WATER

Issue 184. May 2014

Stormwater Management Under the Proposed Auckland Unitary Plan

Introducing the Urban Runoff Quality Database and Information System

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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

RMA – Fundamentally Flawed?

Water New Zealand is considering a project that provides a critical assessment of the Resource Management Act (RMA) in the context of how effective it has been with the management of our water resource and the protection of our environment.

In particular, I would like to know if we would be better off now if we had let the planning and environmental laws of the 1980s develop further, rather than mesh them together in an attempt to have a super law covering all things planning and environmental. I would also be interested to know if a centralised agency administering the environmental law would be more effective than the regionally devolved administration we have now.

The study would develop a project brief to undertake some initial investigative work into the potential savings and improvements to the environment that could be realised under a more conventional set of planning and environmental laws.

As the RMA is substantially wider than water, *Water New Zealand* would seek the views, based on this initial work, of others who have an interest in the area to understand where (if any) their frustrations are, and to see if there is consensus around the issues with the current legislation. It would also aim to gauge interest in working further to identify the savings and efficiencies that could be realised through an alternative approach.

So how did the present regime start? It started with some important people wanting to do something different, essentially experimenting with our environmental and planning statutes to develop a piece of legislation that covered off planning and environmental issues. Hence the Resource Management Act was born. It was introduced as a Bill by the third Labour Government in 1990 but enacted by National in 1991. It pulled together planning (Town and Country Planning Act) and environmental (the Water and Soil Conservation Act among others) considerations along with a number of other statutes into a single Act.

Its implementation was hailed as world leading by its proponents, and primarily developed with the newly coined term "sustainable management" as a key philosophy. Little consideration appears to have been given as to how the planning and environmental laws of the day operated. While its instigators portrayed New Zealand internationally at the leading edge of environmental law reform, it is interesting to note that not a single other jurisdiction has adopted the concept.

Under the new regime, the collaborative catchment based approach to water resources management and associated pollution control, were relegated in importance. The new approach was effects based – avoid, remedy, and mitigate the adverse effects on a case-by-case basis – a concept that the Land and Water Forum has recently highlighted as an issue.

Applying this effects based philosophy when considering social, cultural, and economic factors alongside environmental matters almost always creates conflicting views and inconsistencies across catchments and regions. While this approach may be appropriate for planning urban developments – is it really appropriate for water management where environmental protection conditions should be science driven? Many discharge consents even quote directly from the Act (typically section 107) making compliance totally qualitative, subjective and often drawn from the opinion of an individual officer.

So where has the RMA left the protection of our environment? The very fact that the statute refers to the management of resources, rather than the protection of the environment, provides an insight as to its underlying philosophy. Also, is regionally based regulation the best platform for protecting our environment? Or would a centralised agency, independent of local politics with a focus on the "bigger picture" be more effective?

The uncertainty around obtaining or renewing consents makes the planning and development of infrastructure difficult to say the least.

And then there has been the cost. We now have an entire legal, planning, and science services 'industry' dedicated to preparing documentation and the associated supporting planning and scientific studies to show how we will avoid, remedy and mitigate effects, being repeated over and over on case-by-case bases. This work, coupled with the extensive consultation and inevitable appeasement that goes with politically motivated regulation provides substantial uncertainty around the outcome. In some cases it costs applicants an unbelievable amount of money. Surely a substantial portion of this work could be undertaken at a strategic policy and standards setting level rather than re-litigated at every consent application.

In short, the RMA is not delivering effectively for planning or the environment. It is neither business nor environmentally friendly, but has created a gravy train of advisors and support services to help business and service providers navigate their way. There is the potential to interfere at all levels and in particular at the political (local and regional) level. In the 23 years since the enactment of the Act, there have been only five national standards enacted (and one proposed)[1]. In the water area this gap in the regulatory environment has led to massive inconsistencies across the country and minimal to no guidance on setting standards; often resulting in continued litigation around what should be science based decisions.

Is it not time now to acknowledge that it is time for change? Which is more important – what is best in terms of the environment and the costs to society of the present regime; or, preservation of 23 years of legal precedent? ■

Steve Couper,
President, Water New Zealand

Footnotes

[1]Air quality, contaminants in soil, ecological flows and water levels, electricity transmission, telecommunications facilities, sources of human drinking water

New Members

Water New Zealand welcomes the following new members:

ANDREW DEAN
KEANE KANNAN
EMILY BOTJE
TRENT FOWLES
DARREN MICHALSKI
JANIS QUIDING
LUCAS DUFTY
TOBY COYLE
DAVID SLOAN
JASON LINAKER
JIM COOKE
MICHELLE BISHOP
CHARLIE SCHORR-KAN

Murray Gibb

Strategic Directions

By the time this edition of *WATER* is issued, *Water New Zealand's* Board will have reviewed the Association's strategic direction. Organisations commonly review their strategies in order to clarify the 'what', 'why', 'when', 'where', and 'how' questions about their purpose and aspirations, and how to achieve them. The last review occurred in 2011.

To give some context to this, not for profit membership organisations such as *Water New Zealand* generally operate under incorporated society legislation. That requires them to have sets of rules. In our case the Association's constitution is very clear about why *Water New Zealand* exists. Its single purpose, set out in black and white in rule two, is to be the "pre-eminent organisation in New Zealand for promoting and enabling the sustainable management and development of the water environment."

Achieving that purpose is a tall order given the plethora of organisations providing representation in the water space in New Zealand. The Land and Water Forum numbers 21 organisations in its Small Group with a further 31 on its Plenary.

A lot of water has flown under the bridge since 2011 so it is timely that a review is done.

The Land and Water Forum has produced three reports with a package of policy options. The Government has responded with a number of initiatives aimed at improving the Resource Management Act, promoting irrigation, providing clearer national direction through a national policy statement for freshwater management and establishment of a national objectives framework. All are aimed at improving management of the resource.

In addition, the 2010 Transparency, Accountability and Financial Management package of Local Government Act reforms are being implemented. Further reforms are underway as part of the Better Local Government reform package, including amendments to the Local Government Act and new financial reporting regulations.

The 2011 National Infrastructure Plan made it clear that there was room for improvement in the water infrastructure systems space. A further iteration of the plan is scheduled for 2015.

Standards New Zealand's role is being subsumed into the Ministry of Business, Innovation, and Employment (MBIE). This may make it harder to develop or review standards but the need for national standards will grow. Organisations such as *Water New Zealand* will have to step further into that space.

Rule three of the constitution then sets out four objects which sit under that organisational purpose. These are:

- To promote integrated national and regional policies in the water environment based on sound principles and knowledge
- To facilitate the exchange of knowledge and provide quality products and services to meet the needs of our members
- To benefit society by promoting a better understanding of the water environment and the sustainable management and development of resources, and to provide leadership and informed advocacy on water and wastes
- To promote the advancement and application of fundamental and practical knowledge to natural water resources, water use and the environment

With finite resources and a diverse membership base, getting the right balance of activities devoted to achieving these four objectives, is always going to be a challenge for an organisation such as *Water New Zealand*. Yet paradoxically it is the depth and breadth of the membership base that gives *Water New Zealand* its advantage in the water space. No other organisation can put a thousand people with expertise on water in one place at one time.

In 2011 the Board envisaged four high level objectives being achieved for water within five years. These were deliberately aspirational.

- That New Zealand had a national water strategy;
- Water services in New Zealand would be well regulated;
- International benchmarking verified well performing water services businesses in New Zealand; and that
- *Water New Zealand* was well resourced and well engaged with its members, meeting their collective needs for advocacy, along with the promotion and delivery of relevant standards and services.

Seven strategic goals were developed to achieve the vision:

- *Water New Zealand* was the 'go to organisation' for all key stakeholders for relevant advice and information. Stakeholders included members, media, politicians and international organisations. Our advocacy role met the needs of members
- New Zealand had a national water strategy. There was evidence of well performing three waters infrastructure. The National Infrastructure Plan reported progress in the performance of the water sector. The Land and Water Forum's recommendations were implemented
- *Water New Zealand's* members were well engaged. Special interest groups were well aligned, and members were satisfied with the performance of the organisation
- Water infrastructure operated in an effective regulatory environment
- *Water New Zealand* was well resourced and technically enabled
- *Water New Zealand* ran well supported conferences, and provided effective education and information channels
- *Water New Zealand* had an actively sought skill base

A business plan was then developed to detail how these goals would be achieved. This is reviewed by the Board annually to check off how well we are doing at achieving our goals.

How well are we doing in achieving what was envisaged? Setting a national objectives framework for freshwater management is arguably the single most important reform in water management since the current regulatory regime was implemented in 1991.

Water regulation continues to be supplied under a plethora of statute rather than fit for purpose regulation as occurs elsewhere.

While it occurs, benchmarking doesn't reveal as much as it might. On the plus side it is increasingly being accepted as a useful management tool.

Is *Water New Zealand* well resourced and well engaged with its members, meeting their collective needs for advocacy, along with the promotion and delivery of relevant standards and services? It is this question and how to do better, that will dominate discussion on the day. ■

Murray Gibb
Chief Executive, Water New Zealand

IMPLEMENTING REFORM

Water New Zealand's Annual Conference & Expo

Claudelands, Hamilton | 17–19 September 2014

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 and 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 are looking forward to seeing you in Hamilton later this year, 17–19 September. Mark the following key dates in your diary!

Key Dates

Wednesday 28 May	Registrations open
Friday 18 July	Earlybird registrations close
Monday 28 July	Poster summaries close

Conference Theme

The 2014 conference will have a core theme of ***'Implementing Reform'***.

This year's conference explores the debate on alternative models for managing water assets under the theme of *'Implementing Reform'*. This year's theme will include lively debate about shared services for local government, mandatory environmental reporting, a National Objectives Framework for freshwater, and the health of our rivers.

The programme will include general streams as well as specialist streams of Operations, Modelling, ASTT Trenchless Technology, and IWA International Water Assocation. The general technical streams will be divided into sub-streams.

Sponsorship Opportunities

Sponsorship opportunities are available to any member of *Water New Zealand* wishing to maximise their involvement at the *Water New Zealand* Annual Conference and Expo. There are a range of sponsorship opportunities available to suit all budgets, with benefits of investment dependent on the level of sponsorship commitment and the type of package.

Visit **waternz.org.nz** or email waternz@avenues.co.nz for further information.

2014 Awards

A number of awards will be presented at the Conference Dinner. In 2014 these are:

- Ronald Hicks Memorial
- Opus Trainee of the Year
- CH2M Beca Young Water Professional of the Year
- Hynds Paper of the Year: Gold, Silver, Bronze
- ProjectMax Young Author of the Year
- Mott MacDonald Poster of the Year
- Orica New Zealand Operations Prize
- Expo Awards: Best Expo Stand

Visit **waternz.org.nz** for more information about the awards and for criteria.

Registrations

Registrations will open via **waternz.org.nz** on **Wednesday 28 May**. An email will be sent to *Water New Zealand* members and past conference attendees once registrations have opened.

Expo Sites

Expo sites are now on sale!

Held for the duration of the Conference, the expo gives delegates and trade visitors the opportunity to meet with leading equipment manufacturers and service providers and

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see state-of-the-art equipment, technology and services. Over 100 companies take part and the expo sites at this event are extremely popular.

Visit **waternz.org.nz** to view further information and to book a site.

Poster Summaries

Poster presentations are always a popular component of the Annual Conference. Poster Summaries need to be submitted by **Monday 28 July**. Please visit **waternz.org.nz** for more information and to submit your poster summary online.

For more information please contact Hannah Smith, *Water New Zealand* – E: hannah.smith@waternz.org.nz or P: +64 4 495 0897

NEW ZEALAND ENGINEERING Excellence Awards

"Celebrating Ingenuity" – New Zealand Engineering Excellence Awards Open

Entries are now open for the 10th NZEE Awards

Entering the Awards provides you with:

- Recognition
- Publicity
- Networking opportunities
- Exposure to potential clients, business, and decision leaders in government
- A chance to showcase your work

The awards categories recognise People, Projects, and Products, with a Supreme Award for the best project and product. Leadership, innovation, entrepreneurship, and young engineers are also recognised along with the use of leading edge technology. Entries close 5pm 1 July.

Winners will be announced in Auckland at the black tie gala dinner on 28 November.

For more information visit: **nzeeawards.org.nz**

The next issue of *WATER* will be published in July. The themes are water storage, rainwater harvesting, infrastructure resilence, irrigation, and the Labour Party Water Policy.

If you have any story ideas, contributions, or photos, please send these to editor@avenues.co.nz and Bernadette Stevenson or Robert Brewer will respond.

For all advertising matters, contact Noeline Strange on +64 9 528 8009 or +64 27 207 6511, or at n.strange@xtra.co.nz

To view the themes for 2014 visit waternz.org.nz and use the drop down links PUBLICATION/*Water New Zealand* Journal.

The deadline for the July issue of *WATER* is Monday 9 June.

Trade Waste Management – A Partnership Between Industry and Utility Providers

Trade Waste Special Interest Group, Water New Zealand

Relationships between industries producing waste streams that are processed by councils need to be collaborative for both parties to benefit. It is clear that the fiscal health and success of industry and communities are not mutually exclusive and that these relationships can be synergistic.

Sadly this is not always the case.

This article looks at the perils and pitfalls of such relationships and provides advice on outcomes that benefit councils, industries, and the environment.

Firstly, industries and councils need to abandon 'them and us' approaches and start working towards the bigger picture. The on-going economic survival and health of many smaller communities is vitally dependent on councils processing locally produced industrial wastewater streams.

There are many examples in New Zealand where industry and councils have collaborated to mutual advantage and also resolved environmental difficulties. The Morrinsville wastewater treatment plant is a good example where industry requirements have been balanced with community needs to the benefit of both. While the initial engagement was challenging, Morrinsville now has a wastewater treatment plant that meets the current load and has spare capacity for future growth. Industries successfully manage their contribution to reducing the operational cost of the plant with wastewater pre-treatment. It is a win-win for both parties.

Matamata-Piako District Council has an agreement allowing discharge from Greenlea Premier Meats and the local Fonterra plant. It stipulates effluent parameters and specifies penalties if these are breached. Within limits the industries determine the amount of pre-treatment they will undertake. The higher the pre-treatment, the lower the charges. While Fonterra and Greenlea Premier Meats are the two major contributors, other small industries also have trade waste agreements with the Council that stipulate standards of discharge.

Greenlea is a meat processor while the Morrinsville Fonterra plant produces milk powder and butter products. Both were asked to fund a percentage of the treatment plant cost based on the difference between what the Council would have to do without this discharge, and with it.

One aspect of the success of this new pre-treatment plant was the Council's willingness to help make it attractive to both industries by financing the cost of the plant over the life of the 15 year discharge consent.

Another important factor in the success of the agreement was that all parties sought, and were privy to, relevant and valid information.

Research was essential. For a considerable period of time, remote data measurement systems were installed to record the discharge from Greenlea and Fonterra. The end result was that all parties were able to make intelligent and informed decisions. The Council was able to see what was affecting their wastewater treatment plants and thus take this data into account in future designs. The two businesses were able to plan ahead for their own future discharge requirements.

Importantly all parties entered into negotiations before the new plant was built, not afterwards.

Unfortunately there are also war stories aplenty where industries and councils have been adversaries rather than allies over management of wastewater. There are too many examples of mismanagement and unwise business decisions causing ecological disasters.

With the application of some simple principles, such problems can be avoided.

1. Measure

You cannot manage what you do not measure. Good information from data collection systems both at industrial discharge-to-sewer and the inlet-to-wastewater treatment plant are essential for sound and economical effluent treatment.

2. Manage Costs

Costs must be managed economically – it costs money to process sewage. There needs to be agreed rules between producers and processors to ensure this cost is managed economically and fairly.

3. Align Vision

Remove the 'us-and-them' adversarial stance. That paradigm, maintained by some, has to go. Industries and councils need to communicate well and work together. Adversarial approaches are not conducive to collaboration and increase risk both to ratepayers and the environment.

4. Remove the Politics

There is no place for political rhetoric in the provision of water infrastructure services. Elected officials must consider carefully the full financial, social, and environmental impact on their town when "welcoming an industry in". Doing so without the requisite information carries too much risk.

5. Location! Location! Location!

Industries must choose their location wisely. Two primary factors "new-to-town" industries must take into consideration are the capacity of existing utilities to support their requirements, and the likelihood of establishing good ongoing working relationships with the relevant councils.

6. Specialist Advice

Run the numbers beyond the dollars and seek specialist advice. Meaningful, current, and relevant data is vital to economic and environmental success. You cannot manage what you do not measure – this is a singular and most important point.

Elected officials must look very hard at industry proposals and seek knowledgeable independent and specialist advice. It is impossible to make sound decisions on multi-million dollar investments for complex wastewater infrastructure without highly experienced and genuinely independent advice.

Effective management of industrial effluent discharge through wastewater treatment systems has evolved into a specialised discipline. Too often decisions are being made by people without requisite knowledge. Ratepayers would not trust the safe transporting of their family in an aircraft where the pilot had been voted into the cockpit rather than being highly trained. Too often we entrust our equally precious environment into the hands of poorly informed elected officials. Too often this has resulted in environmental and financial disasters.

> "Importantly all parties entered into negotiations before the new plant was built, not afterwards."

7. Ownership Model

The cost of ownership model requires a paradigm shift. Projects must be based on a total cost of ownership rather than the lowest price conforming model. The existing paradigm where asset managers may be influenced and overruled by finance planners driven by the cheapest price is outdated. Historical evidence repeatedly proves this to be false economic practice. The cheapest price is rarely the least expensive option in the long-term. Major community infrastructure projects need to be designed with a 30 to 50 year life expectancy framework in mind. Soon to be introduced amendments to the Local Government Act will require a minimum of 30 year planning for every council.

The Matamata-Piako District Council, Greenlea Premier Meats and Fonterra worked collaboratively using a model similar to this seven point structure to successfully upgrade the town's wastewater treatment plant.

When it All Goes Wrong

So what are the steps necessary when things go wrong?

1. Man-Up and Take it on the Chin – Avoid Blame

The research findings of past 'failures' commonly point to councils' due diligence being undertaken without adequate data or independent advice. Too often decisions on the adequacy of data were made by finance managers rather than the manager of the asset.

When something goes wrong it is human nature to respond immediately rather than first gathering all the facts and considering them.

It is natural to blame someone else when something goes wrong. It's coded into our DNA. It's a dominant gene in politicians. Litigation in such cases makes ratepayers and industries poorer. Only the lawyers win. The sooner fault is acknowledged the sooner everyone can move forward towards resolution.

2. Cancel All Witch-Hunts

Witch-hunts don't solve problems. They waste time, money, and resources.

It is far more important to understand what went wrong, both to prevent it from recurring and to implement strategies for better future management of the issue.

3. Go Back to Basics

Do the measurements and take the samples, and, whatever you do, don't take short cuts on the preliminary data. The chances are it was those short cuts that caused the problem. Despite political pressure to "get it sorted out now", data collection needs to be thorough.

There is no doubt that there will be future examples of things going wrong and then being managed poorly. Industry professionals have a duty to inform councils that what may appear to be smart fiscal management in the short term may well be a liability in future.

Let us hope that greater use of such principles will minimise future damage. Let's do it once and do it right! ■


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KNOWLEDGE TO GROW

To give readers an insight into Party policies on water we are giving the Maori, Green, Labour, and National Parties the opportunity to describe the issues they see as important leading up to the General Election. In this issue, the Green Party's Spokesperson for Water, Eugenie Sage, MP, outlines the Party's approach to water and its management.

Green Party Water Policy: Working for Clean Rivers, Lakes, and Aquifers

Eugenie Sage MP – Spokesperson for Water, Green Party

Over the Christmas break I followed the Tarawera River downstream from its source at Lake Tarawera outlet to the Tarawera Falls. It is a beautiful two hour walk through mixed rata and pohutukawa forest. The river has shaped spectacular gorges and there are deep pools overhung by rata trees for swimming.

The Tarawera Falls are one of New Zealand's natural wonders. Above the falls a torrent of water suddenly disappears underground to surge out of fissures in a 60 metre high rhyolite cliff, creating a spectacular waterfall. From Lake Tarawera to the falls and some distance downstream, the Tarawera is how all New Zealand's rivers should be – clean, cool, clear, and beautiful. Closer to the sea, industrial pollution from the Kawerau pulp and paper mills means the Tarawera is known as the "black drain".

"Sixty-one per cent of monitored river swimming spots in New Zealand are categorised as unsafe for swimming. These sites are chosen for monitoring because they are places that people want to go swimming. All of our rivers should be fit for swimming. You shouldn't have to risk getting a stomach bug, or have to ring a council hotline, or check a website before you head down to the local swimming hole."

And sadly many of our lowland rivers are heavily polluted, often as a result of land use in their catchment rather than direct discharges. Sixty-one per cent of monitored river swimming spots in New Zealand are categorised as unsafe for swimming. These sites are chosen for monitoring because they are places that people want to go swimming. All of our rivers should be fit for swimming. You shouldn't have to risk getting a stomach bug, or have to ring a council hotline, or check a website before you head down to the local swimming hole.

The Green Party supports strong national and regional rules that will ensure our rivers are clean enough for us to swim in and are healthy for aquatic insects, fish and plants. We want rivers where eels lurk under the banks and that can support a healthy trout population.

"Our biggest water quality problem, in terms of kilometres of rivers affected, is diffuse pollution from more intensive land use."

Nutrients belong in the soil not in our rivers and aquifers. The expansion of intensive agriculture, especially dairying, is causing major leaching and loss of nitrogen and phosphorus into our waterways. This causes algal blooms and unhealthy rivers.

Nitrate leaching from fertiliser and cow urine from high animal numbers is also putting our drinking water at risk. Taranaki, Waikato, Canterbury, and Southland all have monitored wells that exceed safe levels of nitrate. The full impact of past and current farming practices on our groundwater has yet to be felt.

In the Selwyn-Waihora Zone in mid-Canterbury, Environment Canterbury has identified that nitrate leaching from current and future land use means that nitrate levels in more than half the wells in the zone risk exceeding World Health Organisation standards for healthy drinking water. Elevated nitrate levels are a health risk for newborns and the elderly and are associated with blue baby syndrome.

The Green Party's vision for water reform in New Zealand is a strong *National Policy Statement for Freshwater Management* (NPS FW) that has a goal of phasing out freshwater contamination and over-use. We would replace the weak NPS FW implemented by the National Government with the strong draft NPS recommended by the Board of Inquiry. A strong NPS with a clear goal for freshwater is the first of many necessary steps towards cleaning up our rivers, lakes, and streams.

The Green Party supports setting a minimum standard for intensive agriculture. Voluntary measures and good management by agribusiness to reduce pollution from agriculture are useful but they need to be supported by rules.

While pollution problems from point source discharges have reduced, we still need to improve the quality of our urban stormwater discharges.

Our biggest water quality problem, in terms of kilometres of rivers affected, is diffuse pollution from more intensive land use. We envision National Environmental Standards based on good science, the experience of the agricultural sector and councils, to set limits for the amount of nitrogen, phosphorus, faeces, and sediment entering our waterways. We need to ensure that our land use matches land capacity.

Our rivers, lakes, and aquifers are being overloaded with nutrients. We need to recognise that there are environmental limits to dairying's expansion. The Green Party would put a moratorium on further land use intensification where pollution is already a problem, in sensitive catchments such as around high country lakes and in the Mackenzie Basin, and where water is over allocated. A moratorium would give farmers and councils the breathing room to ensure a stable transition to sustainable agriculture.

We support a fair price on the commercial use of water for irrigation. A price signal on water will promote the efficient use of water. Putting a price on the commercial use of water is consistent with other private uses of public resources. For example commercial users of public conservation land pay a concession fee to the Department of Conservation. Just as that fee helps to support the work that DOC does to protect our native wildlife, the fee on water would help to support cleaning up our rivers, lakes, and streams.

We oppose any further drainage of wetlands. We have already drained more than ninety per cent of our wetlands and we need to protect the few that remain. We recognise the valuable role that wetlands play in storing water, smoothing flood peaks and helping to remove polluting nutrients.

Above – The Tarawera Falls in the Bay of Plenty, Opposite page top – Eugenie Sage MP at Tarawera River, Opposite page bottom – Boundary Stream in the Hawke's Bay

We will protect our wild rivers by not allowing any new dams and strengthen water conservation orders to ensure that land use in catchments covered by a water conservation order protects water quality.

The Green Party will provide financial support for riparian fencing and planting. We need national standards to keep stock out of streams and rivers, particularly cattle and deer. Planting riparian areas helps to reduce the amount of sediment and polluting nutrients entering rivers. We will set up a contestable fund administered by regional councils to help fund labour and materials.

Retiring erosion-prone land can improve water quality by reducing sediment loadings. Winding back the National Government's restrictions on central government assistance for smaller communities to upgrade their wastewater treatment would help make this more affordable.

Reducing the impact of waste on the environment and the loss of productive resources from the economy is important to the Green Party. We are proud to be responsible for the Waste Minimisation Act. We need to extend producer responsibility to more products and provide more support for innovative uses of the waste we create.

If you want a clean green economy that works for us all, give your party vote to the Green Party in September. We stand on our record of working with both major parties to achieve smart green change. Whether it is insulating homes, reducing waste, or protecting our precious wetlands – a party vote for the Green Party means we can achieve good green change for both people and the planet. ■

Ship-Shape: Sealing the Legal Cracks

Helen Atkins – Partner; Vicki Morrison-Shaw – Senior Associate; and Phoebe Mason – Law Clerk, Atkins Holm Majurey

Introduction

Nutrient leaching statistics might imply that New Zealand's water law is a leaky tub but reforms are intent on plugging the gaps. The introduction and first reading of the Environmental Reporting Bill in March forms the next step in the Government's endeavour to scrub up freshwater law and regulation in New Zealand. This article explores the content of the Bill and provides an overview of some political parties' criticisms of the Bill.

Irrigation developments are also driving change. Variation one to the *Canterbury Land and Water Regional Plan*, partially spurred on by the consenting of the Central Plains Water irrigation scheme, tightens controls on water takes and permits as well as implementing further regulation on farm discharges into waterways. In the North Island, news of the withdrawal of TrustPower's investment from the Ruataniwha/Tukituki dam project in the Hawke's Bay has led those in opposition to the scheme to predict the demise of the dam, although negotiations for investment continue.

We also cover two recent water cases – one in which an innovative argument on the meaning of 'riverbed' ultimately fails to find favour with the Courts, and one in which the fluoridation of water is unsuccessfully opposed.

Environmental Reporting Bill

Until now, reporting on the state of the environment in New Zealand at a national level has been at the discretion of the Ministry of the Environment, with only two reports ever produced. The introduction of the Environmental Reporting Bill by Environment Minister Amy Adams aims to change this, proposing tri-annual 'synthesis reports', and six-monthly 'domain reports', prepared by the Secretary for the Environment and the Government Statistician, with the Parliamentary Commissioner for the Environment providing independent review and commentary. Each domain report will cover one of the five environmental 'domains': air; atmosphere and climate; freshwater; land; or marine.

Regulations will set out the topics to be reported on. The topics must be issues affecting significant areas, resources or numbers of people. Guided by the topics, the reports will cover: the state of New Zealand's environment; the pressures causing changes to the state of the environment; and the impacts of the changing state of the environment on ecological integrity, public health, economic benefits derived from utilising natural resources, and culture and recreation. The reports must also give a broad assessment of the changes to the state of the environment over time, and how New Zealand's environment compares with national or international standards.

The purpose of the Bill is to streamline the mechanics and accuracy of data collection so as to focus discussion on the environmental issues themselves.

A key feature of the Bill is that the reports are required to be politically independent, so as not to be influenced by the government of the day but rather will contribute to a collection of objective data.

The twin foci of the reports are the environment itself and the economy. Environment Minister Amy Adams said in her speech at the first reading of the Bill:

"In order to protect our environment, while encouraging economic prosperity, we need to be able to have an honest debate about the interactions between the environment and the economy, have a clear picture of what the trade-offs and opportunities are, and the impacts our choices are having. Any argument that only seeks to present half the picture does little to advance our understanding."

"Until now, reporting on the state of the environment in New Zealand at a national level has been at the discretion of the Ministry of the Environment, with only two reports ever produced."

Parliamentary Commissioner for the Environment, Dr Jan Wright has welcomed national reporting, however some have their doubts about the Bill. The Green Party is concerned that the Bill's dual focus on the environment and the economy risks legitimising environmental degradation through short term Gross Domestic Product and job benefits, as well as making for a highly complex reporting task. In addition, the Green Party says that proposed non-disclosure of base information used in a report may prevent proper scrutiny of the released reports, and the high-level topic-setting power provided by the Bill to the Minister for the Environment and the Minister for Statistics could politicise the process and undermine the independence of the reports. That being said, the Greens voted in favour of the First Reading of the Bill, alongside National, the Maori Party, ACT and United Future. Labour and New Zealand First voted against the Bill's First Reading.

Variation One to the Canterbury Land and Water Regional Plan: The Selwyn-Waihora Variation

Variation One is the first change to the proposed *Canterbury Land and Water Regional Plan* (LWRP) related to a specific area, namely the catchment of Te Waihora/Lake Ellesmere. It puts in place policies and rules to help achieve community goals for freshwater that have been set under the collaborative *Canterbury Water Management Strategy* (CWMS).

The Selwyn Waihora Zone Committee, a joint committee of Selwyn District Council, Canterbury Regional Council and Environment Canterbury, with additional representation from six Runanga, has set up a package for water management in the area. The package, of which Variation One forms a part, aims to improve cultural and environmental outcomes in the catchment while maintaining both farm viability and economic growth.

Variation One was driven by substantial increases in water use, irrigation, and intensive land use in the area over the last 20 years, combined with decreasing flows in lowland streams; high nitrate concentrations in shallow groundwater and lowland streams; accumulation of phosphorous in lake-bed sediments; and a 10–30 year lag between the nutrient leaching and the groundwater systems actually showing the effects of poor health. In addition, the recent consenting of the major Central Plans Water irrigation development heralds an increase in both irrigation and intensification.

The Variation seeks to ensure security of water supply for irrigation; a thriving, well-resourced, financially viable, and sustainable community; abundance and diversity of aquatic life, supported by water quality, flows and habitat; decline of nutrient inflows through land owner action; improved health of Te Waihora or Lake Ellesmere; and sufficient flow rates for swimming and aquatic life.

To this end, the Variation:

- Introduces 'Schedule 24: Farm Practices', which requires farm land use to take account of water quality through the use of OVERSEER-based nutrient budgets, regulated fertiliser use, regulated irrigation, and waterway fencing.
- Seeks to reduce discharges of nitrogen, phosphorous, sediment and microbial contaminants by setting baseline nitrogen levels, and through use of both the farm practices guidelines and audited Farm Environment Plans.
- Imposes collective nutrient loss limits on irrigation users, on a scheme by scheme basis.

"In order to protect our environment, while encouraging economic prosperity, we need to be able to have an honest debate about the interactions between the environment and the economy, have a clear picture of what the trade-offs and opportunities are, and the impacts our choices are having. Any argument that only seeks to present half the picture does little to advance our understanding."

- Restricts the transfer of water permits – and in particular prevents the transformation of irrigation takes into groundwater takes, the movement of down-plains takes up-plains, and requires the surrender of 50% of the take in any other case.
- Restricts the reallocation of water permits so as to reflect demonstrated use.

The Variation is accompanied by extensive technical reports, covering quality and quantity of both groundwater and surface water, as well as cultural, social and economic impact assessments.

> "In coming to its decision on the special leave application, the Court of Appeal held that factual findings made in the lower courts and the logic of statutory interpretation made it impossible to accept Mr Jefferies' argument. In the Environment Court, it was found that from time to time the river water overtopped the bund and ran down the eastern arm, and in that sense, the channel remained part of the river bed."

Submissions closed on 21 March 2014, and are currently being processed. Once a summary of submissions has been notified, further submissions may be lodged by any person representing a relevant aspect of the public interest; any person that has an interest in the proposed Variation greater than the interest of the general public; and Environment Canterbury itself. A hearing will then follow in due course.

Ruataniwha/Tukituki Dam

The Ruataniwha/Tukituki dam project in the Hawke's Bay has been under deliberation by a Board of Inquiry since hearings finished in late January this year. However, on Thursday 27 March 2014, TrustPower, who had been a significant backer of the scheme, formally announced its withdrawal from investment, stating that the project did not fit within the company's "risk and return framework". In response, on 1 April 2014 Ngai Tahu Holdings Ltd announced that it too would also withdraw its investment in the proposal unless a "suitable partner [was] found."

It is understood that Ngai Tahu is continuing to work alongside the Hawke's Bay Regional Investment Company as they negotiate "on a confidential basis with a number of parties considering investment in the scheme, either as equity or debt, some with engineering, construction and water management experience."

Recent Water Cases of Interest

1. Definition of Riverbed: Jefferies V Wellington City Council

This was an inventive, but ultimately unsuccessful, appeal against two abatement notices issued against Mr Jefferies.

Mr Jefferies had placed a 1.5m high 'bund' or embankment on the edge of the bed of the Mangaroa River to stop the bank on his land eroding away. The bund had the effect of diverting the Mangaroa River onto its western bank, while leaving Mr Jefferies' eastern bank mostly dry.

The first abatement notice alleged unauthorised deposition of material, placement of the bund and associated diversion of water. The second abatement notice related to the tipping of a substantial quantity of clean-fill down a cliff from Mr Jefferies' land onto the riverbed.

Mr Jefferies appealed the issue of the abatement notices arguing that the land on which the bund had been constructed was not in fact a riverbed. Rather, he submitted that it was the role of the New Zealand Geographic Board under the *New Zealand Geographic Board (Nga Pou Taunaha o Aotearoa)* Act 2008 to name natural features like rivers, and that as a LINZ topographical map had referred to the piece of land as a drain, it could not be a riverbed. His counsel described the section of land as 'out of play' as a riverbed as the bund had dried it up.

Both the Environment Court and the High Court dismissed the appeal and the High Court declined Mr Jefferies' application for leave to appeal to the Court of Appeal. Mr Jefferies then sought special leave from the Court of Appeal.

In coming to its decision on the special leave application, the Court of Appeal held that factual findings made in the lower courts and the logic of statutory interpretation made it impossible to accept Mr Jefferies' argument. In the Environment Court, it was found that from time to time the river water overtopped the bund and ran down the eastern arm, and in that sense, the channel remained part of the river bed. In addition, the water hit the bund as it flowed around the corner, showing that but for the bund, the eastern arm would have been part of the river. The "bed" was to be judged prior to the illegal activity taking place.

The Court held that the Geographic Board could not control a Court finding on the definition of a riverbed. Moreover, Mr Jefferies had not formally produced the LINZ map he relied on in evidence, nor had he directly raised the point in the courts below.

2. Fluridation of Water: New Health New Zealand Inc V South Taranaki District Council [2014] NZHC 395

New Health unsuccessfully challenged the decision of the South Taranaki District Council to add fluoride to the drinking water supplies of Patea and Waverley in the interests of dental health. New Health challenged the decision on the grounds that the Council did not have legal power to fluoridate; that adding the fluoride was a breach of the right to refuse medical treatment in the *New Zealand Bill of Rights Act 1990*; and that the Council had failed to consider several mandatory relevant considerations in deciding to fluoridate.

The Court clearly stated that its role was not to judge the merits of fluoridation, but rather to rule on the power of a council to fluoridate a water supply.

Justice Hansen carefully and fully set out the role of a local authority in regards to the provision of drinking water for its population. The Court found that there was clear statutory authority allowing local authorities to fluoridate and that this derived from the broad power to supply water under the *Local Government Act 2002* and the express recognition in the *Health Act 1956* that such water may contain fluoride.

The further question of whether fluoridation unjustifiably infringes the human right to be able to refuse medical treatment was dealt with in depth by the Court, and included an assessment of United Kingdom, Australian, Irish, Swiss, Canadian, and American case law on the point. The Court came to the conclusion that fluoridation is not a 'medical treatment' even though it is undertaken for therapeutic purposes, namely dental health. However, the Court saw no relevant distinction between the use of chlorine to purify water and prevent disease, and the use of fluoride in water to prevent dental disease. 'Medical treatment' required a more personal, individual element. Moreover, in this case the general benefit to the greater public overrode personal rights to refuse. This was particularly the case where an end user could filter the fluoride out of their water.

The Court assessed fluoridation against the criteria in the *Bill of Rights Act* to justify a breach of rights, and held that if fluoridation did breach the right to refuse medical treatment, it would nevertheless be a justified and permissible breach, given the importance of the goal of dental health of the population, and the proportionate nature of the fluoridation to that goal. The appeal was dismissed. ■

Life's good here.

As New Zealanders, we are mighty proud of this country and all it has achieved. What excites us most though is where we're going. Because history has proven that as a nation we get a lot done; we know that the years ahead are going to be exciting and inspiring. Are you looking forward to what's ahead, New Zealand? **We are...**

The Water Sector – "Green" by Definition or Not?

Claire Feeney – Director, Environmental Communications Limited

Environmental training is emerging as a game-changing tactic for sectors that embrace it. Previously reserved for unsung technicians like wastewater treatment plant operators, it is entering mainstream environmental management, business, and education. Why? Because there is a big and growing body of evidence that such training boosts business performance, creates jobs, and enhances people and places, even – especially – when times are tough.

Yet the counter-factual myths persist: in recessions, governments say "Let's boost the economy first and reduce public debt next, then this will give us the money to invest in sustainability later", and businesses say "I can't afford to save the planet – I have to save my business first!" At the same time, people are urged both to buy more "stuff" to keep the economy going, while becoming increasingly disillusioned with empty consumerism – and are simultaneously urged to save more in order to reduce private debt. Of course, they also want some of the increasingly scarce jobs.

Macroeconomist Josh Bivens investigated the employment effects of the December 2011 US law approving environmental regulations to reduce emissions of mercury, arsenic, and other toxic metals. It could prevent up to 11,000 premature deaths each year and deliver many other health benefits but a lot of people were concerned it would "kill jobs". When Bivens investigated[1], he found that far from killing jobs, the so-called "toxics rule" could create over 100,000 jobs in the US by 2015 – within a mere four years.

Bivens' message is that going green won't kill jobs during hard times: when the economy is doing well, environmental regulation has no effect on job growth; but when it isn't, such regulation is very likely to create jobs.

And these days, we need more jobs – and green jobs most of all.

Green Jobs

Globally, green jobs could yield 15–60 million jobs by 2032[2], lifting tens of millions of workers out of poverty and unemployment while improving both social and environmental outcomes, according to a report by the International Labour Organisation.

The UN Environment Programme (UNEP)[3] defines green jobs as "work in agricultural, manufacturing, research and development (R&D), administrative, and service activities that contribute substantially to preserving or restoring environmental quality. Specifically, but not exclusively, this includes jobs that help to protect ecosystems and biodiversity; reduce energy, materials, and water consumption through high-efficiency strategies; de-carbonize the economy; and minimize or altogether avoid generation of all forms of waste and pollution."

UNEP says that from a broad conceptual perspective, employment will be affected in at least four ways as the economy is oriented toward greater sustainability:

- First, in some cases, additional jobs will be created – as in the manufacturing of pollution-control devices added to existing production equipment [see Josh Bivens]
- Second, some employment will be substituted – as in shifting from fossil fuels to renewables, or from truck manufacturing to rail car manufacturing, or from landfilling and waste incineration to recycling [and waste avoidance/prevention]
- Third, certain jobs may be eliminated without direct replacement – as when packaging materials are discouraged or banned and their production is discontinued
- Fourth, many existing jobs (especially such as plumbers, electricians, metal workers, and construction workers) will simply be transformed and redefined, as day-to-day skill sets, work methods, and profiles are greened.

Environmental Training

It's clear that the skills needed by workers in green jobs relate to[4] "all facets of the society, not just renewable energy, reuse and recycle of waste... resource utilization... green housing and sustainable planning, but also including wider areas, such as commerce, tourism, hospitality, information technology and finance" and more.

But there is a skills gap here – and environmental training can bridge it. There is a growing focus on professional development for people, old and young, to provide the green skills that every sector of the economy needs.

> "Globally, green jobs could yield 15–60 million jobs by 2032[2], lifting tens of millions of workers out of poverty and unemployment while improving both social and environmental outcomes, according to a report by the International Labour Organisation."

The words 'training', 'learning', 'awareness' and 'education' are often used interchangeably. Other terms like 'professional development' or 'learning and development' are also common. So, I define the term 'training' in a very specific way:

Training is the acquisition of work-related knowledge, skills and practices that will improve a specified aspect of on-the-job performance in measurable ways, ideally as defined in a clear statement of performance standards and/or outcomes.

Globally, training is increasingly being seen as a way of building workforce and organisational capacity. Total spending for in-house and external training services was predicted[5] to increase by 8–10% in 2011, while European research[6] found that training is delivering good outcomes, and is increasingly demand-driven, with people identifying their own workplace training needs and pathways.

Environmental skills are increasingly among those in demand from trainees, and given increasing concern about matters environmental and economic, this trend is also likely to continue. "Green learning" will consume a larger proportion of corporate social responsibility budgets, and trainers who are knowledgeable about environmental matters and sustainability are likely to be in greater demand[7].

One key way in which green jobs are already benefiting New Zealand's economy and environment is by increasing the skills of the existing workforce. There is a lot of high level talk about the "knowledge economy" but governments struggle to translate that into practical realities.

But once you've seen, as I have, the transformative effects of environmental training on staff and organisations, you know that environmental training is the vehicle par excellence for building an economy based on skills and knowledge. People who develop environmental skills can rise to positions of seniority they had never previously dreamed of. I've seen environmental training become a vehicle for literacy and numeracy training, as people learn how to follow detailed designs, read meters and log their environmental tasks. Building skills like these generates tremendous increases in staff loyalty and engagement, productivity and of course, profitability for the companies concerned.

Yet it's clear that there's no "one-size-fits-all" environmental training package: the skills needed for sustainable forestry are very different from those needed in a manufacturing plant. And while people in both sectors would call themselves sustainability managers and recognise similar core values, the training they'd be rolling out in their respective companies would be very specific to each workplace.

No Sector Left Out

On the very day I published the first edition of my book on environmental training, I came across an article[8] saying that such is the drive for more sustainable retail in the UK that retail companies are recruiting entire sustainability teams – building a workforce of sustainability professionals in the retail sector. This was exactly in line with my experience of environmental training for the civil construction sector: we ended up creating a whole new profession – environmental managers – on large construction sites.

Every sector in a global sustainable economy needs its own environmental professionals, and they will add tremendous value to businesses and communities.

As the ILO says, a "new development model – one which puts people, fairness and the planet at the core of policy-making – is urgently needed, and is eminently achievable". And not only is it achievable – it's happening already.

Storm Cunningham calls it the "restoration economy". He says[9] that restoration of built and natural environments already constitutes a major but overlooked part of global economic activity and will soon account for the vast majority of development.

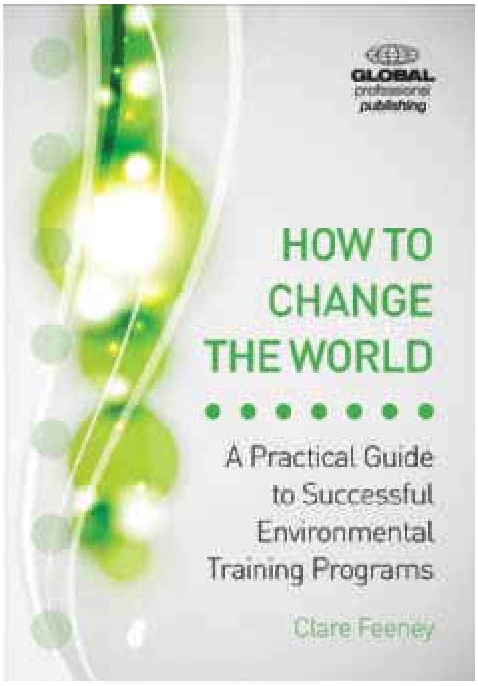
And the economic need is great. Ecosystem services are good things the natural world does for us for free, and a 2008 study[10] estimated the annual economic cost of loss of ecosystem services by biodiversity and ecosystem degradation at 3.3–7.5% of global GDP, or US$2–4.5 trillion. Green jobs can transform these huge and avoidable economic losses into health, social, environmental, and economic gains.

Because green jobs are so embedded in the wider economy, it's also difficult to tell how many there are, and recent US research showed it was very difficult to find an agreed definition that would allow a head count to be done. The US Bureau of Labor Statistics' *Green Goods and Services Survey*[11] found that the "green" economy accounted for 3.4 million U.S. jobs in 2011, with the vast majority of jobs in the private sector.

However, the survey didn't count direct jobs in environmental restoration, and its focus on overtly green goods and services means it would have also failed to count many other green jobs in mainstream firms – like the sustainability experts in the retail and civil construction sectors – and possibly in the water sector too. Most estimates of green jobs therefore significantly underestimate the real total.

The Water Sector – Green by Definition, or Not?

Clearly, jobs in water sensitive stormwater management – of both urban and rural runoff – would qualify as green jobs. But what about jobs in water and wastewater treatment? This work can have significant environmental effects in both source and sink areas and in terms of infrastructure construction, operation and maintenance.



Clare Feeney's Book *How to Change the World – A Practical Guide to Successful Environmental Training Programs*, published September 2013

New Zealand's 2003 infrastructure stocktake focused attention on more sustainable infrastructure and the *NAMS Manual* has steadily built up its sustainability content. Infrastructure sustainability has come under renewed forcus more recently from the Infrastructure Sustainability Council of Australia, with the sprinkling of New Zealanders attending its training coming away very inspired.

There is both an opportunity and a threat here. Think of the civil construction sector, so closely allied to the water, wastewater, and stormwater sector. What will it do when the big government money runs out for the post-recession stimulus work? What will it do when there are no more roads, railways, and bridges to build? It will be the collateral environmental skills these firms have built as a result of more stringent environmental standards that will keep them in business. The smart firms will already be positioning themselves for restoration work.

UNEP says[2] that, "A successful strategy to green the economy involves environmental and social full-cost pricing of energy and materials inputs, in order to discourage unsustainable patterns of production and consumption. A green economy is an economy that values nature and people and creates decent, well-paying jobs."

We've seen the international economists like Stern and Stiglitz come to the party and, following in the footsteps of our very own Marilyn Waring, New Zealand's Department of Statistics together with the Treasury are now measuring genuine indicators of social and environmental wellbeing.

This is helpful, because before we know how much we need to spend on an environmental initiative or a catchment management plan, we need to know the value of what we can protect or enhance.

Greening the Monetary Economy

This means moving into the still contested territory of fully monetising social, cultural, and environmental values and costs, as well as financial ones. For example, the benefits of good water supply and wastewater services are critical for a healthy and productive workforce. Protected water supply catchments are often havens of biodiversity and public amenity, while fresh and coastal waters can recover their ecological health and commerical viability (think fisheries and tourism, for a start) when wastewater and stormwater providers target this outcome. We also need to get more explicit about the tradeoffs we make and the costs and benefits of the big interbasin transfers of water and wastewater that keep our cities ticking over.

The upside of this is that if we continue to move towards using indicators of wellbeing together with full cost accounting, there will be more jobs, better jobs, and better outcomes for people, places, and profits.

Thinking upstream and downstream of the pipe could focus the whole water sector on its wider role in ecological, cultural and social health as well as human health – and the wealth that acompanies such healthy assets.

This is the water sector's challenge in the post-carbon restorative economy of the 21st Century.

Clare Feeny

About the Author

Clare Feeney helps companies tap into the productivity and profitability benefits of good environmental management. She is a professional speaker, author and trainer on business and the environment and has worked in the environment field for over 30 years. Her first book, *How to Change the World – A Practical Guide to Successful Environmental Training Programs*, was published in September last year in the UK. You can find out more about her work at clarefeeney.com and http://7stepstosuccessfultraining.blogspot.com

Footnotes

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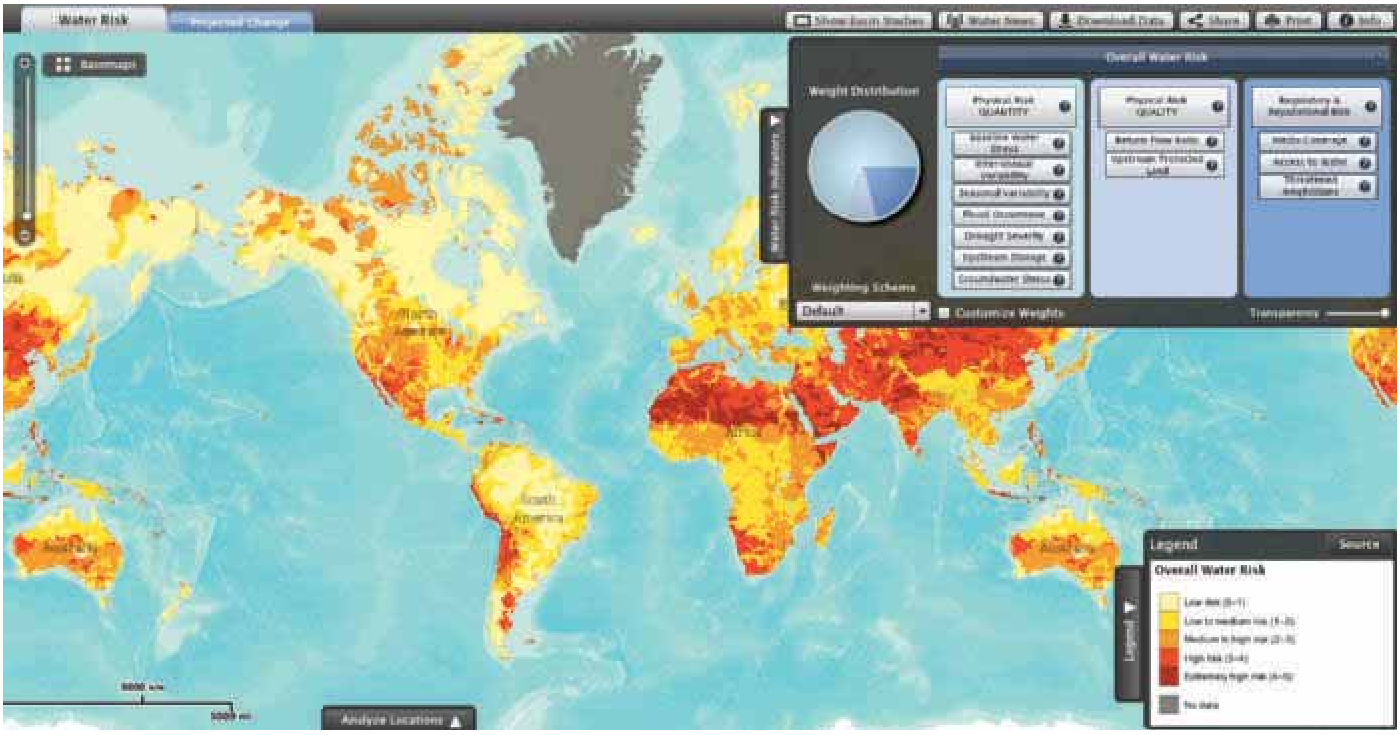
Interactive Maps Show Global Water Stress

The World Resources Institute has developed two interactive maps as part of its Aqueduct project showing global water stress in relation to agricultural production and water risk by country and river basin. The atlas gives an illuminating graphic illustration of the areas of the globe under water stress. New Zealand is included and shows stress related to agriculture, particularly seasonal and lacking storage, which is well known in the industry. Visit wri.org to view the maps.

"The atlas gives an illuminating graphic illustration of the areas of the globe under water stress. New Zealand is included and shows stress related to agriculture, particularly seasonal and lacking storage, which is well known in the industry."



Memorandum to Restore Waiapu Catchment Signed

Primary Industries Minister Nathan Guy and Associate Minister Jo Goodhew have announced a collaborative partnership to restore the Waiapu catchment in the Gisborne District.

Mr Guy said the signing of a Memorandum of Understanding between MPI, Te Runanganui O Ngati Porou and Gisborne District Council demonstrates a long term commitment to work together and with landowners to address the erosion control problems in the catchment.

The Waiapu River has the highest suspended sediment yield of any river in New Zealand and one of the highest in the world.

"If nothing is done, erosion and sedimentation could double by 2050," said Mr Guy.

In December 2010, the Crown and Ngati Porou leaders signed a deed of settlement (the deed) regarding Ngati Porou's historic claims against the Crown. The deed provides for the development of a high-level Relationship Accord signifying a new era of collaboration between Ngati Porou and the Crown, and commits the Crown to working with iwi and landowners to 'mitigate severe erosion in the Waiapu catchment'.

"This [MOU] is a great example of this Government working together with iwi and local councils to invest in and develop our regions. This long-term partnership will create significant environmental, cultural, social and economic benefits for iwi and the local community," said Mr Guy.

Associate Minister Goodhew highlighted the Government's recognition of landowners' need for as much support as possible to treat erosion on their land, particularly in the gullies where much of the soil loss and sedimentation occurs.

The announcement follows the recent consultation on operational improvements to the East Coast Forestry Project – a funding programme to assist landowners with their treatment of land to prevent soil erosion, through planting trees or indigenous regeneration.

To date, approximately 42,000ha have been covered by erosion control treatments under the East Coast Forestry Project.

Approximately 60,000ha of untreated land are eligible for East Coast Forestry Project funding across the Gisborne District, of which approximately 25,000ha is in the Waiapu catchment.

The East Coast Forestry Project has $26M available for new soil erosion projects until 2020.

"I would like to take this opportunity to thank those of you who made a submission on the operational improvements to the East Coast Forestry Project (ECFP)" said Ms Goodhew.

The shared vision for the restoration of the Waiapu Catchment by 2113 is: Ko te mana ko te hauora o te whenua; ko te hauora o nga awa; ko te hauora o te iwi – Healthy land, healthy rivers, healthy people.

The Urban Runoff Quality Database and Information System

Jennifer Gadd; Annette Semadeni-Davies; Jonathan Moores; and Uwe Duesing – National Institute of Water and Atmospheric Research Limited (NIWA)

Abstract

NIWA and Auckland Council, with input from the University of Auckland, have recently launched the Urban Runoff Quality Information System (URQIS), providing free access to a database of New Zealand urban runoff quality data. Data have been supplied by organisations such as regional councils, territorial authorities, roading agencies and research institutes throughout New Zealand, many of which hold large datasets of stormwater quality data collected over the last 10 years.

The database provides a repository for the collected data and for the dissemination of this data in a form that is fit-for-purpose for a range of uses and users. Statistical summaries of data held in the database are available via URQIS. This tool has been designed as an open-access online interface that enables analyses of variations in runoff quality by characteristics such as land-use and region. This article gives an overview of the data held within the database and illustrates the use of URQIS to search the database for two contrasting land use types.

"This tool has been designed as an open-access online interface that enables analyses of variations in runoff quality by characteristics such as land-use and region."

Keywords

Stormwater, urban runoff, water quality, database, contaminant concentrations, URQIS

1. Introduction

Urban runoff is a major source of contamination of streams and estuaries, resulting in the transport of sediments and metal, and organic contaminants to sensitive receiving environments. Assessments of urban runoff quality often rely on literature values because monitoring can be difficult and resource-hungry. Literature values are also necessary when predicting future urban runoff quality following a change in land use. While locally-developed empirically-based models such as Auckland Council's Contaminant Load Model (CLM, Timperley et al., 2010) are available to calculate contaminant loads, concentration is often required for effects-based assessments.

One of the key references for concentration-based data is the *Urban Runoff Data Book* (Williamson, 1993), which is now over twenty years old. Although still a very valuable reference, this publication pre-dates the considerable effort that has been made in the last 15–20 years to collect urban runoff data in New Zealand by organisations such as regional councils, territorial authorities, roading agencies, research institutes, and universities. The availability of more recent

> "Urban runoff is a major source of contamination to streams and estuaries, resulting in the transport of sediments and metal and organic contaminants to sensitive receiving environments. Assessments of urban runoff quality often rely on literature values because monitoring can be difficult and resource-hungry."

local data and changes, such as the removal of lead from petrol has given rise to the need to take a fresh look at characterising urban runoff quality in New Zealand.

This article reports on a centralised database of New Zealand runoff quality data, most of which would otherwise remain inaccessible to the public, and an online interface for querying the database, called the Urban Runoff Quality Information System (URQIS; http://urqis.niwa.co.nz/). The database and the interface have been developed by NIWA in partnership with Auckland Council and the University of Auckland to provide a repository for urban runoff data collected throughout New Zealand and for the dissemination of this valuable data to the public in relevant and meaningful formats. In addition to URQIS, the database is also being used to produce an update to Williamson (1993), which is due for publication later this year.

The relationship between the URQIS database and the planned data book is shown in Figure 1. Data sent to NIWA by contributing organisations are first entered into a standardised data entry spreadsheet (Excel) and are assessed against a prescribed quality control protocol. The assessed data are then entered into a relational database (Access) which underlies URQIS. Analyses of database data are to be reported in the data book. URQIS users can run data queries, which return summary statistics and graphical summaries for a range of user-selected attribute-based comparisons. An example query is given in Section 3.

2. Scope of the Database

The database holds data on water and sediment quality of urban stormwater and streams. Metadata are included with each water quality data record and form the basis of searches within the URQIS web tool. These data and metadata are overviewed below. The database does not include runoff data from catchments where the majority of the land-use is rural or marine sediment data. Full lists and descriptions of the parameters included in the database, study and site metadata, water quality metadata, and sediment quality metadata are available upon request from NIWA.

2.1 Urban Runoff and Sediment Quality

Runoff and sediment quality held in the database include physio-chemical properties and concentrations of solids, metals, nutrients, bacteria, and hydrocarbons (see Table 1). These data may have been collected during a single storm event, a short-term investigation over several storms, or from long-term monitoring. The data may include single grab samples, multiple samples throughout a storm (for example using automatic samplers), or multiple samples combined before analysis. The database can also include event mean concentrations (EMCs) and continuous data, for example collected using sondes, where available.

The database can hold sediment quality data for sediments collected from the beds of urban stormwater drains and streams, as well as street dust collected from roads. As with the water quality data, the sediment data may include physical properties or concentrations of solids, metals, nutrients, bacteria, and hydrocarbons (see Table 2), or both.

Figure 1 – Relationship between the collected data, the runoff quality database, URQIS, and the updated data book

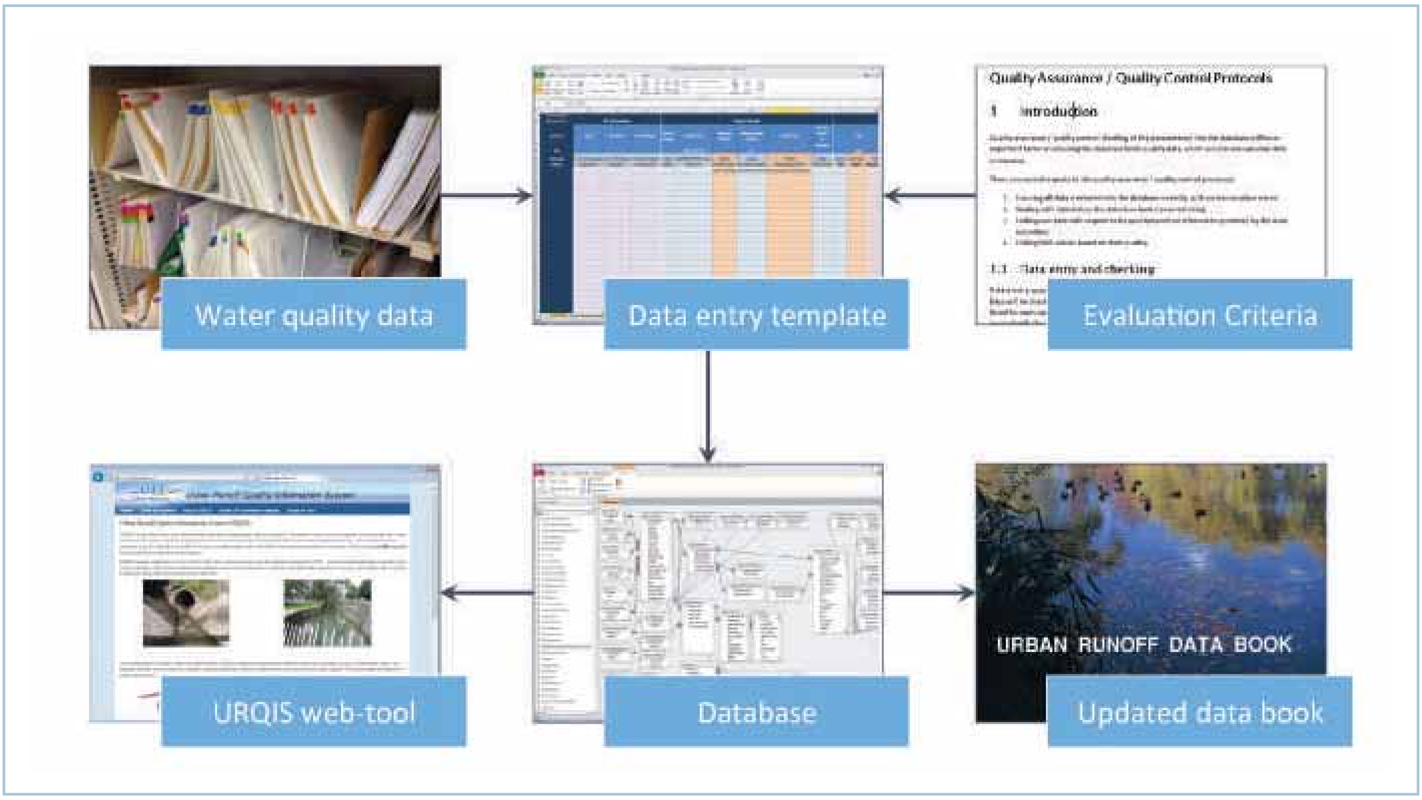


Table 1 – Water quality data that can be included in the database

Discrete data fields	Parameters
Solids	Suspended solids concentration (SSC); total suspended solids (TSS); volatile suspended solids (VSS); availability of particle size distribution (PSD)
Physical and Chemical Characteristics	Temperature; pH; conductivity; salinity; dissolved oxygen (percentage saturation or concentration); turbidity; black disc; carbonaceous BOD5; COD; hardness ($CaCO_3$); alkalinity
Common Metals	Total, dissolved and particulate: zinc, copper, and lead
Other Metals	Total and dissolved: aluminium; antimony; arsenic; cadmium; chromium; iron; magnesium; manganese; mercury; molybdenum; nickel; silver
Micro-organisms	*Enterococci; Escherichia coli*; Faecal Coliforms
Nutrients	Total nitrogen (TN); nitrite (NO_2N); ammonium; (NH_4-N); nitrate; (NO_3-N); total dissolved; nitrogen (TDN); total Kjeldahl nitrogen (TKN); dissolved Kjeldahl nitrogen; total phosphorus (TP); total dissolved; phosphorus (TDP); dissolved reactive phosphorus (DRP)
Hydrocarbons	Oil and grease; total petroleum hydrocarbons (TPH) in bands C6–C9, C10–C11, C12–C14, C15–C20, C21–C25, C26–C29, C30–C44
Polycyclic Aromatic Hydrocarbons (PAH)	Total PAH; Naphthalene; acenaphthene; acenaphthylene; fluorene; anthracene; phenanthrene; fluoranthene; pyrene; benzo[a]anthracene; chrysene; benzo[b]fluoranthene; benzo[j]fluoranthene; benzo[b]fluoranthene ; + benzo[j]fluoranthene; benzo[k]fluoranthene; benzo[a]pyrene (BAP); indeno(1;2;3-c;d)pyrene; dibenzo[a;h] anthracene; benzo[g;h;i]perylene
Other Contaminants / Indicators	Chloride; fluoride; total and dissolved potassium and sodium

Table 2 – Sediment quality data that can be included in the database

Data Field	Parameters
Common Metals	Particulate zinc, copper and lead
Other Metals	Particulate aluminium; antimony; arsenic; cadmium; chromium; iron; magnesium; manganese; mercury; molybdenum; nickel; silver
Digestion Method for Each Metal Analysed	Total, total recoverable; acid soluble; 2M HCl; ANZECC; simulated gastric extraction
Nutrients	TN; TKN; TP
Hydrocarbons	As for water quality
Polycyclic Aromatic Hydrocarbons (PAH)	As for water quality

2.2 Metadata

Metadata provide information that characterises the site where the samples were collected, and the methods used to collect samples. Not all metadata are required for each sample although there are some, such as location and land-use, that are necessary.

2.2.1 Study and Site metadata

The database can hold a considerable amount of metadata relating to the study and site, from which the samples come. Much of this is required information as it indicates the general location and type of land use, from which the samples were collected. This information can be used to build queries within the database.

The fields listed in Table 3 are those required for every entry into the database. There are also optional fields if additional information is supplied, such as the catchment size, percentage imperviousness of the catchment and references for any publications relating to the data (e.g., reports).

"The database can hold a considerable amount of metadata relating to the study and site, from which the samples come. Much of this is required information as it indicates the general location and type of land-use, from which the samples were collected. This information can be used to build queries within the database."

Table 3 – Study and site metadata

Study and Site Metadata fields	Parameters
Study Name	Name of the study for which the samples were collected. Note that several sites can come under the same study.
Study Year	Year of completion for the sampling (or current year if monitoring is ongoing).
Sponsoring Organisations	Organisations responsible for: Commissioning data collection (e.g., councils, roading authority) Collecting the data (e.g., in-house monitoring, consultants) Maintaining the data and submitting it to the database
Site Name	Name of sampling location (e.g, Whau @ Wolverton Road).
Easting and Northing	Map reference of the study site, including co-ordinate systems.
Town or City	Name of urban area where the monitoring site is located.
Catchment	This can either be a catchment for stream samples or a stormwater system/suburb if the sample is stormwater. If the catchment is a specific contributing area such as a section of road, roof or carpark, this should be identified.
Land Use	Various classes of residential, commercial and industrial land use, roading, and open space.
Type of Water Body Where Samples Were Taken	Freshwater (lakes or streams); stormwater; wastewater or combined storm and wastewater.
Presence of Sewer Overflows Upstream	Whether there are any sewer overflow structures (e.g., combined sewer overflows, pumping stations) upstream.
Stormwater Treatment Type if Present	Dry retention pond; wet detention pond; wetland; infiltration basin/trench; raingarden; swale/filter strip; oil/water separator; sand filter; proprietary filter device; proprietary hydrodynamic device; green roof; porous pavements; treatment train; street sweeping; other.

2.2.2 Water Quality Metadata

Water quality metadata describe monitoring at each site. Each water quality record has the following associated data, where available:

- Start and end dates of the monitoring period
- Date and time each sample was taken
- Type of flow regulation structure present if applicable (e.g., sharp-crested v-notch weir)
- Flow monitoring equipment used if applicable (e.g., bubble gauge; stilling well)
- Type of sampling (grab sample, manual probe, automatic sampler) and type of sample collected (e.g., flow-weighted composite; time-weighted composite; first flush; not mixed)
- Type of event sampled such as a storm event, baseflow or continuous data (which may encompass both types)

Optional information relating to the event sampled includes rainfall depth, rainfall duration, antecedent dry period, mean and peak flow rates, and the total volume of stormwater in the event. Some metadata are only applicable to storm events and, for many studies, many of the optional metadata are not available. However it is hoped that over time, with increased usage of the database, those undertaking stormwater monitoring will collect such information so that it can be included in the database, allowing for a more comprehensive set of queries to be run.

2.2.3 Sediment Quality Metadata

The sediment quality metadata include the type of sediment sampled, e.g., whether it is stream bed or bank sediment; street dust; suspended solids; or soils. Data are also requested on the methods used to sample the sediment, any sieving or fractionation of the sample and the digestion methods used, which is particularly relevant for interpreting the results of metal analyses. This information can be applied to multiple samples at a single site (i.e., at different depths).

3. Urban Runoff Quality Information System (URQUIS)

URQIS is the freely available web tool that provides users with the ability to query the database. A query results in an analysis of the selected data, executed by running a set of R-scripts (R Development Core Team, 2012). URQIS allows users to compare the quality of urban runoff by land use, region, water type (treated or untreated stormwater, urban streams), and flow conditions (storm flow or baseflow). At this stage, users cannot run queries for sediment quality.

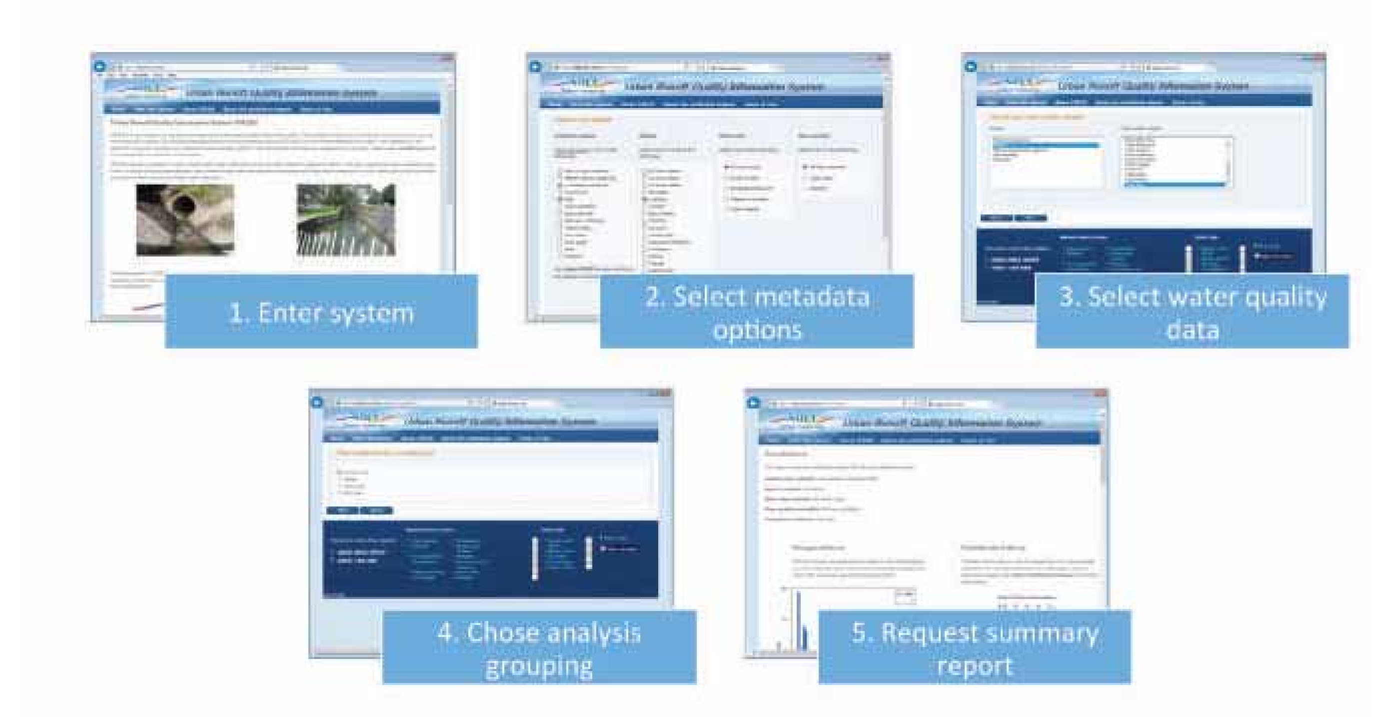
For each data selection, outputs are presented in four ways, both online and in a PDF report:

- Tables of summary statistics
- Histograms showing the distribution of the selected data
- Probability plots showing the likelihood that any given value is exceeded
- Box plots showing key statistics and the distribution of the data

These outputs are described further below and are illustrated using the example of a comparison of total zinc (TZn) concentrations in urban runoff from two contrasting land uses (low density residential and CBD) for all water types and flow conditions in the Auckland region. Low density housing (8–11 dwellings per hectare) is characterised by low traffic counts and low imperviousness (around 30%), whereas the city centre has high imperviousness (80–100%)

and busy traffic. Zinc sources include unpainted or poorly painted galvanised steel roofing, galvanised street furniture, and wear and tear of tyres. The set-up for this query is illustrated in Figure 2, which shows screen shots from the URQUIS web site.

Figure 2 – Setting up a data query within URQIS: users are prompted to select from a range of metadata and water quality options as they progress through the system



3.1 Summary Statistics

Since urban runoff quality data sometimes include values that are below the laboratory reporting level or limit of detection, URQIS uses a method designed for censored data called robust regression on order statistics (robust ROS) (Helsel, 2012). Briefly, uncensored (above detection) sample data are used to plot a distribution of the data and this distribution is used to estimate values for the censored (below detection) data points.

Plots and summary statistics can then be calculated from the combined set of uncensored and estimated data. This method produces reliable results for small (n=20) and moderate (n=50) sized data sets. In some cases, there are insufficient data to adequately model the regression, and statistics are not calculated when the number of samples is three or less. When almost all data (>90%) is censored (below detection), a regression cannot be modelled and again statistics are not calculated.

The summary statistics provided for the example query are shown in Figure 3. The statistics are as follows:

- No.: the total number of data points in the data set, including censored data.
- No. below detection: the number of censored data points in the data set.
- % below detection: the percentage of censored data points in the data set. If greater than 80%, the summary statistics have low reliability.
- Median: the middle value or 50th percentile. 50% of the data in the data set lie above this value and 50% lie below.
- Mean: the arithmetic mean of the data. For urban runoff this is commonly higher than the median due to the log-normal distribution of the data.
- Standard deviation: this shows the variation or dispersion from the mean. A large standard deviation indicates a wide range in the values and a small standard deviation indicates that the data tend to lie closer to the mean.
- Lower and upper quartiles (also known as the 25th and 75th percentiles): the values below which 25% and 75% of the values fall, respectively. The percentiles are obtained by first calculating the ordinal rank, rounding the result to the nearest integer, and then taking the value that corresponds to that rank.
- Minimum and maximum: values recorded in the data sets.

"Plots and summary statistics can then be calculated from the combined set of uncensored and estimated data. This method produces reliable results for small (n=20) and moderate (n=50) sized data sets. In some cases, there are insufficient data to adequately model the regression, and statistics are not calculated when the number of samples is three or less. When almost all data (>90%) is censored (below detection), a regression cannot be modelled and again statistics are not calculated."

Summary statistics for data set and by groups

*Summary statistics are provided for the whole dataset, and for the individual groups you selected to compare by (landuse type, region, water type or flow condition). See **About the Statistical Outputs** for further information.*

	No.	No. below detection	% below detection	Median	Mean	Std. dev.	Minimum	Lower quartile	Upper quartile	Maximum
Whole dataset	548	0	0	0.22	0.26	0.26	0.014	0.094	0.31	3.2
CBD	289	0	0	0.29	0.36	0.28	0.08	0.24	0.38	3.2
Low-density residential	259	0	0	0.086	0.14	0.17	0.014	0.064	0.16	1.8

Figure 3 – Summary table produced by URQIS comparing TZn concentrations in water samples collected at low density residential and CBD sampling sites, respectively, in Auckland for all water types and flow conditions

3.2 Histogram

URQIS generates a histogram of all the data selected (Figure 4). A histogram is a graphical representation of the distribution or spread of the data, which indicates the range and skewness of the data. A rug plot is also provided at the bottom of the histogram, indicating the value of every individual data point (in contrast to the histogram, which groups data values). For this graphic, censored data is plotted at half the laboratory reporting level. The total number of samples (N) is indicated.

3.3 Normal Probability Plots

The normal probability plot (Figure 4) shows graphically how closely the data approximates to a log-normal distribution (or a normal distribution in the cases of pH, temperature or dissolved oxygen). The straight diagonal line indicates a log-normal (or normal) distribution. In the plot, censored data are shown as open circles and are always plotted on the log-normal line. The number of censored data and uncensored data are shown in the legend. The probability of a contaminant concentration exceeding a given value can be read off the upper x-axis.

3.4 Box Plots

Box plots indicate the spread of the data and allow a graphical comparison between selected groups of data (i.e., land use type in Figure 5). In addition to box plots for each group, there is also a box showing the distribution of all the data. The modelled data from the robust ROS are used to produce the plots to ensure consistency with the summary statistics. Box plots are not drawn when the number of samples is three or less or when almost all data (>90%) is censored (below detection).

The box plot is plotted along a log-scale for all water quality variables except temperature, pH and dissolved oxygen. For each group of data, the band in the middle of the box indicates the median concentration. The left and right bounds of the box indicate the 25th (lower) and 75th (upper) percentiles. Whiskers extend to the nearest data points that are within 1.5 times the middle-fifty or inter-quartile range (IQR – calculated as the 75th percentile value less the 25th percentile value) of the median value. Data points lying outside this range (outliers) are shown as individual points.

The boxes also have 'notches', which indicate the 95% confidence interval for the median (R Development Core Team, 2012). These are appoximated automatically within R as:

$$\pm 1.58\left(\frac{IQR}{\sqrt{N}}\right)$$

where N is the number of samples. In some situations, the notches extend beyond the hinges of the box. This indicates that the confidence interval, which is symmetric, is greater than the IQR, which is typically asymmetric for these data.

"The box plot is plotted along a log-scale for all water quality variables except temperature, pH and dissolved oxygen. For each group of data, the band in the middle of the box indicates the median concentration. The left and right bounds of the box indicate the 25th (lower) and 75th (upper) percentiles. Whiskers extend to the nearest data points that are within 1.5 times the middle-fifty or inter-quartile range (IQR – calculated as the 75th percentile value less the 25th percentile value) of the median value. Data points lying outside this range (outliers) are shown as individual points."

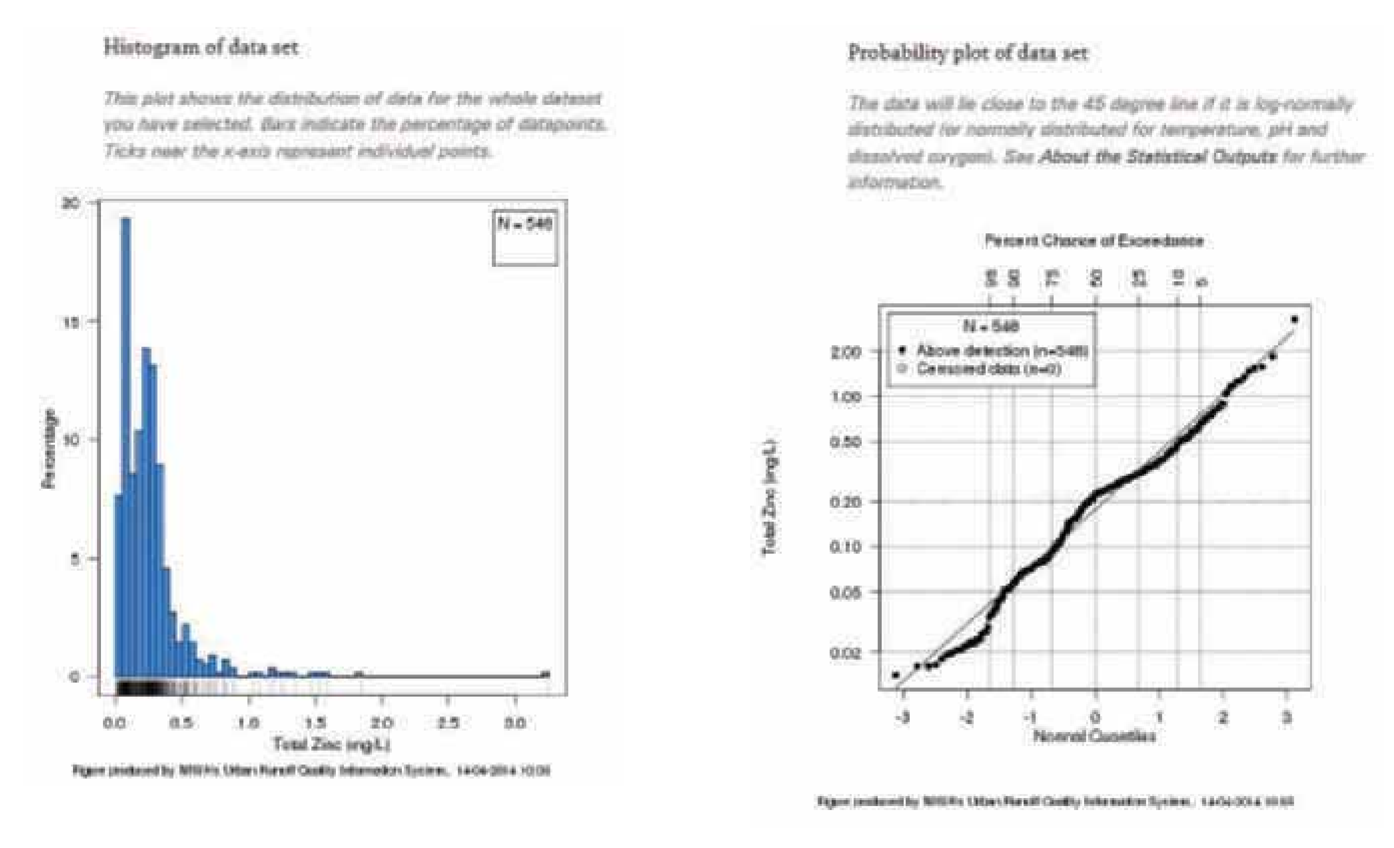


Figure 4 – Histogram and probability plots produced by URQUIS for TZN concentrations for samples taken from low density residential and CBD monitoring sites in Auckland for all water types and flow conditions

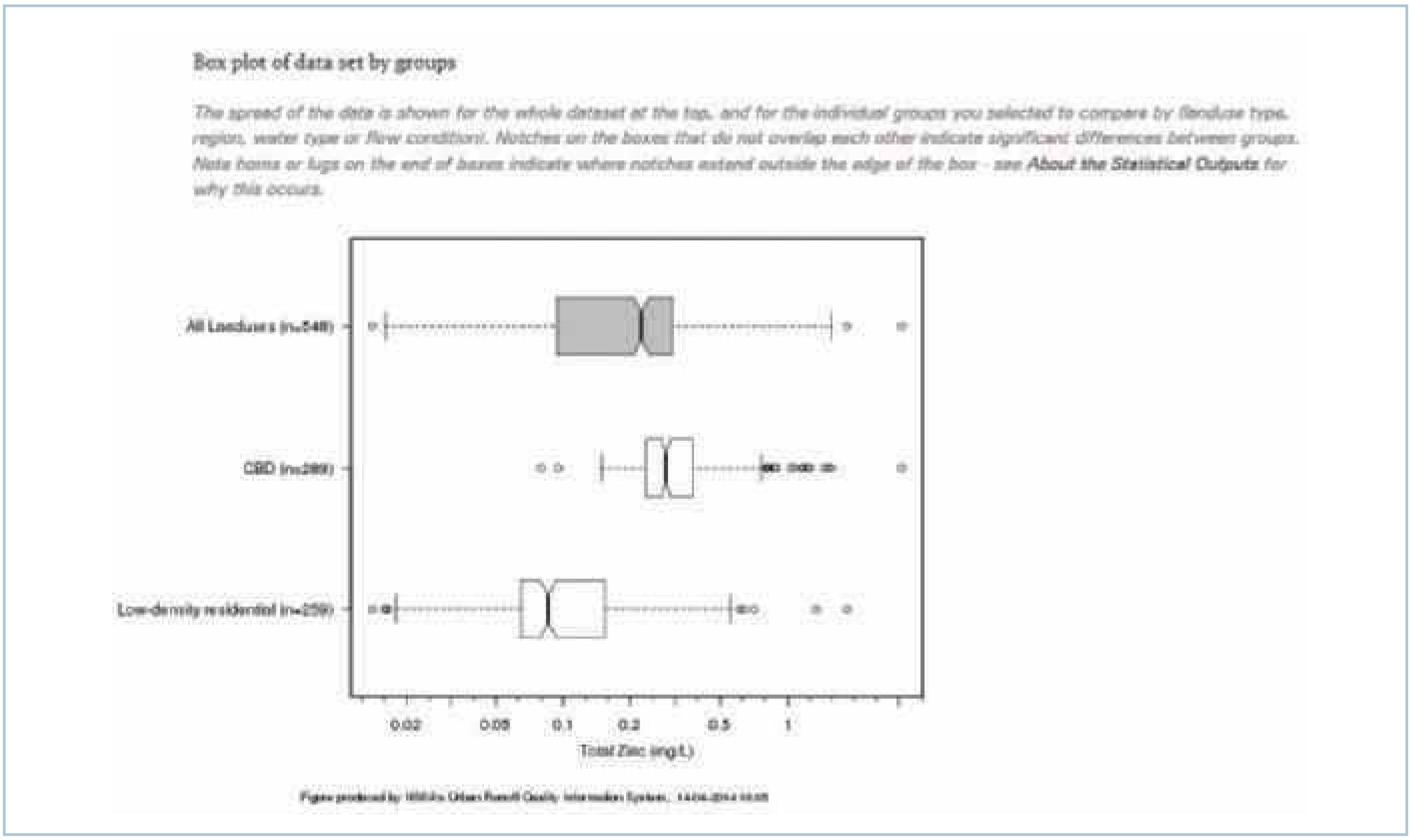


Figure 5 – Box plot produced by URQUIS for TZN concentrations for samples taken from low density residential and CBD monitoring sites in Auckland for all water types and flow conditions

3.5 Interpretation of Results

The results of the example query show that:

- The number of water samples from Auckland that have been analysed for TZn are similar for low density residential (293) and CBD (289) land uses, and that there are few samples with concentrations below the level of detection.
- While the maximum TZn concentrations are similar for the two land use types, CBD water samples have minimum, mean and median values greater than those for the low density residential water samples.
- The histogram shows a bi-modal distribution with two distinct peaks: the lower one reflecting the modal (most common) concentration in low-density residential water samples and the higher one reflecting the modal concentration in CBD water samples.
- TZn concentrations in water samples from low density residential areas have a greater spread than those in water samples from CBD areas.
- Outlier concentrations in water samples from low density residential areas tend to be lower than the 25th percentile, whereas the outlier concentrations in water samples from CBD areas tend to be greater than the 75th percentile.

4. Conclusions

An urban runoff database has been developed to collate stormwater, stream water and sediment quality data collected by councils and other organisations throughout New Zealand and to act as a source of representative values where monitoring cannot be undertaken.

Combining the data from multiple studies around New Zealand allows users to examine relationships that may not have been apparent with more limited access to data. The database holds many different types of monitoring data and multiple different parameters for both water and sediment quality. Metadata relating to the site, sample, and event characteristics are included in the database. This metadata enables comparisons of the data held in the database according to a variety of attributes.

"Combining the data from multiple studies around New Zealand allows users to examine relationships that may not have been apparent with more limited access to data."

Statistical summaries of data held in the database are available free of charge via the URQIS website. At present, URQIS allows users to build queries based on land use, region, type of water body, and flow conditions. It is hoped that the inclusion of comprehensive metadata will allow for more complex analyses in the future as the database grows. The use of URQIS was demonstrated in this paper by comparing North Island TZn concentration taken from two contrasting land use types (low density residential and CBD).

Contact Information

Go to http://urqis.niwa.co.nz/ to enter URQUIS.

Contact urquis@niwa.co.nz if your organisation has data that could be included in the database or if you would like to give feedback.

Acknowledgements

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Finally, the following organisations have supplied data for the database: Auckland Council; Christchurch City Council; Environment Canterbury; Greater Wellington Regional Council; Industrial Waste Solutions (IWS), Kaikoura District Council; Nelson City Council; New Zealand Transport Agency; Otago District Council; Environment Southland; Tauranga City Council; Waikato Regional Council and Wellington City Council.

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Constructed Wetland Research Project – Extending Detention, Scour Protection, and Early Warning System in a Dual Purpose Constructed Wetland

Adrian Tonks – Engineer, Cooks Costello

Executive Summary

A reconfiguration of the TP10 constructed wetland design has been undertaken to extend detention to 10 days while still maintaining extreme event stormwater attenuation. The reconfigured design was developed during appeal mediation of a granted consent for combined treated wastewater and stormwater disposal. Located in Ruakaka the 6ha wetland, when fully developed, will receive stormwater runoff from up to 180ha mixed land use and 3000m³/day dry weather treated wastewater flows.

The wetland discharges to Ruakaka Estuary and wildlife sanctuary, which in turn drains into Bream Bay with seawater takes for the Bream Bay Aquaculture Park. Appellants' concerns provided much of the design brief and included long detention times, mixing of treated wastewater and stormwater, containment of accumulated contaminants during extreme events, containment of wetland water in event of spills and early warning systems; meanwhile the stormwater attenuation requirements were achieved within the same footprint. The reconfiguration includes a wetland partition, drop weirs, and bypass flume. Investigation was undertaken with MIKE Urban by DHI with UHM and Kinematic Wave + Infiltration models for design events and 6.5 year rainfall record respectively. Analysis included flows, effect on upstream ponding, detention times, and exacerbation of wetland water levels for plant health.

> "The wetland discharges to Ruakaka Estuary and wildlife sanctuary, which in turn drains into Bream Bay with seawater takes for the Bream Bay Aquaculture Park."

Introduction

Marsden City in Northland is a mixed use environment that has evolved from two industrial subdivisions of 95ha and 35ha, with construction completed in 2009. Both subdivisions achieve stormwater quantity compliance in separate wet ponds that discharge to the Ruakaka Estuary, and in turn to Bream Bay. While the ponds provide a treatment function, the water quality compliance requirements remain the responsibility of the upstream lot owners.

A future issue for the growth of Marsden City and the wider Ruakaka area is wastewater treatment and disposal. During construction of the northern 95ha subdivision and associated 6ha wet pond a resource consent for the disposal of MBR quality treated wastewater to this structure was sought, with its conversion to a TP10 constructed wetland being one of the conditions. Consent was granted and subsequently appealed by NIWA's Bream Bay Aquaculture Park, Iwi, and a local environmental group. Whilst the consent application was for wastewater discharge, the appellants concerns principally related to stormwater quality.

During the resource consent appeal mediation a research study was undertaken to develop a reconfigured wetland design that addresses the appellants' concerns. This submission discusses the parties' objectives, how these were achieved in the reconfigured wetland, and opportunities that the design offers. The appeal was successfully mediated outside of court and resource consent has been granted.

Discussion

The wetland redesign developed through balancing the requirements of both parties while working within the physical constraints of the site.

The appellants sought:

- An extended hydraulic retention time (HRT) of the mixed stormwater and treated wastewater, ideally at least 6 days under most conditions
- Enhanced stormwater and wastewater mixing within the wetland
- Reduced scouring out of accumulated sediments and reduced damage to wetland plants/associated biofilms by high velocity inflow
- Reduced flushing of contaminant laden water and containment of accidental spills or WWTP malfunction
- Increased monitoring frequency to enable early warning, giving time to

Figure 1 – Marsden City and 6ha wet pond. Construction monitoring aerial photograph 2009

enact a management response at the NIWA's Bream Bay Aquaculture Park research facility

Meanwhile the applicant's team required:

- No negative effect on the flooding upstream within Marsden City
- Water quantity compliance to be maintained (the districts' environmental engineering standards require attenuation of the post development 5yr and 100yr ARI plus climate change events to be mitigated to 80% of the pre development pre climate change peak flows of the corresponding events with a UDSA TR-55 Type 1A hyetograph)
- Additional attenuation capacity over and above the present requirements to be preserved for future use, as best as able

The Original Wetland Design

The wetland proposed in the original design has a 6ha footprint and conforms to the ARC TP10 banded bathymetry constructed wetland, with sediment forebay, and ephemeral and deep water zones. Due to the wetland size, islands were incorporated to limit short circuiting. Treated wastewater disposal into the wetland is via a gravel bed, located adjacent to the sediment forebay and furthest from the wetland outlet. The average dead storage depth is 0.56m and live storage to emergency spillway (OTP 4.85m) is 3.2m. The wetland orifice outlet (IL OTP 1.65m) discharges to a farm drain, with 315ha catchment, which in turn discharges to Ruakaka River.

Upstream of the wetland is a 95ha mixed use urban catchment comprising of three sub catchments. State Highway 15A separates Marsden City from the wetland and as a consequence the lower reticulated network conveys both the primary and secondary flows via three Ø1650 pipes at grades of 0.25%, these discharge into the wetland at IL OTP 2.2m. Within Marsden City the lowest elevation catchpit grate is GL OTP 4.9m.

The subdivision reticulation and pond were designed with a MIKE Urban UHM SCS hydrological and hydraulic model. In addition, this study has also utilised the Marsden Point OTA rainfall record from October 2006 to March 2013 with a Kinematic Wave + RDI hydrological model. Both the unit hydrograph and rainfall runoff have been scaled to utilise the wetland full attenuation capacity. The Marsden Point rainfall record includes the March 2007, June 2007 and January 2011 tropical cyclone events, which caused widespread flooding throughout Northland.

Reconfigured Wetland Elements and Feature

The reconfigured wetland is split into two 3ha sections, with the sediment forebay and wastewater gravel bed included in the first section. Separating the two sections is an intra-wetland weir with crest level at OTP 3.5m. The two sections are linked by an intra-wetland Ø225 orifice with IL OTP 1.5m. The intra-wetland link is positioned below the permanent water level to contain and aid TPH volatilisation within section one.

The inlet Ø1650 pipes are laid at a negative 9% gradient over the final 10m length and discharge to a bypass flume with IL OTP 2.9m. The bypass flume discharges into the second wetland section, section two. Spliced externally to the invert of the Ø1650 pipes are low flow pipes ranging from Ø300 to Ø450, with sizing based on the water quality event from the contributing catchments. The spliced low flow pipes act as drop weirs, and are laid to the same gradient as the upstream pipe run. The low flow pipes are fitted with back flow prevention gates at the outlet to the sediment forebay.

To increase hydraulic retention, section one is deeper with a dead storage depth of 1m, although the sediment forebay is 2m deep. Section one is essentially a wet pond, although would suit floating vegetated islands (FVI), which – subject to the development of research based evidence demonstrating their potential for phosphorous removal – may prove beneficial in reducing the alum dosing regimen at the wastewater treatment plant.

Section two maintains its TP10 constructed wetland banded bathymetry characteristics and has an average dead storage depth of 0.56m.

Design Approach and Sizing

The reconfigured design follows progressive although somewhat iterative steps:

1. The high flow negative gradient pipes are adjusted up to the point that there is not an observed change in ponding depth within the upstream catchment for the 100yr ARI +cc design event.
2. The low flow pipes and intra-wetland orifice are sized for the design water quality event, with surcharge within the high flow pipes not exceeding the outlet invert to the bypass flume. Two design water quality events were accessed: the NZTA 90th percentile event of 22.5mm/24hours and the ARC TP10 1/3 2yr ARI event of 37mm/24hours. On inspection of the reconfigured wetland function over the 6.5 year rainfall record, the NZTA WQV event was ultimately selected for sizing purposes as it produced greater detention times and on average resulted in four bypass events per year.
3. The intra-wetland weir crest level is adjusted to the point that water from section two flows back into section one for the 5yr and 100yr ARI +cc design events, along with larger bypass events from the rainfall record. Above the crest level the two sections function as a single attenuation volume, as the water level recedes the back flow prevention gates on the low flow pipes stop water from section one short circuiting the intra-wetland weir via the bypass flume.
4. The wetland outlet orifices are sized as normal to achieve water quantity discharge compliance.

The design objectives are to preferentially hold onto both the stormwater first flush and wastewater for as long as possible, for these to dilute each other and not be flushed out during extreme weather events, while still achieving the stormwater peak flow mitigation requirements. Figure 2 shows the water level decay rate of the reconfigured and TP10 wetlands for the water quality event over twenty eight days.

> "Treated wastewater disposal into the wetland is via a gravel bed, located adjacent to the sediment forebay and furthest from the wetland outlet."

Both the reconfigured and TP10 wetland outlets have been sized to achieve compliant discharges for the 5yr and 100yr ARI plus climate change events, and therefore both wetlands have the same design event peak discharge. Figure 3 below shows that the reconfigured wetland requires 4% greater attenuation volume than the TP10 wetland, although the difference is likely to vary with compliance requirements within other districts.

One of the design objectives was to reduce flushing of contaminant laiden water from the wetland during extreme events. This has been acheived through the intra-wetland weir crest level, demonstrated in Figure 4.

The 6.5 year rainfall record from Marsden Point (10/2006 – 3/2013) has be used to evaluate the effect of cumulative events on the reconfigured wetland.

Figure 2 – 22.5mm water quality event Reconfigured and TP10 wetlands (28 days)

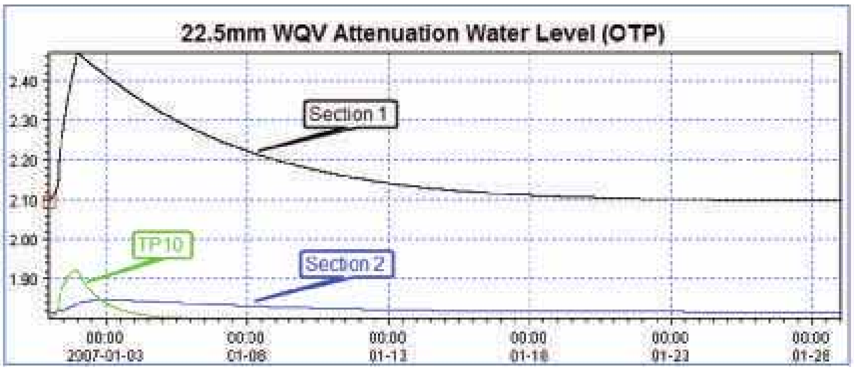


Figure 3 – Attenuation of 100yr +cc ARI design event with wastewater inflow

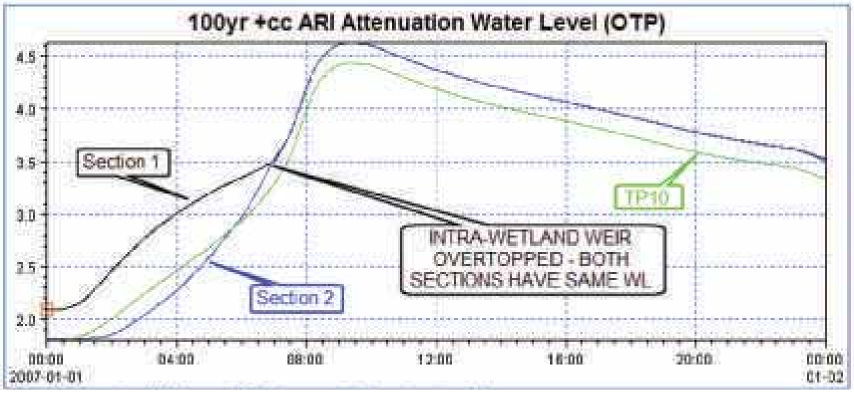


Figure 4 – Section 1 flushing resistance

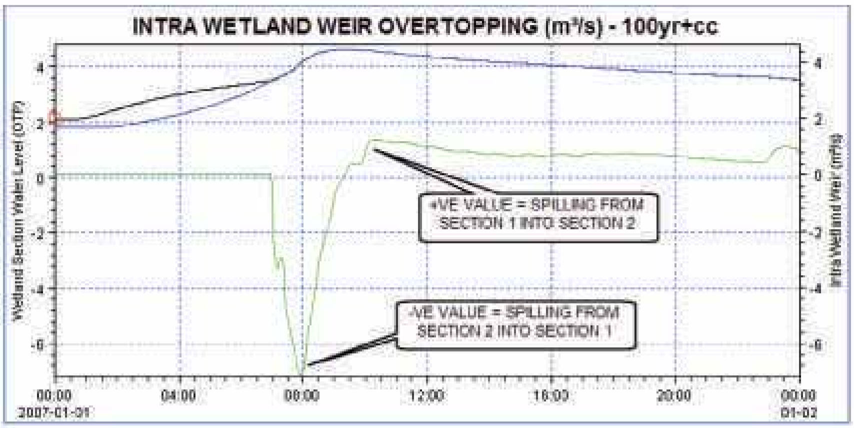
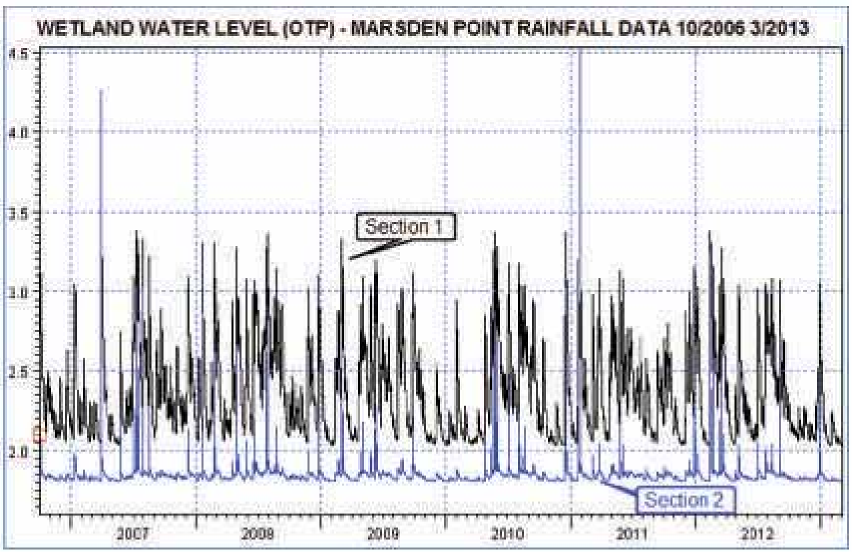


Figure 5 – 6.5 year rainfall record continuous simulation. Cumulative effect on reconfigured wetland water level



Reconfigured Wetland Section 1 – analysis (long term minimum live storage water level = 2.036m OTP)							
Depth Exceeding	>10mm	>50mm	>100mm	>200mm	>400mm	>800mm	>1600mm
Instances	22	64	93	106	114	93	7
Maximum Duration (days)	618.01	219.49	156.21	97.26	51.27	9.22	0.37
Average Duration (days)	81.15	31.51	18.20	12.68	7.10	1.97	0.10

Reconfigured Wetland Section 2 – analysis (long term minimum live storage water level = 1.812m OTP)							
Depth Exceeding	>10mm	>50mm	>100mm	>200mm	>400mm	>800mm	>1600mm
Instances	75	98	83	63	43	20	4
Maximum Duration (days)	162.83	21.53	4.92	1.84	1.26	0.92	0.44
Average Duration (days)	23.38	4.86	1.31	0.65	0.36	0.20	0.21

Table 1 – 6.5 year rainfall record. Summarised reconfigured wetland water levels

TP10 Wetland – analysis (long term minimum live storage water level = 1.797m OTP)							
Depth Exceeding	>10mm	>50mm	>100mm	>200mm	>400mm	>800mm	>1600mm
Instances	345	265	182	99	51	17	4
Maximum Duration (days)	21.51	7.04	3.87	2.27	1.65	0.99	0.38
Average Duration (days)	3.00	1.44	0.92	0.66	0.40	0.21	0.17

Table 2 – 6.5 year rainfall record – summarised TP10 wetland water levels

The purpose of Table 1 is to aid interpretation of the water level graphed in Figure 4 above and to also investigate whether wetland plant health would be adversely affected. As expected wetland planting would not be suitable in section one unless floating vegetated islands are utilised. Note: 'depth exceeding' is the depth above minimum operational level, i.e., the live storage; 'instances' is the number of times a given live storage depth is exceeded; 'maximum duration' is the longest duration of a single instance; and 'average duration' is the sum of instance durations divided by the number of instances.

"As expected wetland planting would not be suitable in section one unless floating vegetated islands are utilised."

The following figure shows high flow bypass instances versus rainfall intensity and section one water level (red line at 2.9m OTP). Bypass occurs either when section one water level exceeds 2.9m OTP or where inflow discharge (m^3/s) exceeds the low flow pipe capacity, such as during convective thunderstorm events. The latter provides a mechanism to moderate velocity entering the stormwater sediment forebay.

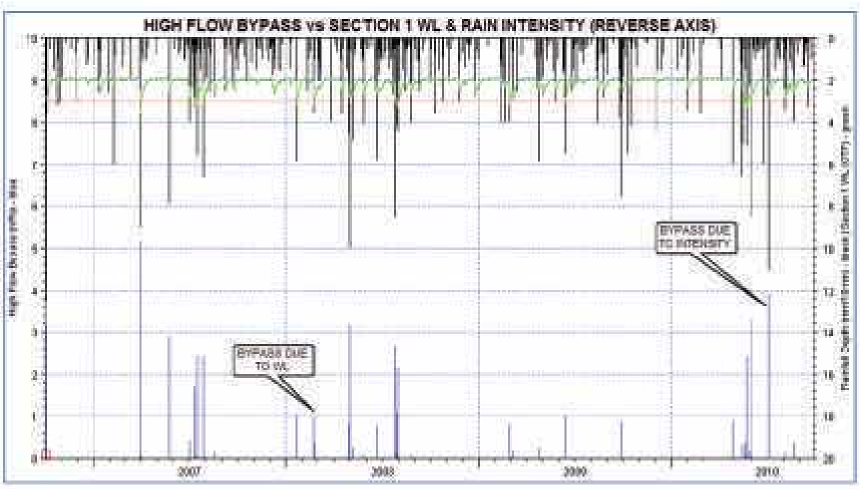


Figure 6 – four year rainfall record (2006 – 2010) – high flow bypass

The Marsden Point 6.5 year rainfall record model run includes wastewater inflow corresponding to either wet weather (69.4l/s inflow) or dry weather (34.7l/s inflow) conditions. Rainfall with >=8.4mm/hr intensity or >=20mm/day is treated as a wet weather flow.

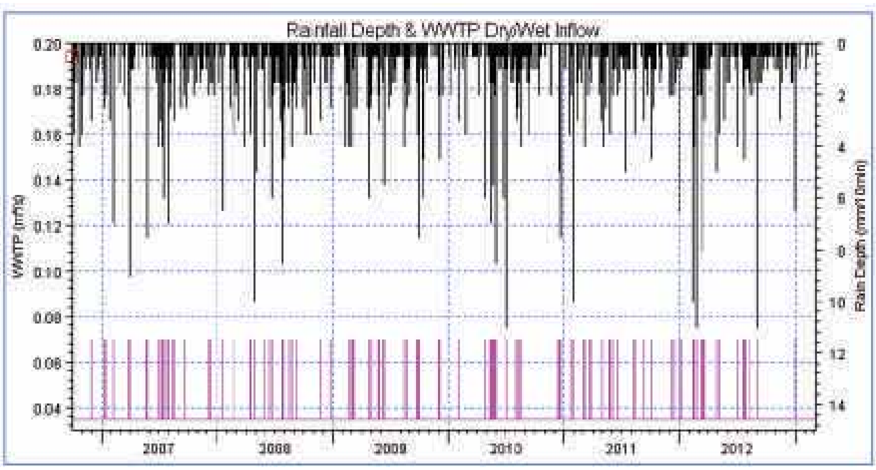


Figure 7 – 6.5 year rainfall record – wastewater dry/wet weather inflow

"'Dry days' are those where less than 2mm fell within 24 hours of the time step. 'Wet days' are consistent with the wastewater disposal definition of wet weather, and 'rain days' are those that fit neither of those criteria."

A pivotal aspect of the redesign brief is extended detention. Hydraulic retention times have been compared between the reconfigured design and the TP10 wetland. Because HRT is a function of volume, two further scenarios have been compared; these are the reconfigured design without additional dead storage and the TP10 wetland over attenuated such that the water levels match the reconfigured design.

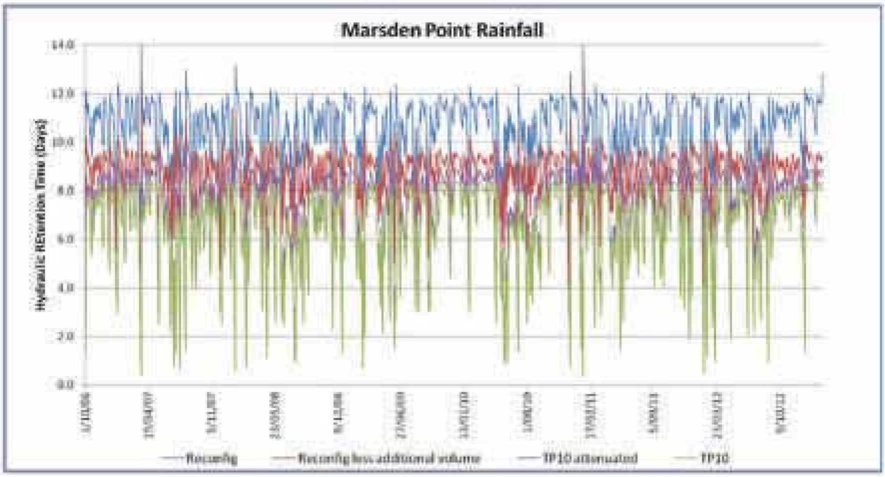


Figure 8 – 6.5 year rainfall record. Hydraulic retention time (days) – 4 hour averaged time steps

		Reconfigured	TP10	Reconfigured less additional volume	TP10 Attenuated
Overall	Min	5.6	0.3	4.0	0.3
	Lower Q	9.8	5.6	8.1	6.0
	Medium	10.8	7.0	8.9	7.5
	Upper Q	11.5	7.9	9.4	8.4
	Max	15.0	8.4	13.10	10.8
Dry Days	Min	5.8	1.5	4.2	1.5
	Lower Q	10.0	6.2	8.4	6.6
	Medium	11.0	7.4	9.1	7.8
	Upper Q	11.6	8.0	9.4	8.5
	Max	13.3	8.4	11.5	10.8
Rain Days	Min	6.5	1.2	4.1	1.2
	Lower Q	9.3	4.8	7.7	5.1
	Medium	10.1	5.9	8.4	6.4
	Upper Q	10.9	6.9	8.9	7.4
	Max	13.0	8.1	11.1	9.4
Wet Days	Min	5.6	0.3	4.0	0.3
	Lower Q	8.3	1.4	6.9	1.5
	Medium	9.1	2.5	7.6	2.9
	Upper Q	10.2	3.4	8.6	4.0
	Max	15.0	7.7	13.1	8.2

Table 3 – 6.5 year rainfall record. Summarised hydraulic retention time (days)

The hydraulic retention time has been calculated from 10 minute time step data of the water volume and discharge from each section. The discharge rate is used to look forward and determine the elapsed time for the water volume associated with that time step to be displaced. This is a first in first out queue and hence assumes no short circuiting occurs within the wetland.

In the reconfigured wetland the sections are in series. The time elapse for the section one volume to be displaced becomes the seed time step in section two and the overall time elapsed time is the reconfigured wetland HRT. Due to the volume of data and processing requirements of the 10 minute time step, data is averaged in four-hour steps with linear interpolation between averaged steps used to determine the elapsed time. Sensitivity checks using a shorter one hour averaged step found no significant difference compared with the longer time step results.

Figure 7 shows the hydraulic retention time for the various wetland scenarios over the 6.5 year rainfall record. Table 3 provides analysis of Figure 7. 'Dry days' are those where less than 2mm fell within 24 hours of the time step. 'Wet days' are consistent with the wastewater disposal definition of wet weather and 'rain days' are those that fit neither of those criteria. Of the 2668 days within the rainfall record 1989 were dry, 570 were rain days, and 109 were wet days.

The reconfiguration design objective of a minimum 6 days HRT under most circumstances is readily achieved with an Overall Median of 10.8 days. A significant difference between the reconfigured and TP10 wetland occurs during the rain and in particular the wet days. A fair assessment between the wetlands is provided by comparing the Reconfigured Less Additional Volume, which has the additional dead storage removed, and the TP10 Attenuated, which is tuned to match the Reconfigured water level. As can be seen from this comparison the extended HRT is not solely due to the increased water volume.

Early Warning and Containment

Water quality monitoring proposed with the original design, involved routine bimonthly grab sampling from a range of locations within and remotely of the wetland. Test locations within and adjacent to the wetland included the stormwater and wastewater influent, the outflow and the farm drain both up and downstream of the wetland outlet. Whole Effluent Toxicity Testing (WETT) was also to be undertaken annually on the discharged wetland water.

In an effort to provide an early warning system for the Bream Bay Aquaculture Park it was proposed by the appellants to refine the test regime granularity, however the increased frequency was unlikely to improve the warning quality.

For the reconfigured design an alternative monitoring approach is taken with the addition of a monitoring station, which continuously monitors parameters and spectral fingerprint. Data collected by this suite of instruments allows for remote real time monitoring, alert generation and automatic grab sampling for further lab testing. Elsewhere this technology is used for monitoring and automation in municipal raw water takes, wastewater treatment plant discharge and a range of other water quality and process applications. Water samples are delivered from the test locations to the centrally located monitoring station by air lift pump, avoiding the need for electrical supply and pumps at each of the sample locations. The monitoring station will receive samples from six test locations, those proposed with the original design, plus at the intra-wetland link. The monitoring station equipment includes a UV-Vis spectrometry analyser, conductivity probe, dissolved oxygen and temperature probe, NO_3, ammonia and pH probe, pneumatic air lift pump and telemetry equipment. While capable of continuous monitoring, hourly sampling allows for switching between each test location, which are rotated every 10 minutes.

Through continuous monitoring and telemetry alert generation the Bream Bay Aquaculture Park will be provided with the level of early warning sought. A feature of the monitoring software is recognition of an out of the ordinary spectral fingerprint, which will potentially enable detection of contaminants that are neither perceived nor prescribed within the consent conditions, should these arise. Grab sampling and WETT testing is still required for some parameters due to technical limitation or sample point proximity and to verify the continuous monitoring results. By reducing the grab sampling requirements the monitoring station provides significant long term cost savings.

> "For the reconfigured design an alternative monitoring approach is taken with the addition of a monitoring station, which continuously monitors parameters and spectral fingerprint. Data collected by this suite of instruments allows for remote real time monitoring, alert generation and automatic grab sampling for further lab testing."

A feature of the two wetland sections is that the outlet from section one can be closed during a spill event management response, with further influent stormwater diverted to section two via the bypass flume.

Conclusions

The reconfigured wetland design uses drop weirs to separate the first flush water quality volume from influent stormwater and a bypass flume to divert the remaining volume from larger events. The two water volumes are separated by an internal partition, which is overtopped during extreme events, at which point the two sections function as a single volume thereby preserving the extreme event attenuation capability. The live volume requirements are 4% greater in the reconfigured wetland compared to the TP10 wetland.

Section one has a dead storage depth of 1m. Irrespective of the permanent water depth, section one is not suitable for wetland planting due to prolonged elevated water levels, although the use of floating vegetated islands would be suitable.

Scouring and flushing out of section one is reduced by the combination of the wetland partition – which is sized so that section two overtops into section one during extreme events – and by the drop weir low flow pipes that divert high influent flows associated with short duration high intensity rainfall events.

The hydraulic detention time is extended by the reconfigured design, which has an overall Median HRT of 10.8 days versus the TP10 overall Median HRT of 7 days. More significant is the HRT during rain (Median 10.1 and 5.9 days) and wet (Median 9.1 and 2.5 days) periods for the respective wetlands. The reconfigured wetland extended detention is in part due to the increased water volume, although primarily the effect is from the wetlands function. Wetland flushing is significantly reduced with minimum HRT of 6.5 days verses the TP10 1.2 days during Rain events and 5.6 days verses 0.3 days during Wet events.

The automatic monitoring station with telemetry provides an early warning system along with significant cost savings over time when compared to grab sampling. In the event that a spill or malfunction occurs, section one of the reconfigured wetland can be closed with all stormwater bypassing to section two while a management response is implemented.

Acknowledgements

Dr Susan Clearwater, et al. National Institute of Water & Atmospheric Research Ltd (NIWA).

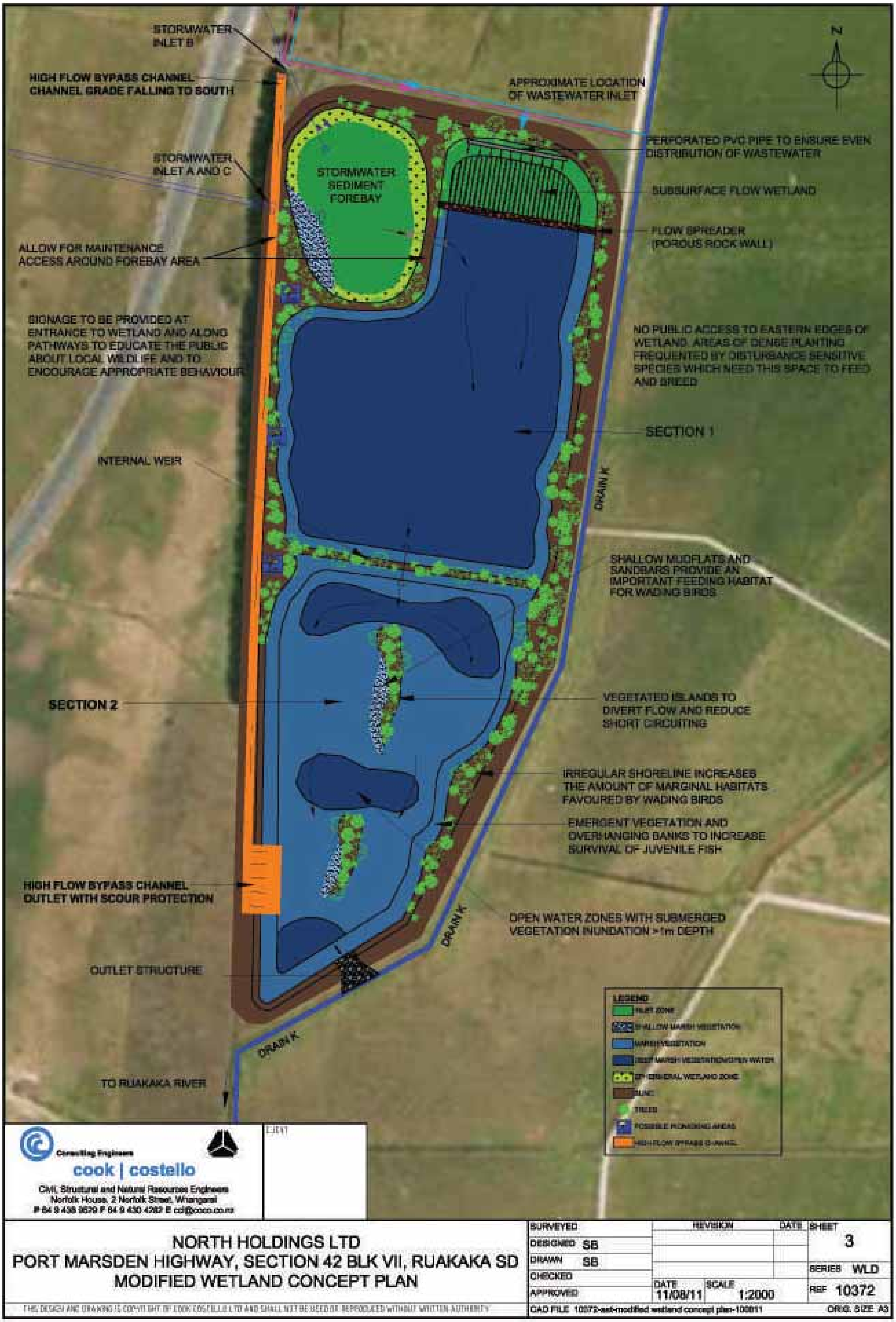
Tara Okan, Rob Dexter, et al. DCM Process Control Limited.

References

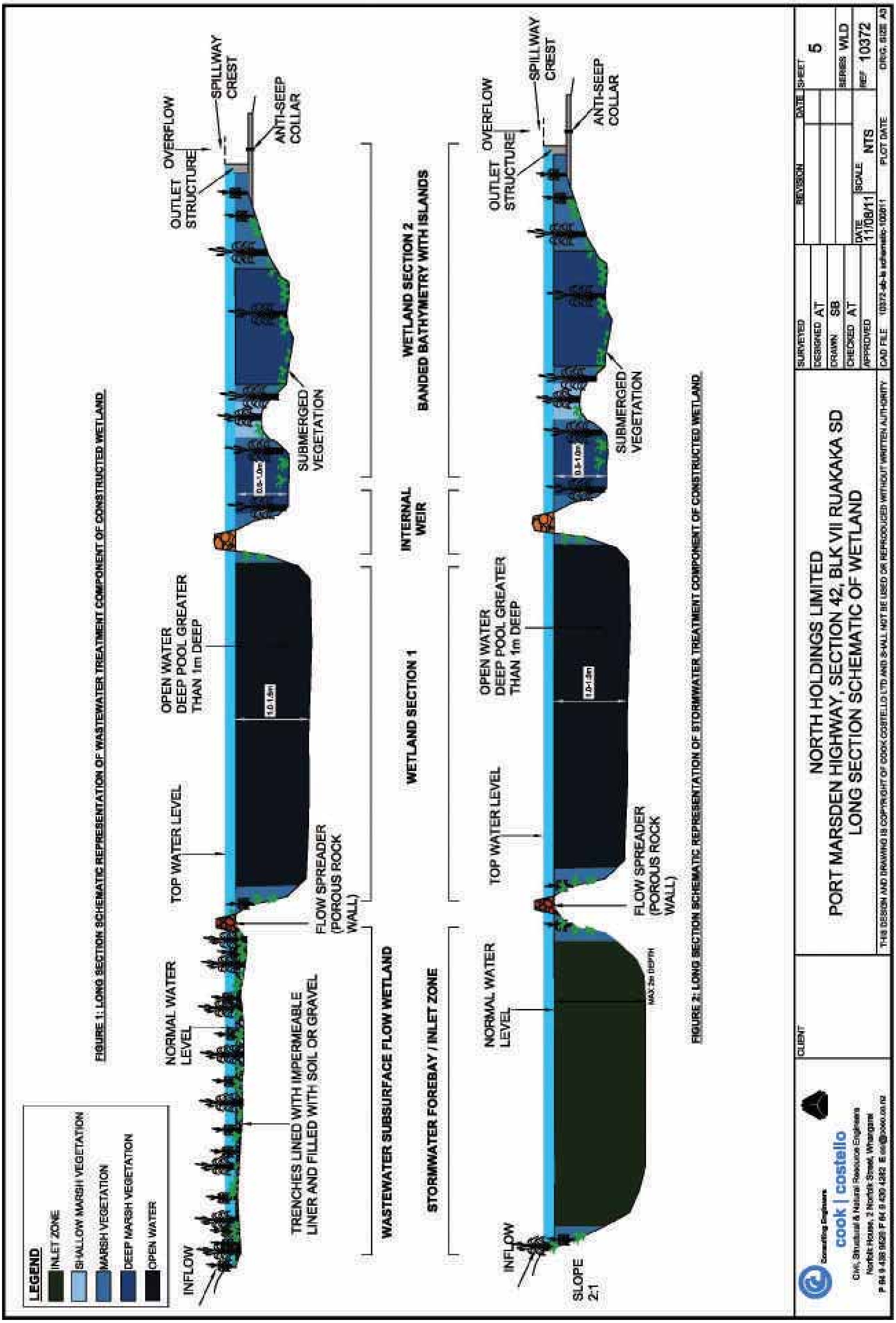
Auckland Regional Council (2003) 'Technical Publication 10 – Design Guideline Manual: Stormwater Treatment Device', 'Chapter 6 – Wetland Design, Construction & Maintenance'

See pages 34–36 for Appendices.

Appendix 1 – Modified Wetland Concept Plan



Appendix 2 – Reconfigured Wetland Section



Appendix 3 – Monitoring paramenters, frequency and locations

Appendix 3: Monitoring parameters, frequency and locations

Parameter	Units	WWTP Influent	Stormwater	Wetland Within 20m Radius SW SS	Wetland Mid Point	Wetland Outlet	Drain K Upstream	Drain K Downstream	Drain K @ McCathie	Ruakaka R Upstream	Ruakakak River Downstream
E coli	MPN/100mL	Instrument	2		-	12 / 4	Instrument	Instrument	12 / 4	12 / 4	12 / 4
F-specific bacteriophage	Number per 50 L	2 / 0.5	-		-	-	-	-	-	-	-
WETT	-	-	-		-	4 / 2	-	-	-	-	-
Total Nitrogen	mg / L	Instrument	-		-	-	-	-	-	-	-
Nitrate/Nitrite	mg / L	Instrument	-		-	-	-	-	-	-	-
Total Ammonia	mg/L	Instrument	-		Instrument	Instrument	Instrument	Instrument	12 / 4	12 / 4	12 / 4
Dissolved Reactive Phosphorous	mg / L	Instrument	-		-	-	-	-	-	-	-
Total Phosphorous	mg / L	Instrument	-		-	-	-	-	-	-	-
Total Organic Carbon	mg/L	Instrument	-		Instrument		-	-	12 / 4	12 / 4	12 / 4
Dissolved Oxygen	% Sat	-	-		Instrument	Instrument	Instrument	Instrument	12 / 4	12 / 4	12 / 4
Carbonaceous Biochemical Oxygen Demand	mg / L	Instrument	-		-	-	-	-	-	-	-
Total Suspended Solids	mg / L	Instrument	Instrument		Instrument	-	-	-	-	-	-
Total petroleum hydrocarbons	mg/L	-	Instrument		Instrument	Instrument	Instrument	Instrument	12 / 4	12 / 4	12 / 4
VOC & sVOC	g/m³	-	-		-	4	4	4	4	4	4
pH		Instrument	Instrument		Instrument	Instrument	Instrument	Instrument	12 / 4	12 / 4	12 / 4
Alkalinity (as $CaCO_3$)	mg/L	12 / 4	2		-	12 / 4	12 / 4	12 / 4	-	-	-
Conductivity	mS	-	-		Instrument	Instrument	Instrument	Instrument	12 / 4	12 / 4	12 / 4
Temperature	°C	-	-	Instrument	Instrument	Instrument	Instrument	Instrument	12 / 4	12 / 4	12 / 4
Salinity	ppt	-	-		Instrument	Instrument	Instrument	Instrument	12 / 4	12 / 4	12 / 4
Flow metering	m³/day	Instrument	-		-	Instrument	-	-	-	-	-
Visual check (oils, scum)		-		12	-	12	12	12	12	12	12
Visual Clarity	black disk	-	-		-	4	4	4	4	4	4
Hue	Munsell scale	-	-		-	4	4	4	4	4	4
Turbidity	mS	-	-		Instrument	Instrument	Instrument	Instrument	12 / 4	12 / 4	12 / 4
Aluminium	µg/L	4	-		-	4	4	4	4	4	4
Cadmium	µg/L	4	-		-	4	4	4	4	4	4
Chromium	µg/L	4	-		-	4	4	4	4	4	4
Copper	µg/L	4	2		-	4	4	4	4	4	4
Lead	µg/L	4	2		-	4	4	4	4	4	4
Mercury	µg/L	4	-		-	4	4	4	4	4	4
Nickel	µg/L	4	-		-	4	4	4	4	4	4
Zinc	µg/L	4	2		-	4	4	4	4	4	4
Arsenic	µg/L	4	-		-	4	4	4	4	4	4
Beryllium	µg/L	4	-		-	4	4	4	4	4	4
Selenium	µg/L	4	-		-	4	4	4	4	4	4
Silver	µg/L	4	-		-	4	4	4	4	4	4
Thallium	µg/L	4	-		-	4	4	4	4	4	4

Frequency in times per year, i.e. 12 / 4 is initially monthly, the 3 monthly


Precious.

Stormwater Management Under the Proposed Auckland Unitary Plan

Colin Cranfield and Alex Colibaba, Harrison Grierson

The ongoing subdivision of land at Hobsonville Point in north-west Auckland has been caught up in the change to legislation as a result of the Auckland Housing Accord agreed between the Auckland Council and the Government. What has this meant for stormwater management on projects that are in progress?

The Auckland Council and the Government signed the Accord on 3 October 2013 – an agreement to urgently increase the supply and affordability of housing in Auckland. The Accord will mean housing developments in Special Housing Areas (SHAs) will be considered under the more streamlined development processes outlined in the *Proposed Auckland Unitary Plan (PAUP)* and subordinate documents, until the Plan becomes operative in September 2016 and the Government's Resource Management Act reforms for planning processes takes effect.

> "But since the Catalina Precinct project was already in progress the development rules changed from the Operative Plan to the PAUP and subordinate documents. This meant that designs already approved for the project had to be modified, including changes to the stormwater management plan."

The Accord sets a target of 9,000 additional residential houses being consented for in the first year, 13,000 in the second year, and 17,000 in the third year.

The Auckland Council notified the *PAUP* on 30th September 2013 just in time for the Accord to be signed by Housing Minister Nick Smith and Auckland's Mayor Len Brown. With the *PAUP* notified and the Accord signed, Council is able to unlock new land for development (SHAs) and fast track the building of more houses, many of which are to be in the affordable range for first time home buyers and low income families.

The following criteria apply to SHAs:

- Alignment with the Auckland Housing Accord
- Alignment with Auckland Plan and proposed Auckland Unitary Plan
- Availability and readiness of infrastructure (physical and social)
- Iwi requests and/or views
- Land owner requests and/or views
- Location, such as reasonable access to employment and essential services
- Local board views
- Demand to build – the developer is likely to achieve early consent activation and the intended yield of sites/dwellings within the accord period
- Demand for housing – evidence that the development will meet an existing need
- Affordability – the development's contribution to housing affordability either in terms of overall housing supply or pricing of the house

All new developments approved under the Accord will be subject to the rules of the *PAUP* and subordinate documents which include new Guidance Documents for Water Sensitive Design and a new Code of Practice for Land Development and Subdivision that includes a comprehensive chapter on Stormwater and Flood Risk Management.

Since the signing of the Accord, Council and the Government have announced two tranches of SHAs. In October, 11 SHAs across Auckland were created and in December, another 11 SHAs were also created. Following each announcement Council has accepted applications for subdivisions, which will be fast tracked under the new legislation. A third tranche of SHAs is expected to be announced in May 2014.

In some of the locations identified as SHAs, development is already underway, such as Hobsonville Point, which is the site of the former Hobsonville Airbase where the Catalina Precinct was confirmed as an SHA (October announcement). This has created the opportunity to fast track development.

"But since the Catalina Precinct project was already in progress the development rules changed from the Operative Plan to the *PAUP* and subordinate documents. This meant that designs already approved for the project had to be modified, including changes to the stormwater management plan."

The original stormwater management plan was based on Low Impact Design (LID) treatment methodologies whereas the amended plan is based on Water Sensitive Design (WSD) treatment methodologies.

"While the principles of LID and WSD are essentially the same, the application of the options under the *PAUP* are more aligned to, at source attenuation and treatment and the use of natural systems for stormwater management, than they were under the Operative Plan."

This change in application has had an effect on the layout and number of the lots, the road network and the utility services on the Catalina Precinct project, and will have similar effects on other projects in progress at the time of the signing of the Housing Accord.

Development Under the Operative Plan

The Network Discharge Consent (2010) for the Peninsular, required stormwater to be treated using LID and proprietary devices in accordance with TP108 and TP10. A stormwater management plan was prepared for the Catalina Precinct (Harrison Grierson), which included:

- Rainwater tanks for water reuse on each lot
- Stormwater reticulation for runoff conveyance
- A wetland for treatment of three of the four post development subcatchments, and a proprietary treatment device for the fourth subcatchment.

As the runoff is finally discharged to a coastal marine area there was no requirement for stormwater attenuation on the development.

Development Under the *PAUP*

To allow fast-tracking of developments, the Auckland Council Housing Project Office was established to implement the objectives of the Housing Accord, and works in collaboration with project designers during the development of an SHA stormwater management plan. They agree stormwater treatment methods and techniques before an application for subdivision is lodged.

"The changing approach to balancing development with supporting ecosystems in Auckland is now based on Water Sensitive Design. WSD principles should be applied at all levels of development be they regional, catchment, site, or even individual lot scale."

In the case of the Catalina Precinct, the original stormwater management plan has been modified and is the base document for an application for a variation to the Network Discharge Consent. For the Catalina project, the following solutions have been agreed:

- Rainwater tanks for water reuse on each lot.
- At source stormwater treatment for the main roads with significant traffic volumes using rain gardens and tree pits.
- Roads with impervious areas of less than 5,000m^2 do not require stormwater to be treated.
- Conveyance and discharge of flows up to the 10 year ARI storm event by dedicated reticulation.
- Final treatment by a constructed wetland in a natural gully. The outlet is to be sized to discharge the 10 year ARI storm event flow while higher flows generated up stream will be discharged overland to the coastal marine area, by passing the wetland.
- In the subcatchment that doesn't drain to the wetland, stormwater treatment will be at source detention, reticulation to raingardens for treatment before discharge to the coastal marine area.

What is the Outcome for the Project?

The design details are still being finalised but overall the outcomes are considered positive, including:

- Improved environmental, landscape, and amenity outcomes
- Anticipated increase in property values because of the improved subdivision features ("green" roads, increased areas of soft landscaping, and improved visual impact)
- Minimal increase to the cost of stormwater management on the subdivision
- Anticipated neutral cost impact for the adoption of the *PAUP* rules over the Operative Plan rules

For other subdivision projects in progress at the time of the notification of the *PAUP* and subsequently indentified as an SHA, the level of changes may be significant. This will depend on the specific site features such as existing streams, extent of the floodplain, flood prone and flood sensitive areas (if any), geological and ecological characteristics, cultural and heritage issues, and contaminated areas.

The changing approach to balancing development with supporting ecosystems in Auckland is now based on Water Sensitive Design. WSD principles should be applied at all levels of development be they regional, catchment, site, or even individual lot scale.

Concepts for stormwater management need to be developed at the planning stage and focus on protecting the values and functions of natural ecosystems, addressing the effects of stormwater as close as possible to the source and designing treatment systems that mimic natural systems and processes.

+GF+

"A bawdi is a traditional stepwell where the water may be reached by descending a set of brick laid steps. Where there are no local bawdis, villagers are forced to walk long distances and carry water back up from the lower valley to maintain their crops and provide a safe drinking supply for themselves and their livestock."

Catchment Management in the Indian Himalaya

Mike Chapman – Senior Hydrologist, Harrison Grierson

In August this year, I will head to the Indian Himalaya to assess developments made in the region's water supplies following my time working with a local NGO (The Rural Centre for Uman Interests) 14 years ago. In this article, I outline the state of the infrastructure on my initial visit and compare it with our own experience in New Zealand.

In 2000 I worked with the Rural Centre for Human Interests on catchment management in the state of Himachal Pradesh in the Indian Himalaya. I found the water management issues and challenges were numerous and complex. Some were unique to the setting and circumstances of rural Indian people, while others shared common threads with issues faced in New Zealand.

The foothills of the Himalaya are remote. The country is steep with poorly structured soils, and high erosion. Severe deforestation has occurred over centuries to provide wood for fuel, livestock fodder and for traditional Hindu funeral pyres. The region is accessible by a marginal road network often impassable by landslips during the monsoon. The hilltop villages are accessed by mule and walking tracks through ravines and along ridge lines. Located far above the fertile floodplains, these villages do not benefit from readily available water and fertile soil to grow crops such as tomatoes, onions, peppers, and apples.

Those villages fortunate to benefit from local groundwater springs (bawdis) can prosper. A bawdi is a traditional stepwell where the water may be reached by descending a set of brick laid steps. Where there are no local bawdis, villagers are forced to walk long distances and carry water back up from the lower valley to maintain their crops and provide a safe drinking supply for themselves and their livestock. The stark contrast at the village level between poverty and relative wealth is often a direct reflection of water availability. If you are born into one village you cannot simply move to another; there are cultural hurdles to overcome to try to improve your lifestyle and prospects. In the Hindu religion you must accept to a large extent the living situation to which you are born into. This is especially so in traditional rural areas.

Careful management of freshwater is crucial to protect the spring sources. Water yield can be patchy in this tectonically active region. While the annual rainfall is quite good (~2800mm to 3800mm), it falls

mostly during the two-to-three months of the monsoon season from July through to September. The rest of the year the region is extremely dry. There are numerous intermittent streams that transport huge volumes of sediment and rise rapidly during the wet season. Spring sources can come and go over the course of a season or disappear altogether for no apparent reason after many good productive years.

Managing stormwater runoff during the monsoon season is critical to the livelihood and indeed survival of rural communities. Catchment management is undertaken at the local grass roots level. Rural technologies such as contour trenching, infiltration trenches, spring protections, check dams, rain tanks, and attenuation tanks are all employed to control and store stormwater as close to source as possible. The results are successful if the local people take ownership by constructing and maintaining the technology. Soil erosion is reduced, water is held within the upper catchment, and check dams and contour trenches encourage recharge to sustain bawdis and stream base flow.

Water is closely linked to the Hindu religion. The fickle nature of spring supply reinforces the Hindu belief that you should not alter water from its natural state. To alter a spring source, to manipulate natural water systems, is seen as interfering with God's will. Local people are reluctant to engineer the bawdi to help secure the supply and protect its purity from contamination. This reluctance is understandable; some of the traditional open water bawdis in the lower valleys that are used for ceremony and religious festivals are hundreds of years old and have maintained a good sustainable supply with minimal intervention or engineering.

Nevertheless security of supply remains a problem in many places and sensitive solutions are required. Respecting the cultural and religious value of freshwater is equally if not more important than providing good quality supply. Water supply solutions in North India cannot be implemented unless the religious component is respected and not compromised.

Rural technology NGOs encourage new integrated systems whereby water from the spring source is sealed firstly and then directed to tank storage for domestic supply and also to new Bawdi springs, which are built in the traditional stepwell style.

What struck me was the common thread with what we are trying to achieve in New Zealand with our catchment management. Many of the techniques that are used by communities in North India are aligned with the principles of what we call 'water sensitive design'. The concepts are embedded within the Hindu way of life, they make sense, and they are crucial for survival. The difficulty is striking the right balance between security of supply and cultural sensitivity.

Catchment management in the Himalayan foothills is complex with the physical challenges intimately woven with religious and cultural values. On my return from my follow-up visit later this year, I hope to be able to share with you some insights about progess made in the region, and how well communities have integrated technologies for improving water supplies with their culture and religion.

Clockwise from far left – Traditional Bawdi (Spring), Rebuilding a collapsed Bawdi, Collecting water from a traditional Bawdi stepwell, Newly completed Spring Protection

Porous Concrete Pavement: Could it be the New Permeable Pavement?

Amelia Cunningham – Senior Civil and Environmental Engineer, GHD

Reducing peak flows from road runoff, particularly as a result of redevelopment and road widening projects is under increased scrutiny. The need to comply with relevant planning rules regarding the reduction in peak stormwater flows and/or stormwater quality treatment is a requirement for many regions in New Zealand.

In Auckland, the Proposed Auckland Unitary Plan (PAUP), although generally more permissive than previous regional planning documents with respect to new development, does require additional stormwater quality and quantity measures to be considered where there are:

- Increases in impervious areas (>5,000m^2)
- Traffic movements on roads greater than 5,000 vehicles per day
- Carparks with more than 50 spaces
- Discharges to stormwater management areas where flows need to be moderated ('SMAF' areas)

However, these will now require further consideration in relation to stormwater management. In many cases this will require both stormwater quality and quantity controls.

Perceived Issues with Permeable Pavement

Permeable paving is often seen as a stormwater management solution that can be employed to reduce impervious area and effectively attenuate and treat stormwater runoff from road carriageways. However in New Zealand its application has been limited.

This is primarily due to issues relating to pore clogging, poor braking parameters, and in many cases, settlement due to poor construction. For these reasons, its use has been limited to small installations such as driveways and carparks.

Porous Concrete Pavement

Porous concrete pavement, also referred to as no-fines concrete or pervious concrete, has a large pore size with an increased void ratio and therefore high porosity, resulting in higher infiltration rates and being less prone to clogging and settlement. It is a relatively new technology and is a potential alternative to permeable pavement.

Figure 1 – Porous concrete section

Limitations on Use

The application of porous concrete pavement in road corridors has been restricted by two key issues:

- Reduced compressive strength, which means that it is not suitable for vehicle loading; and
- Ravelling, which is essentially a breakdown of the material due to vehicle tracking, particularly in turning areas, has also been problematic

With this in mind, to-date it has only been used in trials on footpaths, most recently the Clemows Lane footpath trial in Albany.

Figure 2 – Clemows Lane porous concrete footpath

NorSGA Transportation Infrastructure Project

The Northern Strategic Growth Area (NorSGA) transportation infrastructure project provided a platform to develop an improved specification for porous concrete for use in a transportation setting.

NorSGA was identified in the Auckland Regional Growth Strategy as a key growth area and Auckland Transport identified this project as being critical to accommodating future population and economic growth.

"Permeable paving is often seen as a stormwater management solution that can be employed to reduce impervious area and effectively attenuate and treat stormwater runoff from road carriageways. However in New Zealand its application has been limited.This is primarily due to issues relating to pore clogging, poor braking parameters, and in many cases, settlement due to poor construction."

The NorSGA project involved the design and construction of infrastructure components including roads, stormwater drainage and treatment, wastewater, and water supply to service parts of the NorSGA area in Massey North, Massey East and Hobsonville.

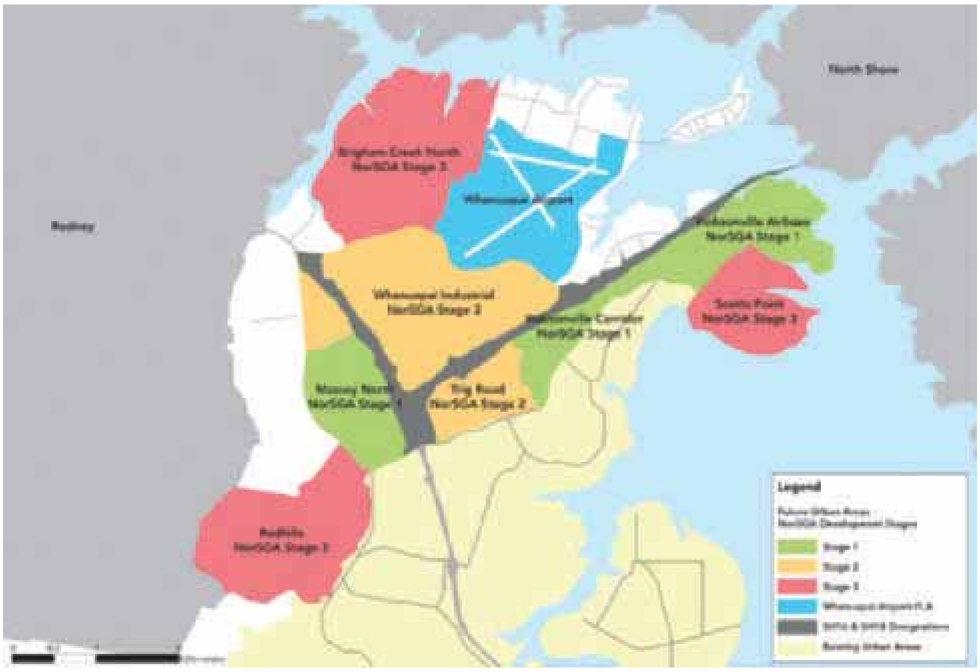


Figure 3 – NorSGA growth area

GHD developed feasible WSD features for all of the proposed roads, broadly based on a concept outline developed by Synergine.

GHD, working with Auckland University, identified a number of areas where these normal boundaries of WSDs were extended and allowances were made in the designs for future monitoring.

Feasible WSD is Multi-Disciplined

Traditionally WSD has been considered in isolation from other design disciplines. However with the NorSGA project, the transportation, structural, and stormwater design disciplines came together to develop solutions that met the needs of the project both from a transportation and stormwater perspective.

In 2012, GHD completed the design for the NorSGA project. One of the key drivers from the (former) Waitakere City Council was to develop and extend the "normal boundaries" of Water Sensitive Design (WSD) for the stormwater management of road corridors, effectively developing a ''demonstration project' for future projects in the greater Auckland region.

The project team worked together to develop a combined structural pavement, road, traffic safety, and stormwater engineering design solution.

Working together rather than in isolation resulted in practical, constructible solutions, providing the required design life of the pavement without compromising the requirements of each design discipline. The WSDs developed included swales, tree pits, and rain gardens.

The opportunity for porous pavement was recognised for Northside Drive West and Tahi Drive, as stormwater from the area is treated and attenuated in a series of stormwater ponds. There were no specific requirements for the WSD features; however the general aim was to work towards Auckland Council's TP10 Stormwater Treatment Devices design standards.

Designing Porous Concrete Pavement as Part of the Road Carriageway

Construction of the road itself was considered in the detailing of the sub-base. For ease of installation, a homogenous sub-base of GAP65 was used. This enabled the contractor to prepare the sub-base in the normal way. The pavement was designed in such a way that issues with edge compaction were not present.

On Northside Drive West a shallow V-drain was used between the road and porous pavement as this section was required to be self-serving for small rainfall events. However, in other areas, this could simply be removed and replaced with an edge beam as used on the superelevated sections of porous concrete on Tahi Road.

Figure 4 – Porous concrete section at Northside Drive West with v-drain

Infiltration Versus Pavement Drainage

One of the common issues when using permeable paving in carriageways is the distinct difference in the sub-surface drainage used.

Normally it is intended that lateral flow through the sub-pavement layers is restricted using sub-soils to avoid piping of fines. In permeable pavements, the intention is to provide peak flow attenuation and treatment by allowing stormwater to infiltrate to ground. Commonly this has resulted in transport providers not tolerating permeable pavements adjacent to road carriageways.

To overcome this, subsoils were placed between the road pavement and porous concrete pavement. This was easy to implement, having already adjusted the design levels and materials for the sub-base.

Pushing the Limits

Generally, permeable paving is limited to sites <5% longitudinal slope. However, the aim of the 'demonstration project' was to push the boundaries and the parking areas along the approach to Northside Drive West have a longitudinal slope of 7%.

Figure 5 – Porous concrete section on Northside Drive West at 7% longitudinal slope

Developing an Improved Porous Concrete

The two key factors that needed to be overcome in the use of porous pavement in trafficked areas were to:

- Increase the relative compressive strength
- Decrease ravelling from vehicle tracking

This was to be done without compromising safety concerns regarding braking, operational performance, and longevity.

GHD assisted in the development and refinement of a new specification for the porous concrete pavement and then began a relatively simple process to improve the mix to meet the required performance criteria.

GHD worked with the contractors A&R Earthworks, sub-contractor Cameron Civil Ltd and Firth Concrete and used the following process:

- Develop varying porous concrete mixes and assess the infiltration rate and compressive strength
- Undertake traffic field testing to withstand tracking with a 20 tonne truck
- Trialled a number of fibres to determine the best, which was found to be multimesh
- Identify the most appropriate design mix, which gave the required compressive strength whilst maintaining an appropriate void ratio
- Design steel reinforcement – two layers of 662 galvanised mesh were employed to improve the strength of the slab

Advanced Porous Concrete Pavement

The selected porous concrete pavement consisted of:

- 200mm porous concrete slab with multimesh fibre reinforcing with two layers of 662 galvanised mesh (minimum compressive strength of 20MPa at 28 days and infiltration rate greater than 3,000mm/hr)
- 220mm GAP65 sub-base
- 300mm in-situ stabilised upper subgrade with assumed CBR>3.5%

Figure 6 – Advanced porous concrete test panel being poured on-site

Compressive Strength Testing

The preferred (advanced) porous pavement underwent site and laboratory testing using a modified ASTM 1688 method. The samples produced the required 20MPa compressive strength.

Table 1 – Advanced porous concrete test results

Density	2179 kg/m^3		
Void ratio	16.6 %		
Compressive strength	**7 Days**	**28 Days**	**Cores 28 Days**
	15.1 MPa	20.1 MPa	21.0 MPa

Infiltration Testing

Infiltration rates in traditional permeable pavement are normally limited by the bedding or base course. Recognising this, AP40 was selected as the base course so that infiltration rates were not reduced. This also increased the stability of the overall road pavement and made construction simpler.

Infiltration rates were tested in accordance with ASTM 3385.

Table 2 – Infiltration rates of advanced porous concrete

Infiltration rates	9,077 –1,7629 mm/hour

Traffic Testing

Site test panels were tested using a 20 tonne truck, initially without load, and then fully loaded. Turning movements were analysed to assess ravelling. The selected pavement did not deteriorate, crack or ravel. However, no long term durability testing has yet been carried out and the pavement should be inspected periodically over time to assess deterioration.

Figure 7 – Porous concrete section on Tahi Road with interspersed tree pits

Treatment and Attenuation Capacity

The treatment capacity and attenuation characteristics of the porous concrete in-situ have not yet been determined and monitoring devices have been installed as part of the design in liaison with the Auckland University and the former Waitakere City Council. These allow for monitoring of water quality and flow across the porous concrete pavement sections, but to-date this has not yet commenced.

Conclusion

GHD has developed a porous concrete specification that overcomes many of the existing issues with porous pavement. The changes made to the specification increase compressive strength and hence probable durability. This product has the potential to be used in many other applications.

The use of porous pavement within the road carriageway significantly reduces land-take requirements that would normally be required for the construction of stormwater quality ponds, swales, rain gardens, or other stormwater treatment devices. This consequently could reduce overall project costs.

The ability to use this technology in the road carriageway itself frees up valuable underground space for services and can work as an integrated solution with tree pits and/or rain gardens where required.

This new improved porous concrete has the potential to be applied to a number of urban design applications such as footpaths, architectural features, car parks, multi-use areas, town centres, and much more.

The increased use and application in a range of fields will continue to provide cost-effective WSD solutions.

The Cement and Concrete Association of New Zealand is currently working on developing a coloured porous concrete. The ability to do so will no doubt open further applications.

Acknowledgements

GHD would like to acknowledge the following companies:

- Auckland Transport
- A&R Earthmovers Limited
- Cameron Civil
- Firth Concrete
- Synergine
- Auckland University Civil and Environmental Engineering Department

Judges Bay Upgrade – Award-Winning Sustainability

The Judges Bay upgrade was completed in the Summer of 2011/12 and has already become an incredibly popular swimming and relaxation destination for the people of Auckland.

Aucklanders flocked to try out the new pontoons in the bay and enjoy the wonderful new facilities before the Winter set in. This was a remarkable turn-around for a bay, which was often closed due to water quality issues.

The park upgrade was implemented by Auckland Council, Parks and Recreation Department. A design consortium was established, led by Reset Urban Design, with the aim of preserving and celebrating the rich cultural heritage of the bay and parkland. In 2012 the upgrade project was awarded the prestigious IPENZ Arthur Mead Award for the application of environmental awareness of an engineering project.

The detailed brief was to create an all tides swimming destination with modern and friendly community spaces and on-going ecological integrity.

Water Quality was a key driving factor in ensuring the project would succeed in these aims. Stormwater Solutions Consulting Limited joined the design team to provide the low impact stormwater expertise for stage two of the project.

An holistic approach was adopted to incorporate the stormwater management system into the overall landscaping design. Raingardens and swales were utilised to enhance the streetscape and mimic the natural environment, as well as adding amenity values for the local community. These surface and at source treatment devices also played a part in reinstating the idea of the historic stream which had, until recently, been piped. A proprietary filter (StormFilter) was installed in the lower catchment to ensure all stormwater flows are treated prior to discharge to the bay.

The planting choices for the raingarden and swales were taken from the local fauna palette to ensure that the ecological environment was enhanced. This was also translated within the filter media for the raingarden and swales, which was sourced locally. The plant selection for the treatment devices such as native nikau palms, carex and flax species from the local fauna palette will ensure the plants will endure the same climatic patterns that they are genetically prepared for. The reduction in waste and replacement of the plants was considered at the outset of the project.

Seamless communication between all design partners was the key to deliver the outcomes of urban design integration of low impact design. Bronwyn Rhynd of Stormwater Solutions based the design around low impact principles to provide treatment of the stormwater prior to discharge to the bay in an attractive and functional way. The innovative approach was implemented throughout the stormwater management design to ensure the best outcome was achieved. A collaborative team approach from client to consultant stretched the capability of improving the water quality as much and as consistently as possible.

The upgrade of the stormwater system to incorporate low impact design and sustainability values for treatment, reduced the environmental risk of degradation of the quality of the water within the bay. The adjacent road runoff was a concern to the community as this was degrading the water quality within the bay. The focus on improvement of this was foremost in the designer's mind in choosing the devices for treatment.

The teamwork employed on the implementation and design of Judges Bay is evident in the resultant 'inner city jewel'. The combination of design of the amenities, the informative signage, the water quality, and the look and function of the project has given Auckland a wonderful inner city destination.

Key Stormwater Points:

- **Rain gardens and swales provide 75% suspended soil removal for an average annual basis**
- **Surface flow devices have a reduced construction footprint, with respect to other device types**
- **Proprietary devices for the lower catchment flows ensure that all runoff from the local catchment is treated**
- **The new wharf structure is located to hide the outfall thus creating an improved visual identity**

Clockwise from top left – Raingarden, Roadside Swale, Outfall designed by Tonkin Taylor

"From the outset, one of the key goals of SCIRT was not only to create resilient infrastructure for the people of Christchurch, but to raise the bar for the industry as a whole in New Zealand through open sharing of engineering knowledge and construction techniques."

Designing for Resilience where the Only Constant is Change

Richard (Rico) Parkinson – Environmental Engineer, Opus International Consultants and Chris Maguire – Project Manager and Water Resources Engineer, MWH Global

Abstract

The Canterbury earthquakes damaged the wastewater pipes in Christchurch, reducing the security and resilience of the remaining network. An alliance between Canterbury Earthquake Recovery Authority, Christchurch City Council, New Zealand Transport Agency and five non-owner participants created the Stronger Christchurch Infrastructure Rebuild Team (SCIRT). Working with many other companies, they are all coming together for the vision of creating resilient infrastructure for Christchurch.

The liquefaction effects and damage of large flexible pipelines has not been well documented around the world, and initial investigations found very few examples. With multiple large diameter flexible pipelines being installed after the earthquakes, which included Pressure Main 11 (PM11), the design of these carried a large number of uncertainties. In particular, the soil strengths were thought to potentially change during a liquefaction event to a very low value, and then return to lower than the existing soil strength.

Designing Pressure Main 11 on its current soil strength no longer ensured a resilient design. To ensure redundancy against seismic effects for the installed pipeline, measures to mitigate the potential loss of side support were trialled. A geogrid/geotextile wrap around the embedment material was shown to provide additional support to the pipe after the side support was removed. This trial verified the structural design of the pipeline and removed the need for the additional mitigation measures.

1. Introduction

Following the September 2010 and February 2011 earthquakes in Canterbury, there was substantial damage to the wastewater infrastructure network. Wastewater pipes were damaged due to seismic movement and liquefaction effects.

Damaged wastewater infrastructure included Pressure Main (PM) 11 A&B, two nominal diameter (DN) 600 cast iron pipes, which carried approximately 30 per cent of Christchurch's wastewater from the terminal pump station 11 to the Christchurch Wastewater Treatment Plant. The damage to PM11 A&B meant that there was now only one pressure main to transfer wastewater from Pump Station 11. The design of the replacement pressure main was fast-tracked to provide resilience and to allow repairs to the remaining infrastructure. It was decided that the pressure main should be constructed using DN1200 Glass Reinforced Plastic (GRP), as it had performed well in other wastewater mains in Christchurch.

Designing for the effects of seismic movement and liquefaction on large flexible pipelines carried a number of unknowns. The largest uncertainty was the varying soil strengths, which are thought to vary during a liquefaction event and which can cause a long-term reduction in the residual soil strength.

Designing flexible pipes such as GRP based on static soil strength no longer ensured a resilient design. This gap in the current understanding of flexible pipeline design under seismic events experiencing liquefaction led to the investigation, analysis and design of measures to mitigate the potential loss of side support caused by reduced soil strengths.

Christchurch City Council requested that the project be delivered within SCIRT. To enable PM11 to be delivered as a fast-tracked project, required a complex delivery model, where the designs had to be produced in stages with construction being carried out simultaneously while the investigations into the mitigation measure were carried out. The SCIRT structure and culture enabled this flexibility in design and delivery to achieve a successful outcome.

2. SCIRT Structure and Culture

SCIRT, a virtual organisation operating within an alliance-led contractual arrangement between owner participants: Canterbury Earthquake Recovery Authority, Christchurch City Council and New Zealand Transport Agency, and five non-owner participants (City Care, Downers, Fletchers, Fulton Hogan, and MacDow). Along with the many other companies involved, they work cohesively under the SCIRT vision of "creating resilient infrastructure that gives people security and confidence in the future of Christchurch".

From the outset, one of the key goals of SCIRT was not only to create resilient infrastructure for the people of Christchurch, but to raise the bar for the industry as a whole in New Zealand through open sharing of engineering knowledge and construction techniques.

In the traditional setting, the idea of commercial organisations openly discussing ideas and sharing detailed technical knowledge about projects is rare. However SCIRT is designed to openly share information about the best possible technical approach to design and construction around earthquake resilience, pushing the industry benchmark for resilient earthquake design higher than previously possible.

This collaboration was demonstrated well in the design of PM11, with over 30 people involved from more than 10 organisations, all working together to achieve the best possible design.

A key element of the design process is the Early Contractor Involvement (ECI). This enabled the Delivery Team to share knowledge about constructability of the designs and to suggest design improvements or alternatives. This collaborative approach is not only between the design team and delivery team but is also encouraged between the different delivery teams themselves.

The Pressure Main 11 project was one of the first major projects to go through the SCIRT design and delivery process. A steady change in techniques, standards and best practices, meant creating a resilient design was an ever-changing target at SCIRT. With the unquantified effects of seismic loadings and liquefaction on pipelines being continually discussed and investigated locally, nationally, and worldwide.

3. Liquefaction and Seismic Mitigation

Pump Station (PS) 11 conveys most of the wastewater from south-west Christchurch to the central wastewater treatment plant at Bromley via the PM11 pipelines, servicing in excess of 100,000 people. The catchment of PS11 and the extent of the potential catchment when future network changes are completed is shown in Figure 1. PS11 was dependant on the continuous operation of a single 1200mm diameter concrete pressure main after the earthquakes.

With the consequences of service failure and time to repair any pipeline damage, a second 1200mm pressure main 3.6km in length was to be installed to add security to the network. Figure 2 shows the route alignment of the new and old pressure mains. The alternative routes provide mitigation against large isolated land movements.

The existing pressure main was constructed from concrete. It was however, decided that the new PM11 was to be constructed from a flexible material to provide resilience to the network by having an alternative failure mode. GRP was chosen due to the minimal open excavation size required at any one time.

The existing 1200mm diameter concrete pressure main failed in three locations, all joint failures near thrust blocks. These failures are believed to have been caused by the differential settlement between the thrust blocks and the pipe. Geogrid and aggregate thrust blocks have been used to ensure the thrust restraints are a similar density to the trench embedment to reduce the potential for differential settlement (see photos and figure 3 on Page 55).

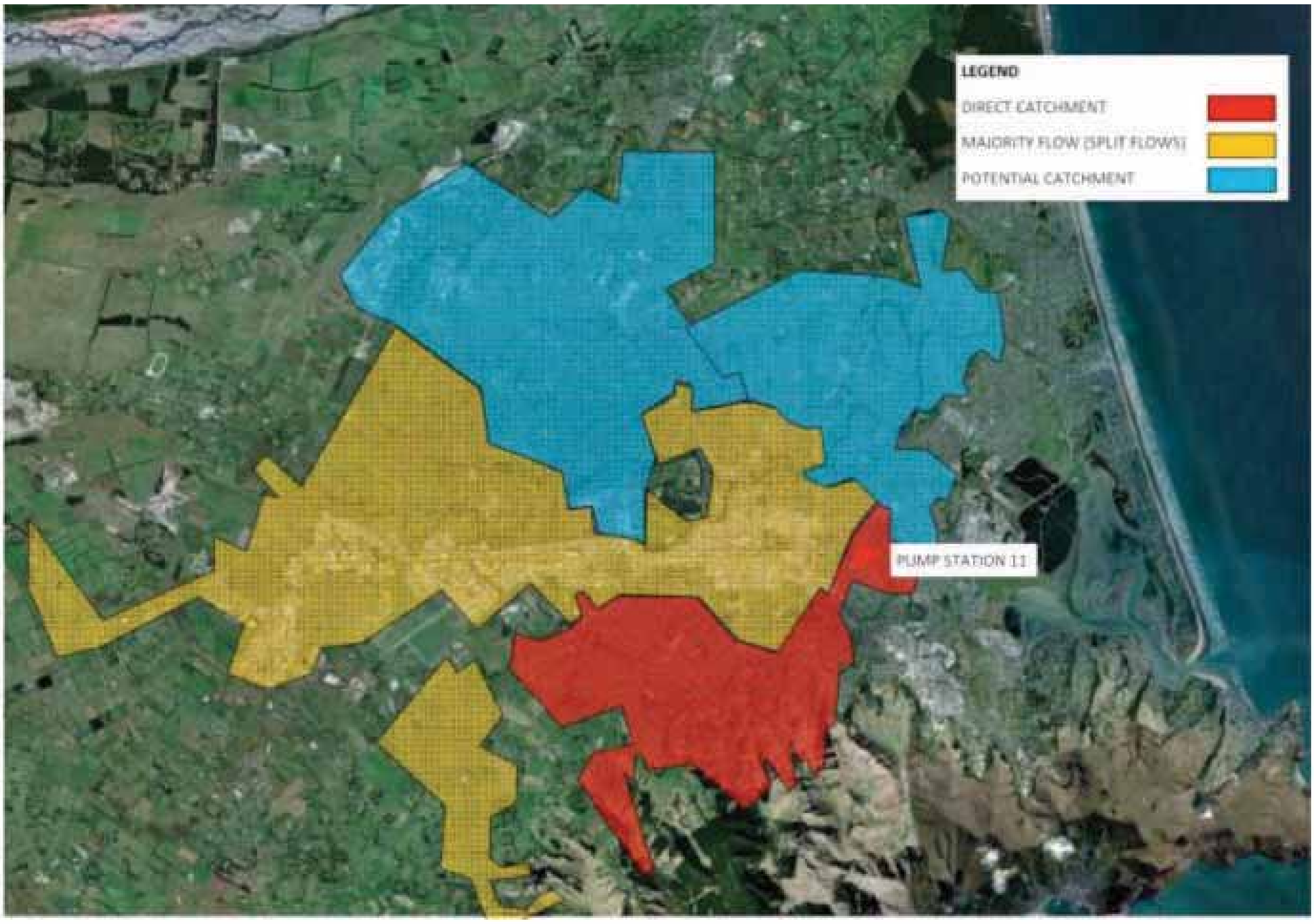


Figure 1 – Pump Station 11 Catchment Area

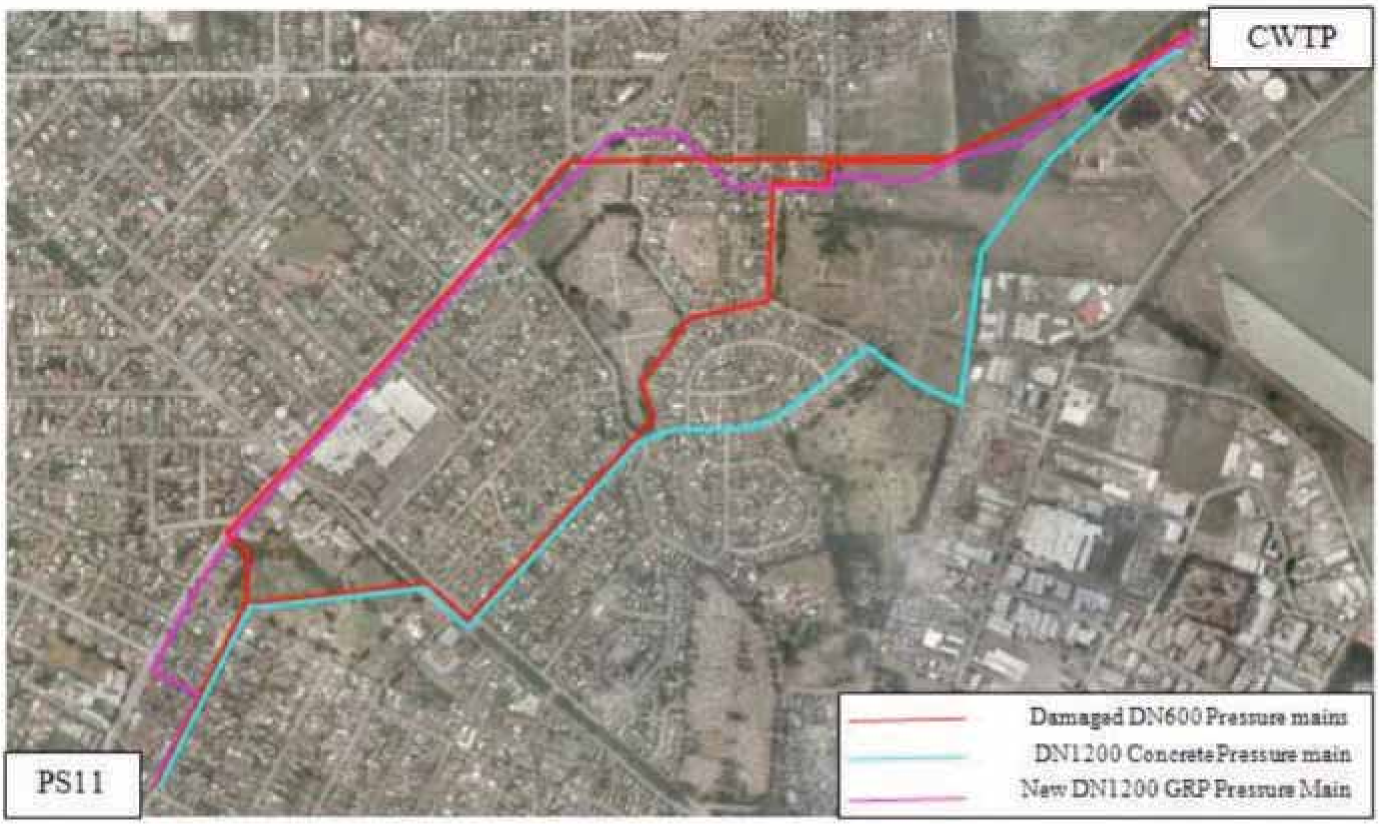


Figure 2 – Pressure Main 11 Alignments

Thrust block installation

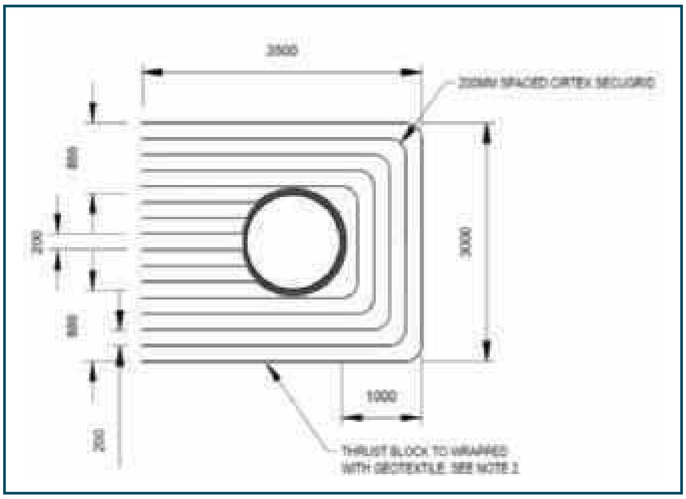


Figure 3 – Thrust Block Design

"To determine if this risk may compromise the pipe's lifetime performance under the design code, a trial to measure the observed deflections was carried out on a combination of installed trench mitigation measures and compared to predicted deflections."

Geotechnical investigations were undertaken and the results showed that the alignment of the pipeline is highly susceptible to liquefaction. The investigation showed that liquefaction settlement along the pipe route could vary from 0–140mm for a one-in-500-year seismic event and 0–150mm at the same locations in a one-in-2,500-year event.

The new GRP pipeline provides mitigation against these potential settlements by using a double bell coupler that allows for a one degree rotation. This rotation equates to 100mm per 5.7m of pipe length.

The joints have been positioned for maximum pull-out resistance, rather than providing a compressible length in the joint, as most of the observed joint failures to pipes in the area were due to pull-out rather than compression of the joints.

All joints are also wrapped in a geotextile sock to reduce the risk of point loads being applied to the coupler, which can cause cracking (see image below left). This may occur if aggregate becomes wedged in the joint from the rotation during seismic movement.

The mobility of soils during liquefaction can cause settlement of the pipeline, but the additional pore water pressures it creates can also cause uplift, seen as liquefaction boils breaking through road surfaces.

To mitigate this, a composite compacted aggregate raft reinforced with geogrid was installed to help prevent movement against the upward thrust from the excess pore water pressures (see embedment installation image below right).

4. Testing and Design Verification

With a limited understanding of the effects of liquefaction on a large flexible pipeline, one of the risks was the potential short-term loss of side support causing deflection and potential collapsing of the pipeline due to the weight of non-liquefiable backfill material crushing the pipe.

One case of a pipeline collapsing was found during the background research investigation (Davis, 2000). It was believed the weight of backfill crushed the corrugated iron pipe when the soil around the pipeline liquefied. The GRP used in PM11 was not at risk of collapse, but may exceed the long-term allowable deflection for the pipe and reduce the overall operational life of the pipe. This instance could occur if the side support was reduced to near zero during liquefaction, allowing the backfill weight to cause the pipe to vertically deflect. This deflection could be fixed in position as the

Far left – Geotextile sock over coupler, Left – Embedment installation supporting soil regained its strength after the liquefaction event.

PM11 has been designed in accordance with normal practices outlined in AS/NZS2566.1:1998. This however does not allow for the potential loss of side support caused by liquefaction, and the differential settlement along the length.

To determine if this risk may compromise the pipe's lifetime performance under the design code, a trial to measure the observed deflections was carried out on a combination of installed trench mitigation measures and compared to predicted deflections.

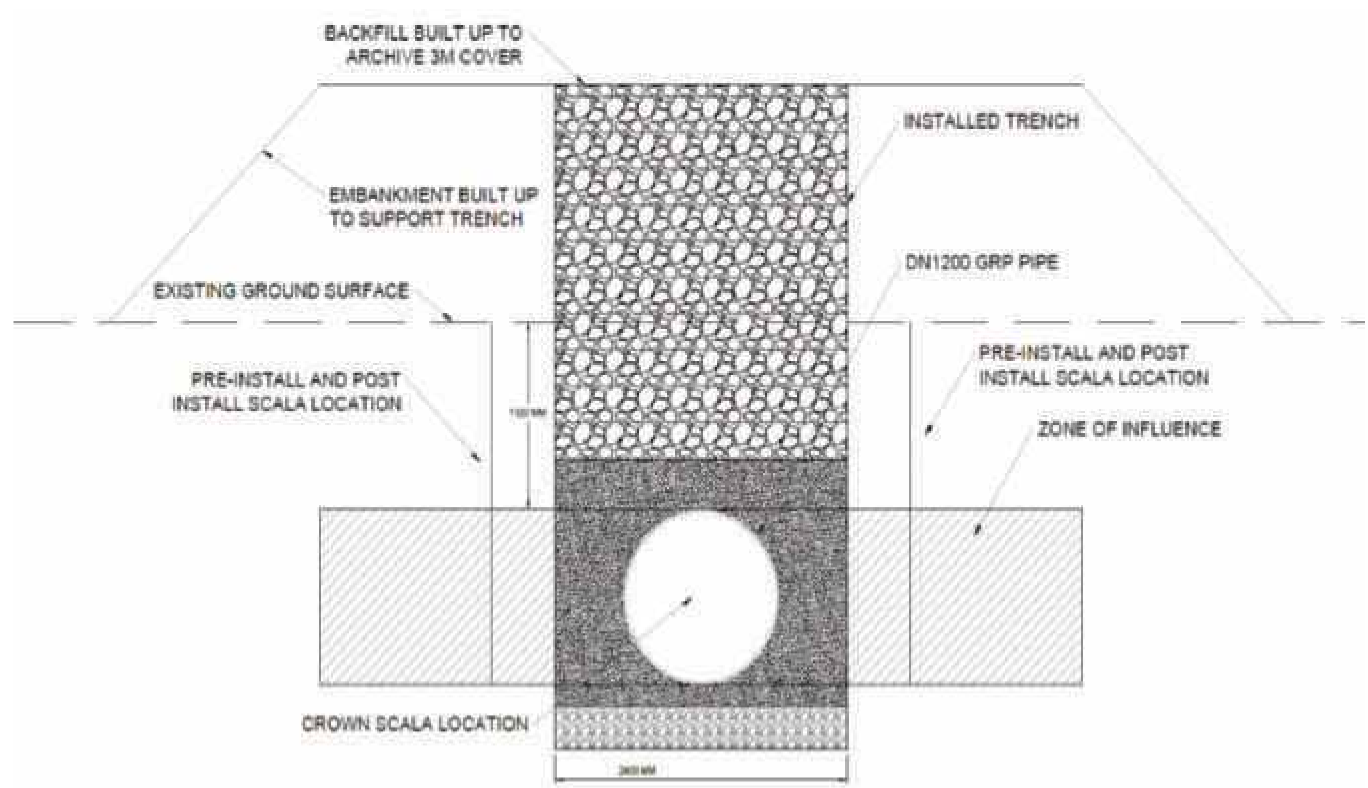
The mitigation measures proposed for the pipeline were:

- A layer of geotextile (Class C2) wrapped around the bedding, haunching and backfill to prevent migration of fine to ensure the structure of the trench and backfill
- A layer of geo-grid (Secugrid 30/30 Q1) wrapped around the bedding and haunching of the trench to provide improved lateral support to the pipe if the outside of the trench liquefied and lost its strength (Photograph 4)
- A layer of geo-grid (Duragrid 30/30) between the AP20 bedding and 300mm AP40 base to provide a rigid and consistent base for the entire pipeline

The trial consisted of installing three lengths of pipe, each one with a different combination of mitigation measures, then removing the side support outside the embedment zone. The deflection of the pipe was measured using a laser profiler at pre construction, during construction and post removal of the side support within the zone of influence.

Far left – Geogrid embedment wrapping, Left – Installation of pipes for testing

Figure 4 – Testing installation design



The 3 lengths of pipe were installed using the same construction methodology, with the following combination of mitigation measures installed for the different lengths:

- A "control" length installed with the base geo-grid mitigation
- A "geotextile" length installed with the base and geotextile mitigations installed
- A "geo-grid" length installed with the base, geotextile and geo-grid mitigations installed

Eight laser runs were completed, with one completed prior to any embedment material being placed (#1). One run was completed immediately after the installation of embedment and backfill (#2), and one was completed three days later (#3).

Three laser runs were completed (#4–6) during the removal of the supporting material (up to the zone of influence of the pipe). One run was completed immediately after the removal of the material within the zone of influence (#7). The final run (#8) was completed 3 days after with no side support.

Table 1 summarises the observed deflection results of the three installed pipes, along with the predicted and allowable value using AS/NZS2566 calculations.

Table 1 – Deflection Summary

	Pre-construction	Post-construction	Support Removed
Run	#1	#2–6	#7–8
Control	0.15–0.55 (0.35)	0.6–0.95 (0.79)	1.35–1.8 (1.62)
Geotextile	0.3–0.35 (0.29)	0.95–1.5 (1.18)	2.2–3.1 (2.6)
Geo-grid	0.25–0.45 (0.25)	0.7–1.45 (0.84)	1.1–2.3 (1.37)
Predicted	0.0	1.58–2.15	5.0–10.0
Allowable	–	3	3

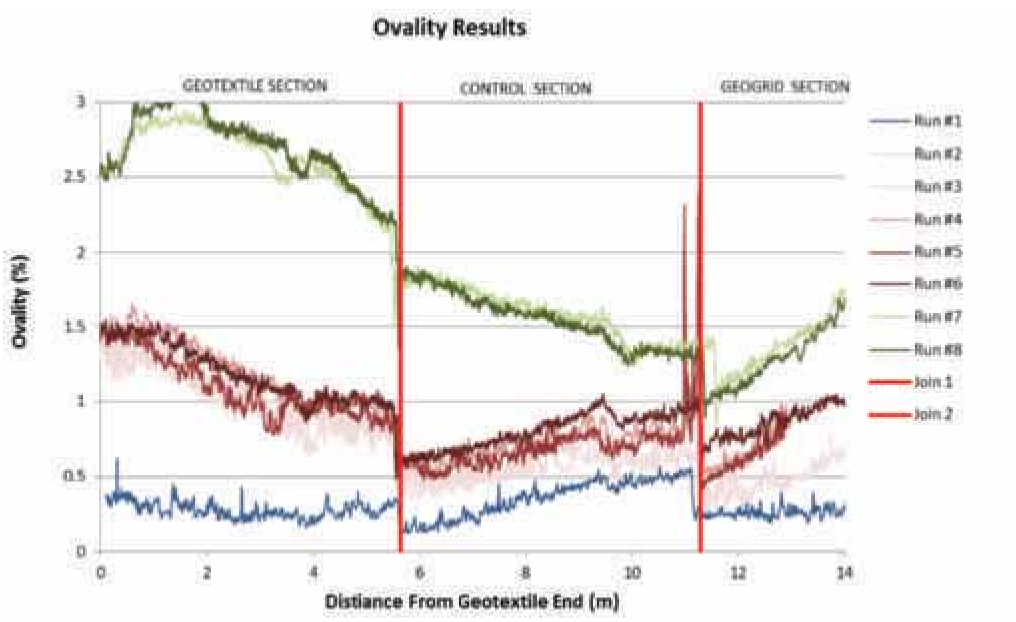


Figure 5 – Ovality measurements

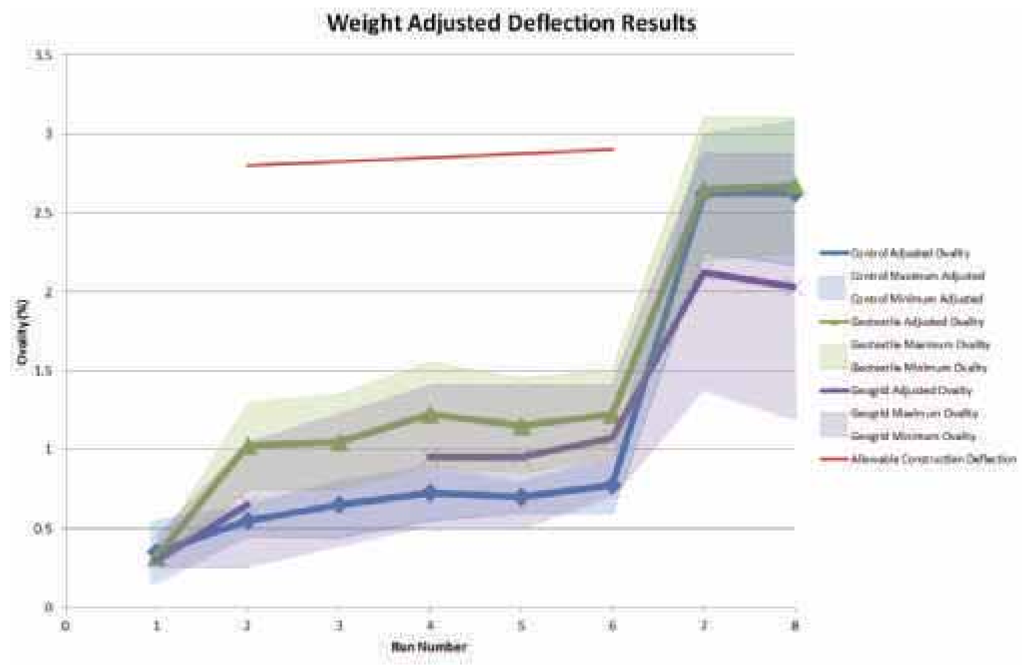


Figure 6 – Adjusted deflection results

Figure 5 shows the measured deflections from the laser profiler. Blue represents the pre-construction laser profile measurements, red is post-construction, and green shows the support removed.

Figure 6 has had the deflections adjusted to allow for the observed loss of backfill material that remained above the pipe, the "geotextile" length lost very little backfill above the pipe, while the "control" and "geo-grid" lengths lost between ~20–40 per cent of the backfill directly above the pipe.

This adjustment due to the backfill losses above the pipes, makes the results comparable, and shows that the geo-grid mitigation measure did improve the side support of the embedment material.

Due to the additional cost and time required to install the geo-grid for the project, the mitigation measure was not installed. The increased cost was not seen as cost-effective as the pipe was verified to be within its limitation, even with the complete loss of the side support.

The base mitigation measure was installed to make sure a uniform base was achieved, both to ensure consistent construction, and to reduce the potential settlement directly under the pipe. It also ensured easier construction as it provided a dry platform to lay the pipe and embedment material.

The geotextile mitigation measure was installed to reduce the potential effects of liquefaction material entering into the embedment structure and altering the embedment make up.

"The base mitigation measure was installed to make sure a uniform base was achieved, both to ensure consistent construction, and to reduce the potential settlement directly under the pipe. It also ensured easier construction as it provided a dry platform to lay the pipe and embedment material."

Conclusions

The investigations and analysis carried out to better understand the mitigation measures being installed on the pipe helped reduce the time and cost of the project, while also validating the design. Although not used in this project, the analysis helped to determine that geogrid wrapping of a pipe's embedment is a potential solution against liquefaction effects by providing an increased support to the embedment material.

The SCIRT processes ensured that uncertainties could be investigated without delays to the delivery timeframe for projects. The delivery teams worked in conjunction with the design team to ensure the best design was achieved.

The vision of providing resilient infrastructure for the future of Christchurch while ensuring value-for-money has helped create an environment at SCIRT in which innovation and collaboration are integral in achieving successful design and delivery. ■

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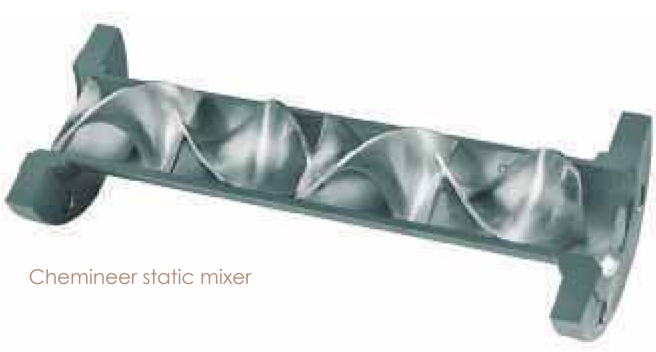
NOV Mono Extends Portfolio to Include Mixers and Agitators

The Chemineer™ range is dedicated exclusively to mixing technology and the manufacture of quality equipment for fluid agitation applications. Founded in 1952, Chemineer is a global brand competing in a variety of markets including chemical and petrochemical, polymers, food and beverage, pharmaceutical, water and wastewater treatment, FGD/energy, biotechnology, agricultural processing, mineral processing, oil and gas, and pulp and paper.

Since joining NOV Mono, a division of National Oilwell Varco in 2013, the division now offers progressing cavity pumps, artificial list systems, industrial mixers, grinders, screens, and aftermarket spares and services. With over 1,600 employees and facilities worldwide, NOV Mono now stakes a claim as a one stop solution provider.



Chemineer static mixer

Chemineer specialises in Turbine Agitators, Prochem™ Side-Entry Mixers, Kenics™ Static Mixers and Heat Exchangers, and Greerco™ High-Shear Mixers. The company's applications experience, advanced mechanical design and manufacturing quality ensures quality built into every unit.

Chemineer distinguishes itself from competitors with its internally engineered application software, proprietary mixers designs, state of the art laboratory, and willingness to partner with customers to provide a complete mixing solution. Technologically advanced software is used to design and customise every mixing solution to effectively optimise the most complex and critical applications.

> "Chemineer distinguishes itself from competitors with its internally engineered application software, proprietary mixers designs, state of the art laboratory, and willingness to partner with customers to provide a complete mixing solution."

NOV Mono is a division of National Oilwell Varco. It comprises a group of specialist companies offering progressing cavity pumps, artificial lift systems, industrial mixers, grinders, screens and aftermarket spares and services, across a broad spectrum of industrial sectors including water and wastewater, oil and gas, chemical, pulp and paper, food and beverage and agriculture.

The company first began manufacturing progressing cavity pumps in 1935 and industrial mixers in 1952, so has a heritage of over 75 years. NOV Mono has facilities around the world including Australia, New Zealand, USA, China, South Africa, France and UK, which are supported by a large network of international distributor partners. ■

Chemineer Model 20 HT agitator

Nu-Way Energy Introduces the SP100 Air Operated Double Diaphragm Pump to New Zealand

Nu-Way Energy has unveiled its most innovative air operated double diaphragm pump in New Zealand.

The SP100 Series, designed and manufactured in the USA by Tuthill Corporation under the brand name Sotera Systems®, incorporates several key features unique to this pumping principle. The first is the patented QuikSeal® threaded ring construction.

The threaded ring is designed for quick-turn access to clear ball checks and replace diaphragms. This clever design eliminates the need for multiple fasteners (bolts) on the manifolds and fluid caps reducing parts and complexity. It has the added benefit of reducing maintenance time by up to 50%. This design also reduces "pinch points" on the diaphragm resulting in longer diaphragm life.

The second is the patented, QuickFlow® air valve design. This non-centering ceramic air valve features an extremely fast trip-over, resulting in a 67% reduction in pulsation and the highest and smoothest flow in the industry (up to 17.5gpm for the ½" model; 57gpm for the 1" model). In many applications pulse dampeners can be eliminated making the pumping system less complex and saving money.

> "I was really impressed when I tested the SP100 and saw the smooth flow fluids through the pump."

The third benefit is a 20% improvement in air efficiency compared to competitive pumps. Less air consumption saves money over the long run.

Senior Technical Manager for Flint Global, Bob Broomhall, tested the SP100 and remarked, "I was really impressed when I tested the SP100 and saw the smooth flow fluids through the pump."

"I'm used to seeing the hoses dance around because of the pulsation. The SP100 barley moves the hose when it's running," Mr Broomhall said.

The SP100 can be configured in materials compatible with a wide range of chemicals, making it as versatile as it is innovative. This, along with the elimination of stalling and freezing make the SP100 the most advanced AODD pump available today. ■

Glen Cornelius – Managing Director, Harrison Grierson

Harrison Grierson Re-Engineers Itself

Transforming a 129-year-old business is not for the faint-hearted.

In March, engineering and design consultancy Harrison Grierson launched its new visual identity reflecting two years of significant change for the company.

Managing Director Glen Cornelius said, "We've changed our corporate structure, our shareholding and our board."

"We've reviewed our brand, company values, and positioning in the market. This has redefined who we are as a business and what's important for us," Mr Cornelius said.

"We've done huge work internally on establishing our brand values and incorporating those values into everything we do. We've gone from being somewhat internally focussed to being passionate client champions, determined to really understand our clients and deliver great solutions."

Almost every facet of the business has been re-engineered since Mr Cornelius was appointed in January 2012 – including its organisational and capital structure, its IT systems, its offices, and directors.

However it is the company's brand strategy which Mr Cornelius said has been transformational.

"A compelling brand purpose can help shape every form of business communication. From our office environments, our behaviours, our services, and how we communicate both internally and externally," Mr Cornelius said.

"We've done huge work internally on establishing our brand values and incorporating those values into everything we do. We've gone from being somewhat internally focussed to being passionate client champions, determined to really understand our clients and deliver great solutions. It's been a major change for most people and consequently we've made a giant leap forward as a company."

Mr Cornelius said launching the new visual identity was the culmination of two years' extremely hard work for Harrison Grierson's almost 300 staff.

"We've made some tough decisions and put big demands on our people."

"Our new visual identity with its new logo, colours, typography, imagery, and graphics is making a public statement that we've transformed ourselves and that we're fresh, dynamic, innovative and energised."

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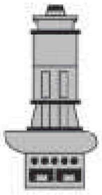

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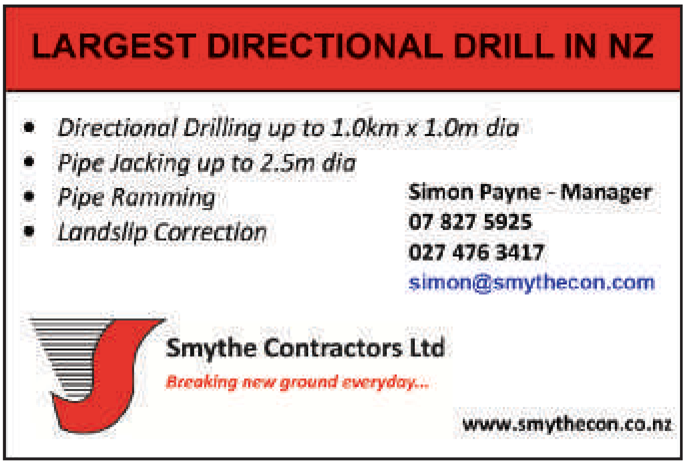

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