvement in this way.
- **Consent appeals are proposed to change from de novo to appeals by way of rehearing.** This change would effectively narrow the scope of the Environment Court's task on appeal.
- **New measures are proposed to empower faster resolution of Environment Court hearings.** This is by increasing the Environment Court's power to enforce agreed timeframes as well as a number of related matters.
- **To improve the transparency around Council consent processing fees.** Councils will be required to set fixed charges for certain types of resource consents and to publish accounts specifically covering their consenting activities.
- **A specified Crown-established body is proposed to process some types of consent.** This is either by expanding the call-in provisions or developing new legislation to enable the Minister to designate nationally important issues to be eligible for an alternative consenting process.
- **Measures are proposed to promote better natural hazard management.** These include amending section 106 to apply to all land use consent decisions, instead of being limited to subdivision consents.
- **New provisions are proposed to enable more effective iwi/Maori participation in planning.**

Concluding Remarks

These two reform packages alone are significant and if implemented as proposed will have a profound effect on the way in which we manage natural and physical resources in this country. These reforms and those happening in the area of local government will see a shift from local decision making to more central government intervention and control, which is (according to some commentators) more reflective of the previous Town and Country planning regime of the Muldoon "think big" era.

While most will agree that some change is required for the RMA to work effectively into the future, just what that change is, and how that change can be best be provided for is still the topic of much debate. Some critics say that the proposed changes to sections 6 and 7 have gone too far in seeking to balance environmental concerns with the economic and that such changes will ultimately be at the expense of the environment. Others express concerns about the effects that limiting appeals to the Environment Court will have on the robustness and quality of resulting decisions. While it is too early at this stage to say whether all of the proposed changes will survive the legislative process in their current form, what is clear is that there will be some changes and these changes will be designed to improve and streamline the functioning of the RMA. We will provide further comment on the reforms and responses to the reforms in future articles. ■

Footnotes

[1] http://www.mfe.govt.nz/publications/water/freshwater-reform-2013/index.html.

[2] 5pm on 8 April 2013

[3] http://www.mfe.govt.nz/publications/rma/improving-our-resource-management-system.html

[4] Ibid page 8.

[5] At 5pm 2 April 2013.

In this issue of *WATER* we examine and debate the recent release by the Government of its freshwater policy document – *Freshwater Reform 2013 and Beyond*. Starting with the view from the Hill we get a response from *Water New Zealand's* Peter Whitehouse followed by other key stakeholders including Federated Farmers, Local Government New Zealand and the Parliamentary Commissioner for the Environment.

For those readers of Water who are unfamiliar with the report released by the Government it is available (along with other related documents) on the Ministry for the Environment's website at www.mfe.govt.nz/issues/water/freshwater/freshwater-reform-2013/

Government Releases Freshwater Proposals

On 9 March, Environment Minister Amy Adams and Primary Industries Minister Nathan Guy released a document outlining the Government's proposed plan of action for improving water quality and the way freshwater is managed.

In a joint statement Ministers said the proposals contained in the document were consistent with and based on the Land and Water Forum's (LAWF) recommended approach.

"These reforms are about the Government supporting communities to make decisions, plan and set freshwater objectives and limits, and then meet the challenges over time of managing our land and water use within those limits."

"*Freshwater Reforms 2013 and Beyond* gives effect to the LAWF's core recommendations contained in their report to us – *Fresh Start for Fresh Water*," Ministers said.

"We believe that from this moment on, we start the most comprehensive and positive reform of our freshwater management system for a generation."

"LAWF's significant work over the last four years has provided a strong basis for improving New Zealand's freshwater management system."

Hon Amy Adams – Environment Minister

Hon Nathan Guy – Minister of Primary Industries

"The Government is now at the point of being able to advance freshwater reforms that have wide buy-in, consider the long-term impacts of the way we manage our freshwater resource and provide greater certainty for those that need reliable access to water."

"These reforms are about the Government supporting communities to make decisions, plan and set freshwater objectives and limits, and then meet the challenges over time of managing our land and water use within those limits. They are also about ensuring we recognise the rights and interests of iwi in freshwater."

Ministers say the document outlines a clear path of reform ahead that will be addressed through a comprehensive and measured approach, starting this year.

A key element of immediate proposals is the introduction of a National Objectives Framework. Among other things, this means the Government would require that, for the first time, New Zealand waterways would need to meet a national bottom line to ensure they are a healthy place for fish and plant life, and that they are safe for recreational activities.

"The framework will ensure that councils have access to the best science, iwi values are understood and considered appropriately and freshwater objectives and limits are set in a consistent and well-targeted way," Ministers said.

Amy Adams says issues around water management remain challenging, but the cost of not dealing constructively with them has been significant and can no longer be ignored.

"The key tenet of the Government's proposals is that improving our water management system will require solutions that start now and build over the long-term. There is no quick fix."

"We know that managing water more efficiently through irrigation has the potential to increase our agricultural exports by $4 billion per year by 2026."

"Issues with our waterways have been building over a number of generations, and it is going to take a similarly long time to fully realise solutions for these issues."

Nathan Guy said New Zealand's natural assets offer huge potential for economic growth but only if water is used and managed carefully within environmental limits.

"We know that managing water more efficiently through irrigation has the potential to increase our agricultural exports by $4 billion per year by 2026."

"To deliver this we need to allocate existing water more efficiently, and develop schemes that will store and distribute water for the benefit of both the economy and the environment."

Freshwater Reforms and Big Changes for the RMA

Peter Whitehouse – Water New Zealand

The Government recently released a discussion document, *Freshwater Reform 2013 and Beyond*. The release was in response to the work and reports of the Land and Water Forum and is intended as an initial package of reforms, with more to follow going forward.

Reforms 1 and 2, are billed as "Planning as a community' and cover an alternate collaborative planning process for freshwater related regional plans and policy statements, effective provisions for iwi/Maori involvement in freshwater planning.

Reforms 3, 4 and 5, "A National Objectives Framework", include detail on the development of the Framework. Actual values chosen for each freshwater body are intended to be a local decision, but the minimum states that apply to those values will be set at a national level through the framework. All water bodies will be subject to two core values, ecosystem health and general protection for indigenous species, and human health for secondary contact (i.e. E.coli and cyanobacteria.

Improved management of water resources, and in particular water quality, is an issue of significant public concern. The Cabinet Paper (one of a number underpinning the reform package), *Water Reform Paper Two: Objective and Limit Setting under the National Policy Statement for Freshwater Management 2011* notes in Annex B that only three of the 16 regional councils consider its notified plans will fully reflect the National Policy Statement on Freshwater Management by 2014. The remainder suggest compliance will not occur until sometime between 2020 and 2030.

If the new regime proposed under the Framework is permitted to display a similar inconsistent and protracted implementation programme it will only serve to discredit the scope and 'once in a generation' vision of the reforms intended. Improved management of this key strategic resource is a high national priority, and requires much tighter timelines than those suggested in the discussion document.

Reform 4 proposes further national direction and guidance on setting freshwater objectives and limits, while Reform 5 addresses improving the process for Water Conservation Orders.

Reforms 6–11 discuss managing within quantity and quality limits and cover matters such as freshwater accounting systems, improving the efficiency of water use, specification of permits, including the possibility of a standard template, addressing science, research, knowledge and information around freshwater quality, stronger government leadership to ensure effective water quality management, including regulating for good practice, and the development of good management practice toolkits.

Many of these reforms will be incorporated into a proposed significant reform of the Resource Management Act. This reform package is outlined in a second discussion document, *Improving Our Resource Management System*.

The decision to make significant improvements to the Resource Management Act should be welcomed. The issues, challenges and opportunities identified in the discussion document are well known. Lack of consistency nation-wide in terms of planning rules, the complexity of planning documents and the costs associated with variable requirements for similar activities, act as a 'drag' on the economy and can result in perverse environmental outcomes. Similarly, it is long overdue that discussion occurs on the decision making process – where is national decision making appropriate and what should be the role of local and regional entities in that process?

The discussion document makes reference to greater national direction, including a proposal that a specified Crown body is established to process some types of consents and in other cases that guidance material be generated.

It is also proposed to develop a new national planning template, and a move to have all councils, or a combination of councils, develop plans, based on the national template, within five years. Streamlining and simplifying the planning process will result in significant efficiency gains.

An emphasis on increased collaboration in the planning process, the establishment of an independent hearings panel, and the limiting of appeals to the Environment Court are further measures included.

"The discussion document makes reference to greater national direction, including a proposal that a specified Crown body is established to process some types of consents and in other cases that guidance material be generated."

The proposal that seems to be creating considerable angst in some quarters is that which would see the current sections 6 and 7 combined into a single section that will list the matters decision makers will be required to "recognise and provide for". Deleted from the list in the current sections 6 and 7 are:

- the ethic of stewardship;
- the maintenance and enhancement of amenity values;
- intrinsic values of ecosystems;
- maintenance and enhancement of the quality of the environment; and
- any finite characteristics of natural and physical resources

The new list is non-hierarchical and includes 14 principles, "all persons exercising functions and powers under it in relation to managing the use, development and protection of natural and physical resources shall recognise and provide for…"

Rebalancing the legislation to what was originally intended, i.e. equitable consideration of economic, environmental, culture and social well-being, is long overdue. Reducing complexity and cost and ensuring consistency and equity is a fundamental of good legislation and the proposed reforms will lead to that. Substantive reform will always involve cost and court controversy but that is not a reason to delay it.

Further reforms in the water area are also recommended in the recently released report of the Local Government Infrastructure Expert Advisory Group. These include recommendations on water metering and volumetric charging, greater use of shared services, and regional delivery of water services with delivery at arm's length from political decisions through a publicly owned CCO or similar business unit.

There are also recommendations regarding population thresholds for council amalgamations.

All and all exciting and challenging times for those who can see the large opportunities the proposed package of reforms presents.

Freshwater Changes Show Promise – Commissioner for the Environment

The Government's proposed changes to freshwater management are much needed, but only if they are implemented properly says the Commissioner for the Environment, Dr Jan Wright.

Dr Wright, who has made submissions to Government on the proposed changes says moves to improve water quality are welcome.

"It's vital we make progress on water quality, and the proposed changes are a step in the right direction."

"It's vital we make progress on water quality, and the proposed changes are a step in the right direction."

"However, the effectiveness of the reforms will lie in the detail of their implementation. That detail will determine whether water quality across New Zealand is maintained and improved as the Land and Water Forum intended, or becomes worse."

"One thing I do disagree with is the plan to allow Water Conservation Orders to be bound by regional plans. Water Conservation Orders exist to create a network of nationally protected rivers – regional councils should not be put in the position of deciding whether or not particular rivers are nationally outstanding."

Water Policy: Regional Councils Ready to Bring Expertise to the Table

Local Government New Zealand has cautiously welcomed the Government's proposals in "*Freshwater reform 2013 and Beyond*".

However, co-ordinating the proposed Government reforms to the Resource Management Act with the proposed changes to fresh water policy will be a challenge, says LGNZ Regional Chair, Fran Wilde.

"Water is a resource that underpins our economy, is the foundation of the nation's natural character and is culturally important. Getting it right is vital. Also, both reform work streams are on very tight timeframes with limited opportunity for consideration and feedback by stakeholders, including the public. For example, careful analysis of the practical implementation issues and costs associated with data collection should be carefully understood. This is exactly the type of issue recently highlighted by the Productivity Commission as leading to poor regulatory design and unnecessary implementation costs. Having got to this point after several years of deliberation by the Land and Water Forum, the length of the consultation period is disappointing."

"Regional councils have the collective experience to help with practical application of these types of reforms and we want to work in partnership with central government to ensure that they hit the mark and can be properly implemented with a minimum of extra cost to the community."

"National expressions of water related policy are important, but each region has particular needs relating to their catchments and other geographically specific considerations. This is where regional councils can step in and fill a vital gap," Ms Wilde said.

Water Reforms Wet the Lips of Federated Farmers

The Government's policy response to the Land & Water Forum (LAWF) has received the enthusiastic backing of Federated Farmers.

"This is a positive Government endorsement of the monumental multi-stakeholder effort which went into LAWF," says Ian Mackenzie, Federated Farmers environment spokesperson.

"Government has picked up on and set a pathway for delivering 'Planning as a Community,' 'National Objectives Framework' and 'Managing within limits.'

"What we have are positive, pragmatic and prioritised pathways reflective of the recent RMA discussion document. Government is not expecting communities to solve everything yesterday, but will instead help communities to build solutions from the ground up."

"One of the big things to emerge from LAWF was the importance of good science and good information to inform constructive collaborative governance. That is important because water is an area of policy beset by emotion and a lot of politics"

"Collaborative governance was one of the key LAWF recommendations and the Government has effectively endorsed that by including collaborative governance in its own policy proposals."

"This is positive not just for better community outcomes, but enduring community outcomes."

"This potentially moves us to a system based upon community collaboration and away from drawn-out processes that are expensive as they are litigious. The emphasis upon communities is vital because water is not a Wellington issue but is very much a local one."

"This is a positive Government endorsement of the monumental multi-stakeholder effort which went into LAWF," says Ian Mackenzie, Federated Farmers environment spokesperson."

"This is why we need to be absolutely clear on the values we are managing waterways for."

"The development of the National Objectives Framework is fundamental because it helps to define water policy objectives set under the National Policy Statement on freshwater."

"Frameworks and community collaboration provide clear but useful guidance for councils on process, management frameworks and limits. It should give those councils moving to set limits now, solid reasons to reassess what they are doing and how they are engaging with their communities."

"Proposed reform also puts Good Management Practice, or GMP, right at the heart of improved economic and environmental gains."

"GMP is about getting nutrient management right along with water use efficiency. The importance of GMP is well explained in the proposed reform and is given a lot of support. That gets a big tick from Federated Farmers."

"We do have some issues, like the use of 'challenges' instead of 'opportunities,' because that is what reform is all about. It is an opportunity to positively redefine our entire conversation about water," Mr Mackenzie concluded.

The Green Response – How Much Water to go Under the Bridge Before Action Taken?

Perhaps unsurprisingly the Green Party has been less than enthusiastic about National's freshwater reform package saying it "lacks concrete steps to protect our waterways when urgent action is required".

"Amending the Resource Management Act to encourage Councils to use collaborative processes at the start of the plan making process is no surprise as this was promoted by the Land and Water Forum.

"The freshwater discussion document lacks concrete action to protect our waterways and prevent further water pollution," Green Party water spokesperson Eugenie Sage said. "The package is light on regulation and heavy on reliance on Environment Ministry guidance. The document recognises that water quality is declining, yet a major gap is the lack of any specific limits for contaminants such as sediment, nitrate and periphyton in the proposed National Objectives Framework." "Discussion is needed on what limits are needed on contaminants, not whether we should have limits." "The Government is dragging its feet on safeguarding water quality and river health, yet fast-tracking irrigation development when we know that agricultural intensification increases water pollution."

"Urgent action is needed to safeguard water quality yet Government won't consider regulation to do this until 2016." "Amending the Resource Management Act to encourage Councils to use collaborative processes at the start of the plan making process is no surprise as this was promoted by the Land and Water Forum. Further reducing appeal rights to the Environment Court risks reducing plan quality.

"Without effective rules and a price for commercial water use, water quality will continue to decline especially with National's heavy promotion of, and subsidies for irrigation, and the pollution which agricultural intensification causes."

"Without effective rules and a price for commercial water use, water quality will continue to decline especially with National's heavy promotion of, and subsidies for irrigation, and the pollution which agricultural intensification causes," Ms Sage said.

Advancing the Framework for Managing Freshwater Quality in New Zealand

Alex Jepsen – Senior Planner, Opus International Consultants

Alex Jepsen – Senior Planner, Opus International Consultants

This article is an edited version of a dissertation written in partial fulfillment of the requirements of a University of Auckland Master of Legal Studies, specialising in Environmental Law.

Introduction

New Zealand's new freshwater management framework is in its infancy with implementation barely begun. Because of this, it is interesting to examine how these matters have been handled elsewhere around the globe. This article then, looks to an overseas case study example, the European Community Water Framework Directive, where an ambitious framework for managing freshwater quality is nearing the date of full implementation. Observations of the European experience provide some useful insights for New Zealand with regard to the difference between its early vision and the practical outcome upon implementation. There is an opportunity for New Zealand to learn from the European experience as we advance the implementation of our freshwater reform package, as presented in the Government's recent publication *Freshwater Reform 2013 and Beyond*.

New Zealand's Existing Framework

In New Zealand, the Resource Management Act 1991 (RMA) is the principal piece of environmental legislation which determines how we manage the use of natural and physical resources and assess the effects of activities on the environment. The National Policy Statement for Freshwater Management 2011 (Freshwater NPS) is an instrument under the RMA which states national level objectives and policies for freshwater management that are relevant to achieving the RMA purpose. Together these documents provide the existing legal framework for managing freshwater quality in New Zealand, and under delegated authority, regional councils (and unitary authorities) have responsibility for implementing the existing legal framework for managing freshwater quality through their regional policy statements and regional plans.

Need for Reform

New Zealand's freshwater quality is good overall, and it rates well internationally. However, monitoring has shown that its quality is declining in many places across a range of indicators.

Previous research undertaken to inform this article[1] looked to New Zealand's existing legislative framework comprising the RMA and the Freshwater NPS, and gave consideration to whether it is robust enough to guide the process of plan preparation at the regional level to provide for effective management of freshwater, taking into account the cumulative effects of both point and non-point source pollution. The finding of the research, and therefore the starting position of this article, is that the current framework is not sufficiently robust and that further reform is necessary.

Fundamentally what is lacking in New Zealand's current framework is a clear understanding of what the legislation aims to achieve; strong direction being given to those with responsibility for implementing the framework to ensure they commit to a clear and decisive regulatory approach to achieving the overarching goal; and a clear procedural framework to ensure consistency of implementation across regions.

These are the challenges to which the Government's recently announced freshwater reform package aims to respond.

Background to the Reforms

In 2009, the Government set its strategic direction for freshwater reform and initiated the Fresh Start for Freshwater programme. This involved the establishment of the Land and Water Forum (LWF) who were tasked to investigate and report on the key issues for freshwater management in New Zealand, and to produce some goals and long term strategies which would guide the Government's programme for freshwater reform.

A first report from the LWF identified the key problems for freshwater quality and its management, including (but not limited to):[2]

> "The freshwater reform package presented in the Government's recent publication *Freshwater Reform 2013 and Beyond* is based on and consistent with the LWF recommendations."

- Failure to acknowledge or manage limits: which is problematic in terms of being able to manage the cumulative effect of both point and non-point source discharges and runs the risk that the cumulative total may exceed the capacity of the environment to sustain itself.
- Inconsistencies in planning and regulation: objectives, policies, rules and methods for water quality differ between regional councils and some regional councils place greater emphasis than others on managing their water quality.
- Inadequate central-local government collaboration: responsibility for managing water quality is delegated to regional councils yet central government has not coordinated a consistent approach.
- Lack of engagement with stakeholders and iwi: meaning community values are not properly recognised.

The Government responded in 2011, taking the initial step to improve freshwater management at a national level by developing the National Policy Statement for Freshwater Management (Freshwater NPS). The Freshwater NPS provides broad narrative objectives for freshwater, and its policies compel regional councils to establish more definitive water quality limits at the catchment level, based on the receiving capacity of each water body in their region. However, while the Freshwater NPS gives some general direction as to the national outcomes sought, it does not specify how to achieve those outcomes. It remains up to regional councils to determine their own procedures and methods.

The LWF continued its work through 2012 and produced two further reports containing more detailed recommendations focus-ing on the need to develop national instrument(s) which would better define the national objectives for the state of freshwater in New Zealand (through a collaborative process that brings stakeholders and iwi together), and set out a standardised process for these national objectives to be expressed at regional level using measurable environmental states (limits).

The freshwater reform package presented in the Government's recent publication *Freshwater Reform 2013 and Beyond*[3] is based on and consistent with the LWF recommendations. In summary, there are three key reform areas to be progressed immediately including: collaborative planning, a national objectives framework, and setting water quantity and quality limits. Other reforms will be developed as part of the Government's longer term programme of reforms. The proposed reforms respond to some key identified challenges for freshwater management in New Zealand. But how will the vision for an improved freshwater management system play out in practice?

Case Study – European Community Water Framework Directive

The Water Framework Directive (WFD) was adopted by the European Community in 2000. It has been in its implementation phase for 13 years, long enough to observe differences between its early vision and the practical outcome upon implementation.

One of the notable features of the WFD is its ambitious overarching goal to prevent further deterioration of the quality of freshwater bodies in terms of their capacity to support aquatic ecosystems, and to progressively improve the quality of water bodies over time, i.e. water quality cannot get any worse, it can only get better.

The WFD elaborates on this goal by setting objectives which describe what Member States need to do in order to attain them. Specifically, Member States must aim to achieve 'good surface water status' for all relevant waters by 2015 (except that heavily modified and artificial waters need only achieve good surface water potential).

This desirable environmental state of 'good surface water status' is defined in the WFD using both qualitative and quantitative criteria which define the capacity of a freshwater body to support aquatic ecosystems. In other words, these criteria set the limit, over which it will no longer be able to support the aquatic ecosystems that it is intended to support.

The overarching goal of 'non-deterioration' is an ambitious and aspirational goal, while at the same time it offers a simple statement of what Member States are expected to achieve. The objectives then prescribe a freshwater quality state that must be achieved in order to meet that goal, described by qualitative and quantitative criteria. In this way the WFD provides a good model for the structure of clauses necessary in order to provide a clear understanding of what the legislation aims to achieve.

However, a criticism of the WFD is that the direction it gives to Member States to protect the quality of fresh water bodies is weak. Specifically, Member States are directed to implement the necessary measures to enhance and restore the quality of fresh water bodies "with the aim of" achieving good status. It has been argued that this expression suggests that Member States are obliged only to try their hardest to achieve that objective but are not subject to an absolute requirement to realise it.[4]

Indeed, it has been found that there are differences in opinion amongst Member States as to whether the good status objective is something they have to achieve as an actual end result, or whether they only have to demonstrate that they have undertaken the necessary procedures and actions in an effort to achieve it. An interpretation one way or the other was determinant of the level of will and commitment a Member State made to achieve the overarching goal, and the strength (or weakness) of the regulatory approaches they employed.[5]

"These are the challenges to which the Government's recently announced freshwater reform package aims to respond."

A key lesson for New Zealand from these findings is that it is of crucial importance to give strong direction and comprehensive guidance to those who have responsibility for implementing the freshwater management framework, so that there is a consistent understanding of the goal they are expected to achieve. It is also important that the framework contains strong regulatory methods so that there is some obligation and accountability associated with that goal.

Summary

The freshwater reform package presented in the Government's recent publication *Freshwater Reform 2013 and Beyond* is a continuation of the long term programme for improving freshwater management in New Zealand. The proposed reforms respond to some key identified challenges for freshwater management in New Zealand including: the need to set national objectives and limits (in collaboration with stakeholders and iwi), and to develop a consistent procedure for implementation.

How the current vision for an improved freshwater management system plays out in practice remains to be seen but, learning from the European experience, as New Zealand progresses towards legislative and regulatory drafting, consideration should be given to the strength of direction contained in the provisions because this will influence the level of commitment to be gained from those implementing the regime.

Footnotes

[1]Jepsen, A "Advancing the framework for managing surface freshwater quality in New Zealand" (2013) Unpublished dissertation written in partial fulfillment of the requirements of a University of Auckland Master of Legal Studies, specialising in Environmental Law.

[2]Land and Water Forum Report of the Land and Water Forum: A Fresh Start for Freshwater. Land and Water Forum (New Zealand, 2010).

[3]See link www.mfe.govt.nz/issues/water/freshwater/freshwater-reform-2013/index.html.

[4]Howarth, W "Aspirations and Realities under the Water Framework Directive: Proceduralisation, Participation and Practicalities" (2009) 21(3) Journal of Environmental Law 391.

[5]Keessen, AM, van Kempen, JJH, van Rijswick, M, Robbe, J and Backes CW "European River Basin Districts: Are They Swimming in the Same Implementation Pool?" (2010) 22(2) Journal of Environmental Law 197.

Infrastructure Resilience – An Alternative to Stormwater Ponds

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Abstract

A stormwater pond was constructed by a private development company in 2004 at Carol Lee Place, Albany Heights, Auckland in order to meet stormwater quality, extended detention and peak flow attenuation objectives for a 2.97 hectare residential catchment. The pond has since failed to perform to the required standards and is undersized to achieve the required stormwater management objectives and meet consent conditions. In 2010 the former North Shore City Council undertook a detailed evaluation of the existing pond and identified a number of options for its redevelopment. The main constraint was limited space within the existing drainage reserve for the construction of a fully compliant device. Five alternative options were identified and assessed, with Option 4 determined to be the best practicable option. This concept incorporated a raingarden overlaying an underground modular crate-type detention tank system. This solution is a unique device that is able to achieve the required stormwater management objectives to the greatest practicable degree. The concept has since gone through a detailed design process and planned for construction in March and April 2012. It is anticipated that the system will have wide-reaching implications and could be replicated in similar situations throughout the Auckland region and beyond.

Keywords

Rehabilitation, raingarden, crate detention tank, extended detention, permeability, hydraulic conductivity, retrofit, stormwater pond

1. Introduction

A stormwater management pond was constructed by a private developer at the bottom of Carol Lee Place, Albany Heights, Auckland in 2004 for the purpose of meeting stormwater quality, extended detention and peak flow attenuation objectives for a 2.97 hectare residential catchment. Increases in the density of development within this catchment since the stormwater management system was constructed have resulted in the pond becoming significantly undersized to achieve the intended functional objectives. In 2010 the former North Shore City Council (NSCC) undertook a detailed evaluation of the existing pond and identified a number of options for its redevelopment.

The main constraint for the development of a fully-compliant device was the limited space within the existing drainage reserve, in addition to moderately steep topography and the presence of residential dwellings in close proximity to the pond.

This paper presents a summary of the options assessment and a description of the selected option, which entailed a space-efficient device incorporating a dual-function detention tank/raingarden system. Five options were examined for the redevelopment of the Carol Lee Pond, which included:

1. A technically optimum pond, which extended beyond the drainage reserve and on to the adjoining recreational reserve
2. A 'detention only' pond, also extending beyond the confines of the drainage reserve
3. An optimized existing pond within the current pond footprint;
4. A hybrid system involving a modular underground tank overlain by a modified raingarden device
5. A pond with vertical sides within the drainage reserve boundary

Further details of each option are discussed in Section 4 of this paper. Option 4, which incorporated a modified raingarden overlaying an underground modular 'crate-type' detention tank system was selected as the preferred option for the redevelopment. This solution resulted in a unique device which combined the superior water quality performance of a raingarden while making use of the efficient storage volume afforded by underground detention tank modules, combining to achieve the desired stormwater management objectives.

2. Background

In 2002, NSCC and the former Auckland Regional Council (ARC) granted resource consents to construct a stormwater management pond off of Carol Lee Place, Albany Heights, as part of the overall stormwater management requirements for a 35 lot residential subdivision development. Subsequent variations to these consents were granted which impacted on the extent and make-up of the contributing catchments, and the sizing and performance of this pond. Figure 1 shows the location of the device in the context of the surrounding roads.

"The main constraint for the development of a fully-compliant device was the limited space within the existing drainage reserve, in addition to moderately steep topography and the presence of residential dwellings in close proximity to the pond."

Field investigations and desktop analyses have demonstrated that the current Carol Lee pond failed to perform to the required standards and was insufficiently sized to achieve the minimum stormwater management objectives required by the conditions of consent – outlined further through Section 3 of this paper. Due to its depth and steep embankment configuration, the pond also had low visual and aesthetic values and posed a safety risk to the public and potential difficulties with maintenance and cleaning.

Due to the reasons outlined above, in 2010 NSCC undertook a comprehensive evaluation of the pond in its form at that time against the various relevant stormwater management objectives (i.e. those required by the associated resource consents, as well as current best practice objectives), as well as the scoping of redevelopment options to improve its stormwater management performance and amenity values.

3. Original Pond and Catchment Characteristics

3.1 Existing Catchment Description

The existing contributing catchment to the Carol Lee pond is entirely comprised of fully-developed residential land uses, and includes

"Auckland Council are seeking to maintain the Wayside Stream as one of the best urban streams in the city so that it continues to form a green corridor through the catchment, providing for excellent amenity, ecological value, ease of movement and safe stormwater conveyance (Auckland Council, 2012)."

Figure 1 – Location plan

portions of Carol Lee Place, Hatfield Place, Quail Drive and Gills Road. The pond is within the 'Wayside Stream catchment' and it discharges to an unnamed watercourse which ultimately leads to the Lucas Creek and the upper Waitemata Harbour. Auckland Council are seeking to maintain the Wayside Stream as one of the best urban streams in the city so that it continues to form a green corridor through the catchment, providing for excellent amenity, ecological value, ease of movement and safe stormwater conveyance (Auckland Council, 2012).

The following parameters were used within a TP108 analysis to determine the required water quality and extended detention volumes, as well as pre and post development 2, 10 and 100 year

ARI storm event peak flow rates from the catchment (based on TP10 and TP108 methodologies):

- Total catchment area :– 2.97 ha (of which about 60% is impervious)
- Catchment length :– 0.26 km
- Catchment slope (Sc) :– 0.104
- Time of concentration (Tc) :– 10 minutes

Table 1 summarises the results from the TP108 analysis of the catchment (disregarding any benefits of the existing pond function).

"It is noted that the options evaluation undertaken in 2010 was based on the more recent 2003 version of TP10. This latest standard imposes more rigorous controls when compared to the earlier 1992 and 1999 versions, resulting in a comparatively superior outcome."

Table 1 – Existing catchment analysis

WQ Volume (50% credit)	ED Volume	2 Year ARI Peak Flow (m^3/s)		10 Year ARI Peak Flow (m^3/s)		100 Year ARI Peak Flow (m^3/s)	
482 m^3 (241 m^3)	620 m^3	Pre	Post Uncontrolled	Pre	Post Uncontrolled	Pre	Post Uncontrolled
		0.207	0.328	0.443	0.586	0.767	0.932

3.2 Original Pond Design Objectives

Due to the timing of the development, the initial objectives for the stormwater management system at Carol Lee Place as required by the conditions of consent were originally aligned with ARC's (now superseded) earlier version of TP10 (1999), being summarised as follows:

- Permanent water storage volume of 120m^3 and wetland plants to provide water quality treatment;
- Extended detention to mitigate channel erosion, by storing the 30mm event and releasing over 24 hours;
- Maintaining pre-development 2, 10 and (if possible) 100 year ARI storm event peak flow rates.

It is noted that the options evaluation undertaken in 2010 (and described in Section 4 of this paper) was based on the more recent 2003 version of TP10. This latest standard imposes more rigorous controls when compared to the earlier 1992 and 1999 versions, resulting in a comparatively superior outcome.

3.3 Original Pond Performance Analysis

The water quantity performance of the original pond was modelled using HEC-HMS software, and its efficiency and capacity were assessed against TP10 (2003) criteria. The various parameters for the original pond at Carol Lee Place were derived from as-built drawings and were confirmed during on-site investigations. These parameters are summarised as follows:

- Length to width ratio :– 1:1
- Side slopes :– 2:1
- Bench above permanent water level :– No
- Forebay :– No
- Top of Bank (ToB) surface area :– ~320 m^2
- Pond floor surface area :– ~70 m^2
- Total pond depth (floor to ToB) :– 3m
- Slow release outlet :– 50mm diameter at pond floor level
- Primary outlet :– 100mm slot in riser, 1.0m from the base
- Secondary outlet :– 550mm scruffy dome, 1.9m from base
- Emergency spillway :– 2.8m long broad crested spillway

The original pond did not maintain a permanent water level due to the fact that the lowest outlet orifice was located at the pond floor level (refer to Figure 2), leaving no allowance for sedimentation build-up and thus introducing a long term risk of blockage. This effectively meant that the device was not providing a sedimentation function or any other form of water quality treatment. Figure 2 shows the configuration of the original pond and outlet system.

The summary presented in Table 2 (refer to Section 4.1.6 of this paper) indicates that the original pond largely mitigated peak flows for the 2 year ARI event to pre-development levels; however the 10 and 100 year pre-development rates were not maintained. Extended detention was not provided in view of the 150mm orifice being grossly oversized for this purpose, while in addition (and as already mentioned) the pond did not provide any effective stormwater quality treatment.

Furthermore, the primary piped outlet from the original pond discharged directly into an open channel within a fenced and residential private property, and continued overland through three other properties prior to discharging to the Gills Road Reserve. Site investigations in late 2011 identified that as a result, the past outfall arrangement has created severe stream bank erosion and channelisation, as further discussed in Section 5.1.2 of this paper. This situation was far from ideal, as the overland flow path is not fenced, and high flows along this flow path could have introduced a safety hazard.

4. Options Assessment for Pond Rehabilitation

Due to the reasons outlined in Section 3 of this paper, in 2010 NSCC undertook to consider redevelopment options for the Carol Lee pond in order to improve its stormwater management performance, as well as it, aesthetic and safety values. This section of the paper provides an overview of the options identification and analysis subsequently undertaken in 2010.

4.1 Options Considered

The five options examined for the redevelopment of the Carol Lee Pond are outlined below. Each option was assessed against the 2003 version of TP10 to determine the likely water quality performance, and with the use of HEC-HMS to estimate the functionality of the device in terms of its potential water quantity performance.

4.1.1 Option 1 – Technically Optimum Pond

Option 1 entailed a 'technically' optimum scenario, assuming the device footprint could extend beyond the drainage reserve and onto recreational reserve land (refer Figure 3). This option consisted of a constructed pond designed in accordance with TP10 (2003), and included the following parameters:

- Length to width ratio :– 3:1
- Side slopes :– 3:1
- Bench above permanent water level :– Yes, 0.3m wide
- Top of Bank (ToB) surface area :– ~1060 m^2
- Pond floor surface area :– ~160 m^2
- Total pond depth (floor to ToB) :– 2.8 m

"The original pond did not maintain a permanent water level due to the fact that the lowest outlet orifice was located at the pond floor level (refer to Figure 2), leaving no allowance for sedimentation build-up and thus introducing a long term risk of blockage."

Figure 2 – General view of original pond looking south west with close-up of outlet

Due to the volume requirements coupled with the relatively gentle pond embankment slopes, length to width ratio and the provision of a safety bench, this option resulted in a an excessive footprint which was not practicable for the site due to topographical constraints, geotechnical concerns, the wider recreational requirements of the reserve, and the pressure to keep the redeveloped system within the boundary of the drainage reserve.

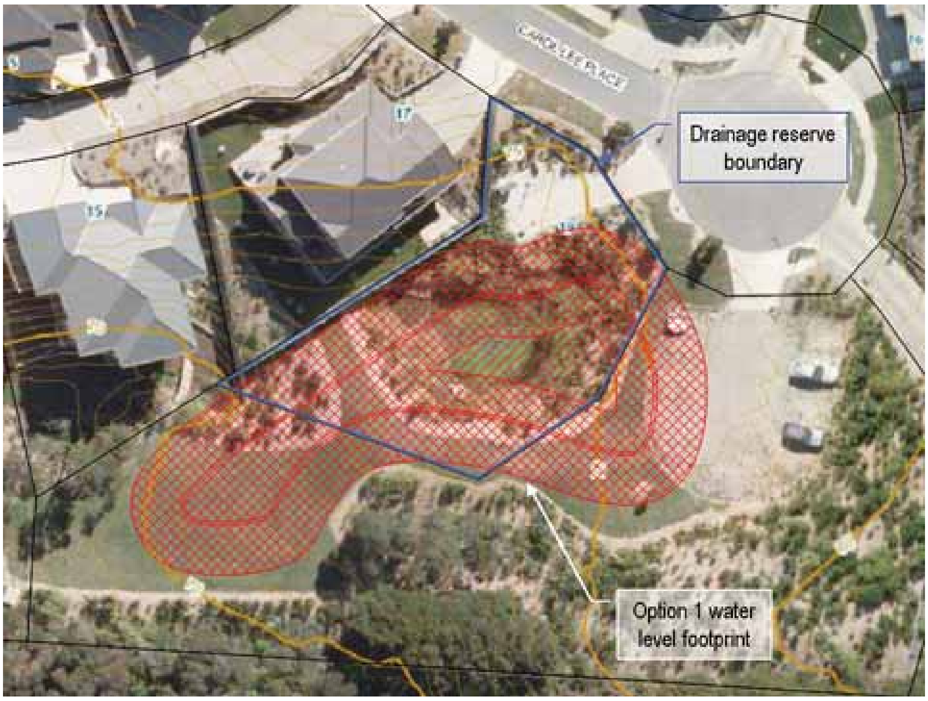

Figure 3 – Concept design footprint for option 1

As detailed above, this option represented an ideal scenario and was designed in accordance with TP10 (2003) to achieve full water quality treatment, extended detention, and pre-development 2 and 10 year peak flow rates (refer to Section 4.1.6 of this paper for a tabulated performance summary of Option 1). Due to the form of a pond of this design, largely dictated by the large volume required for extended detention as well as the length to width ratio and shallow side slopes, the 100 year post-development peak flow rate was also attenuated to a large degree.

The ballpark rounded cost associated with this option was estimated at $270,000, excluding any land costs associated with works outside of the drainage reserve.

4.1.2 Option 2 – Detention Only Pond

The second option was a stormwater pond designed largely in accordance with TP10, albeit with compromises on the provision of water quality treatment. The parameters which affect water quality performance of a stormwater pond (including permanent

"Due to the form of a pond of this design, largely dictated by the large volume required for extended detention as well as the length to width ratio and shallow side slopes, the 100 year post-development peak flow rate was also attenuated to a large degree. The ballpark rounded cost associated with this option was estimated at $270,000, excluding any land costs associated with works outside of the drainage reserve."

Figure 4 – Concept design footprint for option 2

Figure 5 – Concept design footprint for option 3

water storage and length to width ratios) were reduced, while extended detention and full 2 and 10 year peak flow attenuation were provided for as a priority. Due to the detention volume requirements, the pond footprint under this option also extended beyond the drainage reserve boundary (refer to Figure 4).

As with the 'technically' optimum solution (Option 1), the 100 year peak flow rate was also attenuated albeit to a lesser extent. It was also noted that the compromised water quality performance could be partially alleviated by introducing a bathymetric wetland design within the permanent water storage area of the pond. Such a design would increase the effective water quality volume by a factor of 1.5. The main design parameters for this option are:

- Length to width ratio :– 2:1
- Side slopes :– 2:1
- Bench above permanent water level :– No
- Top of Bank (ToB) surface area :– ~660 m^2
- Pond floor surface area :– ~130 m^2
- Total pond depth (floor to ToB) :– 3.6 m

The performance of the Option 2 pond is summarised in Table 2 – refer to Section 4.1.6 of this paper.

If the drainage reserve boundary were not a significant obstacle, this option would be considered to be practicably and technically feasible, albeit with a compromise in terms of the stormwater quality objective.

The relative water quality treatment efficiency (in accordance with TP10 2003 table 3.1) for this option was estimated to be approximately 50%. With a wetland-base design within the permanent water level and a factored equivalent water quality volume of 112m^3, the relative efficiency for a wetland scenario would be approximately 60%.

The ballpark rounded cost associated with this option was estimated at $230,000, excluding any land costs associated with works outside of the drainage reserve.

> "A reduced raingarden depth (relative to TP10, 2003 guidelines) was also considered necessary in this instance to the physical restraints on site."

4.1.3 Option 3 – Optimised Pond within Drainage Reserve Boundary

The third option considered was a rebuilt, optimised pond within the current boundary of the drainage reserve (refer to Figure 5). The concept design of this option effectively constituted a scaled-down version of the optimum pond. All management objectives are therefore compromised by approximately 50%; however the parameters could have been further optimised and tailored to meet specific priorities while compromising on others. The adopted design parameters for this Option were as follows:

- Length to width ratio :– 1.5:1
- Side slopes :– 2:1
- Bench above permanent water level :– No
- Top of Bank (ToB) surface area :– ~500 m^2
- Pond floor surface area :– ~40 m^2
- Total pond depth (floor to ToB) :– 3.5 m

The estimated performance of the Option 3 pond is summarised in Table 2 (refer to Section 4.1.6 of this paper), noting that the water quantity performance is based on an arrangement where all relative objectives are balanced (i.e. preference was not afforded to one outcome over another):

With the configuration modelled above, the relative water quality efficiency for this option would be approximately 60%. With a wetland base design as detailed in Option 2, the relative efficiency for Option 3 could also be increased. However, a pond or wetland in this location would not achieve an acceptable length to width ratio, again compromising treatment performance.

The ballpark rounded cost associated with this option was estimated at $200,000.

4.1.4 Option 4 – Combined Raingarden and Underground Detention Tanks

The fourth option involved the development of a hybrid raingarden and underground tank system within the confines of the drainage reserve (refer to Figure 6). This option aimed to eliminate the need for a deep pond or wetland in this location in order to improve the aesthetic and safety values of a treatment system in this location. The functions of the raingarden (i.e. both water quality and quantity) would be complimented by a 'crate' type underground detention system to further achieve water quantity objectives. The concept effectively moved the main storage function of the device to below ground, largely removing long term safety risks normally associated with deep pond systems. Furthermore, the use of an underground crate system enabled more efficient use of space to achieve maximised storage volumes through near vertical excavation boundaries, compared with minimum 1(v) in 2(h) to 1(v) in 3(h) slopes required for a pond system.

The concept design for Option 4 adopted outcomes from recent research in relation to raingarden performance (Facility for Advancing Water Biofiltration, 2009). This research indicates that a permeability rate of between 100–300mm/hr (represented by 'k' values) is desirable for raingarden biofiltration media. This increased rate of permeability relative to current TP10 standards (which prescribes a 'k' value of 0.3m/day or 12.5mm/hr) is beneficial from a water quality perspective, as well as in terms of optimising the design and sizing of raingardens. A reduced raingarden depth (relative to TP10, 2003 guidelines) was also considered necessary in this instance to the physical restraints on site. This reduced media depth is also supported by recent research which indicates that most of the suspended particles captured by raingarden systems typically accumulate within the upper media horizon (100–200mm) (Facility for Advancing Water Biofiltration, 2009). As such a permeability rate of 100mm/hr and a raingarden depth of 600mm were used for the Option 4 concept design. It is reiterated that these values are not strictly in-line with TP10 (2003) but were considered to be appropriate under the circumstances of this retrofit scenario.

It was also recommended through the concept design of Option 4 to relocate the current outfall location to a point within the public reserve land south of the pond; thereby diverting overland flows away from private property (refer to Figure 6).

The adopted concept design parameters for the Option 4 concept are summarised as follows:

- Raingarden soil media depth :– 600mm
- Raingarden area :– 261 m^2
- Raingarden secondary outlet :– Scruffy Dome 350mm above raingarden floor
- Raingarden emergency spillway :– Reinforced grass 3.0m wide spillway with 4h:1 Side Slopes
- Atlantis tank area :– 352m^2 (332m^2 net storage area)
- Atlantis tank depth :– 1310mm
- Atlantis tank 2 year ARI Outlet :– 2 x 280mm OD PE80B SDR17 (242 ID)
- Atlantis tank 10 year ARI Outlet :– 2 x 280mm OD PE80B SDR17 (242 ID)

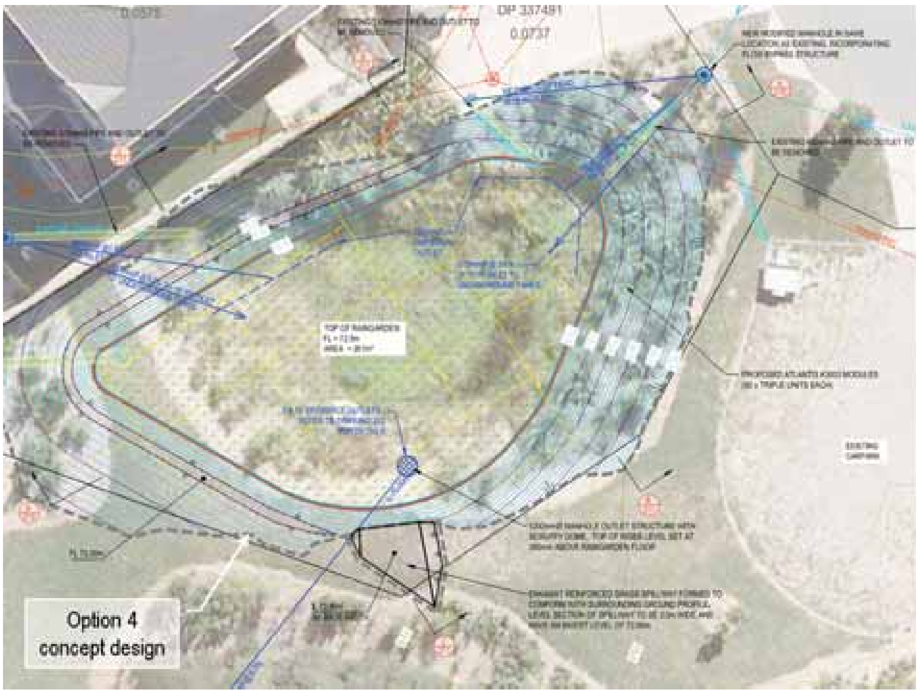

Figure 6 – Concept Design for option 4 – combined raingarden and detention tanks


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The performance analysis results for Option 4 are summarised in Table 3 (refer to Section 4.1.6 of this paper).

With the concept configuration for Option 4, the relative water quality efficiency for this option would be approximately 75% when accounting for the proposed (and current best-practice) higher permeability media. When assessed against TP10 requirements (with a lower k value), a less overall treatment efficiency was obtained.

The configuration adopted for the concept design of Option 4 was unable to fully contain the runoff volume from the 34.5mm storm event due to the confined and limited extent of the drainage reserve, noting that the overall depth of the system was restricted by geotechnical limitations, primarily during the construction phase. This resulted in a compromise in terms of meeting the full extended detention objectives prescribed by TP10 (2003), which stipulates that the full 34.5mm storm volume must be provided for within the system and designed to be slowly released over a 24 hour period. However as indicated in Table 3, most of this runoff volume is able to be routed through the raingarden (as modelled through HEC-HMS) while achieving a slow release rate during the 34.5mm storm event. This is in line with the broader aquatic habitat and stream channel protection philosophies which are established in both TP10 and the Auckland Council Regional Plan (Air, Land and Water).

The concept design for Option 4 resulted in full attenuation of the 2 and 10 year ARI events to pre-development levels, and attenuation of the 100 year ARI event to within 5% of pre-development levels. As such, the performance of this device in terms of peak flow attenuation would comply with the requirements of the ARC resource consents and design guidelines.

The ballpark rounded cost associated with this option was estimated at $360,000.

4.1.5 Option 5 – Stormwater Pond with Vertical Walls

The fifth option involved a detention pond system within the boundary of the drainage reserve, similar to Option 3, albeit with the maximisation of the potential pond volumes via the use of structural retaining walls around the pond boundary. With the use of near-vertical retaining structures, the achievable detention volumes within the drainage reserve would enable Option 5 to fully meet stormwater quantity objectives.

"A concept design and assessment of this option was not undertaken, however the broad idea was included for comparative purposes. With the adoption of near vertical walls around the pond boundary (which rough calculations suggest would need to be greater than 3.5m and up to 6.5m high in order to achieve the extended detention and peak flow attenuation volumes) and by relaxing any design factors affected by safety considerations (including safety benches and permanent water depth), the potential storage within the pond could largely achieve the full suite of stormwater management objectives."

A concept design and assessment of this option was not undertaken, however the broad idea was included for comparative purposes. With the adoption of near vertical walls around the pond boundary (which rough calculations suggest would need to be greater than 3.5m and up to 6.5m high in order to achieve the extended detention and peak flow attenuation volumes) and by relaxing any design factors affected by safety considerations (including safety benches and permanent water depth), the potential storage within the pond could largely achieve the full suite of stormwater management objectives. A system designed within these parameters would however not be ideal in terms of water quality treatment due to the physical restrictions preventing an optimum length to width ratio. Such a system would also pose significant safety and maintenance issues due to the high water depth resulting from the dead and live storage volumes, and would have negative aesthetic impacts.

The costs associated with the retaining structures would be prohibitive, as reflected by the overall estimated ballpark cost for this option of $580,000.

Option 5 was not considered further due to the significant health and safety risks and negative aesthetic values associated with the high vertical drops and deep water depths.

4.1.6 Performance Summary of Options

For comparative purposes, the performance summaries of the original pond and Options 1, 2 and 3 have been collated within Table 2 below, while the performance of Option 4 is summarised in Table 3.

"Option 4 would result in a facility with a comparatively higher amenity value and superior stormwater management performance."

Table 2 – Performance summary of original pond and options 1, 2 & 3

	WQ Volume (Req'd = 75% TSS eff.) (m^3)		ED Volume as per TP10 (m^3)		Pond Volume (ToB)	2 Year ARI Peak Flow (m^3/s)		10 Year ARI Peak Flow (m^3/s)		100 Year ARI Peak Flow (m^3/s)	
Original Pond	Req'd	Actual	Req'd	Actual	656 m^3	Pre	Post	Pre	Post	Pre	Post
	241	0	620	0		0.207	0.229	0.443	0.568	0.767	0.905
Option 1	Req'd	Actual	Req'd	Actual	1600 m^3	Pre	Post	Pre	Post	Pre	Post
	241	242	620	622		0.207	0.149	0.443	0.438	0.767	0.814
Option 2	Req'd	Actual (x1.5)	Req'd	Actual	1350 m^3	Pre	Post	Pre	Post	Pre	Post
	241	75 (112)	620	622		0.207	0.144	0.443	0.442	0.767	0.866
Option 3	Req'd	Actual (x1.5)	Req'd	Actual	835 m^3	Pre	Post	Pre	Post	Pre	Post
	241	130	620	329		0.207	0.272	0.443	0.555	0.767	0.895

Table 3 – Performance summary of option 4 – hybrid raingarden & detention tanks

Raingarden Area (m^2)		ED Volume Routed via RG (HEC-HMS) (m^3)		Total Vol. (RG + Tank)	2 Year ARI Peak Flow (m^3/s)		10 Year ARI Peak Flow (m^3/s)		100 Year ARI Peak Flow (m^3/s)	
TP10 media (modified media)	Actual	Req'd	Actual	~647 m^3	Pre	Post	Pre	Post	Pre	Post
1367 (259)	~261	620	~611		0.207	0.183	0.443	0.442	0.767	0.806

4.2 Options Analysis

A detailed analysis of each of the identified options was undertaken in order to establish the preferred option based on a number of criteria and considerations. These included the main stormwater management objectives, being water quality, extended detention, and peak flow rate attenuation, as well as qualitative matters such as amenity values, safety issues, maintenance requirements and cost.

Figures 7, 8 and 9 present graphed relationships of each of option against the stormwater management objectives for the device and the relative footprint associated with the particular pond redevelopment concept, while also relating these outcomes to cost estimates for each concept (the size of each 'bubble' in the graphs indicates the relative cost of each option). A full cost / benefit analysis was not undertaken for this options assessment due to the overarching limitations on each option, as discussed below.

Option 1 represented the ideal option in terms of stormwater management outcomes; however it presented an obstacle in terms of safety and maintenance associated with a deep wet pond in an established residential area, as well as difficulties with the footprint extending across the recreational reserve. Due to these reasons (among others) this option was not considered to be viable and was therefore discarded from further analysis.

The Option 2 pond would not fully achieve stormwater quality treatment requirements but would meet extended detention and peak flow attenuation objectives. As with Option 1 however, Option 2 would result in a deep pond and a footprint that extends outside the drainage reserve area, resulting in the same drawbacks as Option 1 in this respect (albeit to a lesser degree). Option 2 was therefore discarded from further consideration.

Option 3 would have entailed the most economical solution and a pond which was fully contained within the drainage reserve boundary; however the restricted available area means that stormwater performance would be heavily compromised, together with similar safety concerns as those associated with Options 1 and 2.

In view of the poor performance that could have been realistically achieved by a wet pond system in such a confined area (as considered under Option 3), the relatively large area serviced and the detrimental visual, amenity, safety and maintenance aspects associated with such systems, Option 4 (involving the construction of a raingarden complimented by underground detention devices) was identified as a viable alternative. While Option 4 had the second highest cost of the five options (excluding land costs associated with Options 1 and 2), Option 4 would result in a facility with a comparatively higher amenity value and superior stormwater management performance.

Furthermore, it is widely accepted that raingarden devices are inherently superior to wet ponds from a stormwater quality view point, and also offer extended detention benefits due to the slow release rate achieved via percolation through the soil media. When coupled with the underground detention tanks (designed to address water quantity objectives), it was therefore considered that Option 4 represented the best use of space and would result overall in the most desirable stormwater management facility. It was therefore concluded that Option 4 constituted the best practicable option for the redevelopment of the Carol Lee Place pond.

4.3 Summary of Options Analysis

As a result of the detailed options analysis undertaken in 2010, Option 4, the hybrid raingarden and detention tank system was identified as the best practicable option for the rehabilitation of the Caro Lee Place pond. The system could be designed to be in-line with current best practice standards for raingarden systems, with increased permeability and reduced media depths to provide a device that could achieve 75% TSS removal. Through the provision of an underground detention cell network, the device could also be designed to achieve water quantity objectives to the greatest practicable degree, while remaining within the footprint of the drainage reserve. In order to achieve 2 and 10 year ARI storm event peak flow attenuation to pre-development levels, a compromise was necessary with regard to the 34.5mm extended detention methodology as prescribed by TP10 (2003). Despite this compromise as well as the comparatively higher cost, when coupled with the enhanced amenity values and safety risks associated with this concept, Option 4 was identified as the preferred option, and was accepted by the former ARC as the BPO for the purposes of the associated resource consents (varied by way of Section 127 of the RMA).

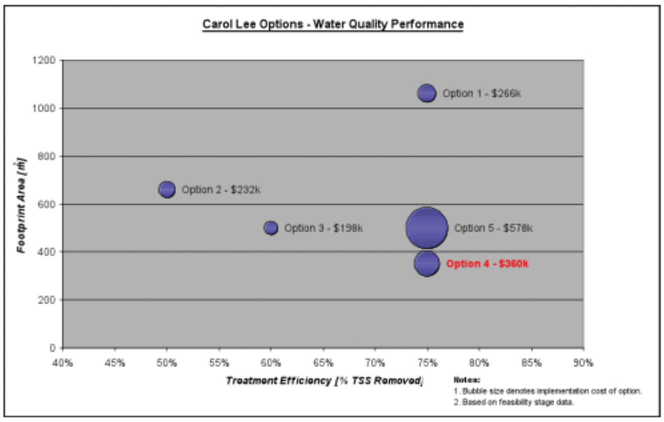


Figure 7 – Summary of relative water quality performance

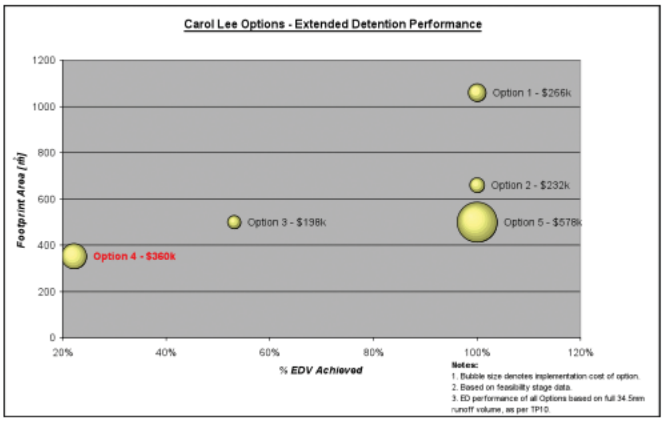


Figure 8 – Summary of relative extended detention performance

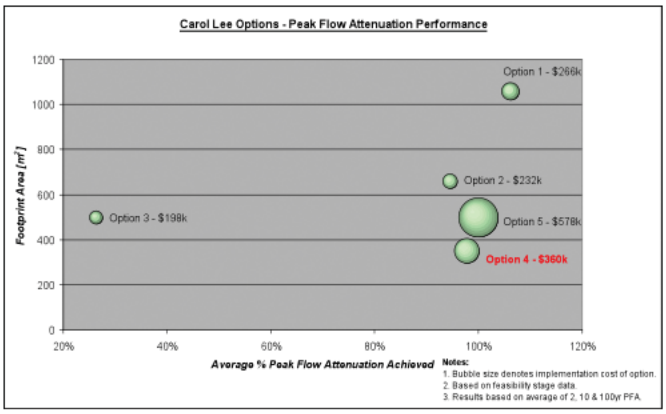


Figure 9 – Summary of relative peak flow attenuation performance

5. Hybrid Raingarden and Detention Tanks System

5.1 Overview

The proposed device involves the construction of a hybrid stormwater attenuation and treatment device, in the form of an underground modular cell detention tank (comprised of Atlantis modular crate detention systems), overlain by a raingarden system, constructed directly above the underground tank system. An overview of the detailed design phase for the device (undertaken in late 2011 and early 2012) is provided in Section 5.2 of this paper.

5.1.1 Overarching Objectives

Current stormwater management objectives for the Auckland region are determined by a number of contributing documents, including the RMA, National Policy Statements, Regional Policy Statements, Regional Plans, District Plans and non-statutory guidelines such as TP10. Both the RMA and the Regional Plan (Air, Land and Water) provide for the assessment and authorisation of discharges (including stormwater discharges) when they are demonstrated to be the best practicable option (BPO) for the specific circumstances. This is an important concept with respect to the Carol Lee Pond, as it has been demonstrated that due largely to the physical constraints of the site and retrofit scenario for the works, it is not practicable to retrofit the full and ideal stormwater management objectives for such a development. In this context therefore, the proposed hybrid management system is arguably the BPO for the catchment.

The current 2003 version of TP10 establishes the following overarching primary stormwater management objectives (noting that these are more rigorous than those prescribed through the earlier versions):

- **Stormwater quality treatment** for the removal of 75% total suspended solids on an average long-term basis
- **Extended Detention** for the control of stream channel erosion from more frequent flows and larger runoff volumes, by storing the runoff from the first 34.5mm (in contrast to 25–30mm as per the prior versions of TP10) of rainfall and releasing it over 24 hours
- **Peak Flow Attenuation** to pre-development levels for the control of stream bank full erosion (by attenuating the 2 year ARI event) and for flood mitigation (by attenuating the 10 and 100 year ARI events)
- **Scour protection** for the mitigation against potential scour and erosion arising from concentrated point stormwater discharges

Furthermore, in view of the location of this device within an established residential area, NSCC's (now Auckland Council's) objectives for this project included not only the provision of a functional and efficient stormwater system, but also a facility that is aesthetically pleasing, safe and well received by the local community.

5.1.2 Revised Design Objectives

The concept design for the hybrid device provided for full water quality treatment (i.e. to a 75% TSS removal standard based on current best practice parameters for the raingarden media) and full 2 and 10 year ARI storm event peak flow attenuation to pre-development levels, as well as partial extended detention (using the HEC-HMS routing method) and 100 year ARI storm peak flow attenuation.

Further site investigations subsequent to the concept design phase, revealed significant levels of erosion within the downstream receiving environment (refer to Figure 10 – the images highlight the attempts made by Auckland Council Stormwater Operations to provide temporary remediation of the erosion through polythene lining). This is likely to be attributable to the largely unmitigated discharge of small and frequent storm event flows from the Carol

Lee pond. As such, rather than shifting the outfall location to an existing depression to the south of the reserve as originally conceived – potentially introducing an additional erosion risk, it was instead resolved to provide for extended detention of small storm event flows to the greatest practicable degree and to maintain the existing discharge route. The discovery of these erosion issues also led to the inclusion of restoration works for the downstream affected sections of stream into Auckland Council's projects programme, with the stream restoration works projected for construction as a separate project during the 2012–13 earthworks season.

The theoretical 34.5mm storm event extended detention volume relative to the pond's contributing catchment is approximately 620m^3 (refer to Tables 1, 2 and 3 above). The concept design for the hybrid device did not provide a significant volume dedicated to extended detention – instead focussing on providing for full 2 and 10 year ARI storm event peak flow attenuation, and adopting a HEC-HMS modelling approach to address extended detention. The modelling approach to extended detention relies on the 34.5mm storm being 'routed' through the management device using HEC-HMS, thereby accounting for outflows from the system throughout the storm event. These outflows result in a significantly reduced storage volume requirement when compared with the more conservative approach prescribed by TP10 (2003), whereby the full 34.5mm storm volume must be provided for within the system (i.e. not accounting for outflows). However, through the detailed design stage for the hybrid system in light of the discovery of severe downstream erosion, the device has now been designed to provide for extended detention in accordance with TP10 to the greatest practicable extent (specifically, within the drainage reserve boundary and to the maximum depth achievable under the geotechnical limitations).

> "Furthermore, it is widely accepted that raingarden devices are inherently superior to wet ponds from a stormwater quality view point, and also offer extended detention benefits due to the slow release rate achieved via percolation through the soil media."

The detailed design results in approximately 490m^3 of storage volume being provided for within the system, and with the extended detention outlet orifice being sized to release this volume over a 24 hour period (through a 65mm orifice). The revised detailed design achieves a greater balance between the modelling approach to extended detention and the more conservative methodology as prescribed by TP10.

Figure 10 – photos taken during site visit on 9 September 2011, illustrating severe downstream erosion

As a result of the shift in approach relative to the water quantity performance of the device, the remaining volume within the device that is available to attenuate larger storm event peak flows is reduced. This is due to the geotechnical and areal limitations on the overall storage volume achievable and available. As such, the detailed design for the device is no longer capable of providing full peak flow attenuation to pre-development levels. The device, however, is able to attenuate peak flows to a greater extent than the existing pond arrangement – being significantly less than the post-development peak flows.

5.1.3 Risks and Constraints

The Carol Lee Pond rehabilitation project presented several risks and constraints, the most notable of which are:

- The stormwater infrastructure discharging at the northern part of the device is deep, thereby requiring deep excavations to accommodate the proposed underground detention device
- Steep topography including deeply incised pond embankments result in steep (and deep) excavations and careful construction management controls
- Close proximity of dwellings and well established residential areas to proposed inlet and outlet pipes, requiring the construction of stormwater pipes by way of trenchless technology in close proximity to buildings
- Severe stream channel erosion directly downstream of the existing pond discharge point, with associated risks to overall land stability in close proximity to residential dwellings
- Proposed underground tank – raingarden combined system has not been tried before introducing a risk of "unproven" technologies

These risks and constraints were addressed through the detailed design phase of the project.

5.1.4 Resource Consent Requirements

The original pond design was subject to a number of resource consents issued by the former Auckland Regional and North Shore City Councils (including stormwater discharge, earthworks, land use and subdivision consents). The proposed pond redevelopment has been permitted through successful variations to these consents where relevant, and to a new land use consent to enable the reconstruction works.

5.2 Detailed Design

5.2.1 General

The detailed design of the hybrid device did not alter dramatically from the concept design and further developed the main features of the system, refer to Figure 11. Stormwater runoff from the contributing pipe network will be directed to the raingarden in the first instance, whereby runoff from first flush flows will be diverted to the raingarden surface through a dispersal pipe inlet system. Flows through the raingarden will drain vertically and discharge directly into the subsurface Atlantis tank system.

Flows in excess of the first flush will be diverted away from the raingarden by way of specifically designed inlet structures and made to discharge directly to the underground tank. Extended detention and peak flow attenuation has been provided for within the underground tank system, with the flows being regulated by a 1800mm diameter outlet manhole structure.

The hybrid raingarden-tank system will discharge to the same downstream environment which currently receives flows from the existing pond outlet. The proposed outlet will incorporate a 1200mm diameter US Army Corps of Engineers style stilling well as provided for by TP10 (U.S. Department of Transportation (2006)).

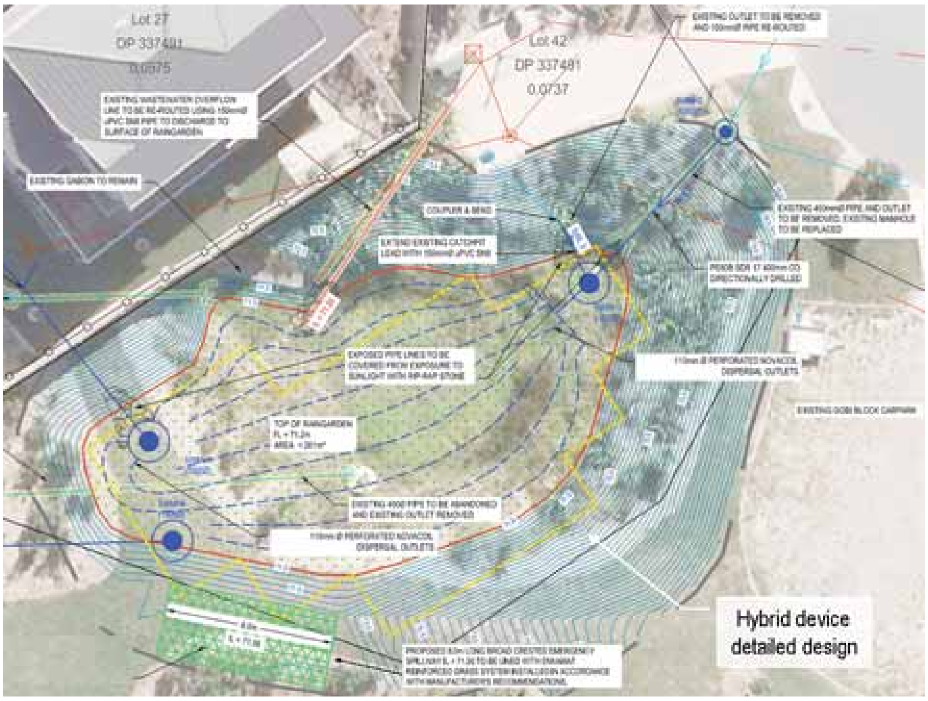


Figure 11 – Detailed design plan of hybrid device

5.2.2 Geotechnical Considerations

The proposal involves deep excavations within the existing pond footprint in order to accommodate the underground Atlantis tanks and overlying raingarden. A geotechnical report was undertaken which addresses land stability, construction management, groundwater levels, drainage, flotation, sedimentation, and downstream erosion considerations, among other issues. This assessment proposed specific design considerations that have been incorporated within the detailed design of the device.

5.2.3 Design Inlet Consideration

Runoff is directed through the piped network into the device through two manholes, referred to as SWMH1 and SWMH3 (refer to Figure 12). These manholes are each to be constructed with an internal diversion weir to direct all flows of up to the 34.5mm storm event (extended detention – 'E.D.') to the raingarden through the dispersal inlet lines. The internal diversion structure and all associated components are to be Hot-Dip Galvanised after fabrication. During a storm event in excess of the E.D. capacity the internal weir is overtopped and stormwater flows are directed straight into the underground detention tanks. Water within the detention tanks is discharged through a single manhole riser outlet, with the flow rate controlled through four orifices (designed to pass the 2 and 10 year storm events). Once the capacity of these outlet orifices are exceeded or in the event of blockage, flows are able to build up within the outlet manhole and overflow through the grated lid into the raingarden.

As both the inlet and outlet manholes are to be constructed within the underground tanks, 100–150mm Ø river rock backfill is to be used between the tank modules and the manhole to prevent movement of the modules. In order to prevent fouling (and blockage) of the dispersal lines and Atlantis modules, a series of 10mm gap bulk debris screens are to be installed within SWMH1, SWMH2 and SWMH3 to retain debris within the risers. These debris screens are to be bolted to the riser walls to allow for removal for inspection and maintenance. For the 2 and 10 year outlets, within the debris screens are 90° PVC pipe bends mounted with stub flanges and bolted to the riser walls. These bends are to be orientated downwards so as to prevent any floatables small enough to pass through the debris screen from entering the system.

The extended detention and water quality dispersal lines have been specified as 110mm diameter Novaflo perforated pipes, laid along the length of the raingarden and evenly spaced so as to provide an even spread of flows into the raingarden media.

5.2.4 Raingarden Specifications

In order to provide adequate infiltration rates through the raingarden into the subgrade tank, as discussed in Section 4.1.4 of this paper, a high-permeability biofiltration media is proposed. The higher infiltration rates will assist in enabling the smaller raingarden footprint. To allow for a reduced area of excavation due to limited space available on site, the excavation depth is to be reduced by incorporating a 550mm thick layer of biofiltration media in contrast to the TP10 requirement of 1.0m. These factors, although not strictly in accordance with TP10, are considered to have combined to form the BPO in this instance due to the restrictions associated with this retrofit scenario. It is noted that the non-TP10 factors of the design are supported by recent research in this field (Facility for Advancing Water Biofiltration, 2009).

Raingarden and embankment planting is to be undertaken in compliance with TP10 recommendations. In light of the alternative biofiltration media to be used special consideration is to be given to vegetation suited to well-drained soils.

5.2.5 Atlantis Flo-tank Specifications

To prevent the raingarden filtration media and sediment from migrating into and clogging the Atlantis modules, the tank is to be lined on top with a single layer of geotextile cloth, Bidim A34 or equivalent, securely keyed into the embankment. In recognition of past experience in relation to use of geotextiles within raingarden systems, (where it has been found that there is a tendency for the Geotextile to become clogged in time), the design allowed for the geotextile to be overlaid with a 150mm transition layer of washed sand which would filter any fine sediment thereby mitigating against this risk.

The arrangement of the crate modules has been determined with consideration to excavation for construction with side slopes at a maximum of 1:1 and for practical construction of the tank, taking into account wrapping of the system in geotextile. The void between the temporary excavation and the tanks will be generally filled with 20/7 scoria (for the filling of larger gaps). SAP7 backfill will be used for filling of smaller voids.

The modules are to be constructed four crates high, with allowance for relevant reinforcing for the lower crates due to increased lateral earth pressures. In light of the expected lateral earth loading, the bottom crate is to be constructed with 5 cross-plates, with 3 cross-plates sufficient for the higher 3 crates.

It is recognised that the modular cell construction of the Atlantis subgrade detention system is inherently difficult to clear should significant levels of sediment accumulate within the system. As such, isolating the tanks from the surrounding soil is essential for successful

> "The sand layer is to provide a smooth level surface on which to construct the tank system and to contain a 65mm slotted coil drainage network to remove any surplus groundwater and drain it to the outlet riser."

long term operation of the device. The sides and bottom of the tank are to be therefore wrapped with a double lined geotextile cloth so as to prevent any migration of solids into the system. Wrapping of the tank is to be completed with all seams and folds secured to ensure no soils enter the system. The tank lining will allow for passage of groundwater into the system, preventing excessive hydrostatic pressures building up when the tank is empty thereby mitigating against any risk of tank flotation.

The tank is to be constructed on a 100mm thick layer of compacted plastering grade washed sand. The sand layer is to provide a smooth level surface on which to construct the tank system and to contain a 65mm slotted coil drainage network to remove any surplus groundwater and drain it to the outlet riser.

5.2.6 Outlet Configuration

In light of the significant erosion observed downstream of the existing device, the proposed design for the rehabilitated device incorporates an 'extended detention' function as the primary water quantity design principle. By providing for extended detention to the greatest practicable degree, the overall design for the device results in reduced attenuation levels for peak flow rates during the 2yr and 10yr storms over that which was originally provided for through the concept design for the device. There is still a degree of improvement in peak flow attenuation when compared with the existing pond configuration.

The outlet manhole from the device, SWMH4, is to be fitted with a flow control weir inside the riser, bolted to the riser walls (refer to Figure 13). The weir plate incorporates a 65mm diameter outlet orifice to control the slow release of the extended detention volume.

The device outfall stilling well, SWMH5, has been designed in accordance with the US Army Corps of Engineers guidelines. The stream channel in the vicinity and downstream of the manhole is to be adequately protected against erosion (as mentioned in Section 5.1.2), with these works being proposed as a separate project to be undertaken in the 2012–13 earthworks construction season.

The emergency spillway for the 100yr storm event is to be reinforced with Maccaferri Enkamat 18 erosion reinforcement to ensure degradation of the spillway does not occur through use over time. The reinforcement is to be placed 8m wide over the length of the spillway and total 6.5m length minimum over the embankment – in line with the manufacturer's guidelines.

5.2.7 Operation and Maintenance

A draft operation and maintenance plan (OMP) has been developed for the system, addressing the raingarden, subgrade tanks, manholes and associated components within the hybrid device.

It is noted that a wastewater pump station is located adjacent to the device, and the emergency overflow from this station will discharge to the raingarden surface. Although likely to be a very rare occurrence, in the event of such an overflow, maintenance (potentially including partial replacement) of the raingarden filtration media will likely be needed so as to eliminate any health and safety risks.

Figure 12 – Inlet design detail (manhole SWMH3)

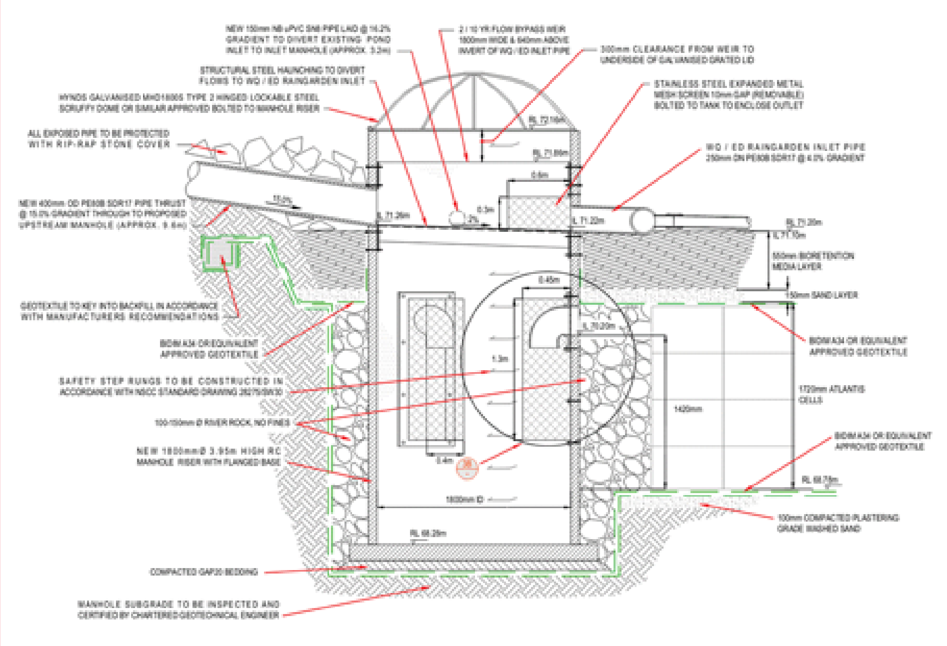
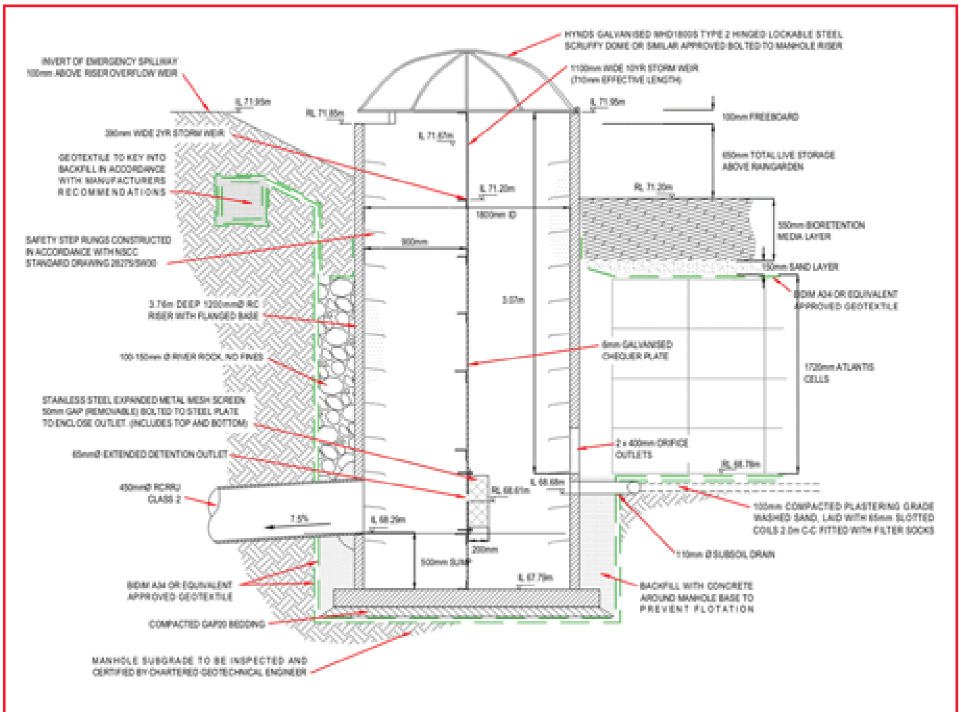


Figure 13 – Outlet design detail (manhole SWMH4)



6. Where to From Here?

6.1 Tender

At the time of writing this paper, the hybrid raingarden and detention tank device has been tendered for construction, with a successful tender yet to be determined.

6.2 Construction

Auckland Council has funding in place to proceed with the redevelopment works upon appointment of a successful tenderer.

6.3 Post-construction Monitoring

Auckland Council plans to develop the draft operation and maintenance plan further, and implement a post-construction monitoring programme in order to monitor the on-going operation of the hybrid system. Important features include the geotextile membrane between the raingarden media and underlying detention tanks, as well as the on-going permeability of the biofiltration media. The operation of the water quality and extended detention flow dispersal system will also be monitored.

6.4 Wider Applications

The hybrid device conceived for the redevelopment of the Carol Lee Place pond is a purpose-designed solution to a particular problem, and is understood to be the first of its kind in the Auckland region. The design adopts a number of advanced techniques to achieve current best practice stormwater management objectives, particularly in relation to the raingarden portion of the device. The permeability rate of the biofiltration media is an important specification to ensure the success of the overall system. It is envisaged that the system can be used as a model for further similar applications around the region, and as a potential alternative to stormwater ponds. In this regard, there are a number of advantages to the hybrid raingarden and detention tank system over traditional wet ponds, which include:

The raingarden media and intrinsic treatment systems provides a higher level of water quality performance relative to the sedimentation-only processes of a traditional wet pond;

The device does not incorporate or rely on a permanent body of water to provide for water quality treatment, and thereby does not introduce a thermal issue (with associated potential adverse impacts on downstream ecology) as with traditional pond systems;

The lack of a permanent body of water largely negates the aquatic weed problems associated with traditional ponds;

The device can provide a better use of space, with the raingarden layer providing opportunities for amenity functions, e.g. park seats and walkways; and,

The lack of a permanent body of water also largely negates the safety issues normally associated with wet pond systems.

7. Conclusions

The Carol Lee Place pond in Albany Heights, Auckland, built in 2004, was significantly undersized and insufficient to achieve the intended stormwater management objectives – being, water quality treatment to a 75% TSS removal standard, extended detention of the 34.5mm storm event, and 2, 10 and 100 year ARI storm event peak flow attenuation. As a result, the undersized pond was causing significant downstream channel erosion.

The options assessment undertaken by the former North Shore City Council identified a unique solution in the form of hybrid

"The hybrid device is soon to be constructed (at the time of writing this paper) and will be closely monitored for operational success."

raingarden and detention tank system as the best practicable option for redeveloping the pond into a device that could better achieve the necessary objectives. Among numerous other benefits, the underground crate system enabled more efficient use of space to achieve maximised storage volumes through near vertical excavation boundaries. Furthermore, the hybrid design will be contained within the confines of the drainage reserve thereby maintaining the recreational functions of the neighbouring parks reserve, while the device presents opportunities for improved amenity values and reduced safety risks relative to the original pond system.

The detailed design process for the hybrid raingarden and detention tank system has resulted in a system that will provide extended detention to the greatest practicable degree as the main priority – almost fully detaining the 34.5mm runoff volume and slowly releasing this volume over a 24 hour period. The raingarden system will provide full water quality treatment to a 75% TSS removal standard, based on the specified 100mm/hr rate of hydraulic conductivity – in line with recent research outcomes. Furthermore, the device will provide peak flow rate attenuation for the 2, 10 and 100 year ARI storm events to levels below those that the pond system achieved.

The hybrid device is soon to be constructed (at the time of writing this paper) and will be closely monitored for operational success. It is anticipated that the system will have wide-reaching implications and could be replicated in similar situations throughout the Auckland region and beyond. ■

Acknowledgements

The work presented in this paper was funded by Auckland Council. Views expressed in this paper are those of the authors and do not necessarily represent policy or the position of the Auckland Council.

Barry Carter from Auckland Council provided an overview role of the Carol Lee Place pond redevelopment project from conception. Colleen Brent from Auckland Council managed the options assessment process and initial development of the hybrid system. Nick Vigar from Auckland Council undertook a technical review of the system on behalf of Council. Greg Edwards, Allen Jia and Jack Turner from AR Civil Consulting Ltd all contributed to the development and design of the hybrid system.

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Roof-Collected Rainwater Consumption and Health

Stan Abbott and Brian Caughley – Roof Water Harvesting Centre, Massey University

Introduction

In New Zealand more than 10% of the population depends on roof-collected rainwater systems for their drinking water – especially in rural and semi-urban areas that are not served by municipal town water supplies. Roof-collected rainwater consumption is also popular because the general public has the perception that rainwater is "pure" and safe to drink. Indeed, the risk of disease arising from roof-collected rainwater consumption can be low, providing that the water is visibly clear, has little taste or smell and, most importantly, the storage and collection of rainwater is via a properly maintained tank and roof catchment system. The microbiological quality of stored roof-collected rainwater can be impacted directly by the roof catchment and subsequent run-off contamination, via direct depositions by birds and small mammals, decay of accumulated organic debris, and deposition of airborne micro-organisms.

Pathogens from contaminated roof-collected rainwater can be transmitted by:

- Direct or indirect drinking of contaminated roof water or ingestion contaminated foods during food preparation.
- Inadvertent contact through ingestion or inhalation of aerosols produced as a result of toilet flushing and gutter cleaning.
- Direct or indirect ingestion via the garden tap.
- Direct contact through using the tap to fill up swimming pools, paddling pools, hot water tubs, car washing, and washing implements and equipment.
- Inhalation/ingestion and microbial contamination of the environment and subsequent ingestion of garden produce contaminated as a result of watering with roof-collected rainwater.
- Bites from mosquitoes breeding in rainwater tanks.

In order to determine the associations between roof water consumption and health this review considers the microbiological quality of roof-collected rainwater, indicator organisms and health relationships, pathogens isolated from roof-collected rainwater, and disease outbreaks and health risk studies associated with roof water consumption.

Microbiological Quality of Roof-collected Rainwater:

Although roof-collected rainwater supplies serving less than 25 people in New Zealand are classified as unregistered supplies and therefore not monitored regularly, a number of reports have been published on the microbiological quality of these private supplies. A study by Dennis (2002) on 60 roof-collected rainwater samples from the South Wairarapa, where approximately 60% of the households use roof water, revealed *E.coli* transgressions in all samples on at least one occasion during a three-month period. Most samples had total coliform counts of more than 500 per 100ml and in two samples

> "Apart from the few roof water-linked disease outbreaks described above, evidence of actual disease outbreaks resulting from drinking roof-collected rainwater polluted by pathogens is rare."

Figure 1 – A concrete rainwater tank in rural Dunedin

E.coli counts of greater than 880 per 100ml were found. In a pilot study (Sedouch, 1999) on 100 roof-collected rainwater samples from the lower half of the North Island, only 18% of samples were found to comply with the New Zealand Drinking Water Standards and 40% of samples were found to have failed "badly" with very high *E.coli* counts (>2419.6 per 100ml).

Of 125 roof-collected rainwater samples from rural Auckland districts analysed between 1996 and 1998, 56% had faecal coliform levels that would have exceeded the 1993 WHO drinking water guidelines (Simmons et al. 2001a). Significantly Aeromonas spp. was found in 16% of the samples leading the authors to conclude that this organism has potential as an alternative indicator of water quality and health risk

In a five year Massey University study (Abbott et al. 2006) we investigated the microbiological quality of roof-collected rainwater samples of 560 private dwellings in New Zealand. At least half of the samples analysed exceeded the acceptable standards for contamination and in more than 40% of the samples we found evidence of heavy faecal contamination. The likely sources of the faecal contamination were faecal material deposited by birds, frogs, rodents and possums, and dead animals and insects, either on the roofs or in the gutters, or in the water tank itself. Importantly, many of the roof water supplies surveyed revealed deficiencies in the use of rainwater catchment systems and components. In a significant number of supplies where we found heavy faecal contamination there was evidence of lack of maintenance; inadequate disinfection of the water; poorly designed delivery systems and storage tanks; and failure to adopt even simple physical measures to safeguard the water against microbiological contamination.

Several overseas studies have also shown that roof-collected rainwater frequently failed drinking water standards with respect to coliforms and / or faecal coliforms values:

- In a survey of the water quality of 100 private farm rainwater supplies in Australia varying levels of total coliforms were found in 52% of the water samples and 38% showed the presence of *E.coli* as well (Verrinder & Keleher, 2001). However, the authors found no relationship between drinking water quality or drinking water-related health risks on the farms and concluded that although many of the water samples were non-compliant it did not necessarily mean there was a health risk to the householders.
- An intensive monitoring programme of the "Healthy Home" in southeast Queensland showed that while roof water and in situ tank water exceeded the Australian Drinking Water Guidelines (NHMRC, 1996) for total and faecal coliforms by a

"Roof-collected rainwater consumption is also popular because the general public has the perception that rainwater is "pure" and safe to drink."

considerable margin (average tank counts of 830 and 120 per 100ml respectively), the water quality from the hot water systems consistently produced zero (compliant) levels of total and faecal coliforms (Coombes et al. 2000). This study also revealed that in rainwater cisterns, the highest counts occurred immediately after major rainfall events (≥ 50mm) which washed organic material from the roof gutters into the tanks. Nevertheless, the authors demonstrated a marked reduction in the bacterial counts over time suggesting that the rainwater cisterns have a self-disinfection action.

- A study by Levesque et al. (2008) on the microbiological quality of drinking water from 102 household rainwater tanks in Bermuda showed that 90% of the samples were contaminated with total coliforms in concentrations exceeding 10cfu per 100ml and 66% of samples were contaminated with *E.coli*. (range 0 – >100). The authors reported that tank cleaning in the year prior to sampling seemed to protect the water from contamination.
- Several other detailed overseas investigations have also raised concerns when they revealed that in many instances stored rainwater does not meet WHO, EPA or other similar standards with respect to one or more bacteriological water quality indicators (Fujioka & Chinn, 1987; Haebler & Waller, 1987; Krishna, 1989). In northeast Thailand, where several million people use rainwater tanks, a major study of rainwater quality by Wirojanagud et al. (1989) on 189 rainwater storage tanks, revealed that only around 40% met WHO drinking water standards. Fewtrell and Kay (2007) reviewed the microbial quality of rainwater supplies in developed countries and found that harvested rainwater supplies varied widely in terms of microbial quality and consistently failed drinking water standards.
- In a three year study in the Netherlands, Schet et al. (2010) demonstrated that roof-collected rainwater was frequently faecally contaminated and incidentally contained potential pathogens such as Campylobacter, Cryptosporidium, Giardia, Aeromonas hydrophila and Legionella. Analysis of samples during a period with variable weather conditions showed a correlation between rainfall intensity and faecal coliform counts (range 0 – 1934) and increased detection of pathogens after heavy rainfall incidents

Figure 2 – A polyethylene rainwater tank on Waiheke Island

"Unfortunately public health surveillance data do not reflect the true rate of waterborne illnesses in the community because they usually only capture case-patients in contact with a health care facility."

Indicator Organisms and Health Relationships

In a recent study on the suitability of Escherichia coli, Enterococci, and Clostridium perfringens for assessing the microbiological quality of roof-collected rainwater, Ahmed et al. (2010) showed that the presence or absence of pathogens did not correlate with any of the faecal indicator bacterial concentrations. These authors questioned the reliability of faecal indicators since the roof water samples tested in the study appeared to be of poor microbiological quality but no significant correlation was found between the concentration of faecal indicators and pathogenic organisms.

Evans et al. (2007) has also questioned the relevance of faecal indicator organisms and has suggested the need for a broader approach to the assessment of rainwater tank water quality, especially the likely role of environmental organisms in regulating tank water quality.

Moe et al. (1991) showed that the incidence of diarrhoea in young children was significantly related to drinking water containing high levels of bacterial contamination (>100 *E.coli* per 100ml) but little difference was observed between illness rates of children using either good quality drinking water (<1 *E.coli* per 100ml) or moderately contaminated drinking water (2–100 *E.coli* per 100ml).

Similarly, in a study that investigated the association between *E.coli* and in household drinking water and diarrhoeal diseases in Cambodia, Brown et al. (2008) found that diarrhoeal disease risks did not increase progressively in magnitude with increasing concentrations of *E.coli* in drinking water. Compared to households with <1 *E.coli* per 100ml in drinking water there was no observed increased risk for having 1–10 *E.coli* per 100ml while households with measured *E.coli* of 11 to 100 per 100ml reported a slight increase in diarrhoea. The authors of this study conclude that the continued use of *E.coli* as a basis for decision-making about water quality, water treatment and overall water handling practices needs to be re-examined in light of the growing body of evidence that suggests that *E.coli* may be a poor indicator of waterborne disease risks in at least some settings.

While the coliform group of organisms have been used as indicators for almost 100 years, research is on-going to find better ways to assess the microbiological quality of drinking water, including new detection methodologies such as molecular techniques (Yates 2007). However, in a recent review of the literature analysing a dataset of 540 pathogen-indicator relationships published during 1970–2009, Wu et al. (2011) found that while only 41% showed correlations between indicators and pathogens they concluded that the poor correlations were the result of studies with insufficient data for assessing such correlations. Recently too Levy et al. (2012) were able to detect some associations between *E.coli* in household drinking water quality and diarrhoeal disease but also suggest that larger sample sizes are needed to account for the inherent variability in water quality exposure measurements using indicator organisms.

Although there is currently considerable debate regarding the public health significance of total coliforms in drinking water, it is important to note that in all waterborne outbreaks between 1991 and 1998 in the USA in which a bacterial agent was identified as the cause of disease, total coliforms were present in all the water samples and they were also detected in 81% of water samples from outbreaks caused by viruses and in 50% of samples where protozoa were responsible for the outbreaks (Craun et al. 2002). Therefore in spite of the controversies concerning the effectiveness of faecal coliforms as indicators of disease risk, these indicator organisms can still be extremely useful for determining contamination of water supplies, including seasonal changes in water quality as well as useful for assessing the success of water treatment methods and preventative maintenance and design systems.

Pathogens Isolated from Roof-collected Rainwater and Disease Outbreaks Linked to Contaminated Roof Water

While rainwater itself is free from pathogens and contamination levels of stored rainwater are generally low if tanks are well protected with covers or lids, obvious sources of contamination of the rainwater runoff from roofs and gutters are from birds, possums, rodents, cats and rotting vegetation. Bacterial pathogens such as Salmonella spp., Campylobacter spp., Legionella spp., and Clostridium perfringens have been isolated, in varying densities, from roof-collected rainwater samples (Broadhead, 1988; Wirojanagud et al. 1989; Fujioka et al. 1991; Lye, 1992; Lye, 2002; Brodribb et al. 1995; Simmons et al. 2001a).

Savill et al. (2001) found the presence of Campylobacter by an MPN/PCR technique in 5% of roof water samples collected from rural locations in the North Island. Although the numbers of Campylobacter detected were very low, there was no correlation between the presence of Campylobacter and faecal coliform and *E.coli* indicator counts.

In a study on 45 water samples of roof water cisterns in the United States, Crabtree et al. (1996) revealed that 48% were positive for Cryptosporidium (mean = 2.4 oocysts/100L) and 26% positive for Giardia (mean =1.09 cysts/100L). In contrast, in a New Zealand study by Simmons et al. (2001a) on 50 roof-collected rainwater samples, Cryptosporidium oocysts were detected in only 2 (4%) of samples and no Giardia cysts were found in any of the samples. The authors of the latter study suggest that the difference in the results of the two studies may reflect differences in the prevalence of the protozoa in the animal reservoirs, the sources, and the degree and frequency of faecal contamination of the catchment or rainwater storage tank

For this review the outbreak classification system of Tillet et al. (1998) has been used to define the strength of association between roof-collected water consumption and illness (Table 1).

	Strength of Association	
Microbiology	Pathogen identified in patient is also found in water	A
	Indicator organisms and/or water-treatment problem of relevance but outbreak pathogen is not detected in water	B
PLUS: Epidemiology	Analytical epidemiology (case control or cohort study) demonstrates an association between water and illness	C
	Descriptive epidemiology suggests that the outbreak is water related and excludes obvious alternative explanations	D
	↓	
Strong Association	(A + C) or (A + D) or (B + C)	
Probable Association	(B + D) or A only or C only	
Possible Association	B only or D only	

Table 1 – Classification system for categorizing strength of association

The 11 roof water disease outbreaks reported between 1978 and 2010 that were considered for this review are shown in table 2.

Year	Location	Cases	Organism	Association
1978	Trinidad	63	Salmonella	Strong
1981	Caribbean	13	Legionella	Probable
1983	England	257	Campylobacter	Possible
1992	Australia	89	Giardia & Cryptosporidium	Possible
1997	New Zealand	4	Salmonella	Strong
1999	Australia	23	Campylobacter	Probable
2000	Australia	28	Salmonella	Strong
2003	New Zealand	5	Salmonella	Strong
2006	New Zealand	4	Legionella	Strong
2009	Australia	27	Salmonella	Strong
2010	New Zealand	93	Norovirus	Probable

Table 2 – Disease outbreaks associated with roof-collected rainwater consumption

Koplan et al. (1978) postulated roof-collected rainwater as possible cause of a 63-case outbreak of Salmonellosis in Trinidad, West Indies, and Simmons and Smith (1997) reported roof-collected rainwater as the probable source of Salmonella Typhimurium infections in a family of four in New Zealand. An investigation of an outbreak of Salmonella enterica serotype Typhimurium DT160 infections in humans in New Zealand (Thornley et al. 2003) found that five of the 170 case-patients had consumed roof-collected rainwater in which the pathogen was also detected. In an investigation of 28 cases of gastroenteritis among 200 workers at a construction site in Queensland, Salmonella Saintpaul was isolated from both cases and rainwater tank samples (Taylor et al. 2000). Animal access was suggested as being the source of the contamination with several live frogs being found in one of the suspect tanks. Recently an outbreak of gastroenteritis was identified at a school camp in rural Victoria, Australia (Franklin et al. 2009). Environmental and epidemiological investigations suggested that rainwater collection tanks contaminated with Salmonella Typhimurium definitive phage type 9 (DT9) was the cause of the outbreak.

Contamination of an open-topped water storage tank by faecal material from birds or bats was the most likely source of infection in an outbreak of Campylobacter gastroenteritis that affected 234 pupils and 23 staff at a UK boarding school over a period of 8 weeks (Palmer et al. 1983). An outbreak of Campylobacter enteritis on a resort island in North Queensland involving 23 cases was probably due to the consumption of contaminated rainwater (Merrit et al. 1999).

In 2006, an outbreak of Legionnaires' disease (LD) was identified in Beachlands, a small, isolated east Auckland suburb (Simmons et al. 2008). Aerosols containing Legionella discharged to air by a marina water blaster may have infected some of the cases directly or may have seeded roof-collected rainwater systems resulting in some of the cases being exposed by contaminated bathroom showers. The authors recommend that roof-collected rainwater systems need appropriate design, careful cleaning and the maintenance of hot water temperatures at a minimum of 60°C to reduce the chances of Legionella multiplying. Twenty-seven cases of Legionnaires' disease were identified in 1981 in persons who had stayed at a single hotel in St Croix. The outbreak was due to Legionella pneumophila serogroup 1 and 3 several new Legionella species were also isolated from the potable water system at the hotel. Following hyper-chlorination of the potable water system, no further cases of Legionnaires' disease in hotel visitors were reported (Shlech et al. 1985).

An underground rainwater storage tank was associated with a mixed outbreak of cryptosporidiosis and giardiasis in Australia in which eighty-nine people supplied with the drinking water became ill (Lester 1992). Investigations revealed that the tank had been contaminated by an overflow from a septic tank.

In 2009, 93 cases of Norovirus gastroenteritis were reported among Turoa Ski Field staff on Mount Ruapehu in the North Island of New Zealand (O'Connor et. al. 2010). Although Norovirus genotypes 1 and 2 were detected in an untreated drinking water sample no Norovirus nor Escherichia coli were detected in the rainwater tanks at the ski field. Since norovirus is usually found in humans, and sometimes in pigs, humans were the only possible source of the virus in this outbreak. Because considerable snow-making occurs at the base of the ski field – and some of this snow often lands on the roofs of buildings – and as the water for the snow is sourced from a pond below the ski area it was hypothesized that contamination of the pond water with human sewage was the source of the outbreak. However, no faecal coliforms were detected in any of the rainwater storage tanks.

Health Risk Studies Associated With Roof Water Consumption

Apart from the few roof water-linked disease outbreaks described above, evidence of actual disease outbreaks resulting from drinking roof-collected rainwater polluted by pathogens is rare. The lack of reports linking communicable disease outbreaks to roof-collected rainwater, may in part be due to the fact while rainwater use is extensive, most systems serve individual households of only a few persons. Residents experiencing sporadic gastrointestinal illnesses are less likely to seek medical attention unless the illnesses are severe and/or life threatening. Contaminated rainwater is also more likely to be a source of sporadic disease episodes because of

> "Health scientists are now in broad agreement that outbreaks form only a minor part of the total drinking-water related illness burden and that a large proportion, and probably the vast majority, of the waterborne disease burden arises outside of detected outbreaks."

possible immunity in a proportion of those exposed, together with asymptomatic infection in others (Simmons et al. 2001b). Visitors or persons who have not consumed roof-collected rainwater previously could be especially at risk from waterborne diseases if the water supply is contaminated with pathogenic organisms.

In a recently published systematic review of evidence regarding the consumption of roof water and health, Dean and Hunter (2012) found that when compared with unimproved sources, roof water consumption was associated with fewer episodes of diarrheal disease. However, the authors point out that their findings are based on very few studies of variable quality and design and as such further research is needed for conclusions to be drawn with greater confidence. Furthermore they report that the small number of outbreaks that they identified most likely represents under-reporting of outbreaks. As reported by Hunter et al. (2001) small outbreaks may involve just a few people and not be detected against the background level of endemic disease.

In South Australia 42% of residents mostly drink rainwater in preference to their mains water without any apparent effect on the incidence of gastrointestinal illness (Heyworth et al. 1998). To investigate the relationship between tank rainwater consumption and gastroenteritis in South Australia, a prevalence survey of 9,500 four year-old children was undertaken and this was followed up with a longitudinal cohort study of gastroenteritis among 1000 four to six-year-old children, selected on the basis of their tank rainwater consumption (Heyworth et al 2006). Although this study found that children drinking tank rainwater were not at a greater risk of gastroenteritis than children drinking public mains water the study had an important limitation in that the majority of the children had drunk tank rainwater for at least one year. Hence an alternative explanation to there being no increased risk associated with tank rainwater was that the children were exposed to potentially low levels of contaminants and may have developed immunity to some organisms. Furthermore it should be noted that no microbial water quality monitoring was done in this study and that 77% of roof catchments were reported to be free of overhanging trees and 65% of gutters had been cleaned in the last year during the study period.

In a double-blinded, randomised controlled study of water treatment filters and gastroenteritis incidence among 300 households in Adelaide, Rodrigo et al. (2010) reported that the consumption of untreated rainwater does not contribute appreciably to community gastroenteritis. However, as the authors point out their findings may not be applicable to susceptible and immune-compromised persons, young children, or the elderly because these groups were specifically excluded from their study. A limitation of this study is the fact because a number of household participants in both groups may well have had partial immunity to low levels of organisms, visitors (who did not drink the water regularly) should perhaps also have been included in the study. A further limitation of study was the lack of an alternative water source control group since all the participants used rainwater. Also of concern is the reported high dropout rate (31%) of participants because this may have contributed to the underestimation of the true incidence of gastroenteritis. While the authors state that they conducted limited water quality testing on rainwater tank samples it would have been useful to see if there was any correlation between the *E.coli* levels and the episodes of gastroenteritis and their severity.

While there are many confounding factors associated with rainwater consumption, there is no question that contaminated tank rainwater increases the risk for acquiring gastrointestinal illness. New Zealand studies have shown that consumption of roof-collected rainwater is associated with a threefold greater risk of campylobacteriosis than that of non-consumers (Eberhart-Phillips et al. 1997). In a case-control study on risk factors for giardiasis among children in Auckland it was found that consumption of roof-collected rainwater significantly increased the risk for this infection (Hoque et al. 2003). A study on salmonella infections in Tasmania found that 81% of the cases had consumed untreated tank rainwater (Ashbolt and Kirk 2006).

Ahmed et al. (2009) used Quantitative Microbial Risk Assessment (QMRA) analysis to quantify the risk of infection associated with the exposure to pathogens from potable and non-potable uses of roof-harvested rainwater in South East Queensland (SEQ). A total of 84 rainwater samples were analysed for the presence of faecal indicators (using culture based methods) and zoonotic bacterial and protozoan pathogens using binary and quantitative PCR (qPCR). The concentrations of Salmonella invA, and Giardia lamblia-giradin genes ranged from 65–380 genomic units/1000ml and 9–57 genomic units/1000ml of water, respectively. After converting gene copies to cell/cyst number, the risk of infection from G. lamblia and Salmonella spp. associated with the use of rainwater for bi-weekly garden hosing was calculated to be below the threshold value of 1 extra infection per 10,000 persons per year. However, the estimated risk of infection from drinking the rainwater daily was 44–250 (for G.lamblia) and 85–520 (for Salmonella spp.) infections per 10,000 persons per year. Since this health risk seems higher than that expected from the reported incidences of gastroenteritis, the authors point out that one critical assumption in this study was that the proportion of gene copies represented both viable and infective organisms because qPCR does not provide information regarding viability or infectivity.

Conclusion

Unfortunately public health surveillance data do not reflect the true rate of waterborne illnesses in the community because they usually only capture case-patients in contact with a health care facility. Less than a third of people who become ill from contaminated water are in fact reported because as mentioned above, persons experiencing sporadic gastrointestinal illnesses will only seek medical attention if the illnesses are severe and/or life-threatening (Wheeler et al. 1999). For the illness to be recorded, the ill person must go to a doctor who will examine the person and then collect appropriate samples for a microbiological analysis. Only if the results are positive will they be recorded in the statistics. Lake, Adlam and Perera (2007) have in a large study shown that for every 219 cases of acute gastrointestinal infections in the community only 1 is actually picked up by surveillance systems.

Health scientists are now in broad agreement that outbreaks form only a minor part of the total drinking-water related illness burden and that a large proportion, and probably the vast majority, of the waterborne disease burden arises outside of detected outbreaks. This contrasts with the view, still periodically heard, that the failure to detect outbreaks of waterborne disease means that contaminated water is not a cause for concern (Hunter et al. 2003).

Because of the many benefits roof water harvesting should unquestionably be encouraged for both urban and rural

> "Unfortunately public health surveillance data do not reflect the true rate of waterborne illnesses in the community because they usually only capture case-patients in contact with a health care facility."

environments since rainwater tanks are a visible and high profile method of conserving water and can be used to reinforce and promote water conservation policies and practices. However, there must be an awareness among the general public, local authorities, and regional public health services about the health risks associated with contaminated roof water. Providing the roof-collected rainwater is clear, has little taste or smell and is collected from a well-maintained system, it is probably safe and unlikely to cause any illness in most users. The health risks of roof-collected rainwater can be minimised by sensible preventative management procedures. Some of the preventative measures are associated with design and installation while others are associated with on-going maintenance. Well-designed systems are low maintenance and will generally prevent problems occurring so that corrective action to restore safe rainwater quality will be needed infrequently. ■

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Preventative Measures and Corrective Actions for Safe Roof Water Harvesting

Stan Abbott – Roof Water Harvesting Centre, Massey University

The health risks of roof-collected rainwater can be minimised by sensible preventative management procedures. Some of the preventative measures are associated with design and installation while others are associated with on-going maintenance. Well-designed systems are low maintenance and will generally prevent problems occurring so that corrective action to restore safe rainwater quality will be needed infrequently.

- Ensure that the roof is appropriate for capturing rainfall; use a clean impervious roof made from non-toxic material
- Remove and replace with approved materials any items containing lead products (e.g. paints, flashings, nails etc)
- Before purchasing materials or paint to be used on roof catchment areas, read and observe the manufacturer's recommendations on labels and brochures regarding the suitability of the products for rainwater collection
- Keep roof catchments clean and clear of moss, lichen, debris and leaves
- Keep roof catchments clear of overhanging vegetation as branches provide roosting points for birds and can provide access for small animals such as rodents, cats and possums
- If appropriate install gutter guards and/or screens as well
- Install screened down pipe rainheads or other suitable leaf and debris protection devices on each down pipe. Recommended screen mesh size is 4–6 mm and these devices should be self-cleaning

> "In the event of any weed or chemical spraying in an adjacent location, advise the contractor that the roof is used to collect drinking water, and that there must be no over-spraying. Obtain a guarantee from the contractor that persistent organochlorine pesticides will not be used."

- Install a first flush diverter to prevent contaminated water entering the tank; first flush diverters must have automated diversion and drainage systems (i.e. no manual diversion or drainage); any roof water collection area, by virtue of its location, susceptibility to undue contamination with organic material, dust, ash, sand, salt or airborne chemical residue, should have a first flush diversion system installed.
- Ensure that chimneys within or adjacent to roof water collection areas are of sufficient height to minimise the settlement of ash or residues on the roof and in the gutters

Figure 1 – Screened rainhead, first flush diverter, calmed inlet, floating out-take and tank vacuum device

- Exercise care when cleaning gutters; make sure the ladder is secure and avoid going anywhere near overhead power lines or better still have the power disconnected before cleaning the gutters
- Inspect gutters regularly and clean if necessary. If possible, disconnect the down pipe(s) that feed the water tank before cleaning the gutters or better still install down pipe debris diverters (ensure that the opened flaps have fully sealed off the downpipes before cleaning gutters)
- If installed, clean tank inlets and screens every three to four months
- In the event of any weed or chemical spraying in an adjacent location, advise the contractor that the roof is used to collect drinking water, and that there must be no over-spraying. Obtain a guarantee from the contractor that persistent organochlorine pesticides will not be used
- Install a "calmed inlet" pipe into the rainwater tank so that the water enters the tank through a 'U" bend to avoid the disturbance of any sediment that may have accumulated in the bottom of the tank
- Install a floating valve draw off pipe in the tank in order to extract water from near the top of the tank (Floating valve must be used in conjunction with calmed inlet)
- Prevent access by small animals, birds and mosquitoes into rainwater storage tanks by screening all tank inlets as well as overflows, and keep access hatches closed
- Prevent entry of surface run-off from areas other than roof catchment into below-ground tanks. Tank roofs must be secure and the sides and bottom of the tank should be sealed to prevent egress
- Inspect tanks annually and if necessary have tanks cleaned out professionally
- Sediments can be removed by installing a tank vacuum system that automatically siphons off the sediment from the bottom of the tank if and when the tank overflows
- A swimming pool vacuum cleaner can also be used for siphoning out sediments
- If tank contamination is apparent the water should be chemically disinfected and/or boiled before the water is used for consumption and food and drink preparation
- Depending on the circumstances, additional water purifying equipment may need to be installed. These include a 20μm washable cartridge filter, a UV steriliser, and a 1μm activated carbon under-bench filter ■

Emergency Water Services Planning for Wellington

Steve Hutchison – MWH New Zealand Ltd and Gary O'Meara – Capacity Infrastructure Limited

Abstract

The supply of water to Wellington city is extremely vulnerable in a major earthquake. The bulk supply lines from the Hutt Valley cross the Wellington fault in five places and restoration of a limited bulk supply to Wellington city following a major rupture of this fault is estimated to take up to 55 days. Functional restoration of the local water network will take up to 30 days longer for the furthest points of the network as there will be limited water available to re-pressurise, test for and repair leaks.

Capacity has been working on earthquake preparedness since its inception in 2004 and has convened a Water Services Emergency Preparedness Group (WSEPG) including representatives from the four city councils WCC, PCC, HCC and UHCC, the Wellington region emergency management office and Greater Wellington regional council. The recent Canterbury earthquakes have increased the focus on this work.

As part of the planning activities this group commissioned MWH to investigate alternative water supply arrangements and to develop a plan for the supply of water following a major earthquake. This investigation covered surface water, groundwater, bottled water, portable desalination and rainwater in addition to the city reservoir storage.

Keywords

Emergency preparedness, earthquake planning, seismic resilience

1. Introduction

Emergency management has taken renewed prominence in network planning since the earthquake events of September 2010 and February 2011 in Christchurch. These earthquakes have highlighted the vulnerability of Wellington City in the event of a significant earthquake, particularly as the roading network in Wellington is highly vulnerable to landslides and other access into the City will be severely limited.

The bulk water sources for the Wellington metropolitan region are concentrated to the north and east of the region. The location of the major fault lines means that there is a strong likelihood the reticulation for most urban areas would be separated from the treated water sources in the event of a major earthquake event.

The scenario used for Wellington region emergency management planning is a major earthquake of the Wellington Fault of magnitude 7.6 on the Richter scale, resulting in 4–5 metre horizontal and 1m vertical fault displacement and widespread disruption to the roading network. A rupture of the Wellington fault is acknowledged as "worst case" however is a realistic scenario for planning purposes. The *It's Our Fault* project (GNS, 2010) recently estimated the chance of a major rupture in the next 100 years as about a 11% probability.

As the reservoir storage is less than that required for the likely restoration times there is a potential gap between the available reservoir water running out and restoration of the reticulated supply. This study was focused on identifying supplementary sources of emergency water to fill this potential gap and consideration of the distribution of that emergency water.

2. Background

2.1 Access Limitations

Roading access both into and within the Wellington region is severely vulnerable to a major earthquake and has been the subject of numerous investigations and improvement projects. Landslides are expected to isolate the regional access roads and there will be considerable damage within the region from the fault movement and liquefaction. The current estimate for land access restoration to the region is 120 days. This will make the external supply of resources particularly difficult as sea and air access will also be disrupted.

2.2 Volume of Water to be Supplied

The initial target for this study was to provide a minimum of 10 l/p/d of potable water for this population for a period of up to 90 days. This was revised to 20 l/p/d to meet the 15 l/p/d as used by international humanitarian guidelines and allowing for some inefficiency in distribution. Allowance has also been included for supply to the major hospitals.

The quantity of water required would be a total emergency supply daily volume of 8,000 m^3 for the region compared to the current average daily bulk supply of 150,000 m^3. It is acknowledged that 20 litres per person per day is a very minimal volume of water and overseas experience suggests that the general population will demand significantly more than this, particularly after an initial recovery period of around two weeks. Resumption of the reticulated water supply as soon as possible would be required for economic activity and daily life to resume.

2.3 Bulk Water Supply Vulnerability

The Wellington bulk water network is operated and maintained by Greater Wellington Water (GWW), a division of Greater Wellington Regional Council (GWRC). The supply sources for the Wellington

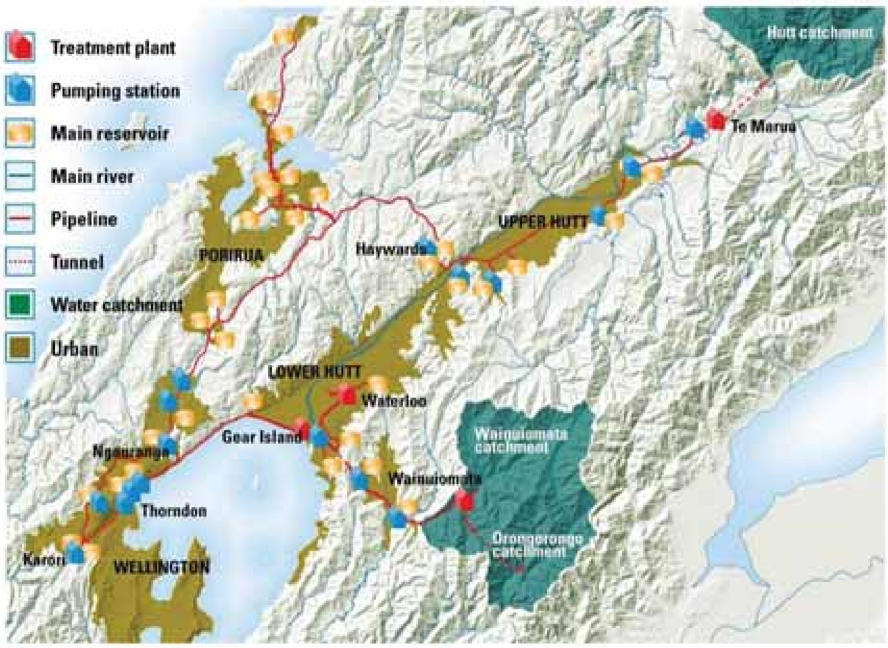

Figure 1 – Greater Wellington Bulk Water Network

"Stored water within each city will need to be supplemented by externally supplied water. This could be through bottled water or water tankered from the Hutt Valley, however severe access limitations are anticipated following a major earthquake."

metropolitan area are concentrated to the north and east of the region. The location of the major fault lines means that there is a strong likelihood the reticulation for most urban areas would be separated from these sources in the event of a significant earthquake event.

Security of supply has been a major focus of GWW staff over the years and efforts to reinforce the network for seismic response are an ongoing focus. Two main trunk lines feed Wellington city, of these the 26km Wainuiomata to Wellington pipeline runs along SH2 between Petone and Wellington, close to the Wellington fault, and is expected to be out of service following a Wellington fault earthquake of significant magnitude. The 56 km Te Marua to Wellington pipeline (which also feeds Porirua City Council's network) crosses the Wellington fault at Haywards but then moves away from the fault and does not pass over higher risk liquefaction areas. This line is of more modern welded steel construction and overall is more resilient.

Recent GWW reports have suggested that it could take 40 to 55 days to restore a 33% supply to Wellington City based on repair of the 56km Te Marua to Wellington pipeline. This time is potentially reduced by 15 to 20 days if a dam and treatment facility were to be constructed at Whakatikei. Wellington City is located furthest from water sources and will therefore have the longest time for restored supply. Upper Hutt supply could be resumed within one week, Hutt City within about 3 weeks and Porirua is expected to take a similar amount of time to Wellington. There is considerable uncertainty regarding these times due to the inherent uncertainties in quantifying the effect of earthquake damage on underground utilities, particularly where they cross known fault lines. Full supply is expected to take 60–80 days to restore the bulk system to the local network in Wellington city. Note that repair of the local networks will take additional time, which has been estimated as up to 30 days for the furthest points in the network, e.g. Miramar. An upper figure of 90 days requiring emergency water supply was used for the purposes of this study.

2.4 Local Water Network Management

The GWW network delivers water to various points of supply in the four cities: Wellington City Council (WCC), Hutt City Council (HCC), Upper Hutt City Council (UHCC) and Porirua City Council (PCC). From the supply points, which are typically terminal reservoirs, pumping and storage is the responsibility of the city councils.

Capacity Infrastructure Services Ltd (Capacity) is a Council Controlled Organisation responsible for water supply for Wellington, Hutt and Upper Hutt City Councils. Porirua City Council currently manages their water supply directly.

Capacity has been working on earthquake preparedness since its inception in 2004 and has convened a Water Services Emergency Preparedness Group (WSEPG) including representatives from the four city councils WCC, PCC, HCC and UHCC, the Wellington region emergency management office and Greater Wellington regional council. The Canterbury earthquakes in September 2010 and February 2011 increased the focus on this work.

Civil Defence Management

A major event such as the Wellington fault rupture considered in this report would be managed under Civil Defence legislation. The Civil Defence structure for such events includes National level, Group level and Local level. Since this study was completed the local Wellington emergency management offices (WEMO, HVEMO and PEMO) have restructured into the Wellington Region Emergency Management Office (WREMO).

3. Supply Sources and Potential Resources

The first step following a major earthquake is reconnaissance to determine the damage to the network. Once reconnaissance is completed emergency water will need to be provided using the available resources with additional resources requested through WREMO. The emergency water sources will include two broad categories:

- Stored water from the existing reservoirs;
- Alternative sources to supplement the reservoir capacity.

These sources are described in the following sections.

3.1 Stored Water

Council owned reservoirs are the primary resource for emergency water. Each of the Councils in this study has undertaken seismic assessments of the reservoirs and has a programme of upgrades underway. Substantial investment has been made in this programme however ongoing investment is required. For example, closer investigation by Capacity has found that only 45% of the 129,130 m^3 storage capacity in Wellington city is considered seismically secure to current standards. That volume could provide 14 days water supply for the planned emergency demand and ongoing strengthening and other improvements are planned to increase this figure.

Automatic shut-off valves are installed at most reservoirs and a programme to install these valves on the reservoirs with capacity of greater than 500m³ is ongoing for some of the Councils. Review of the inlet and outlet pipework has also resulted in seismic improvement works being required at some sites.

3.2 Alternative Emergency Water Sources

3.2.1 Greater Wellington Treatment Plant Sites

Assuming significant damage to the bulk water transmission network, the possibility of sourcing water directly from the treatment plant sites was investigated. Greater Wellington Water operate four treatment plant sites. A comprehensive seismic resilience review of all the GWW facilities was undertaken in 1993.

It was identified during this study that there were no specific provisions to fill water tankers or other mobile water equipment directly from the treatment plant sites. Additional hydrants in the adjacent road main and/or temporary hydrant points would most likely need to be used to fill tankers or other bulk water containers however these would be subject to the resilience of those pipelines. Capacity and GWW have subsequently developed a design for multiple tanker filling hydrants to be installed on a secure pipeline in Knights Road for the Waterloo treatment plant. This facility is planned for construction in late 2012.

Due to the long transmission lines and location of fault lines, GWW are also investigating storage "lakes" for treated water closer to Wellington city to enhance pipeline restoration times and/or provide water for re-treatment. This investigation is at an early stage and storage lakes between 10 and 500 ML size are being considered.

3.2.2 Groundwater

The Hutt Valley has a significant number of groundwater bores, particularly from the artesian aquifer in the lower valley. Information from GWRC records regarding the location, ownership, diameter and permitted flow rate was reviewed to identify private bores. Capacity are currently making arrangements for possible emergency use with a number of these sites.

Very limited groundwater resource was identified in Porirua. Detailed investigation of additional sources was outside the scope of this study.

WCC had previously commissioned a desk top study of the potential for supplying a back-up water source to Wellington city from deep fractured rock aquifers (Beca, 2009). That assessment concluded that volumes potentially suitable for water supply could be produced from wells at 150m or more in depth. 15 sites were identified however none of these sites had been developed at the time of the MWH investigation.

As part of this study the Institute for Geological and Nuclear Sciences Ltd (GNS Science) were commissioned to investigate the likely yield from wells in the Wellington CBD including Miramar Peninsula and Island Bay for the purpose of assessing the viability of groundwater as an option for emergency supply (GNS, 2010). GNS Science concluded that maximum well yield from any one well is likely to be between about 60 to 215m³/d. A target of 2,400 m³/d was defined in their brief and this would require between 12 and 40 wells to provide an emergency supply. GNS Science recommended that groundwater be considered for at least a proportion of the emergency water supply and investigation well drilling and testing be undertaken to obtain more reliable well yield information. Capacity have subsequently identified a location in Miramar and this well was being drilled mid 2012.

> "Council owned reservoirs are the primary resource for emergency water. Each of the Councils in this study has undertaken seismic assessments of the reservoirs and has a programme of upgrades underway."

In parallel to the GNS study, Ian Brown and Associates (IRBA) were commissioned to undertake a review of historical records of groundwater bores in the Wellington city area (IRBA, 2010). A number of semi-permanent springs were noted around Wellington city, including one in Thorndon and various springs in Kelburn. A number of groundwater bores were also identified. The Moore Wilsons bore in College Street/Tory Street is available to public access and is well known. This artesian well was drilled to 151 metres in 1927 to supply the former Thomson Lewis & Co drinks factory and has been regularly tested and confirmed as high quality water. This bore is under artesian pressure from the surrounding high ground. A plaque at the site stated that the production was 0.63 l/s (54 m³/d) however the well is not currently configured to produce that volume. Records were found for a larger nearby well on the corner of Tory Street and Holland Street however that could not be physically located.

In addition to the constructed bores, IRBA were commissioned to review the numerous tunnels around the region, and in particular in Wellington city. Most of these tunnels have some level of groundwater seepage and this was identified as a potential resource. The most likely source of useful water in an emergency situation was the North Island Main Trunk Line Tawa No.2 railway tunnel. The outflow from that tunnel was monitored by Wellington Regional Council staff from 1977 and an average flow of 15 l/s (maximum 20 l/s) was noted in a 1986 investigation. Capacity has subsequently investigated this source and a sample collected was close to drinking water quality. This is considered a potentially viable water source for emergency use and Capacity are planning access improvements for emergency use.

3.2.3 Surface Water Sources

Post major earthquake there will be severe damage to sewerage systems and any streams or rivers near urban areas may be contaminated with sewage. It was not considered likely any major surface water source in the urban areas would be of a reasonable quality to use without appropriate treatment.

There are a number of other small creeks and streams in Wellington above the "build line", which may be suitable for emergency supply, with treatment. It is also likely that untreated surface water supplies may be required for pressure testing local water reticulation to allow repair of water reticulation while the bulk supply lines are being repaired. Boil Water Notices would be required until the water supply could be tested and verified as safe for human consumption.

Capacity has progressed investigation of these surface water sources and is currently planning access improvements to the most viable sites.

3.2.4 Desalination/Membrane Treatment

Desalination is a potential option for water supply in the Wellington region, with the extensive coast line available in many areas. Modern potable water desalination is typically undertaken using microfiltration then reverse osmosis membranes, often referred to as MF/RO. Either sea water or surface water can be treated using this technology. The throughput of sea water is considerably lower than clean fresh water, however surface water is subject to high turbidity during rain events and as noted above other pollutants could limit the use of surface water as a raw water source. The location for a desalination treatment plant for sea water use is also more flexible. Desalination does require significant electricity supply. For example, a single containerised RO unit of 1,000 m^3/day capacity from sea water would have five trains of membranes each with a 35kW electric pump. Raw water supply pumps would be additional to this.

The New Zealand Defence Force (NZDF) has three systems are based on this technology, using the PALL 1530 ROMM system. These can treat up to 5.5 m^3/hr from fresh water of turbity 50 to 500 NTU, but only 1.05 m^3/h of sea water with total dissolved solids (TDS) of up to 40,000 mg/l and turbidity up to 500 NTU.

Greater Wellington Water have subsequently commissioned a pre-feasibility study of a 10 MLD desalination plant for combined supplementary supply and emergency water use. The results from that study were not available at the time of writing.

3.2.5 Rain Water Collection

The Wellington region has a temperate climate with an average annual rainfall of 1,270mm, with a long term mean summer rainfall of around 60mm per month. Even a relatively small roof area of 125m^2 has the potential to collect an average 6,000 litres in a summer month assuming there is sufficient storage for this water. This amounts to 1,500 litres/head/month for a family of four people which is more than double the target supply of 20 L/h/d or 600 litres/head/month. It can be seen that roof water is potentially a very valuable emergency water resource, particularly for non-potable use such as washing. Toilet flushing may also be required, however the sewerage system is likely to be damaged beyond use in many areas.

Roof water can be collected on a 'jury rig' basis by carefully cutting downpipes in such a way that any sizable container (e.g. clean plastic rubbish bins, laundry containers, buckets, storage containers, plastic boxes etc) can be inserted to catch the roof run-off. Unfiltered and first flush roof water is likely to be contaminated by birds and vegetation in the gutters. Treatment with chlorination or boiling would be advisable before drinking.

Porirua City Council has an advanced programme for installing 25m^3 polyethylene water tanks at schools, connected to the roof spouting and including first flush diversion. As of early 2012, 42 tanks had been installed giving a total volume of 1,000 m^3. The rainwater connections will greatly reduce the amount of water cartage required, but will mean that water has to be boiled or otherwise treated before drinking. PCC have identified several stabilized hydrogen peroxide products (e.g. Pour N'Go) for this purpose.

Greater Wellington Regional Council has been encouraging home owner rain tank collection as part of the water conservation/emergency preparedness programmes currently in place. Some differing opinions on rain collection tanks being used for stormwater buffering have been noted in some areas and there is no consistent regional policy on this matter. One local example followed with interest is the Kapiti Coast District Council Plan Change 75 which was introduced in 2008, where all new dwellings constructed will be required to have either a 10,000 litre rainwater collection tank for toilet flushing and outdoor uses or a 4,500 litre water tank for toilet and outdoor use plus a greywater collection system for subsurface garden irrigation.

"The first step following a major earthquake is reconnaissance to determine the damage to the network. Once reconnaissance is completed emergency water will need to be provided using the available resources with additional resources requested through WREMO."

Household water tanks could reduce the emergency supply demand substantially. Several emergency management staff spoken to during this investigation strongly supported the requirement for new houses to install 600–2000 litre rain water tanks for emergency supply purposes.

3.2.6 Bottled Water

Provision of bottled water is an established emergency supply option and is a preferred option as it can be transported in any type of vehicle, has its own container that is protected from contamination and can be reused. It is expected that distribution of bottled water will be a key part of the first response following a major earthquake, bearing in mind the access difficulties.

The Severn Trent (Gloucestershire) flood response in 2006 was reviewed as a case study. Extensive use of bottled water was made in that response, and initially 1 ML per day was requested, rising to 6ML by the end of the first week. The British Army provided logistical support for this operation. This supply was in conjunction with other distribution of water.

It is likely that requests for bottled water would be made through WREMO as part of the response. This option is obviously dependent on both supply and transportation availability to get pallets of bottled water into the urban areas for distribution.

4.1 Distribution of Emergency Water

4.1 Distribution of Stored Water

4.1.1 Critical Mains

Ageing pipes have been progressively replaced with PVC, polyethylene, ductile iron or steel pipe materials over the past 15 years. In the Wellington city network around 35% currently consists of these earthquake resilient pipes (Capacity, 2012). More targeted design is being employed in areas of known hazard. For example, critical pipelines in areas with a known liquefaction hazard are designed with axial restraint to reduce the potential for joint pull-out due to ground movement.

Two categories of critical water supply mains have been defined:

- **Priority One (P1):** These mains are considered important in the distribution of the stored water during the recovery phase after an event. They will be responsible for distributing the water from the reservoirs to key points such as welfare centres, medical centres, water distribution points, etc.
- **Priority Two (P2):** These are the mains that are considered essential to restore supply to the council's pumping stations and main storage tanks. Strengthening of these mains will reduce the recovery timeframes of operational storage, and therefore the recovery of the distribution as a whole.

P1 mains should be repaired and operational before P2 mains due to the limited volume of stored water available to be distributed.

P2 mains would be repaired once the bulk supply lines to the primary reservoirs is restored.

The criticality, vulnerabilities and proposed remedial actions for the P1 mains are being identified by the asset management team at Capacity. All the mains require additional investigation to confirm the most appropriate treatment along with any other network considerations. In addition, the proposed treatments in the list need to be assessed alongside the network renewal and upgrade projects. As many of the high priority projects are for the larger mains specific funding cases may need to be developed.

4.1.2 Cross Connections

Restoration of the bulk water supply mains is the critical path to restore reticulated water supply to Wellington city. The reservoirs cannot be recommissioned onto the network without the ability to replenish them from the bulk network. As the bulk supply will be in service before the local reticulation, several cross connections are available between the bulk and local reticulations so that water can be supplied directly from the bulk supply pipelines without having to go through one of the terminal reservoirs.

4.1.3 Manifolds

Manifold kits to supply water directly from the reservoirs after an event are currently held at key reservoir sites. These kits include a manifold with six faucets that has a stand, a hydrant connection, hose and a valve key and will enable water to be distributed to resident's containers from an in-ground hydrant or emergency distribution tank. Hydrants are located at all major reservoirs. A typical set-up is shown in Figure 2.

Distribution points around the city are to be implemented at key welfare, civil defence, and community centres. The identification of community distribution points is being finalised in conjunction with WREMO as part of the detailed planning for each city.

4.1.4 Emergency Temporary Water Storage Tanks

Local distribution tanks will be necessary for the efficient distribution of emergency water to the community. Several of the Councils have commenced installing rain water tanks that could potentially provide the dual function of rain water collection and emergency temporary distribution of tankered water. The current status of these is noted below.

As described in section 3.2.5 PCC has already installed 42 25,000 litre tanks. Hutt City Council has been working on a programme to install tanks at key water distribution points including civil defence sites. About twenty 5,500 litre tanks had been installed at early 2012 and further 25,000 litre tanks are planned. These tanks have been connected to the potable water reticulation.

Wellington City Council has seventeen tanks of various sizes installed and in storage. A programme to install fifty 25m^3 polyethylene water tanks has been developed by Capacity for installation from 2012 to 2015. These tanks will be connected to the potable water reticulation and also rain water capable where possible.

4.2 Distribution of Alternative Emergency Water Sources

As noted in section 3 the stored water may need to be supplemented with alternative emergency water sources. As part of this study some consideration was made of the resources and logistics around moving substantial quantities of alternative emergency water within the region.

4.2.1 Tankers

Water tankers will be required to resupply the emergency water distribution points to distribute the stored reservoir water to residents. There are very few suitable tankers currently located in the Wellington region and additional tankers will need to be bought in to assist. Requests for water tankers will need to be made through WREMO.

Figure 2 – Capacity Emergency Manifold Stand at Reservoir

Road tankers offer the great advantage of being able to deliver water to neighbourhood delivery points, such as emergency storage tanks and manifolds. They could be used to supply water to Wellington by road or by sea. Four types of water tankers were identified and considered in the study.

Potable water tankers were considered first. In the North Island there are approximately 150 potable water tankers owned by more than 100 contractors that are in the business of supplying drinking water. A list of these carriers was obtained for reference.

Milk tankers were considered next. Fonterra indicate that they would be both willing and able to help. They have a fleet of more than 500 milk tankers, with a typical capacity of 27,000 litres (27 m^3). The peak daily milk production experienced to date is more than 80,000 m^3, which provides perspective when compared to the Wellington region emergency supply volume of 8,000 m^3. The milk production peak occurs in the spring period (October/November) and Fonterra indicated a capacity to assist, with minimal milk spillage, with the proviso that they were not penalized for any spillage that did result.

Water tankers owned by civil engineering contractors were also considered. It is estimated that there are around 10 water tankers with an average capacity of 8,000 litres in the Hutt Valley/Porirua/Wellington area alone. In the North Island there are believed to be at least another 120 such earthwork contractor owned water tankers. These tankers typically have pumps which can be used for loading and unloading. The performance of the pumps is reported to be variable and would be a factor in selection for mobilization.

Concrete trucks had been identified as a potential resource to cart drinking water in an emergency in previous work undertaken by

Iain McIntosh, working with Karori Civil Defence. There are nearly 50 concrete trucks in the greater Wellington/Porirua/Hutt Valley region. They would have to be cleaned to remove most of the alkaline cement residues. Concrete trucks have a capacity of around 6m³ of concrete, however water alone would slop around in the bowl, reducing its capacity to around 4m³.

If a North Island sourced fleet of potable water tankers, milk tankers, roading contractor tankers and concrete trucks was mobilized as shown in the table below it would be possible to move around 8,660m³ of water daily from Waterloo to Porirua, Hutt City and Wellington. Note the tankers are reliant on road access and diesel refueling being available. A concept resource requirement was developed as shown in Table 1.

Table 1 – Tanker Types and Potential Effective Volume

Type of Tanker	Number of tankers	Average volume/ tanker m³	Average Trips/day	Volume per day m³
Potable	75	9	4	2,700
Milk	40	27	3	3,240
Roading	65	8	4	2,080
Concrete truck	407	4	4	640
Total	**220**	**–**	**–**	**8,660**

4.2.2 Sea Transportation

The average number of tanker trips per day assumed that road access is possible, which is unlikely to be the case for at least the first week or so. In particular, SH2 alongside Wellington Harbour is located close to the Wellington Fault and access from the Hutt Valley was assumed to be unreliable. Wellington Region Civil Defence Emergency Management Group have made some consideration of shipping options including landing sites (WRCDEM, 2010) and the shipping options of specific relevance to bulk water or tanker transportation was considered in some detail.

Initially there will be a serious shortage of road tankers in Wellington and options for bringing them in were considered. Two suitable barges were identified in the Wellington/Marlborough Sounds area. Another possible option identified was the New Plymouth based oil rig supply ship Pacific Chieftain which can carry 279m³ of potable water and 590m³ of drilling water. Additional water could be carried as deck cargo, lifting the total potential capacity to around 1000m³. Both Interislander and Bluebridge ferries could be very useful to transport tankers into the region.

The 9,000 tonne HMNZS Canterbury is a strategic lift vessel commissioned in June 2007 with excellent disaster relief capability. While its on-board potable water tanks amount to only 137m³, it has two small RO de-salination plants each capable of producing 40m³/day of potable water. The ship is basically a roll-on/roll-off ferry with a single vehicle deck. It was used to carry polyethylene water tanks to Samoa following the tsunami. It has cargo space of 1,451 m², which can be unloaded via two ramps, either from the starboard side or the stern, or with the help of two 60 tonne cranes lifting through the flight deck. There would obviously be multiple demands on this resource but it would be capable of carrying 30–40 10m³ water tankers at a time.

4.2.3 Railway

Several sources noted that railways are often quickly repaired following earthquake events. This was not investigated any further due to concern over the tunnel stability, however rail access could obviously be valuable in transportation of bulk materials including water post earthquake.

5. Conclusions

This paper describes the reduction, readiness and response aspects of Capacity's planning for the Wellington region metropolitan area. This planning is based on providing water for a nominal 20 litres per person per day (l/p/d) allowance as an initial target in an emergency.

> "The major available resource for emergency water supply is the water stored in the council reservoirs."

The major available resource for emergency water supply is the water stored in the council reservoirs. Significant work has been undertaken to improve the security of this water, including seismic upgrades of the tanks, installation of automatic closing valves, installation of seismic triggers for those valves and improvements to the inlet and outlet pipework where required and this work is still in progress. Accessing that water can be achieved through the use of manifold kits. External water tankers will be required to distribute the stored water to publicly accessible emergency temporary water distribution points.

Critical pipelines have been identified and there is an ongoing programme of works to upgrade these pipelines with seismically resilient materials through the renewals programme. The most critical pipelines are the pipelines that supply the designated water distribution points. The second priority is the feed lines to and from the existing reservoirs. This work will assist recovery timelines and improve the distribution of water to the community post-event.

Stored water within each city will need to be supplemented by externally supplied water. This could be through bottled water or water tankered from the Hutt Valley, however severe access limitations are anticipated following a major earthquake. Other in-catchment surface water sources are being identified, however these require improvement works to be made accessible for ready use.

Emergency tanks are currently located at various locations in the region. Some additional tanks are held in storage and installation of further tanks located at welfare sites and civil defence centres is proposed over the next four years. These tanks will be maintained full with potable water and will have provision for rain water collection where possible, and tankered water distribution. ■

Acknowledgements

Dave Brunsdon, Richard Mowll – Wellington Lifelines Group

John Harding – PHE Consulting Ltd

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Greywater: A Resource Being Used More Than We Thought?

Vanessa Burton – ESR, and the CIBR "Greywater-wise" project team including; Alma Siggins and Jacqui Horswell – ESR, Craig Ross – Landcare Research, and Hamish Lowe – Lowe Environmental Impact

A Lack of National Guidelines

Greywater (the wastewater from showers, baths, hand basins and laundry) has the potential to be diverted from the main wastewater stream and discharged separately to irrigate gardens and landscaping.

The recent drought in the North Island has highlighted the necessity for water conservation. Although New Zealand is considered to be a 'water rich' country, there are certain localised regions where water shortages are not uncommon. For example, Kapiti Coast District Council have included rainwater and greywater use in their regional plan.

In the midst of the outdoor water ban in Wellington in March 2013, a front page article in the Dominion Post (Saturday 16 March) advised residents of Wellington to reuse their greywater to water their garden. This makes sense from a water saving perspective because greywater reuse can reduce demand on conventional reticulated water supplies.

However, it is not yet known if this is a completely safe practice, and there are no official guidelines for people to follow because regulation of greywater use for landscape irrigation is still a developing area in New Zealand. Unregulated greywater reuse is not just a seasonal problem. There is evidence to suggest that small rural communities may be commonly practising unregulated greywater disposal and reuse as a way to reduce the pressure on sewage treatment systems. The extent of this problem is currently unknown.

Figure 1 – Typical greywater outlets as found in the case study community on the west coast of North Island

What is known is that greywater CAN contain microbial and chemical contaminants that have the potential to cause environmental and human health impacts IF greywater reuse is not well managed. Thus, there is an urgent need for the development of a set of greywater guidelines in New Zealand.

This article examines the drivers for greywater reuse in New Zealand in more detail and gives a specific example of what might be going on under the radar.

How is Greywater Reused and What Are the Risks?

The reasons for greywater reuse were explored and summarised in a report completed by Lowe Environmental Impact (LEI) in 2012. Currently the most common reason for diverting greywater is to reduce the pressure on infrastructure such as septic tanks, or because there is insufficient infrastructure, or unwillingness, to pipe greywater from a laundry at one side of the house to a septic tank at the other side of the house.

Homeowners have also reported issues with undersized septic tanks, particularly at holiday homes that have short-term periods of high occupancy, and have seen that reducing the input of greywater is a viable means of maintaining the performance of their septic systems. At the time of the report, water shortage was not found to be a significant driver for greywater reuse in New Zealand, except for in a few specific regions, such as the Kapiti Coast, Central Otago and Nelson. However it is important to note, especially in the context of the recent drought in the North Island, that factors such as climate change, increasing population and increased use of water intensive appliances such as washing machines and dishwashers, could result in increased water shortages in the future, and this may result in a greater demand for greywater reuse.

In situations such as those described, it is not uncommon for homeowners to practice unregulated greywater diversion, often with home-made systems. These may be as basic as the outlet pipe from a washing machine going out onto an area of lawn (Figure 1).

The areas where such practices are carried out are typically rural holiday communities, and are often in environmentally sensitive areas, such as coastal settlements. There are conflicting views as to whether greywater diversion like this is appropriate.

On the one hand, there is concern that there is potential damage to the soil and plant system, and also that there could be a possible risk to public health. On the other hand diversions can help to prolong the life of septic tank systems and reduce the need for additional plumbing for a 'batch' which is only used for several weeks of the year.

The LEI report found that property owners tend to see greywater diversion as low risk, mainly due to the belief that greywater has a low pathogen content, or that once applied to soil the greywater is largely cleaned by the percolation process and exposure to sunlight and air.

In addition to the unknown risks, the potential positive impacts of greywater application are also currently not quantified. Reusing greywater for irrigation has great potential to generate water savings, especially during dry periods. In addition, it is thought that any phosphorus containing detergents or personal care products could actually be having a beneficial fertilising effect on the soil, although it is also possible that this could be offset by leaching also caused by increased phosphorus.

In order to move towards finding an answer for this argument, the Centre for Integrated Biowaste Research (CIBR) "Greywater-wise" project, based at ESR, is investigating greywater reuse, and is aiming to develop a tool for assessing the appropriateness of greywater discharge based on environmental and public health implications.

By working in collaboration with Landcare Research, it is hoped that positive impacts of safely reusing greywater can also be determined.

Case study: Greywater Use in a New Zealand Coastal Community

A coastal community on the west coast of New Zealand's north island has provided an ideal case study for research into greywater use. This community of approximately 400 properties includes a combination of permanent residents and holiday homes or 'baches'.

As part of a survey carried out by the local council, 40% of the community were found to use some form of unregulated greywater diversion/disposal system, many of which had been in use for 10–20 years. This on-going practice has become more prevalent as 'batches' have been added to and expanded. Greywater can originate from a number of sources, i.e. the laundry, bathroom or kitchen, or a combination of more than one of those (Figure 2). Greywater that includes discharge from the kitchen is expected to be highest risk. While there is potential for accumulation of chemical and microbial contaminants in the environment, property owners appear to be unaware of the risks and seem to be more concerned with the benefits of cost savings though avoiding upgrading their septic tanks or doing additional plumbing.

Of the residents with a greywater system, 71% used greywater to take pressure off their septic tank, 26% used it to save plumbing to the other side of the house and just 1% intentionally used it to irrigate their garden or lawn (Figure 3). The vast majority of greywater diverted for disposal purposes ended up as 'soakage', or in other words was simply allowed to run out onto a lawn or into a dedicated soak pit. The majority of residents (96%) expressed concerns about using greywater.

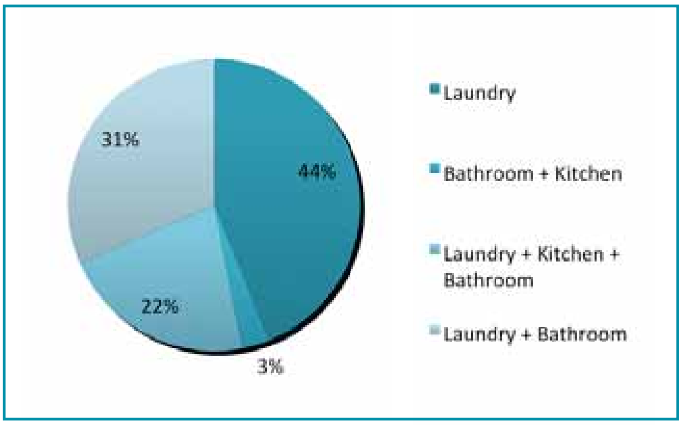


Figure 2 – Greywater sources

Many didn't want to continue using it as they were while only 7% wanted to continue their current greywater disposal practice. The other 52% were unsure about whether they wanted to continue greywater disposal (Figure 4). These statistics demonstrate that there is uncertainty and a lack of knowledge among homeowners who have these unregulated, home-made systems, suggesting that further research resulting in a set of guidelines for greywater reuse would be very useful.

Moving Forward

From discussions with District and Regional Council contacts, private environmental consultancies and industry engineers, the use of unregulated greywater systems is not an unusual practice in other holiday communities throughout New Zealand; and possibly is prevalent in other non-reticulated communities which do not have

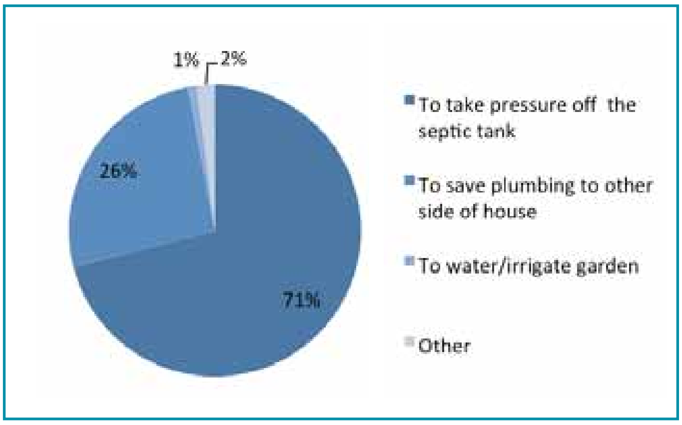


Figure 3 – Reasons for using greywater

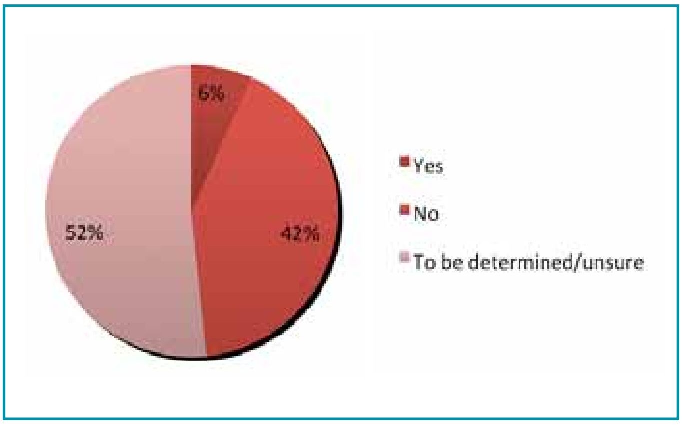


Figure 4 – Householder desire to continue using/diverting greywater

a holiday population influx. Other instances of greywater disposal practices at a similar scale to the case study have been mentioned by multiple sources. As a result, the national usage of greywater is likely to be far greater than initially thought. The potential for this high rate of usage of greywater warrants more effort to determine the impact of such practices, in particular the impact on public health. Once the impacts and risks have been determined, a set of guidelines for future management of greywater can be put together.

As a step towards this, the CIBR greywater programme has plans to complete fieldwork in the case study community this year. The project will take samples from a selection of five properties in the community, with the aim of determining the impact of the greywater on both the soil surface and also the potential for leaching of the greywater down into the water table. These samples will then be analysed to determine the impact of greywater on the physical, chemical and biological properties of the soil. The analysis will look for the presence of the indicator organism E.coli in the samples, something that would have implications for human health. Other analysis will include: molecular analysis of microbial community, soil analysis for particle size, pH, electrical conductivity, organic matter, cations, microbial biomass and respiration. These analyses will help to determine any beneficial or negative effects on the soil health. In addition the samples will be tested for organic contaminants found in household cleaning and personal care products to determine if these compounds remain in the soil after greywater application, and if they cause any environmental impacts.

The results of these analyses will represent a significant step forward in filling in the knowledge gaps surrounding greywater reuse, and as a result will allow there to be steps made towards producing a set of official guidelines on the issue.

Monitoring, Predicting, Preventing and Controlling of (Toxic) Cyanobacteria Blooms in Lakes and Reservoirs

Lisa Maria Brand – Project Manager, LG Sound

Under the FP7 European Commission funding scheme, a novel technology has been developed to effectively control algae blooms in lakes, reservoirs and other large water bodies.

Blue-green algae – also known as cyanobacteria – can cause problems, when blooming in lakes, and reservoirs. Toxins from cyanobacteria have caused many instances of fish kill and death of domestic animals. They can also cause illnesses, paralysis in humans and some are suspected to be involved in the occurrence of liver cancer. Where surface water is used for drinking purposes, cyanobacteria may also endanger the supply, because toxins and odorous metabolites can dissolve in the water and escape conventional treatment, giving rise to health issues and taste and odour problems of the water.

Ultrasonic resonance is an established method to control the growth of algae. It is environmentally friendly and harmless to fish and plants. Low intensity ultrasound, affects the algal gas vesicles and tonoplast, by creating resonance within the algal cell. Effective ultrasonic resonance is frequency specific and needs to be adjusted to a specific ultrasonic program for every algae species present in the water.

Within the ClearwaterPMPC project, a method is developed to selectively control algae in lakes and reservoirs. In-situ monitoring equipment is used to detect and determine algae species, and predict blooms based on water quality parameters. Based on these data, the developed MPC-Buoy (Monitor, Predict, Control) designs the most optimal ultrasonic parameters, to efficiently control and prevent the algae bloom without disrupting the ecological balance.

"Where surface water is used for drinking purposes, cyanobacteria may also endanger the supply, because toxins and odorous metabolites can dissolve in the water and escape conventional treatment, giving rise to health issues and taste and odour problems of the water."

Ultrasonic Research

For the most common cyanobacteria, the optimal ultrasonic program was determined. For this polyester containers of 5m3 where used, to cultivate algae under similar conditions. Ultrasonic transmitters, especially designed for the Clearwater PMPC project, where used to emit different frequencies, waveforms, amplitudes and burst times. The tests continued for 5 days, constantly monitoring algae cell count, Chlorophyll a levels and photo-activity of the algal species. Figure 1 shows the percentage of algae control of Microcystis aeruginosa under different ultrasonic programs.

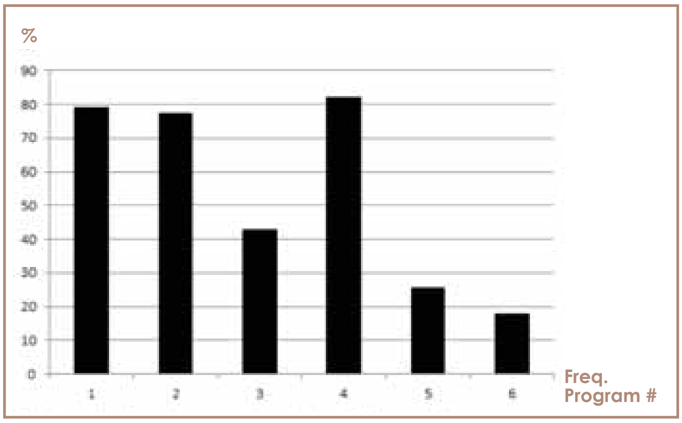


Figure 1 – The percentage of Chlorophyll a, lowered under different frequency programs, show that the effective control of blue-green algae is frequency specific when using low power ultrasound.

The same studies have been repeated for other common bloom forming cyanobacteria, determining the most optimal ultrasonic program to control each algae effectively.

After determination of the most optimal frequencies within the program, the ultrasonic program was specified further, differentiating by burst duration, amplitude and wave form. During this trial, cell concentrations per milliliter where counted, as an indication of the presence and growth of cyanobacteria during ultrasonic treatment. Cell counts for Microcystis aeruginosa are given in Figure 2.

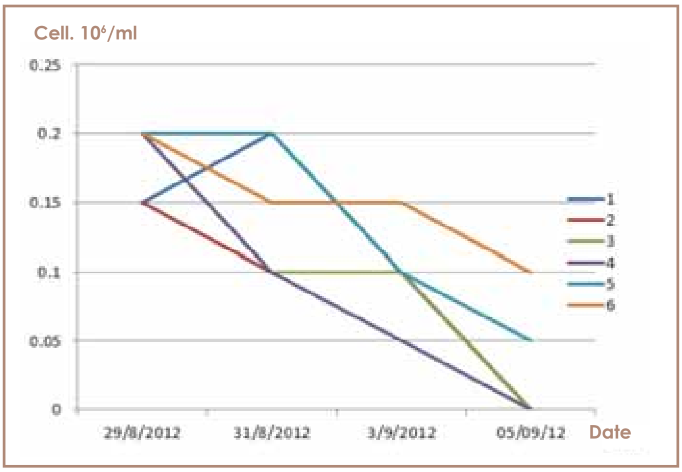


Figure 2: Concentration of Microcystis aeruginosa in cells. 106/ ml, during the trial, showing the possibility to remove cells of M. aeruginosa by 90%.

Clearwater PMPC Project Developed the MPC-Buoy

The ClearwaterPMPC project focusses on the development of the MPC-Buoy, that destroys precisely the algae species that happen to be present at any given time in a lake. For this, the project needs to develop specific ultrasonic programs, consisting of independent frequencies, waveforms, amplitudes and durations that are optimized to any algal species that can be present in a lake. Within the project, fundamental research on the most common type of algae present in lakes, their morphological characteristics and effects on the ecosystem is combined with knowledge about their detection, prediction and sensitivity for specific ultrasonic frequency programs.

"The MPC-Buoy operates on solar panels and batteries, that make autonomous operation possible throughout the year in any country."

The MPC-Buoy

In contrast to currently available ultrasound based algae control systems, the MPC-Buoy works autonomously in a lake or reservoir to determine the water quality and algae type present. Based on that information, it designs the appropriate ultrasonic program to treat the water most efficiently.

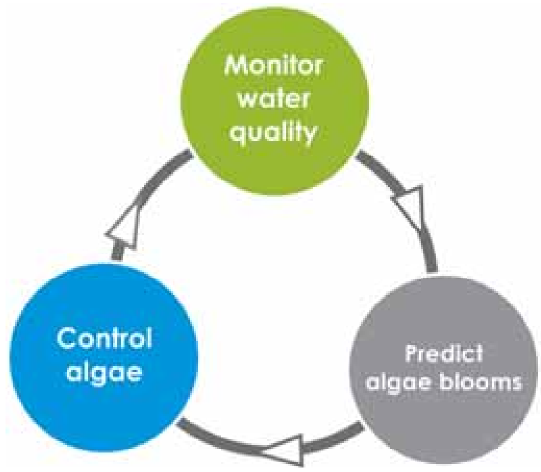
The MPC-Buoy works in 3 steps:

1. Monitoring of Water Quality:

In lakes and bigger ponds the presence of different algae species is in a state of constant change. Seasonal variations are common. Therefore it is important to monitor the presence of the current algae species in order to optimize the treatment. The presence of different algae species is monitored in real time by direct measurement of the fluorescence of the chlorophyll in the living algal cells. The same methodology is used to detect the phycobilin pigments found in blue-green algae (a.k.a. cyanobacteria) and phycocyanin.

These detection data are combined with water quality parameters such as dissolved oxygen (DO), total suspended solids (TSS), pH, Redox, Temperature and outside temperature.

"Collected data is sent by GPRS to a web based server with software that has been designed specifically for the Clearwater PMPC project."



2. Predict Algae Blooms and Species.

Collected data is sent by GPRS to a web based server with software that has been designed specifically for the Clearwater PMPC project. The software displays the collected data, thereby giving lake owners a constant overview of the water quality status. Within the ClearwaterPMPC project, these data are interpreted in combination with the fluorescence measurement of algae pigments to determine which algal species is present. On the same data, a prediction model for algae bloom has been created.

3. Control Algae

Based on this data an adequate ultrasonic program is determined that efficiently targets the algae present in the lake at that time, assuring efficient and fast treatment of the algae. With a treatment range of 500 metre diameter, the buoy is anchored in the middle of a lake. Therefore, within the Clearwater PMPC project, development has been invested to produce the MPC-Buoy fully autonomous. The MPC-Buoy operates on solar panels and batteries, that make autonomous operation possible throughout the year in any country. Cleaning of sensors and ultrasonic transmitters is done automatically and all communication in regard to technical aspects are done through the same software. ■

Sontek FlowTracker Takes Mountain Stream in its Stride

Varying velocities and uneven banks are just two reasons why it's always difficult to measure the flow of a river, but a recent ENVCO Global project in the Hunua Ranges, near Auckland, found that the Sontek FlowTracker was up to the task.

Technical Specialist for ENVCO Global, suppliers of environmental testing equipment, Graham Andrew, recently got his hands wet while assisting a client company to achieve better flow measurement of a stream in the Hunuas.

"In order to comply with resource consent conditions, the client needed to ensure stream flow of 150 litres of water per second, but the weir concerned was built in the 1960s, when accuracy wasn't so important. Our job was to adjust the weir to get more accurate readings," says Graham.

"River levels are converted into flow, based on the rating we are going to make for the client. I used a Sontek FlowTracker to achieve initial measurements for the rating."

The 150 litres of water per second is the minimum amount needed to keep the habitat of the stream going, but it's also important that the client conserve water – in other words, the brief was to find the balance between the needs of the environment and the needs of people.

"My job was to gauge the flow at different heights and tell the client what it all meant, so the major part of this project was setting up the infrastructure in the environment for accurate measuring," says Graham.

For the task Graham used a Sontek FlowTracker to assess the flow, and ENVCO Global also installed an Air Force-Advanced Bubbler System to measure river levels.

"River levels are converted into flow, based on the rating we are going to make for the client. I used a Sontek FlowTracker to achieve initial measurements for the rating.

"It's never theoretical, so my tasks included measuring the height of the river. At various heights I carried out a point measure on flow, and then developed a relationship between the height of the river and flow. For example, one metre at 350 litres a second, three metres at 600 litres a second and so on.

The stream in the Hunua Ranges

"We will join all those readings up and, if it's a good rating, we will be able to measure river height to give the client an accurate flow reading on the graph," said Graham

The Air Force-Advanced Bubbler System measures height, allowing the client to adjust the amount of water that they release into the river to comply with resource conditions.

FlowTracker Handheld-ADV

Standard features

- Multi-language instrument and software (English, Spanish, French, Italian, and German)
- Proven velocity accuracy to as low as 0.001m/s (0.003 ft/s) and up to 4.0 m/s (13 ft/s)
- Automatic discharge calculation – International techniques, including ISO and USGS standards
- Record changing gauge heights and rated flows, with comments in each measurement
- Automatic discharge uncertainty calculation to ISO standard. A FlowTracker First!
- Measure velocities in water as shallow as 2cm (less than 1 inch)
- Keypad interface with real-time velocity and flow display
- Automatic quality control for accurate data collection
- Two or three dimensional velocity measurement
- Recorded data is shielded from power loss
- Lightweight, rugged, and waterproof
- No calibration required – ever!
- Built-in temperature sensor

Optional features:

- 2-D/3-D ADV side-looking probe
- 5m flexible cable
- Deluxe SonTek two piece, top-setting wading rod kit (1.2m or 4ft) including case and mounting brackets
- Wading rod mounting bracket forcontroller/keypad
- Offset mounting bracket for ADV probe
- 2.4m metric rod

For more information email Richard: info@envcoglobal.com

Friatec Announces Appointment

Ryan Kerr

FRIATEC AG has announced the appointment of Ryan Kerr as Technical Applications Manager for Friatec – New Zealand, based in Wellington.

The company says Ryan has completed comprehensive technical training at Friatec in Germany and comes to the team with solid experience in the plastic and pipeline industry in New Zealand.

Ryan's appointment will strengthen Friatec's position in the EF market and will reinforce the company's ongoing commitment to our customer service, providing technical, product & project support and overall will contribute to further business development and growth of the Friatec brand within the NZ and Australasian markets.

Microvi and MWH Global Partner on Large-Scale Water and Wastewater Projects in Asia Pacific

Treatment technology company, Microvi Biotechnologies is partnering with global wet infrastructure firm MWH Global to bring its water technologies to Australia and the Asia Pacific.

Building on a number of commercial projects already operating in Australia, Microvi and MWH are working on projects that deal with the treatment of wastewater removing organic carbon and ammonia and a variety of pollutants in water, including nitrate. Future plans include working with three major water utilities in the Asia Pacific to build large-scale demonstration plants that will incorporate Microvi's technologies based on its proprietary MicroNiche Engineering platform.

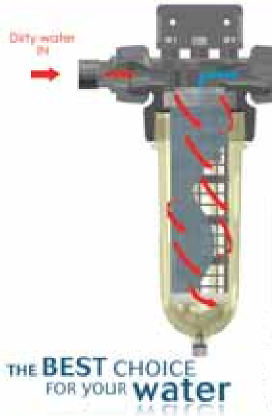
"Building on a number of commercial projects already operating in Australia, Microvi and MWH are working on projects that deal with the treatment of wastewater removing organic carbon and ammonia and a variety of pollutants in water, including nitrate."

"We are pleased to be partnering with such a strong, forward-thinking company to help bring effective, transformative solutions to the water and wastewater industry in the Asia Pacific." said Microvi CEO, Dr. Fatemeh Shirazi.

MWH, a global company with nearly 8,000 employees across six continents, engages in the engineering, construction, and management of some of the largest and most technically advanced wet infrastructure, hydropower, mining and transportation projects for municipalities, governments and multi-national private corporations throughout the world.

"Microvi Biotechnologies is a leader in treatment technology and we are excited to partner to help meet the challenges facing utilities in Australia and across Asia Pacific," said MWH's, global water sector leader for Business Solutions, John Darmody.

Microvi's suite of technologies offer significant advantages over conventional methods including: smaller footprint, no secondary waste or sludge, lower energy demand and ease of retrofit to existing plants. This combination of advantages has the potential to revolutionize the water and wastewater industry. ■



Water New Zealand Conferences & Events

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

86th Annual Water Environment Federation Technical Exhibition and Conference
5 – 9 October 2013
McCormick Place South, Chicago, Illinois, USA
For more information visit www.weftec.org

Pacific Water Conference & Expo 2013
13 – 15 November 2013
Rarotonga, Cook Islands
For more information visit www.pwwa.ws

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