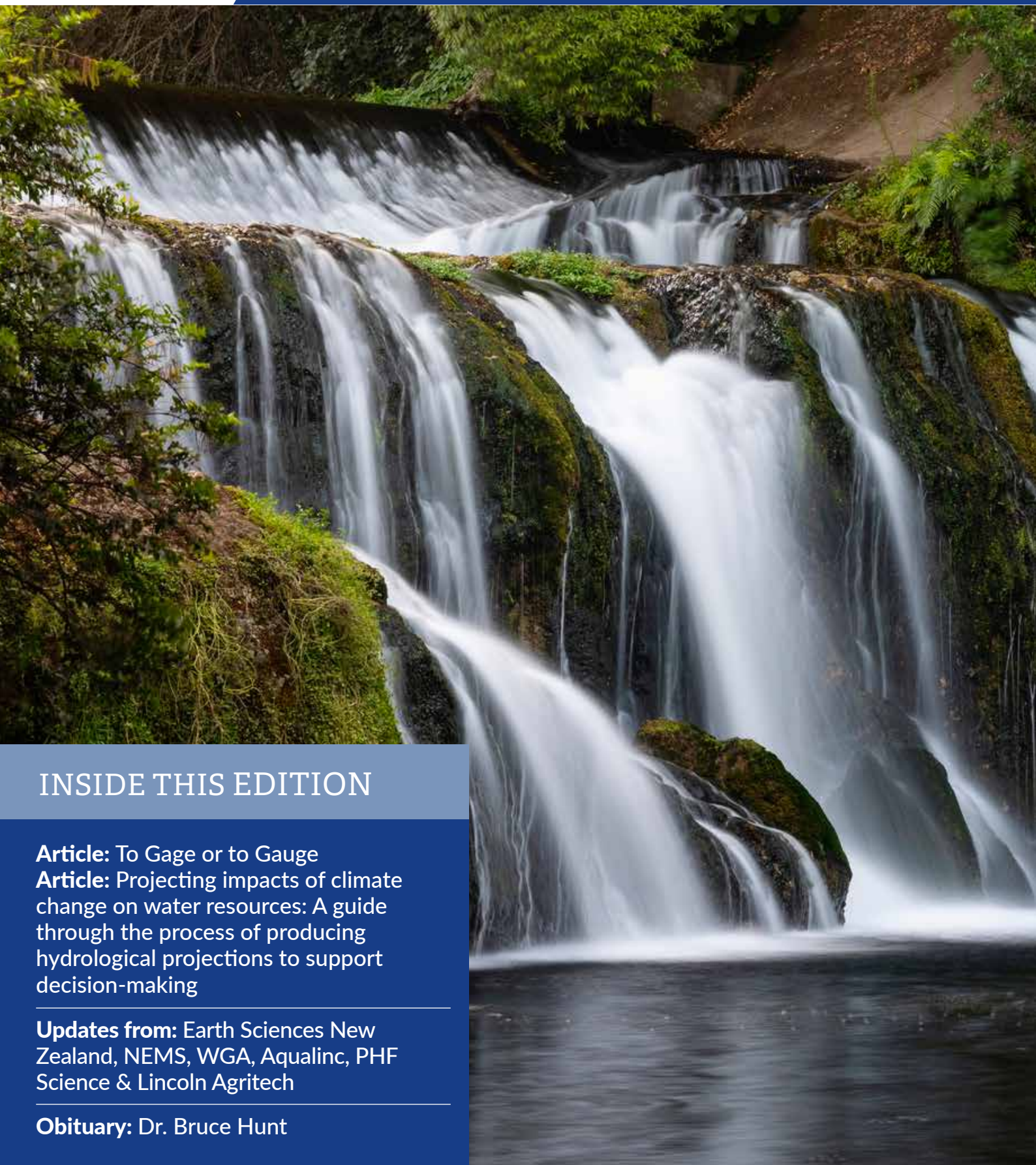




NEW ZEALAND HYDROLOGICAL SOCIETY E-CURRENT NEWSLETTER



INSIDE THIS EDITION

Article: To Gage or to Gauge
Article: Projecting impacts of climate change on water resources: A guide through the process of producing hydrological projections to support decision-making

Updates from: Earth Sciences New Zealand, NEMS, WGA, Aqualinc, PHF Science & Lincoln Agritech

Obituary: Dr. Bruce Hunt

Dr Richard Hawke, Land Information NZ



MESSAGE FROM THE EDITOR

Kia ora – Welcome, New Zealand Hydrological Society Members, to the spring edition of Current.

I am sitting in Wellington and we are certainly getting spring. As soon as we have blossom on the trees it is time for the wind and rain to arrive. But, I know we all – particularly as hydrologists - love a bit of “weather”.

I am pleased to note that we have published the Special Issue of the Journal of Hydrology (New Zealand) on the Christchurch Artesian System. Thanks to all those who were involved in bringing the idea of this issue to reality. And, I would like to note that by the time I see you at our conference (in Hamilton in early December) you should have received issue 2 of the Journal for 2025, which includes another paper on the Christchurch Artesian System. Since the last conference I have spoken to authors who are preparing papers related to Cyclone Gabrielle, so hopefully we will see that work in print soon (and not just as a conference presentation).

This edition of Current includes an update – To Gage or to Gauge - from Nicholas Holwerda after his trip to the 15th Biennial National Hydrological Warning Council training conference and exposition held in the US earlier this year. As part of his report he notes the US Geological Survey has just celebrated their 1000th site with over 100 years of continuous stream stage data. That seems pretty impressive to me.

There is a review of Anthony Fowler’s new book on Auckland’s climate, which includes Cyclone Gabrielle data and illustrates the drought-to-deluge pattern that occurs in Auckland’s rainfall record. Anthony also draws on work he published in the Journal of Hydrology NZ on building a long-term rainfall record for Auckland from the records from various sites.

This issue of Current also includes an outline by Frederika Mourat and Cath Moore of their report (co-authored with others) entitled “Projecting impacts of climate change on water resources: A guide through the process of producing hydrological projections to support decision-making”. And, a writeup from Lee Burberry on his attendance at the Land Use and

Water Quality international conference 2025 that was held in Aarhus, Denmark. There are also updates from Aqualinc, Earth Sciences New Zealand, Lincoln Agritech, PHF Science (NZ Institute for Public Health and Forensic Science) and Wallbridge Gilbert Aztec (WGA). And a note that the review and refresh of the National Environmental Monitoring Standard – Open Channel Flow is underway and should be available on the NEMS website very soon. Finally, there is Bruce Hunt’s obituary. Bruce will be remembered by many of us for his extensive groundwater teaching and research expertise.

Mike Ede, in the first edition of Current for 2025, noted that he was looking forward to the Conference - www.nzhsmsnzconference.co.nz - exceeding the successful technical workshop in Hamilton in late March with over 140 people in attendance and 17 trade stands showing their wares. And he particularly noted seeing all those remote boats on the Waikato River on a sunny field day! Let’s hope the main conference at the end of the year reaches that same standard. We will be joining with the Meteorological Society for the conference so I am sure it will be a great conference. And, if you are forward planning there is the Technical Workshop in Shantytown in March 2026 to add to your diary.

While you are looking at the Society’s website I would encourage you to look at the Hydrological Histories (a new series) we have put on the website. I am looking forward to these Histories growing over time. To encourage you we have put the history of the Cropp Catchment and the Glendhu Catchment Project in this issue of Current. If you have ideas of people, places or things that should be part of the Histories series then please let the Executive know.

Anyway, enough from me now and I hope to see you all at the conference later this year.

Ngā mihi,

Richard

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e-Current is the newsletter of the New Zealand Hydrological Society Inc. Contributions are welcome from members at any time and can be sent to admin@hydrologynz.org.nz

Advertising space is available; contact Lea Boodee at the above address for more info.

The views presented in e-Current do not necessarily represent policies of the Society.

NOTICES

Journal of Hydrology (New Zealand)

The Journal of Hydrology (New Zealand) is published twice a year. - <https://www.hydrologynz.org.nz/journal-of-hydrology>. Issue 1 this year was a Special Issue on the Christchurch Artesian System. Issue 2 is not far away and contains papers on a variety of hydrological topics.

The Journal contains Papers and Notes on all aspects of hydrological science and management. I would especially like to encourage those who presented at the Conference to consider sharing your work with others through publication. Also, I am especially keen on papers on recent weather events.

Papers and Notes can be sent to the Editor (admin@hydrologynz.org.nz) at any time. I aim to have papers and notes reviewed in under two months and publish accepted material within a year. 'Notes' are generally short, maybe 4 to 8 pages. Notes are intended to be pilot studies, work that is not completed or technical information (ie interesting and relevant material that is not a final article).

I am also keen to build my pool of potential reviewers. Hence, on the next membership update that comes out there will be a question asking if you are willing and able to be a reviewer, and if so what are your preferred topics. If you want to discuss your potential publication please don't hesitate to contact me.

Richard, Editor, Journal of Hydrology (New Zealand)
rhawke@linz.govt.nz

NZHS Award Nominations

In line with their mission to support and foster hydrology in New Zealand and elsewhere, and to enable NZHS members to receive advanced training in hydrological sciences, NZHS annually presents several student and non-student awards to its members.

A listing of all the awards, nomination criteria and nomination forms can be found on the NZHS website.
<https://www.hydrologynz.org.nz/awards>

Members are encouraged to think about colleagues who deserve some recognition for their contribution to hydrology and submit nominations.

NOTICES

Oxfam Update

Check the Oxfam link below to see how membership donations are being used to provide clean water to people.



NGĀ MIHI NUI/ THANK YOU

Transforming lives and empowering Pacific communities

Thanks to your amazing support, the Kōtui Programme is kicking off its fifth year with great momentum.

It's making a real difference – changing lives, growing local leadership, and helping communities in **Timor-Leste, Solomon Islands, Papua New Guinea, and Tuvalu** thrive.

Together, we're working towards a fairer future for people and the planet, where women's rights are championed, livelihoods are strong, and local voices lead the way.

YOUR IMPACT AT A GLANCE



8,900+ PEOPLE directly participated in Kōtui activities



15,800+ PEOPLE reached through wider community engagements



Work carried out in **95 COMMUNITIES** supported by **122 CIVIL SOCIETY GROUPS** and **84 LOCAL INSTITUTIONS**



OVER 250 PEOPLE trained in climate finance, gender equality, land rights, and leadership

CONFERENCE



NZHS | MSNZ Conference 2025

On behalf of the organising committee, we would like to invite you to join us for this year's Meteorological Society of New Zealand / New Zealand Hydrological Society Joint Conference in Kirikiriroa Hamilton.

The conference theme is "Stormy with a Chance of Solutions: tackling climate & water challenges". It captures the idea that the challenges posed by climate change and water management are more pressing than ever, and it is through collaboration and shared knowledge that we can hope to find sustainable solutions.

This conference is not just about addressing the problems we face but also about celebrating the progress we have made and the potential for future breakthroughs. Together, we can turn the tide on climate and water challenges, ensuring a resilient and sustainable future for all.

The technical programme will be complemented by social events, providing excellent networking opportunities. The conference will be capped off with fascinating field trips around the Waikato on the last day.

The Waikato region offers stunning natural beauty, rich cultural heritage, and vibrant communities. From the magical Waitomo Caves and the mighty Waikato River to the world-renowned Hamilton Gardens and the enchanting Hobbiton Movie Set, enjoy your trip to our region!

We look forward to a productive and inspiring conference.

Ngā mihi nui | Kind regards,

Nicki Wilson - *NZHS/Waikato RC* and Nicolas Cullen - *MSNZ/University of Otago*
Conference co-Chairs

The conference programme is now available - nzhsmsnzconference.co.nz/full-programme

WORKSHOP



NZHS Technical Workshop 2026

Back to Basics: Core Principles for a New Era

The New Zealand Hydrological Society is excited to invite you to the 2026 Technical Workshop to be held at Shantytown, Greymouth from March 24th – 26th 2026. Over three days, attendees will hear from a number of members of the environmental monitoring industry on a range of relevant subjects, as well as participate in either the annual Data Workshop or the Field Day/Gauging Regatta.

Visit the website here: www.nzhsworkshop.co.nz

CREATIVE HYDROLOGY

We welcome (actually encourage) all members to send us a creative contribution for the next Current.

Q. Why did the well break up with the buckets?

A. It just couldn't handle the relationship.

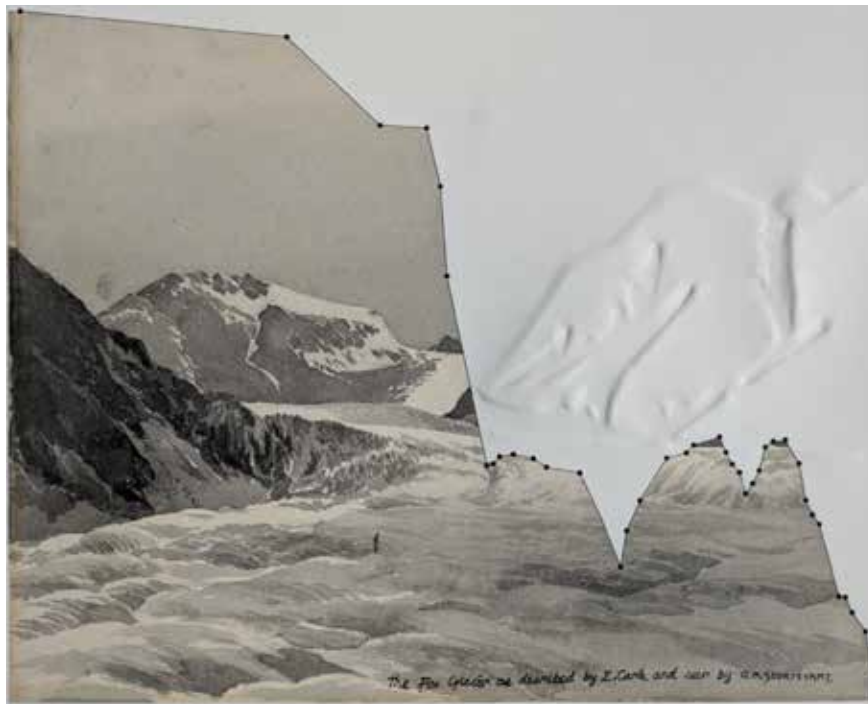
Q. What do you call water that is good for you?

A. Well water

Q. Why did the well never laugh?

A. It preferred dry humour.

Jokes contributed by Lee Burberry, DairyNZ



Daniel Collins. Fox Glacier, Not Looking Up (2025), giclée, pencil and embossing.

'Fox Glacier, not looking up' blends historical art and contemporary science to highlight the beauty being lost as our glaciers shrink, primarily due to climate change. A Giclée reproduction of a watercolour by George Sturtevant from 1896 in the collection at Te Papa, called 'Fox Glacier, looking up', is overlain by measurements of the glacier's length, from a 2023 University of Otago Master Thesis by Ellorine Carle. The segmented part of the picture is replaced by embossing, to convey the idea of a landscape lingering as a ghost. The text at the bottom references a series of paintings by Colin McCahon, who acknowledged the synergy between artists' and scientists' views of landscapes.

This marriage of historical art and environmental data could be applied to a range of subjects, so if a project, public engagement activity, or even just personal or professional interest could benefit from this kind of art, Daniel Collins is open to discussing how to make it work.

Daniel Collins, Pūtahi Research

BOOK REVIEW

Auckland's Changing Climate: 30,000 BCE – 2100 CE by Anthony Fowler

Review by Richard Hawke

Anthony has a long history with Auckland and Auckland's climate, and following an early retirement from the University of Auckland, he took to writing a book for Aucklanders interested in the climate of Auckland. The book is aimed at students in their last year of school or first year of university. It is basically structured, going from the past to the future. At the same time it explores some core research techniques to understand the climate, which are techniques Anthony has published on.

Anthony has structured the book so it starts with some fundamentals and then moves to explaining the present to help place future projections in context. The first chapter is really about the basics, e.g., weather systems, regional variations, climate variability, El Niño-Southern Oscillation (ENSO) and the Interdecadal Pacific Oscillation.

Chapter 2 is about Auckland's climate prior to human arrival and so draws on the key techniques of radiocarbon dating and pollen analysis to provide a reconstruction of Auckland's climate, with a particular focus on the last 30,000 years. By relating Auckland's changing climate to the climate of other places in New Zealand and showing changes in vegetation does make climate real and tangible for the reader.

Chapter 3 is focused on climate change from 1000 to 1853. So, we shift from pollens and glaciers to the Medieval Warm Period, the Little Ice Age and dendrochronology (tree ring analysis, another subject Anthony has published on). Tree ring chronologies, from trees like kauri, tell us an awful lot about the past climate, i.e., very wide/narrow rings are the consequence of exceptionally benign/adverse growing conditions. Thus, you can link Auckland's climate to ENSO.

With the arrival of Europeans in Auckland we get the beginning of a written record of scientific observations. By the mid-1800s several meteorological observatories had been established around New Zealand, including one in central Auckland. Due to the work of scientists like Jim Salinger we have a record for Auckland's average annual temperature from 1869. Anthony includes a box that summarises the NIWA 7-station temperature series. This shows not only how overall warming over New Zealand has been about 1 °C over the last century but that means sites like Masterton, Wellington and Nelson (central sites) have now reached temperatures like Auckland experienced early last century, and sites like Hokitika, Lincoln and Dunedin (southern sites) are now as warm as the central sites were early last century.

Anthony was productive during the COVID-19 lockdown in 2020 when Auckland was in drought. He used the time to construct a monthly rainfall series for central Auckland. Collecting rainfall is simple, but the amount collected is sensitive to how it is collected. Because wind accelerates over and around raingauges, differences in gauge or site characteristics affect how much is collected. So, changes in site, or site conditions, have to be understood to enable sensible long-term analysis. Anthony built a long-term rainfall record from the various site records, which was published in the Journal (Fowler, 2021). The drought in 2021, when average rainfall was 30% less than average and mature trees in downtown Auckland were killed, did shift to deluge. A drought to deluge pattern does occur in Auckland's rainfall record but the rainfall in late January 2023 was extreme, including a daily maximum of 281mm.

The extreme events of January 2023 (the wettest month in Auckland's history since 1853) was followed by the 13 February ex-tropical Cyclone Gabrielle, another extreme event. Anthony uses these two events to discuss return periods and the usefulness of looking a range of data (e.g., monthly totals, daily totals, depth-duration-frequency curves) and puts these events into context using the drought to deluge event of 1912 – 1918.

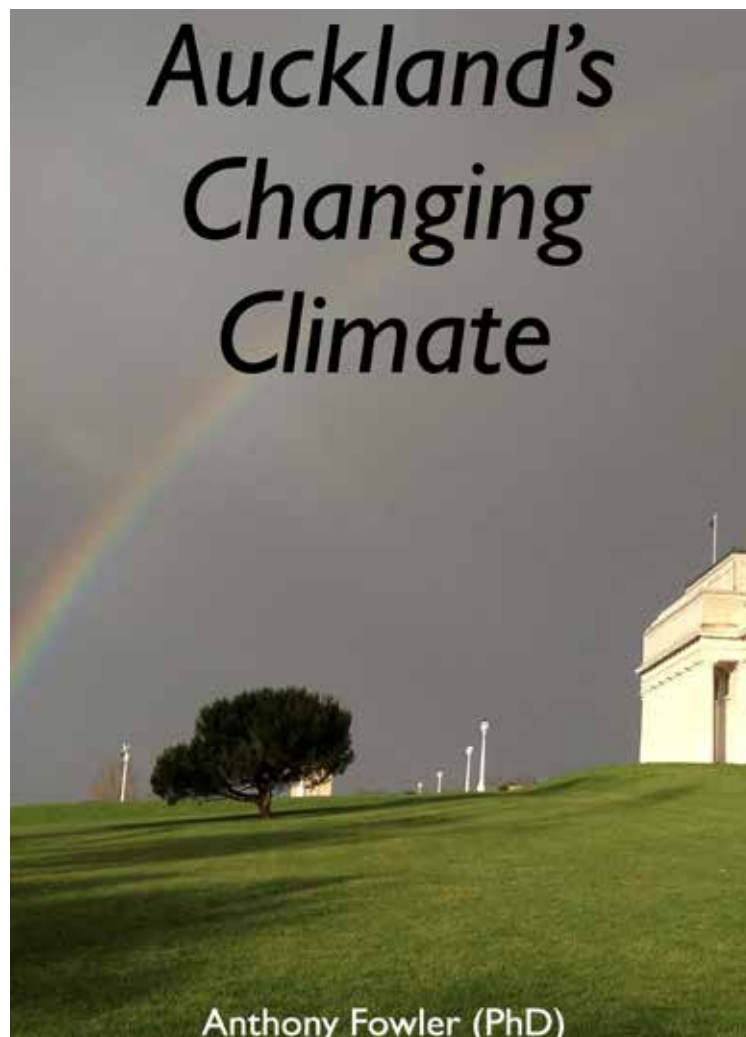
The last chapter, which Anthony admits is longer and more detailed, explores how Auckland's climate is expected to change this century. The chapter uses the context of the Intergovernmental Panel on Climate Change (IPCC) scenarios to look at what might occur in Auckland in terms of temperatures, extreme rainfalls (something Aucklanders experienced in 2023) and rainfall variability. Hopefully the context of the previous chapters makes the chapter on 'what next' more understandable.

The text is enhanced by text boxes to explain concepts (such as the 'greenhouse effect', tree rings, return periods and glacials) and help understanding, but can be left out without distracting from the key story. Similarly, Anthony provides links to a few key references, but on purpose, he does not want a text dominated by links to references. Anthony does include a number of figure and pictures to enhance his story.

Overall, I found the 100-page book an easy read that meets its objective of being an "accessible synopsis of the science" for the target audience of Aucklanders interested in the past, present and future climate of the place they call home.

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Fowler, A.M. 2021: Central Auckland rainfall, 1853 – 2020: towards a homogeneous record. *Journal of Hydrology (New Zealand)* 60: 25-47.



Purchase the book here: [Auckland's Changing Climate](#)

ARTICLE

Perspectives on land use and water quality from the Far Side (i.e., Europe)

Land Use and Water Quality international conference, June 2025

By Lee Burberry

In June I was one of four¹ New Zealand delegates who attended The Land Use and Water Quality international conference 2025 (LuWQ2025) that was held in Aarhus, Denmark. Kiwi representation was few when you consider we numbered 27 at the LuWQ2019 six years prior (also in Aarhus) – presumably a symptom of the current economic climate and political upheaval within NZ rather than concerns about carbon footprints created flying 18,000 km to the far side of the globe. With 22 less Kiwis this time to spread news from LuWQ2025 I feel obliged to act as messenger. Moreover, considering Canterbury Regional Council has just recently declared a [groundwater] Nitrate Emergency², it seems pertinent to reflect on how Europe is progressing with mitigating nitrogen from agricultural land use, since they have been at it now for almost 35 years.

In June I was one of four New Zealand delegates who attended The Land Use and Water Quality international conference 2025 (LuWQ2025) that was held in Aarhus, Denmark. Kiwi representation was few when you consider we numbered 27 at the LuWQ2019 six years prior (also in Aarhus) – presumably a symptom of the current economic climate and political upheaval within NZ rather than concerns about carbon footprints created flying 18,000 km to the far side of the globe. With 22 less Kiwis this time to spread news from LuWQ2025 I feel obliged to act as messenger. Moreover, considering Canterbury Regional Council has just recently declared a [groundwater] Nitrate Emergency, it seems pertinent to reflect on how Europe is progressing with mitigating nitrogen from agricultural land use, since they have been at it now for almost 35 years.



Traffic lights in Aarhus city.

What is the LuWQ conference? Theme and political context

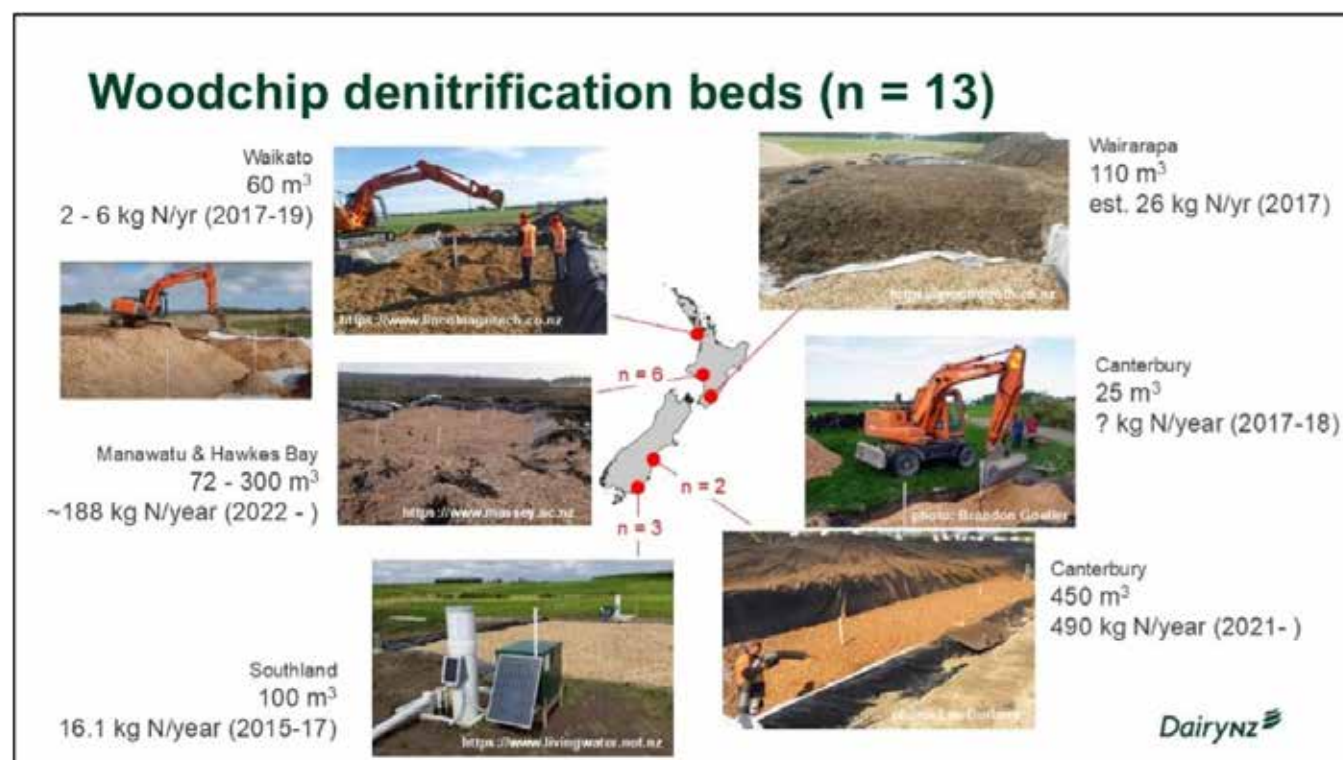
LuWQ is a biennial interdisciplinary conference that is dedicated to the topics of science, management and policy aiming to minimise the effects of agriculture and land use on the quality of groundwater and surface waters. Being international, it attracts a global audience and thus is a great forum at which to learn how different countries are tackling the challenge of managing intensive land use and water quality. European case studies dominate the conference and that is because a reason for establishing LuWQ (in 2013) was to share knowledge on work being undertaken to meet objectives of the European Union Nitrates (1991) and Water Framework (2000) Directives. Since the time of the first LuWQ conference the EU has also introduced the European Green Deal (2019) that is striving for Europe to become the first

climate-neutral continent and incorporates elements of the Nitrate and Water Directives. An objective of the Green Deal is for the EU to reduce nutrient losses by at least 50% by 2030. An explicit objective in the Water Framework Directive (2000) is for EU states to achieve good chemical and ecological status of all water bodies by 2027 at the latest. Nitrate pollution topics dominate at LuWQ, yet land management and water quality issues around phosphorus, pesticides and emerging organic contaminants are also well covered.

My contribution to LuWQ2025

At this year's conference I presented a talk titled: 'Are woodchip denitrifying bioreactors a viable edge-of-field N-mitigation strategy for New Zealand farming?: Insights from field-trials and comparisons with constructed wetlands', in a session dedicated to eco-

technologies for water quality improvement. Laura Christianson from the University of Illinois Urbana-Champaign (widely recognised as the leading world expert on woodchip denitrifying bioreactors) and Chris Tanner (Earth Sciences New Zealand) presented in the same session. After the 3-day conference we teamed up again for an international workshop on the topic of interceptive measures for nutrient mitigation at which progress reports, ideas and case studies from the USA, Denmark, Sweden and NZ were openly discussed. Over the weekend Flemming Gertz (SEGES Innovation, DK) kindly took us all on an educational tiki tour of edge-of-field nutrient mitigation case studies in Jutland that included constructed wetlands, saturated buffers, woodchip bioreactors and phosphorus filters, not to forget some fine lunches of New Nordic Cuisine that lived up to Denmark's reputation for high gastronomic quality.



Extract from my LuWQ2025 presentation summarising NZ woodchip denitrifying bioreactor case studies.

Stikstofcrisis – the N in Netherlands

Initial onus of the EU Nitrates Directive (1991) was on monitoring and identifying nitrate vulnerable zones. Implementation of National Action Programmes (NAPs) followed. NAPs are reported to the EU Commission every 4 years to demonstrate progress and compliance, and outline future strategic plans. From the start, the Netherlands and Denmark generally led the pack with taking actions. This is not

particularly surprising considering the Netherlands was infamous for its large nitrogen footprint (in 1990 the N-surplus in the Netherlands was 328 kg N/ha/year – for some perspective that is almost 10 times the nitrogen leaching rate of the average dairy farm in Canterbury).

I recall at the first LuWQ conference I attended in 2017 listening to presenters from the Netherlands describe how they were going to lead by example

and reduce stock numbers as a drastic action to reduce their nitrogen footprint and meet their EU obligations. Two years later at LuWQ2019 there were presentations that showed those actions were taking effect but were making a dent on the national GDP. The Dutch presenter quipped that other EU member states weren't being so proactive and that Dutch farmers were enraged by the policies (that included a proposal to cut livestock numbers by 50%). Later that year Dutch farmers revolted against the government marking the start of what the Dutch term the *stikstofcrisis* (nitrogen crisis) that culminated in formation of the Farmer-Citizen Movement³ – an agrarian right-wing populist political party that won the provincial elections in 2023. The Dutch made some good headway in reducing their nitrogen leaching during the first 20 years of the Nitrates Directive, e.g., in 2019 N-surplus was down to 166 kg N/ha/year with most gains made from farm practice changes made on leaky sand country. The Netherlands is now on its 7th NAP and the impression I got from LuWQ2025 was that the country has floundered since 2019. More than 90% of surface waterways in the Netherlands exceed regulatory limits and the Dutch are still in the process of trialling edge-of-field nutrient mitigations (as they were back in 2017) and have recognised that action and implementation are best achieved through establishment of catchment groups.

In describing her PhD research that is examining nature-inspired farming solutions, Cécile Alsbach alluded to the disturbing amount of reactive nitrogen drifting around Europe. In leaching tests Alsbach et al.⁴ made on Netherlands soil they discovered drainage through the undisturbed forest soil (that was intended to be the 'natural' baseline for the farmed land experiment) was pH 3 and laden with heavy metals. They attributed the acidity to nitric acid, derived from nitrogen deposition from the atmosphere. The story reminded me of a prophecy Mike Stewart made at the NZHS Blenheim conference regarding the state of nitrate in Te Waikoropupu Springs that he suggested will likely increase in the future because of the trending increase in reactive nitrogen in the atmosphere, which is going to challenge the long-term conservation target of 0.41 mg NO₃-N/L. Another story from the Netherlands that is a sign of how polluted Europe is (and how fortunate we are in NZ) was that of the health advisory notice by the Dutch Institute for Public Health (RIVM) pertaining to domestic chickens. In April 2025 RIVM advised people not to raise chickens outdoors in the Netherlands, since there

was a discovery that PFAS was bioaccumulating in humans, via the food-chain: soil - worms – chickens – eggs – humans. Similar PFAS health stories applied to Denmark.

All eyes on 'A Green Denmark'

At LuWQ2025 the Danes outclassed everybody and proved Denmark to be the most forward-thinking country when it comes to managing land use and water quality. Recognising that, despite decades of scientific research and regulatory changes, the country was not on any track to meet its EU emission targets (that include a 30% N-load reduction to the Black Sea), in June 2024 the Danish government enacted 'A Green Denmark' deal⁵. The deal is a cross-party, pan-sector agreement negotiated between the socialist, liberal and conservative political parties, local governments, councils for agriculture, food and conservation, unions for food- and metal-workers, and industry confederation. A Green Denmark is committed to the goal of 20% of the country being protected for 'nature' by 2030 (the current nature land coverage is 9%). To achieve this goal, Denmark has made the bold decision to retire 15% of its current agricultural land, converting 250,000 ha to forestry and 140,000 ha to wetlands. A Green Denmark includes introduction of the world's first tax on agricultural greenhouse gas emissions that will initially apply to livestock but later also target drained peatland and lime⁶.

The notion is the new forests will sequester carbon and whilst there is a risk the wetted lands will produce methane (that will be counteractive to the goal of becoming carbon-neutral), their primary purpose is for mitigating nutrient loads to the sea. Denmark is like NZ in having drained 90% of its original wetlands, and yet half of Denmark's farmland is artificially drained compared to just 10% in NZ⁷. It is these factors that make edge-of-field mitigation practices and wetland restoration practicable, scale-able solutions for Denmark, incentivised by subsidies available to farmers for implementation. What was interesting to hear at LuWQ2025 was that so far there is no evidence in Denmark of restored wetlands having improved in-stream ecological outcomes - a hypothesis proposed was that it could be because the wetlands have lowered dissolved oxygen concentrations.

Denmark vs NZ

Without delving into financial and socio-political

differences, at this point it is probably helpful to make some key geo-political comparisons between Denmark and NZ, which go some way to explain why Denmark has not been the scene of a national pro-farming revolt (as happened in the Netherlands with the stikstofcrisis). Denmark is a relatively small country – 1/6th the size of NZ with a population of ~6 million. 64% of Denmark is classed as agricultural land, versus ~40% here. The agricultural landscape in NZ is dominated by pastoral grassland (84%), whereas in Denmark most agricultural land is arable farming (although they do farm 11.5 million pigs, which equates to a ratio of ~2 pigs per head of population, which is on par with the cow:person ratio in NZ). Regarding dairy cows (forgive me, but I do work for DairyNZ), Denmark has ~500,000 cows, which is about half the number of dairy cows in Canterbury region (950,000) or 1/10th the size of NZ's national herd (4.7 million)⁸. Once the most important industry in Denmark, agriculture has become of minor economic importance and contributes just 22% to Denmark's export GDP – pharmaceuticals/biotech are the top-ranking export earner. Compare that to NZ where agriculture remains our largest tradeable economy and represents ~70% of merchandise exports. For the farm acquisitions and land restorations in A Green Denmark they will access €5.8b (NZ\$11.7b) of EU funding and supplement this with monies from the Danish state budget. Unlike in the EU, NZ does not operate agricultural subsidies (other than for erosion control and assistance in the case of emergencies); at <1% of producer's income NZ has the lowest level of agricultural subsidies of any OECD country.



A billboard on a school in Aarhus, the message of which resonated with me.

A contrasting difference in nutrient management regulations between NZ and the EU has been the regulatory approach to nutrient limit-setting. In the EU nitrogen loads have traditionally been controlled through restrictions on nitrogen inputs to a farm. For example, to protect groundwater, the EU Nitrates Directive (1991) sets a maximum limit of 170 kg/N/ha/year as the amount of nitrogen from livestock manure that can be applied to land (equivalent to a stocking rate of ~1.85 cows/ha). In NZ, however, we assess N-losses at the farm scale based on modelled outputs (as predicted by OverseerFM). It was interesting, therefore, to learn at LuWQ2025 that from 2027 Denmark will revert to a nitrogen-output-based regulation.

Nitrate in Drinking Water - the infamous “Danish study”

In NZ the ‘2018 Danish study’⁹ is often cited when the topic of nitrate in drinking water is discussed. Since that cohort study on colorectal cancer risk, the research team at the University of Aarhus have made further studies examining other health outcomes, which were summarised at LuWQ2025 by Birgitte Hanson¹⁰. Those works have so far concluded that drinking water nitrate is correlated with increased risk of: colorectal cancer, birth defects, adverse birth outcomes, cancer (in children) and all-cause mortality. They have found no evidence nitrate increases risk of: still birth, timing of puberty, fertility, or male fecundity. Considering the findings, the Danish administration is currently assessing the drinking water standard for nitrate and an expert committee is expected to report a suggestion for a potentially new, health-based drinking water quality criterion by the end of 2025. Since nitrate in groundwater drinking water supplies has been the rationale for the Nitrate Emergency recently declared in Canterbury there will be much interest here in what the Danes decide. In terms of managing the groundwater resource for drinking water, there is no doubt that Denmark is in a different league from NZ and our approach to drinking water resource management – most notably the lack of strategic protection of groundwater resources as an asset for drinking water supply. Denmark has invested heavily not only in resource characterisation, monitoring and land-use management within drinking water supply zones, but also on water conservation measures. Water consumption rates in Denmark are currently less than 100 L/person/day having been 172 L/person/day 40 years ago¹¹. Here in NZ we each,

on average, consume twice that volume. There's no doubt that if, like the Danes, we were paying NZ\$20/m³ for water supplied at the tap, we would think more conservatively about our water usage.



Denmark is proud of its unchlorinated water supply - drinking water bottle given to conference attendees at LuWQ2025

A tough act to follow – the research focus of other European countries

Ireland is one of several EU states that has been farming under a nitrogen derogation of the Nitrates Directive (1991) and is still permitted to apply livestock manure nitrogen up to 250 kg N/ha/year. They have therefore invested heavily in catchment studies to demonstrate that the extra N-loadings have not had any significantly different impact on water quality. At LuWQ2025, Ireland struck me as a country in which the scientists were most connected to the farmers and it reminded me of a strong quality of DairyNZ, and the stakeholder-driven applied environmental science and research we tend to conduct in NZ. Researchers from both Ireland and the UK presented on nature-based solutions for improving water quality (focussed mainly on sediment and phosphorous mitigation). Of the EU states that currently have nitrogen derogation, Ireland is the only one that has applied for an extension in the next NAP, beyond 2026. The story I was told at LuWQ2025 was that Ireland's latest NAP presentation

to the EU Commissioners, which included making a case for continued derogation (i.e., continued intensive farming), followed Denmark's NAP presentation that described their paradigm shift to de-intensify by way of the Green Denmark deal – undoubtedly a tough act to follow.

Several presentations from scientists in Germany showcased the effectiveness of the latest fertiliser regulations that are a revision of regulations first introduced in 2017 that have driven a 40% reduction in artificial fertiliser applied to land. The fertiliser laws in Germany have been repeatedly tightened following events in 2018 when the EU Commission took Germany to the European Court of Justice charging them for failing to improve water quality and claiming infringements of their NAP. Germany faced the prospect of a €17 million (NZ\$34 million) fine on which a daily penalty to the tune of €800,000 to €1.1 million (NZ\$1.6 to 2.2 million) was going to be added, for each day they were in breach of the Nitrate Directive. The case was eventually withdrawn, after Germany made some substantial changes to its fertiliser laws and groundwater quality monitoring programme. Nevertheless, this threat of punitive action under the Nitrates Directive (1991) has gotten the attention of many EU states, given most are failing to meet the long-term water quality objectives of either the Nitrate or Water Directives. At the moment, Denmark is sitting very pretty, but many other states are in a state of anxiety, awaiting the decisions of the EU Commission regarding their NAP proposals. Despite having been operational for almost 35 years it is apparent the EU Nitrates Directive (1991) has not been totally effective or delivered on the long-term outcomes it was intended to. It is currently being reviewed.

Acknowledgements: My attendance of LuWQ2025 was funded by New Zealand dairy farmers as part of DairyNZ's strategic programme Healthy Waterways. This article contains my own personal opinions which do not necessarily reflect those of DairyNZ.

References

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ARTICLE

Hydrology Histories: Cropp Catchment

By Graeme Horrell



New Zealand
Hydrological Society

The Upper Cropp River Catchment (12.2 km²) is the wettest catchment near the West Coast, within the transect of raingauges that spread from Mt Hutt in the east to Fergusons Farm in the Waitaha Valley on the West Coast. Extreme precipitation dominates the basin hydrology, development of soils, vegetation and geomorphology.

The basin was a superb laboratory for studying processes of natural events, providing information on this extreme environment for use in hydrological earth-science models, engineering design, and to enable forecasts from this previously unmonitored hydrological region. It was studied by the Alpine Processes Group of the Ministry of Works and Development in the late 1970s and early 1980s. The Cropp flows into the Whitcombe River, a major tributary of the Hokitika River. The upper basin ranges in elevation from 865 metres at Cropp Hut to Mt Beaumont 2140 metres.

Severe storms

The Cropp Hut received some upgrades in July 1979 to make the accommodation for Canterbury University students more comfortable. A shower was added as an extension on the wall facing the helicopter (Figure 1), and the roof was lined with batts and enclosed by a layer of plywood. We noticed the hut had once blown over and been resurrected and guyed to the ground. Unfortunately, none of the framing was square, adding difficulty when fitting the sheets of ply lining.

It is unnerving to recall that the hut housed six students during a storm on 3 December 1979. The river reached the terrace where the hut was located. A field visit by helicopter eight days later witnessed that the storm had rolled two swing bridges across the Whitcombe River around themselves. The students were still getting over the magnitude of the event, as well as catching up on sleep because the loud punch tape recorder housed in the hut recorded every 0.5 mm of rainfall.



Figure 1: Cropp Hut, 1979. The Cropp Hut automatic raingauge and three-metre storage gauge were installed on 12 July 1979 out of shot, but just to the left of the hut.

Murray Hawke was surveying mass movement of sediment within the Cropp Catchment, which involved painting large boulders bright red, some as large as cars. After this flood, no red rocks could be found.

While 524 mm of rainfall was recorded at Cropp Hut, it was obvious from the flood magnitude that the upper catchment received a larger amount, and that another raingauge was required near the top of the catchment.

Another large storm over 21–23 December 1995 (545 mm) triggered the partial collapse of Remarkable Peak, 2.5 km upstream, and material tumbled down the valley. This followed the wettest 48-hour period on

record: 1049 mm rainfall over 11–13 December 1995 when the Cropp Hut raingauge was damaged by a flash flood, along with the Hut itself, which was turned around and off its piles, with 30 cm of sand inside.

December 1995 still is the wettest month on record, with 2926 mm of rainfall.

The mean annual rainfall, over 42 complete years, for the Waterfall site is 11,364 mm. Storms occur every 8 to 9 days. A one-day storm total in excess of 200 mm occurs, on average, a staggering 11 times per year. The mean annual rainfall for Cropp Hut is 10,257 mm.

Table 1: Cropp River at Waterfall and Cropp Hut maximum recorded rainfall for different durations

CROPP RIVER AT WATERFALL		CROPP HUT
DURATION	MAXIMUM RECORDED RAINFALL (MM)	MAXIMUM RECORDED RAINFALL (MM)
1 HOUR	134	104
3 HOURS	243	190
6 HOURS	366	292
12 HOURS	500	435
1 DAY	868	701
3 DAYS	1137	1034
MONTH	2926	2459
YEAR	16616	14346

Rainfall and raingauges

Short-term and long-term raingauge sites were used to identify the most likely wettest rainfall locations. The Tuke catchment (Table 2) is also very wet.

The first raingauge installed in the Cropp was the Beaumont Basin (three-metre storage) raingauge in 1977. This later proved to be unreliable for total precipitation measurement due to being buried in snow during good snow years. It was closed and removed in April 1980.

The Cropp River at Waterfall storage raingauge was

installed on 4 January 1980, and upgraded to an automatic gauge on 13 June 1982. This gear was lost in a slip in 2000. The site shifted by 100 metres and 15 metres higher in altitude on 31 August 2000. On 6 November 2009, NIWA added satellite telemetry. It is used today by West Coast Regional Council for flood warning.

The West Coast Regional Council installed a radio telemetered raingauge called Base on 2 May 2012. It was located on a flat above the location of the second Cropp Hut raingauge site, which was relocated 330 metres northeast of the original site on 24 February

1996, following the December 1995 flood events. Today both the Cropp River at Waterfall and Cropp Hut raingauges have satellite telemetry, and are

maintained by the NIWA Field Team in Greymouth, led by John Porteous.



Figure 2 (left): Beaumont Basin raingauge, 14 June 1978. Graeme Horrell reading the rainfall total since the previous visit. Figure 3 (right): Cropp River at Waterfall raingauge. Hydrological Society Conference field trip on 20 November 2008. (Later, between 22–25 November, 991 mm rain was recorded.) From left: Bob McDavitt, Mathirimangalam Srinivasan (MS), Suzanne Poyck and Graeme Horrell.

Table 2: Raingauges used to identify the wettest catchment.

RAINGAUGE NAME	CATCHMENT	PERIOD OF MEASUREMENTS	ESTIMATED MEAN ANNUAL RAINFALL (MM)
Remarkable Peak*	Cropp	Short-term	11,854
Cropp Upper *2	Cropp	Became long-term	11,364
Beaumont Basin	Cropp	Short-term	10,842
Cropp Hut #	Cropp	Became long-term	10,257
Cat Creek Shelf	Whitcombe	Short-term	7971
Cat Creek Hut	Whitcombe	Short-term	7334
Noisy Creek	Noisy Creek	Short-term	9883
Cropp Junction	Whitcombe	Short-term	8855
Dickie Spur	Tuke	Short-term	8290
Tuke Spur 1	Tuke	Short-term	10209
Tuke spur 2	Tuke	Short-term	9455
Tuke Hut	Tuke	Became long-term	9769
Tuke Basin	Tuke	Short-term	9346
Tuke Ledge	Tuke	Short-term	8958
Ivory glacier	Waitaha	Short-term	9201
Rapid Creek	Hokitika	Existing automatic raingauge from 1964	7438
Prices Flat	Whitcombe	WhitcombeExisting automatic raingauge from 1971	7543

*300 m higher than Waterfall, on a steep slope

*2Renamed Cropp River at Waterfall

Since records began 1979

Helicopter flights

The regular raingauge site visits by helicopter were undertaken by Dr Mauri McSaveney, Graeme Horrell and Ian Whitehouse. In those early days, we never got over the uncanny feeling of climbing a three-metre raingauge, to find the water level depth since our last visit was equivalent to being over our heads. Raingauges were visited every four to six weeks. If left for eight weeks, they risked overflowing, losing the rainfall total.

Interpretation of weather analysis maps became key to successful helicopter flights that allowed all raingauges of the transect to be read in one day. Any sign of a northwest wind delayed flights. Over time, calibrating weather forecasts to rainfall, we learned some northwesterners are actually dry, most are wet and some very wet. An extremely wet northwesterly was concerning if the storage gauges had not been emptied for four or five weeks, risking overflow. These extremely wet events were appropriately

described by our colleague Trevor Chinn and named “conveyer belts of moisture”. Today they are called “atmospheric rivers”.

In the early years, we used Goodwin McNutt’s Winged Hunters FH1100 helicopters based in Fox Glacier, and were picked up at Glenfalloch in the Rakaia. In 1981, the helicopter funding for Alpine Processes was withdrawn. Friendly helicopter pilots, DOC and Forest Service were approached, and some sites were visited including the Cropp, Tuke and Ivory Glacier. The Tuke trip involved a flight into the Tuke Basin with cans of paint. As payment, I painted Tuke Hut and walked out. Ralph Dickson and I walked to the Cropp via Noisy Bivvy, to find it had very recently blown flat. We crawled in, sheltered for the night, and the next day walked on to Cropp Hut and out to Hokitika Gorge.

These recollections from Graeme Horrell are part of a New Zealand Hydrological Society [series](#) that documents the times and memories of New Zealand's senior hydrologists.

ARTICLE

Hydrology Histories: Glendhu Catchment Project

By Barry Fahey

NZHS member 1964-

I graduated with a Bachelor's degree from University of Otago in 1961 with a double major in Geography and Geology and worked briefly for the New Zealand Hydrological Survey in Green Island. At the time, Kees Toebes suggested I undertake an investigation of rainfall interception by tussock, manuka and radiata pine in the Silverstream catchment west of Dunedin, which I completed in 1964. Events took a different course over the next 20 years.

I completed a PhD at the University of Colorado with the Institute of Arctic and Alpine Research and spent the next 15 years teaching in geomorphology at the University of Guelph in Ontario, Canada. In 1985 I returned to New Zealand and joined the Protection Forestry Division of FRI in Christchurch to establish a research programme on forest road erosion in steep land forests. When that was nearing completion I turned my attention back to tussock grassland hydrology and in the early '90s I teamed up with Dave Murray, who was on the staff at the University of Otago, to investigate the potential role of snow tussock in supplementing stream flow through fog interception, using a large weighing lysimeter relocated from the Glendhu experimental catchments in the uplands of east Otago to Swampy Summit just west of Dunedin.

This was somewhat fortuitous because in 1992 I was entrusted with the operation of the Glendhu paired catchment study. At the time, FRI was seeking interest from staff to assume responsibility for the operation of all their catchment programmes in the South Island including the Maimai near Reefton and Donald Creek in northwest Nelson. Based on my previous interest in tussocks I jumped at the chance to take over the leadership of the Glendhu study. It was originally established by the New Zealand Forest Service in 1979 to assess the potential hydrological impacts of converting indigenous snow tussock to pine plantation. As well as demonstrating that replacing tussock

with pines could reduce water yield by up to 50%, a comparison of storm flood peaks showed that as the magnitude of the event increases, the existing land cover becomes less significant in determining the peak flow response. This information was subsequently added to a worldwide study undertaken by colleagues from the UK, the US, and Chile which investigated the extent to which forests could mitigate flood events compared with shorter vegetation types. The planted catchment was harvested between 2014 and early 2018, and replanted in pines in 2020.

Investigations at Glendhu have helped demonstrate that the retention of a tussock cover is essential if water yields are to be sustained, especially during prolonged dry spells. This has variably been attributed to some combination of low evaporation and fog interception with their relative importance being the subject of some controversy. Regardless, any further large-scale conversion of tussock grasslands to plantation forests is highly unlikely. However, I firmly believe that there is value in retaining long-term catchment studies like that at Glendhu even if they appear to have outlasted the reasons for setting them up in the first place. For example, studies conducted in the Glendhu catchments have led to a better understanding of runoff and flow-generating mechanisms in the prevailing schist terrain. In particular, we now know that hillslopes are more important in sustaining baseflow than headwater wetlands, and that the bulk of the water comprising runoff is quite young. In addition, the catchments have served as a natural laboratory for the investigation of evapotranspiration processes in tussock grasslands and the potential for fog interception to augment stream flow. Results from the large weighing lysimeter originally located at Glendhu showed that fog interception by the tussock cover is minimal.

More recently the catchments have been the venue for numerous studies by Sarah Mager and her students

at the University of Otago, and in a collaborative effort with Rayonier NZ (the forest owners), the University, and the Otago Regional Council, turbidity and suspended sediment data have been collected and used to assess the effects of harvesting on water quality. The catchments have also been an important source of information that has been used in the resolution of resource management issues. For example, rainfall and runoff data were used to calibrate and validate the WATYIELD water balance model, originally developed by Rick Jackson at MWLR in a spreadsheet form and later made more user-friendly through the addition of an interactive graphical interface. It has, in turn, enabled the prediction of water yields at the catchment scale in a variety of circumstances relating to water resource issues in Otago and elsewhere. These include being able to predict the detrimental effect of tussock conversion to pasture in the adjacent Deep Stream and Deep Creek catchments which supply up to 50%

of Dunedin's water supply, and to confirm that fog is unlikely to be a major contributor to tussock water yield at the catchment scale in the uplands of east Otago.

The research effort at Glendhu has recently been scaled back, and now comprises a basic monitoring programme led by Sarah Mager at the University of Otago. Throughout the study my colleague John Payne provided valuable technical support. We also acknowledge the financial and moral support received from Rayonier NZ's Invercargill office in recent years. The Glendhu study is unique in New Zealand, first because of its longevity and also because of the size of the catchments. I consider these as compelling reasons for retaining the monitoring programme in its present form as water yields respond to the second forest rotation. As a colleague once told me "well maintained data appreciate in value like a vintage car".

ARTICLE

To Gage or to Gauge

An insight into the United States stream monitoring networks, discharge measurements, telemetry systems and flood warning

By *Nicholas Holwerda*
Basins Environmental Ltd

Nicholas Holwerda from Basins Environmental attended the 15th Biennial National Hydrologic Warning Council Training Conference & Exposition, held at the Loews Ventana Canyon Resort in Tucson, Arizona, 16–20 June 2025.



After successfully having gained a travel grant from the New Zealand Hydrological Society, I made the long journey to our neighbours across the Pacific.

The National Hydrologic Warning Council Biennial conference theme was “Beyond The Saguaro”. The Saguaro cacti grow everywhere in the Tucson region so they are always right in front of you wherever you go. The theme means to look beyond the cacti. Take this context to your job and look for what is next on the horizon. Focus effort there, as there are drastic changes ahead with technological changes.

After 48 hours of travel, delayed planes and the notorious LAX airport I finally touched down in what could be called a true desert. Forty-four degree Celsius days in a city famous for rodeo, Mexican food, cacti and not a river in sight... in fact, the only surface

water I saw was at the swimming pool. Hydrology conference? Am I in the right place? Well yes, I was. The biannual conference is moved to different states in the USA and this time it was Arizona’s turn.

The Arizona state’s water resource is mostly surface water takes from three major rivers: Salt, Verde, and Colorado. However, the Tucson area is primarily groundwater aquifer supplied. There is huge demand on the surface water supply and aquifers with many perennial rivers non-existent. The major rivers, especially the Colorado, are under huge pressure. The Colorado River supplies water to seven U.S. states (Colorado, Wyoming, Utah, New Mexico, Arizona, Nevada, and California) plus Mexico, but it is facing a major water crisis. Historically, the Colorado River flowed all the way to the Gulf of California in Mexico with an extensive delta and wide ecosystem area with many species. But today, due to extensive water use, the river rarely reaches its natural delta! That’s right, the entire Colorado is empty before it gets to the ocean. Some very old historical water rights mean that companies own the majority of the water for agriculture use, but now they sell the water rights back to the state as it’s more profitable than growing food (although they were forced to sell under law).

The Tucson area receives approximately 200–300 mm of rainfall per year, mostly in 3 months of the monsoon season (July to September). The entire year’s rainfall normally falls in a few major events. Many surface water hydrology sites only flow for a handful of days. This causes flash flooding and is a major problem for the region. Human nature means they forget about the hazards of flooded waters. They take risks and don’t understand the power swift water can have. People get caught out every year in these flash floods (the July Texas floods are an example of this). There are huge challenges for the region’s hydrologists

and flood managers with getting timely alarms and warnings out to the public and stakeholders. managers with getting timely alarms and warnings out to the public and stakeholders.

Due to the rapid flash floods of the southwest of the US, many monitoring organisations do not own ADCP or wader-based gauging equipment. The focus is on rainfall sites and stage sites for floodwarning. The stage sites have cross sections and then theoretical rating curves are developed for flood flows, often using slope-area methods.

Exhibitors at the conference included:

- United States Geological Survey
- Campbell Scientific
- Ott HydroMet
- Aquatic Informatics
- JE Fuller/Hydrology & Geomorphology
- Xylem
- Hyfi
- Microm Environmental
- Synoptic Data
- Blue Water Design
- TriLynx Systems
- Water & Earth Technologies, Inc.
- In-Situ
- Hydrolynx Systems Inc.
- ToltHawk Flood Sensors
- AEM

A large focus of the conference was the ALERT and ALERT 2 telemetry packages of loggers and software. Many of the county and state agencies, conservation partners and federal agencies rely on the ALERT systems for data logging and telemetry. This system is a radio network-based communication system. Many parts of the US do not have reliable cell communication therefore radio is still the primary system deployed. Satellite option is rarely used due to its latency and ineffectiveness for flood warning information.

ALERT & ALERT 2 Telemetry Systems

ALERT (Automated Local Evaluation in Real Time):

- Developed in the 1970s–1980s
- Uses VHF/UHF radio to transmit sensor data from remote sites to a base station

- Event-driven data is sent when a threshold is exceeded (rainfall rate)
- Simple but limited in bandwidth.

ALERT2 (Upgrade):

Released by the National Hydrologic Warning Council (NHWC) and partners in the 2010s. Still uses radio telemetry, but with faster data rates and additional benefits.

ALERT 2 products include everything from radio repeaters, data loggers, transmitters and associated products. The products are used by both USGS and counties in the US with the National Hydrologic Warning Council being a major supporter of their products.

Other topics

During the conference there were fascinating presentations on the following topics plus many more not listed below.

- Parts of California near Los Angeles having near-zero rainfall for 8 months leading up to January 2025. Then the devastating wildfires followed by the February flash floods. The challenges faced for hydrology teams, radio repeaters burnt to ash, and devastation to communities!
- New forecasting tools associated with Pacific atmospheric river systems. The flood warning teams are now utilising methods deployed normally in the Gulf of Mexico for hurricane watch and monitoring. This includes using the US air force and real time sensors to better understand how these weather systems affect the west coast of the US.
- Recruitment challenges faced by agencies and how they are applying training progression to hold staff. Also enabling staff to branch into bespoke hydrological monitoring such as drone use for lidar mapping.
- Various presentations on camera deployments. Many organisations using still imagery cameras for flow estimation, asset protection and dam safety.
- Calibration, validation and verification of sensors. This generated a long question/comments session. It was fascinating to see how far ahead New Zealand is

with nationwide consistency with NEMS. As a whole, New Zealand is achieving far higher quality datasets. It must be noted that many of the systems showcased were strictly for flood warning. Therefore, a tipping bucket raingauge 6 feet up a pole could be fit for purpose.

USGS update

The USGS stream gauge network has just celebrated their 1000th site with over 100 years of continuous stream stage data! And annually now they get 2.5 billion data. That's 2.5 billion individual requests! Funding cuts are on the horizon due to federal government changes, which are projected to potentially reach up to 30%. USGS stream gauge networks are lucky, however, as the majority of their funding is sourced from local bodies such as County offices (similar to a small unitary or city council in NZ) plus private entities. However, their overall budget will decrease. The initial impact was seen at the conference this year with a high number of federal employees cancelling their attendance only weeks out.

Slope area gaugings

Two organisations (PIMA County of Arizona and the Montana Department of Natural Resources) have been using 2D digital elevation (DEV) models to capture flood flow data. They complete the DEV and use Particle Velocity Lab (PIV) to capture surface velocity data from drone videos. As part of their DEV and velocity data they are back-calculating changes in Manning's roughness. They are completing this across the flood channel in an attempt to show how the Manning's roughness can change from very low (0.01) within the channel to higher (0.05) outside the channel. This is the case with dry sand riverbeds and flood plains with sparse vegetation growth. As these organisations complete slope area flood gaugings now they can show how a static Manning's number is not sufficient for a given channel shape in their catchments. Now they effectively apply a dynamic Manning's number during flash flood gaugings as stage changes.



Image: Conference Venue, 15th Biennial National Hydrologic Warning Council Training Conference & Exposition

In summary: it was one of the best-organised conferences I have attended, the amount of presentations was amazing and the content was spot on! Very engaging, from field/site challenges, office systems, data management and warning systems!

I would highly recommend in the future a NZHS representative attend this conference. It is focused more on the technical side rather than the science of hydrology; however, it still relevant to both disciplines. There are so many collaboration opportunities and networking benefits for projects both at home and internationally. The next NHWC conference will be in Charlotte, North Carolina in 2027.

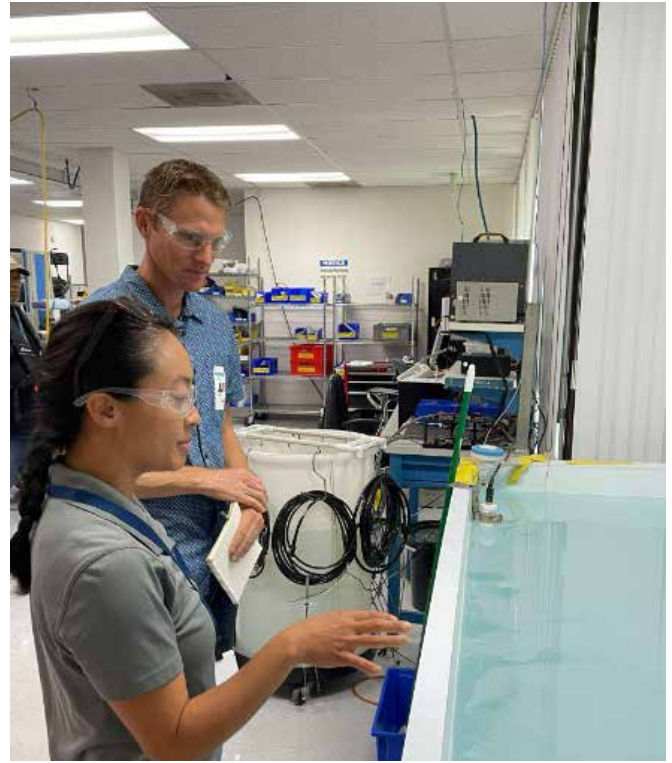
On my travels back from Tucson I stopped at SONTEK in San Diego. SONTEK is one of the leading suppliers of hydrology flow monitoring equipment into New Zealand. Many government, councils and private organisations own equipment from SONTEK. Their flagship acoustic equipment many of you may know includes the Flowtracker and M9 plus RS5 acoustic doppler profiler. The instruments they manufacture are critical in New Zealand for maintaining environmental flows and discharge rating curves. My time with SONTEK included a factory tour explaining the full production process and quality insurance. It was fascinating to see how a team of 55 staff assemble each individual unit by hand. The staff include the management team, service department, manufacturing, RnD, testing/calibration, software and dispatch.

As each unit is effectively hand built, they manually tune the acoustic head with fine adjustments. Each unit is then vigorously tested in a wide variety of conditions. The calibration process is unique to each unit and can only be completed in-house. The team at SONTEK are extremely dedicated and passionate about their jobs.

I would like to express thanks to the committee of the NZHS for allowing the travel grant to assist with some of the travel costs. I also would like to thank the NHWC committee for their fantastic hospitality and conference. And lastly for SONTEK for taking their time hosting me onsite.



Image: *Factory tour inside SONTEK*



ARTICLE

Projecting impacts of climate change on water resources: A guide through the process of producing hydrological projections to support decision-making

By *Frédérique (Frederika) Mourot (Charles Darwin University) and Cath Moore (Earth Sciences NZ)*

This research was funded by the Cooperative Research Centre for Developing Northern Australia and the Australian Government.

With global warming, the hydrological cycle is intensifying and placing communities and the environment under increasing pressure. Such pressure from climate change is also exacerbated by land use change and population growth (Figure 1). Therefore, to adapt to changing climatic and hydrological conditions, decision-makers and communities need to assess the potential future impact of climate change on local water resources. Groundwater-inclusive hydrological projections

can provide such insights, but require extensive knowledge, skills, and resources to be developed adequately to support decision-making needs. Using multidisciplinary skills in climate science, hydro(geo)logy, numerical modelling, and decision-making, Mourot et al. (2025) designed a step-by-step Guide (Figure 2) to:

- help understand the fundamental knowledge and steps involved in the process
- oversee the preparation; and/or
- produce groundwater-inclusive and end-user-focused hydrological projections.



Figure 1: Tributary of the Daly River during the dry season, Northern Territory, Australia (Photo: F. Mourot, May 2024).

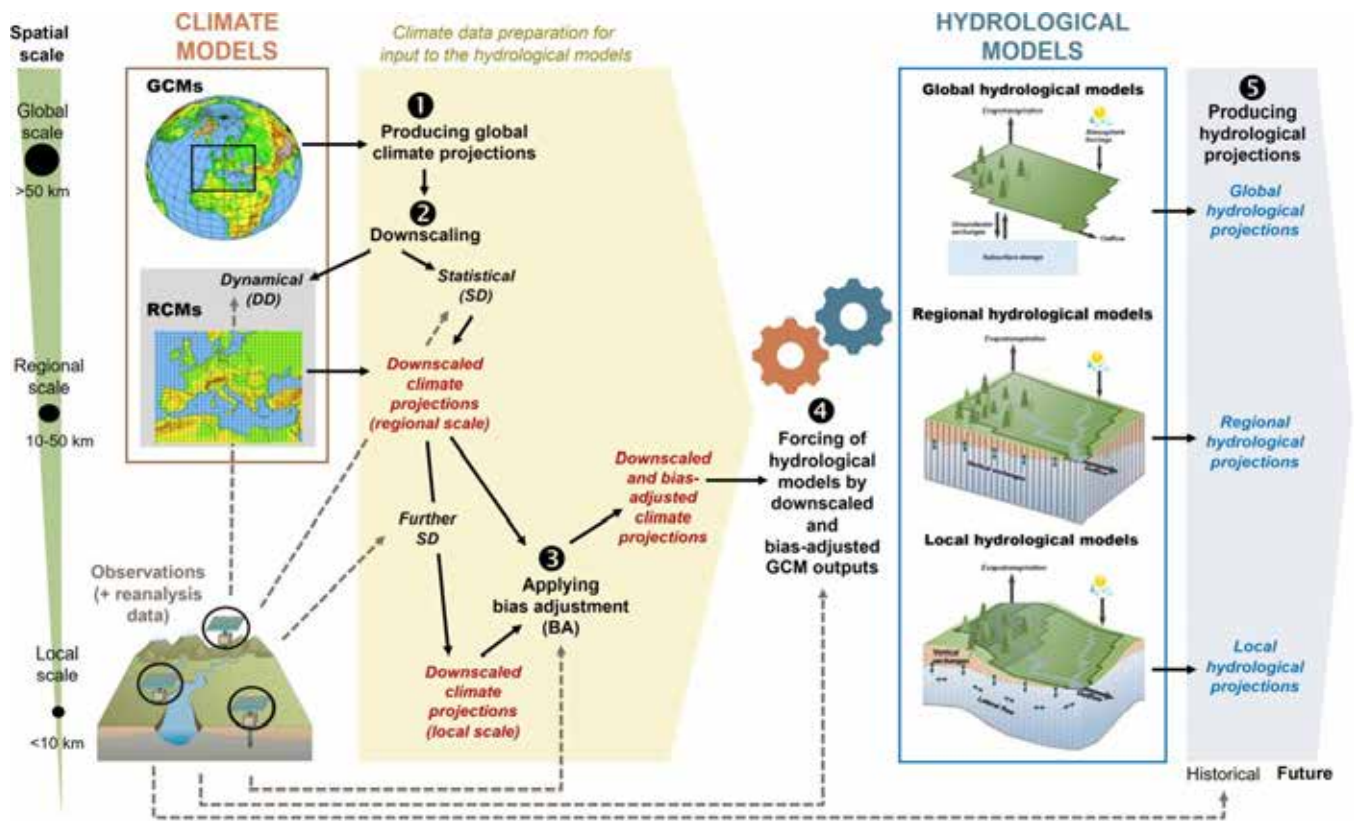


Figure 2: Using climate model outputs to force hydrological models to produce hydrological projections under climate change (figure reproduced from Mourot et al. 2025).

This Guide is available in Open Access in AGU journal Earth's Future:

Mourot, F. M.; Irvine, D. J.; Remenyi, T. A.; Hutley, L. B.; Crosbie, R. S.; Moore, C. R. 2025. Producing hydrological projections under climate change: A groundwater-inclusive practical guide. *Earth's Future* 13, e2025EF006316. <https://doi.org/10.1029/2025EF006316>

Paper's key points:

- Hydrological projections that effectively support water practitioner decision-making and communication are key to climate change adaptation.

- We provide interdisciplinary knowledge and guidance to deliver such effective hydrological projections that ideally encompass groundwater.
- We guide the production of hydrological projection visualisations that clearly communicate result uncertainty to end-users for robust decisions.

The paper also includes a list of acronyms, a glossary of terms, and a step-by-step checklist to support the production of hydrological projections under climate change as Supporting Information.

Read more in this Charles Darwin University media release: <https://www.cdu.edu.au/news/researchers-make-new-guide-help-maintain-water-security-future>

Earth Sciences New Zealand

Compiled By Maiwenn Herpe & Channa Rajanayaka



On 1 July 2025 **NIWA** and **GNS Science** merged to form **Earth Sciences New Zealand (ESNZ)**. This eCurrent update highlights a number of important hydrology and freshwater projects being carried out by ESNZ teams, building on the combined expertise of the two former organisations.

As part of the transition process, for this financial year, ESNZ will function with both GNS Science and NIWA business units.

New research reveals groundwater's dominant role in river health

A research collaboration between GNS and NIWA scientists has revealed new insights into how nutrients and groundwater shape the health of Aotearoa New Zealand's rivers. Published in *Hydrological Processes* and *Frontiers in Water*, the research combined the scientists' expertise in hydrology, chemistry and statistical modelling. Findings show both shallow and deep groundwater contributed over 80% of river flow

at most of the National River Water Quality Network (NRWQN) sites, even during high-flow events. Nutrient transport pathways were also investigated. Phosphorus, often bound to sediment, was primarily carried by fast surface flows during storms. In contrast, nitrogen travelled mainly through shallow groundwater, making medium flow the dominant pathway for nitrate-nitrite nitrogen across most catchments. Importantly, the studies link nutrient loads and flow contributions to upstream catchment characteristics such as rainfall, slope, land cover, and livestock density. These insights offer a practical framework for targeted land and water management strategies, such as riparian planting, wetland restoration, and precision fertiliser use.

The published papers are available to read at <https://doi.org/10.1002/hyp.70161> and <https://doi.org/10.3389/frwa.2025.1584947>. For more information please contact: [Cath Moore](#) or [Jing Yang](#).

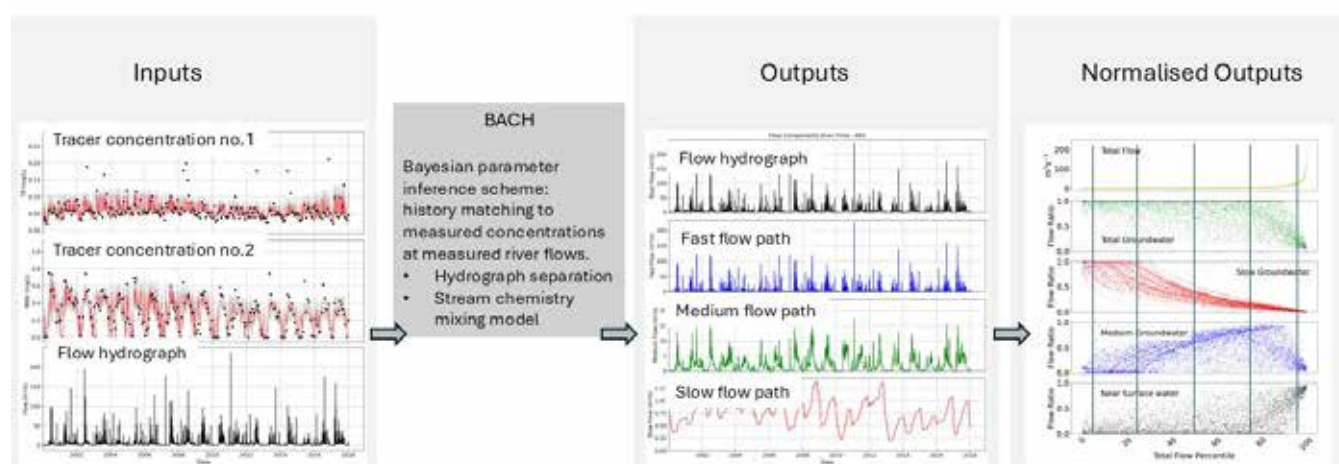


Figure 1: Illustration of BACH model inputs, their concurrent processing by the Bayesian parameter inference scheme, and resulting outputs.

High-flow harvesting: from concept to implementation

As water scarcity intensifies across Aotearoa, particularly in regions such as Northland and Gisborne, High-Flow Harvesting (HFH) has emerged as a promising strategy to strengthen water resilience. Under the Aqua Intel Aotearoa programme, managed by GNS Science, NIWA has partnered with Northland Regional Council and Gisborne District Council to advance HFH from conceptual design to practical implementation. The first phase of this work focused on developing robust guidelines for HFH water allocation. A four-step strategy was introduced: (1) establishing principles aligned with *Te Mana o te Wai*, (2) defining heuristics for practical application, (3) conducting quantitative analysis to assess feasibility, and (4) providing recommendations for implementation. A multi-band allocation framework was proposed (see Figure 2), using hydrological metrics such as 7-day Mean Annual Low Flow and median flow to define cease-to-take thresholds

and allowable abstraction rates. This approach supports flexible, environmentally sustainable, and regionally adaptable water management. The next phase focused on developing an implementation framework. This included identifying opportunities and barriers to applying a multi-band allocation system that allows water abstraction during elevated river flows. Stakeholder workshops with regional councils, government agencies, and technical experts informed this framework. Key recommendations include: investing in flow monitoring infrastructure and real-time data systems, embedding adaptive management principles for long-term sustainability, aligning with national freshwater policies, validating ecological impacts through modelling and monitoring, and promoting cross-regional collaboration to share knowledge and resources.

For more information on High-Flow Harvesting framework, contact [Doug Booker](#) or [Channa Rajanayaka](#). For details on the Aqua Intel Aotearoa programme, contact [Stew Cameron](#).

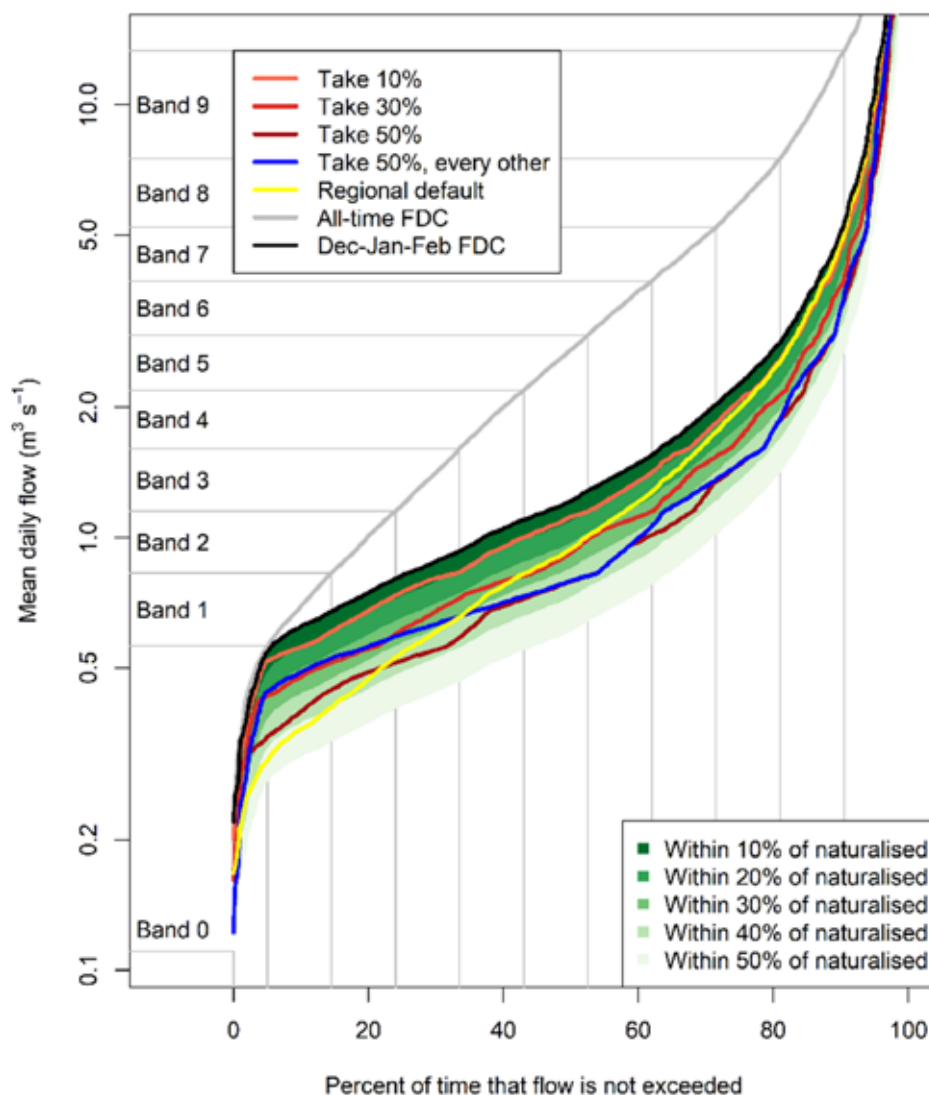


Figure 2: Example scenarios of a multi-band water allocation system.

A nationwide soil moisture dataset for Aotearoa

Soil moisture plays a critical role in New Zealand's environment. It controls how rainfall is partitioned into infiltration or runoff, influences drought and flood risk, and is a key driver of landslides. Despite its importance, soil moisture information in Aotearoa has until now been scattered across different agencies, methods, and spatial scales, making it difficult to form a consistent national picture.

To address this gap, we are developing a harmonised, nationwide soil moisture dataset that combines the best available data from multiple sources. These include in-situ observations from NIWA's climate stations and regional council networks, satellite-derived products such as NASA's Soil Moisture Active Passive (SMAP) and ESA's Climate Change Initiative (CCI), climate reanalysis outputs like ERA5-Land, and modelled outputs from hydrological models. The project is developing workflows to standardise, quality-control, and intercompare these datasets

(Figure 3). A core focus of the project is identifying spatial and temporal gaps in current soil moisture observations and recommending strategies to address them. By combining datasets using ensemble and data fusion techniques, we aim to develop a high-resolution soil moisture product that is suitable for operational and research use and includes uncertainty estimates. As a first application, this dataset will directly support the Endeavour Landslide Watch Aotearoa programme, which requires robust soil moisture inputs to forecast rainfall-induced landslides under different climatic and soil conditions.

By drawing on multiple data streams, we are building a dataset that reflects the best possible picture of the moisture status of our landscapes, helping communities, councils, and agencies better prepare for the extremes of tomorrow.

For more information please contact: [Rasool Porhemmat](#) or [Rogier Westerhoff](#)

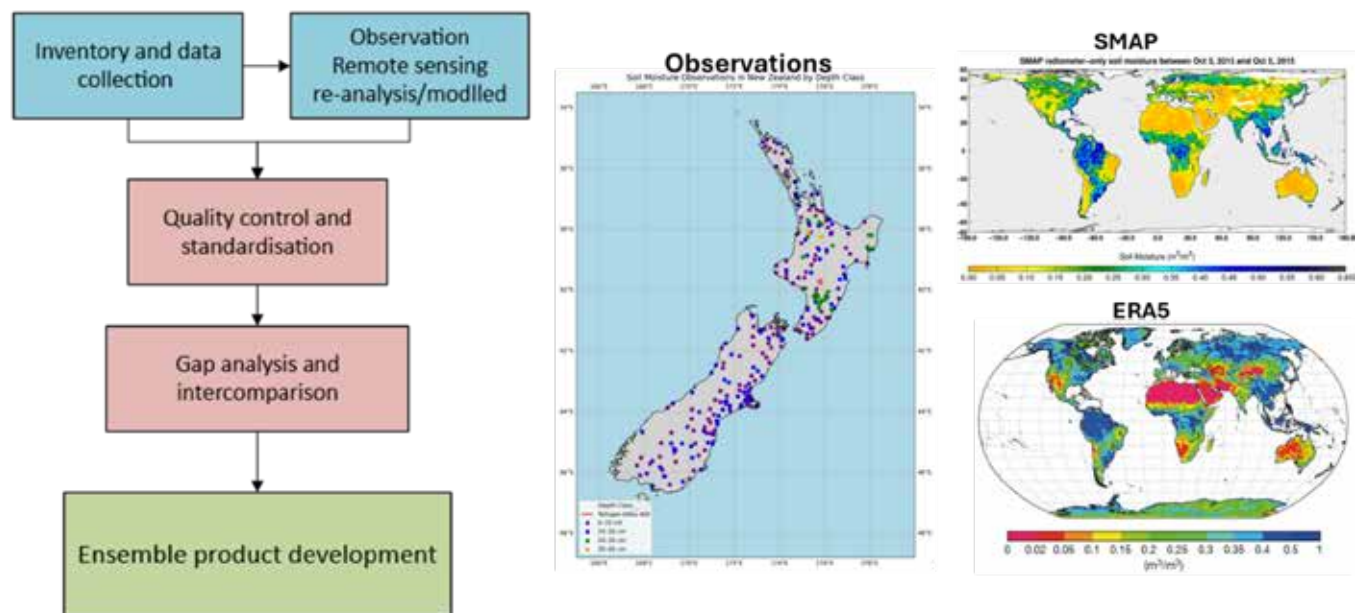


Figure 3: Overview of the methodology and data sources used to develop a harmonised ensemble soil moisture dataset for New Zealand. The left panel shows the workflow steps from data collection to ensemble product development, the centre panel observational data coverage across New Zealand, and the right panel global soil moisture products from the SMAP and ERA datasets.

Building coastal groundwater resilience for Invercargill through integrated modelling

ESNZ is working with Environment Southland (ES) to support climate resilience planning for Invercargill City. The project is developing a fit-for-purpose groundwater–surface water model to assess the impacts of climate change, including sea-level rise (SLR) and vertical land movement (VLM), on groundwater systems, infrastructure, and flood hazards. The modelling framework is underpinned

by a 3D facies model of the Southland Plains coastal system, constructed from ES well log data, which informs a MODFLOW 6 numerical groundwater model. In this early phase, the preliminary model is simulating historical steady-state conditions and future transient groundwater conditions, capturing key processes such as groundwater–surface water interactions and coastal boundary influences. Initial sensitivity analyses are helping to identify critical data gaps that currently constrain robust adaptation planning for major infrastructure, including Invercargill

Airport and Southland Hospital. The project team is also developing datasets based on IPCC Shared Socioeconomic Pathway (SSP) scenarios to test the inland propagation of SLR impacts, inundation risks, and changes in groundwater–surface water dynamics. The outcomes will provide ES with a credible basis for integrated hazard assessment, supporting flood hazard mapping, infrastructure resilience planning, and the identification of future monitoring priorities.

For more information, please contact [Channa Rajanayaka](#) or [Lee Chambers](#).

Freshwater state of the environment update on its way

We provided an update to the Groundwater Quality Indicator (released April 2025), to inform the Ministry for the Environment (MfE) and Statistics NZ's [Our Environment 2025](#). Similar work is now underway for river and lakes.

This [Groundwater Quality Indicator](#) was funded and co-designed with the MfE to better represent the breadth of groundwater quality monitoring and diversity of our groundwaters. The report includes changes on data selection, presentation and reporting, following an independent review on the 2020

Indicator. Long-term monitoring data sets from various sources were aggregated to provide a richer overview of the quality of Aotearoa's groundwaters (regional State for the Environment, national groundwater monitoring, pesticides surveys). The report includes current maps of groundwater quality for thirty-three variables, some of which were not previously publicly available (e.g. arsenic concentrations, Figure 4).

The data analysis confirms a large-scale nitrate contamination issue, based on observed exceedances of reference and drinking-water Maximum Acceptable Values (MAV), and local detection of pesticides. Other MAV exceedances for inorganic chemistry variables are occurring; however, in most cases these have been investigated by regional councils and attributed to natural geogenic sources. Recommendations are provided to enhance future Indicator updates; enable data harvesting of monitoring data; and optimise the representativeness of our monitoring networks.

For more information, contact [Doug Booker](#) (surface water quality indicator) or [Magali Moreau](#) (groundwater quality indicator).

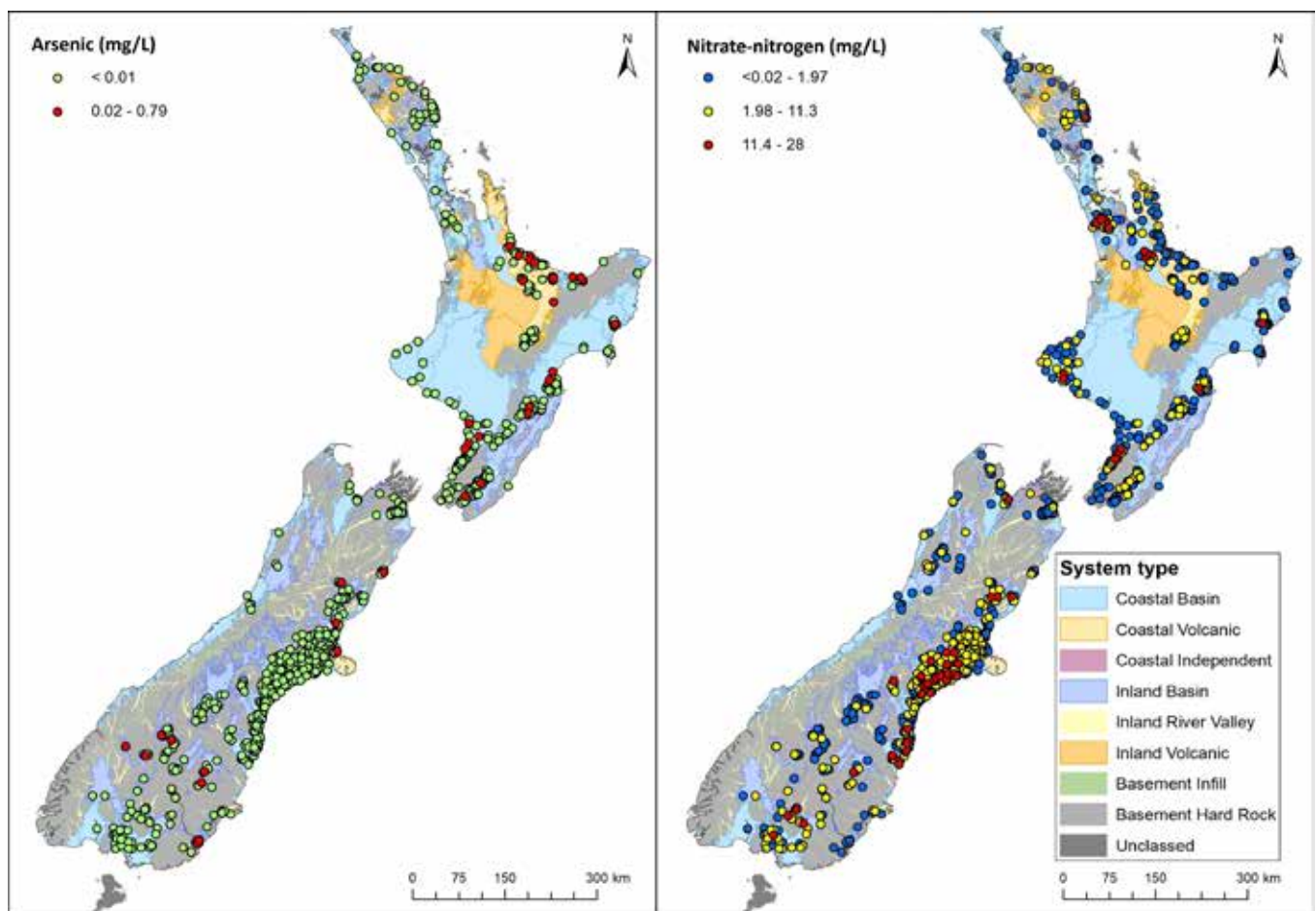


Figure 4: Median concentrations for nitrate-nitrogen (mg/L) and arsenic (mg/L) in groundwater between 2019 and 2024. In this map, the plotting order is consistent with increasing values (i.e. higher values plotted last/at the top). Red dots indicate values above the New Zealand drinking-water standard Maximum Acceptable Values.

UPDATE

National Environmental Monitoring Standards (NEMS)

Compiled by Jeff Watson and Raelene Mercer



Review and refresh of the NEMS Open Channel Flow

The National Environmental Monitoring Standards (NEMS) are generally assessed for the need for review and updating every two years. The NEMS - Open Channel Flow Measurement is one of a number of NEMS that are currently under review. It has undergone a significant number of updates and additions, so the NEMS team thought it useful to outline them here.

This standard has been reviewed by Alex Ring (Environment Canterbury), Phil Downes (Environment Canterbury) and Evan Baddock (Earth Sciences New Zealand). Mike Ede and Jeff Watson are also contributing to the overall production of the new version of the document. There are significant changes to this NEMS as a result of this review.

The most significant changes relate to:

- The restructuring of the Standard into the new NEMS document format
- The addition or revision of sections relating to discharge measurements utilising:
 - o Volumetric methods
 - o Surface velocimetry methods
 - o POEM methods
 - o AECV methods
 - o Salt dilution

- The addition of method codes relating to the gauging methods above
- The addition of several annexes relating to the gauging methods above
- The addition of material relating to site selection
- Changes to the section relating to gauging uncertainty
- Changes to the section relating to hydraulic calculation methods
- Changes to the section relating to QRev and the inclusion of the use of QRev with Flowtracker instruments
- Revised quality coding matrices.

It is expected that this NEMS version will be released around October/November at which time it will be downloadable from the NEMS website (www.nems.org.nz).

The above changes to the NEMS - Open Channel Flow Measurement have also necessitated changes to the NEMS - Processing of Environmental Time-Series Data. This document will also be re-released at around the same time as the NEMS - Open Channel Flow Measurement.

Remember to register on www.nems.org.nz to get an instant update when the new version is released.

UPDATE

WGA

Compiled By Cameron Jasper

WGA

Arowhenua Wetland Restoration Project: National Policy Statement for Freshwater Management principles in practice

In a collaborative project focused on a wetland area adjacent to the Arowhenua Marae, Canterbury, WGA's water scientists and engineers worked with Te Rūnanga o Arowhenua and Boffa Miskell to implement best practices in freshwater management during the conceptual design phase to uphold kaitiakitanga, ensuring environmental stewardship. The project aims to enhance the stream and wetland system through integrated approaches, including pest control, native planting, channel improvements, and specialised civil and stormwater engineering practices.



WGA (**Hayley Whittington & Cameron Jasper**) participated in a site visit and wānanga (learning session), which involved detailed surveying of streams, channels, drainage, and culverts. The wānanga informed the development of conceptual civil engineering designs to mitigate existing flooding issues and establish a resilient hydraulic framework for ecological function. The project will include improved access through the wetlands, including walkways, learning spaces, and gathering areas with connections to the Ōpihi and Temuka Rivers. Te Ao Māori expertise is being provided by Te Rūnanga o Arowhenua, plus collaboration with their plant nursery team from Te Rākau Kōhanga. The conceptual design of the site is being progressed in collaboration with Boffa Miskell landscape architects and ecologists to consider the needs of the rūnanga, local school, residents, the wider community, and existing fauna.

**Tūranganui-a-Kiwa Groundwater Replenishment Scheme: addressing challenges in groundwater allocation**

WGA (**Brett Sinclair**), in collaboration with MAR Ltd and AgFirst, is developing a Groundwater Replenishment Scheme (GRS) for the Poverty Bay Flats/Tūranganui-a-Kiwa to support resilient groundwater management and thereby help address irrigation demands, mitigate climate change impacts, and sustain the local community and economy.



The project focuses on Stage 1 feasibility, designing a GRS using existing infrastructure, including intake galleries, pumps, water supply pipelines from the Waipaoa River and the existing Kaiaponi injection bore. WGA conducted a detailed site assessment, prioritising four key recharge sites based on Makauri Aquifer thickness and hydraulic characteristics, seasonal drawdown, and stakeholder input. These sites would leverage existing infrastructure to deliver water to areas where enhanced recharge would help to address groundwater overallocation and saline water intrusion in the Makauri Aquifer. The project integrates stakeholder landholdings and existing water delivery systems, ensuring flexibility for future expansion based on performance and monitoring.

Rotokauri Greenway Groundwater Monitoring and Contingency Plan: environmentally responsible water management

Hounsell Holdings Limited and Hamilton City Council, supported by WGA (**Catherine Howell & Clare Houlbrooke**), are advancing the Rotokauri Greenway project, a key component of the Rotokauri Integrated Catchment Management Plan. This initiative involves constructing a 4.7 km stormwater management corridor, artificial wetlands, and associated infrastructure to facilitate sustainable urban development in Hamilton's Rotokauri growth cell. The project integrates active transport networks and native plantings with stormwater conveyance to manage water flows from Lake Waiwhakareke to Lake Rotokauri while minimising environmental impacts.



WGA's hydrogeologists have recently developed a comprehensive Groundwater Monitoring and Contingency Plan (GMCP) to oversee groundwater takes and diversions during construction. The GMCP ensures compliance with resource consent conditions by monitoring groundwater levels, discharge volumes, and water quality across over 40 monitoring sites, including new and existing bores and surface water monitoring sites. Key activities include real-time telemetry for geotechnical and environmental monitoring and daily discharge flow measurements.



- The plan incorporates a Trigger Action Response Plan to manage drawdown risks, ensuring mitigation measures like reduced pumping or groundwater cut-off systems are implemented if exceedances occur. Water quality monitoring focuses on parameters such as suspended solids, dissolved oxygen, and pH to prevent adverse effects on the Rotokauri Drain and downstream ecosystems.
- The project, progressing as six staged basins, balances urban development with ecological protection, adhering to the National Policy Statement for Freshwater Management. Continuous data collection since 2010 informs baseline levels, with new bores planned for spring 2025 to refine monitoring. This initiative exemplifies environmentally responsible water management, safeguarding local wetlands and infrastructure while enabling Hamilton's urban expansion.

UPDATE

Aqualinc

Compiled by Kate Mason**Company restructure**

We are moving to our next phase of growth and success here at Aqualinc with the appointment of a new Co-Leadership structure. We are profoundly grateful to our founders, Ian McIndoe and John Bright, as they pass on the baton.

We have welcomed **Toni Fraser** as our new Practice Manager to work alongside **Andrew Dark**, Technical Director. Together they will drive the development.

and growth of our business with Toni coordinating our business support services and Andrew coordinating business development.

Concurrently, **Jim Herbison**, our previous General Manager, has begun stage 1 of his retirement plan by stepping down as GM. He is staying on as a Principal in the business, focusing his skill and expertise on growing our environmental monitoring solutions and telemetry.



Image L-R: Jim Herbison, Andrew Dark, Toni Fraser

New recruits

Matthew Jones

Matthew's role involves contributing to groundwater assessment, data analysis, and modelling. He has a broad scientific background most recently completing a Master's in Water Resource Management with a thesis focusing on groundwater modelling.



Aimee Calkin

Aimee is a Water Resource Scientist with experience in hydrology and environmental management. Her work spans environmental database management, land use assessments, and hydrological analysis.

Her Master's research focused on land use change around Aotearoa's braided rivers, aiming to bridge the gap between environmental science and policy. This work gave her a deep understanding of how geospatial tools and legal frameworks can be integrated to support braided river governance.



Holly Munro

Holly is passionate about finding innovative solutions that not only contribute to a more sustainable planet but also drive cost reduction. She aspires to make contributions to sustainability by gaining insights of human behaviour and how those behaviours impact our environment especially within an agriculture space.

Holly's role involves undertaking environmental impact assessments and writing resource consent applications for groundwater and surface water takes, dairy shed effluent discharges and other related activities.



Projects

The Aqualinc team are continuing to be busy with a mix of consenting projects for primary sector and Council clients, source water risk assessments, field work (sampling, gauging, effluent pond drop tests), and ongoing research projects.

Selected for Taumata Arowai panel

Three of our expert scientists have been selected to join an advisory panel supporting Taumata Arowai, New Zealand's Water Services Authority: **Andrew Dark**, our Technical Director; **Julian Weir**, Principal Engineer – Groundwater Modelling Lead Consultant; and **Ross Hector**, Principal Hydrogeologist.

The panel will be instrumental in reinforcing the regulator's scientific and technical foundation, bringing critical expertise to the forefront of drinking water regulation and advancing the authority's commitment to safeguarding water quality for all, every day.

We will contribute technical guidance to ensure regulatory effectiveness and will serve as trusted advisors during water-related incidents or emergencies, ensuring swift, knowledgeable responses when it matters most.



Image L-R: Julian Weir, Andrew Dark, Ross Hector

MBIE Smart Ideas funding

Nick Dudley Ward was successful in the latest Ministry of Business, Innovation and Employment Smart Ideas funding round with his proposal, **“A multiphysics approach to characterising shallow groundwater systems.”**

The project is a collaborative effort with colleagues from **McMillan Drilling**, the University of Otago, the University of Sydney and the University of York.

and measured irrigation water use by upgrading the science behind irrigation modelling and modernising the tools used by Councils and irrigators. Through nationwide engagement, technical innovation, and robust analysis of water meter data, the project will enable smarter, fairer, and more future-focused management of irrigation demand. At its heart, the initiative is about creating a nationally consistent, credible, and transparent basis for setting irrigation water use limits – one that supports both environmental integrity and rural productivity.

By modernising the IrriCALC system and developing a new, dynamic database of reasonable irrigation use, this project will directly support better decision-making at the regional and farm level. Councils will have access to improved tools for setting limits in water use consents, irrigators will benefit from clearer standards and efficiency gains, and New Zealand as a whole will move closer to achieving balance in freshwater objectives. The expected outcomes include increased economic output from reallocated water, improved environmental outcomes in over-allocated catchments, and reduced regulatory concern over water resources. Ultimately, the work will help future-proof New Zealand’s food and fibre sectors by ensuring water is used where and when it delivers the greatest value – economically, environmentally, and socially.



Image: Nick Dudley Ward



Next generation irrigation demand management tools

The need to more closely align resource allocation with actual use is becoming increasingly urgent. This Council and MPI funded project, led by Aqualinc Research Ltd with support from Irrigation New Zealand, aims to close the gap between allocated

UPDATE

PHF Science

Compiled by Laura Banasiak



Chemical characterisation of phosphorus fractions along Barkers Creek Woodchip Denitrification Bioreactor (WDB)



Figure 1: Phil Abraham drills into the WDB to sample the woodchips (left); inside the WDB (centre); Sophie van Hamelsveld seals the woodchip samples in a mylar bag for snap freezing (right).

In 2024, the PHF Science Groundwater Team undertook an experiment to take samples of woodchip from the Woodchip Denitrification Bioreactor (WDB) at their Barkers Creek research site. Samples were taken at points along the 76 m WDB and at various depths from within the bioreactor. One of the parts of this experiment was to try and determine how phosphorus (P) was being captured within the bioreactor, since it had been noted in previous chemical analyses that the levels of P in the water samples were reduced after passing through the bioreactor.

Phosphorus, while essential for plant life, becomes a water contaminant when present in excessive amounts in waterways, leading to eutrophication and

ecosystem damage. This excess phosphorus fuels the overgrowth of algae and aquatic plants, depleting oxygen levels and harming aquatic life. To study the removal of phosphorus, samples of woodchip were taken, sealed in special light-proof mylar bags and then snap frozen to preserve the woodchip, biofilm and attached sediments in their original state. The samples were then taken to PHF Science, stored at -80°C to be analysed later.

The hypothesis is that P (especially NaBD-P) is stored at the front of the bioreactor and at higher vertical sections of the bioreactor, owing to capture of particulate/colloidal P, Fe, Mn, exposure to oxygen and precipitation of Fe and Mn (hydr)oxides which bind P.

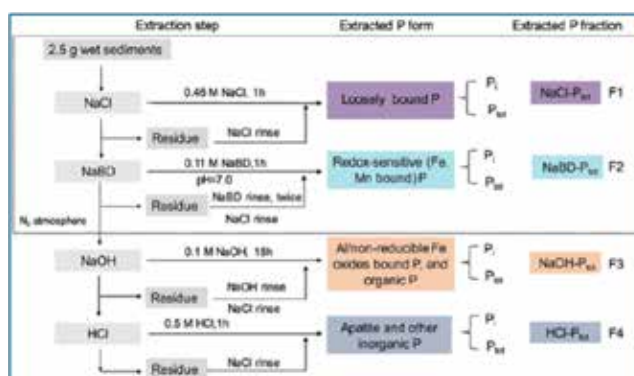
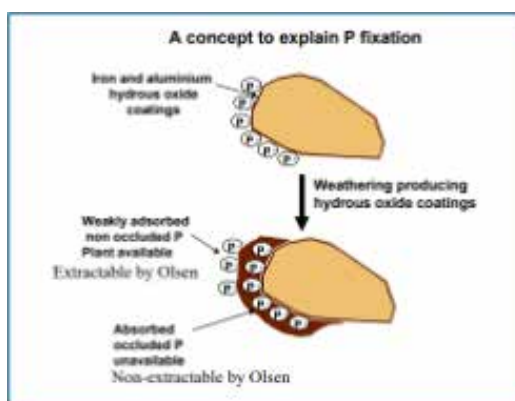


Figure 2: A concept to visualise ongoing P retention by oxide coatings forming on a soil particle (left) from Farmed Landscapes Research Centre (2021); Sequential P extraction protocol (right) from Tu et al. (2019).

To determine what is happening within the bioreactor, sequential chemical extractions of the four P fractions are planned to be undertaken by the Groundwater Team. The method is outlined in Lukkari et al. (2007) and requires that the first two extraction steps must be undertaken in the absence of O₂.

Extraction step 1 determines the amount of loosely bound P (NaCl-iP). Step 2 determines the redox-sensitive fraction of P bound to Fe and Mn (hydr) oxides (NaBD-P). Step 3 determines the non-reducible P, P bound to Al oxides and some nonreactive P (NaOH-P), and step 4 determines the Ca-bound P, such as apatite (HCl-P).



Figure 3: The anaerobic chamber constructed from a repurposed sand blasting cabinet



Figure 4: GW Technicians pose with the new piece of equipment

To conduct the first two steps, a commercially obtained sandblasting cabinet was repurposed to create an airtight space to conduct the experiment. The seams were sealed, a floor was added, and additional foam was used to give the door a better seal. A plastic tub inside the cabinet filled with argon

gas will be used to conduct the chemistry under anaerobic conditions, and a PreSens optical oxygen sensor will be used to monitor the internal and external atmosphere.

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Groundwater Safety in a Warming World

As the world continues to warm, groundwater is expected to support adaptation to climate change, particularly as groundwater is often more resilient to the impacts of climatic change than surface waters. However, in Aotearoa, few studies have sought to examine the vulnerability of our aquifers to climate change.

Our SSIF project (started July 2023) is developing new methodologies to quantify climate change effects on the physical, chemical, and biological quality of groundwater and connected surface waters. The project has three components:

(1) determining climate-related changes to recharge, water table elevation, and groundwater flow dynamics that have the potential to affect the quality of groundwater and connected surface water bodies in several different hydrogeological settings.

(2) determining the impact of increased groundwater salinity within the freshwater range (i.e., at increments below <1500 µS/cm) on pathogen survival (e.g., *Campylobacter*) and assessing the reliability of bacterial faecal indicator organisms (e.g., *E. coli*, enterococci).

(3) examining the impact of predicted sea-level rise on the spatial extent of saline intrusion in coastal aquifers nationwide.

Since our last update, we have completed a lab experiment for component (2), with a second experiment examining the impact of salinity on transport potential, currently in the planning stage. For component (3), we are in the process of writing up a paper detailing our national-scale model, which integrates nationwide water-level monitoring data to identify coastal areas with landward hydraulic gradients and uses published sea-level rise projections to assess changes in salinity risk.

Decentralised wastewater management: toward enhanced freshwater and drinking-water safety

ESR's decentralised wastewater SSIF research (started in July 2024), led by Bronwyn Humphries and Louise Weaver, continues to advance our understanding of risks from onsite wastewater management systems (OWMS) discharges to freshwater and human health. This research highlights why OWMS matters. All of New Zealand's wastewater and drinking water management is interconnected. OWMS is also part of our national wastewater infrastructure with common themes between municipal and OWMS of:

- Poor performance (outbreak risks)
- Underinvestment
- Aging infrastructure

As housing developments throughout New Zealand continue to place increased pressure on our aging municipal wastewater infrastructure, New Zealand is predicted to follow global trends by increasing the use of decentralised methods for wastewater management (Sharma and Gray, 2021). This coexistence between centralised and decentralised wastewater management is already occurring in many parts of New Zealand where existing settlements and large new subdivisions are relying on OWMS within urban and peri-urban areas.

Our first paper outlines the methodology and results from a GIS-based onsite wastewater location estimation research project and was published in the *Journal of Hydrology (New Zealand)* (Qiu et al., 2025). This project estimated over 34,000 OWMS locations within Canterbury with more than 26,000 OWMS being previously unmapped. This spatial data has

enabled Environment Canterbury to prioritise those locations where OWMS densities may pose a risk to drinking water supplies. PHF Science continues to implement this GIS-based map methodology in other regions throughout New Zealand (Figure 5).

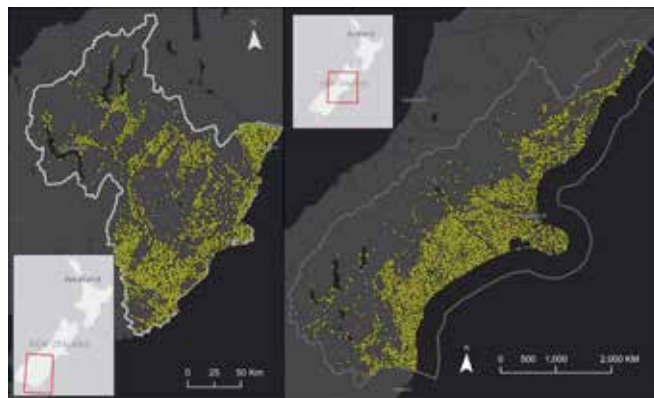


Figure 5: Onsite wastewater management system (OWMS) location estimation GIS investigation for Canterbury and Otago with yellow dots indicating the estimated location of OWMS.

Recently a groundwater tracer experiment was conducted at an OWMS field research site in North Canterbury (Figure 6). Bacterial and viral indicator organisms were injected into a conventional OWMS effluent trench to determine their fate and transport within shallow groundwater. Initial analysis of the results has revealed that *E. coli* remained localised within the proximity of the conventional trench while a viral indicator organism (MS2 bacteriophage) was detected in down gradient groundwater. These results reveal that monitoring for *E. coli* does not give the full risk profile when investigating the impact of wastewater on groundwater quality and highlights the importance of using other organisms such as viral indicators.

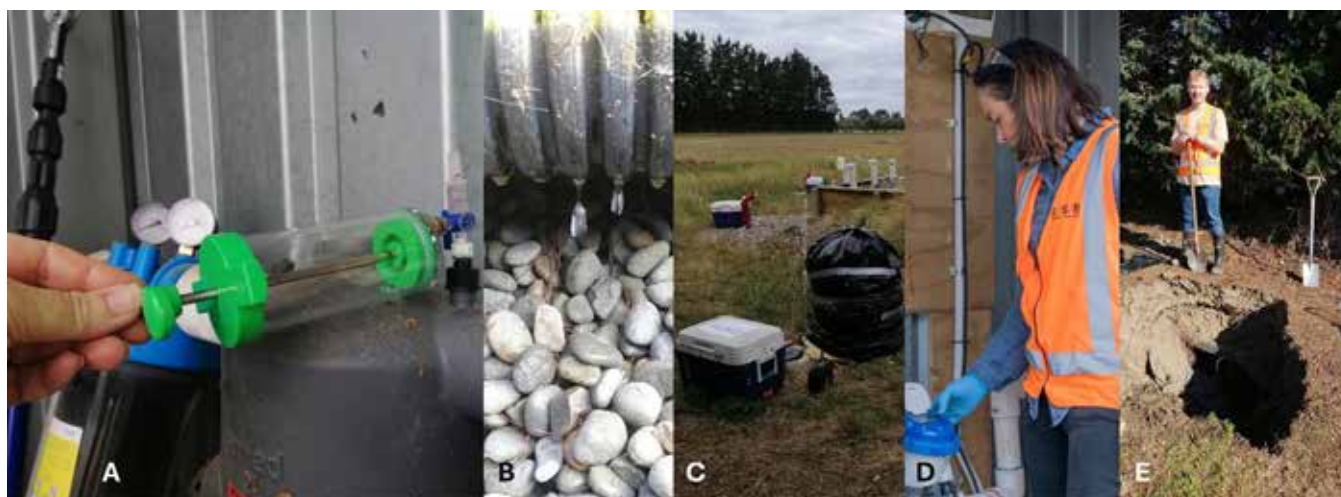


Figure 6: Microbial tracer experiment in March 2025: A) injection of potassium bromide, MS2 bacteriophage and E. coli J6-2 into the effluent delivery line. B) discharge of onsite wastewater to a conventional trench. C) monitoring the fate and transport of the tracers in downgradient groundwater using ISCO 3700 autosamplers. D) Bronwyn Humphries is monitoring effluent flows. E) Greg Hatley at the post-tracer experiment, which destructively sampled the effluent disposal trench to analyse microbial concentrations within the substrate.

A survey is underway on the health risks from composting toilets in New Zealand. As a part of this study, Louise Weaver, Alex Meister, and Panan Sitthirit are investigating the efficacy of pathogen removal via composting toilets. The study will look at composting stages used in New Zealand as a first step in guiding the management of the health risks when using composting toilets, including managing the risk of pathogen and contaminant transport to shallow groundwater.

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Pathogens in groundwater – using novel surrogates, modelling, and data science to understand their fate and transport in aquifers

This project (started July 2024) builds on previous work to quantify pathogen transport in groundwater using novel surrogates and advanced modelling techniques.

Following the successful completion of our large-scale tracer experiment at the Burnham experimental site in late 2024, planning is now underway for a second field experiment.

Meanwhile, our Image-to-Image deep learning model, developed by PhD student Loc Nguyen at Victoria University, continues to evolve. The model uses AI and data assimilation techniques to generate probabilistic, space-time predictions of contaminant transport by learning relationships between hydraulic conductivity and plume behaviour. Results to date show robust performance in both accuracy and computational efficiency.

In parallel, we are developing a paper based on work at the Silverstream field site in collaboration with Prof Andy Binley (Lancaster University, UK), where a permeable reactive barrier (PRB) wall was installed as a trial for potential denitrification. This work combines time-lapse electrical resistivity tomography (ERT) inversion with transport model calibration to evaluate key subsurface parameters of the PRB in a complex alluvial aquifer setting.

Groundwater Health Index – using biological data to determine contaminant presence and changes to the water quality

This project (led by Louise Weaver) is developing novel tools to assess groundwater ecosystem health and indicate the risk of contaminant transport into drinking water. The project has collected data from 99 sites across New Zealand over the past 6 years, providing a unique snapshot and temporal diversity. We are

integrating microbial, macrofauna data (from biofilm sampling, specimen collection, environmental (e)DNA) with physicochemical, land use and geological data into predictive models that are now able to indicate a change to a system and indicate likely contaminants present. This part of the project is a collaboration between New Zealand and international researchers in microbial ecology, ecosystem function, machine learning and modelling.

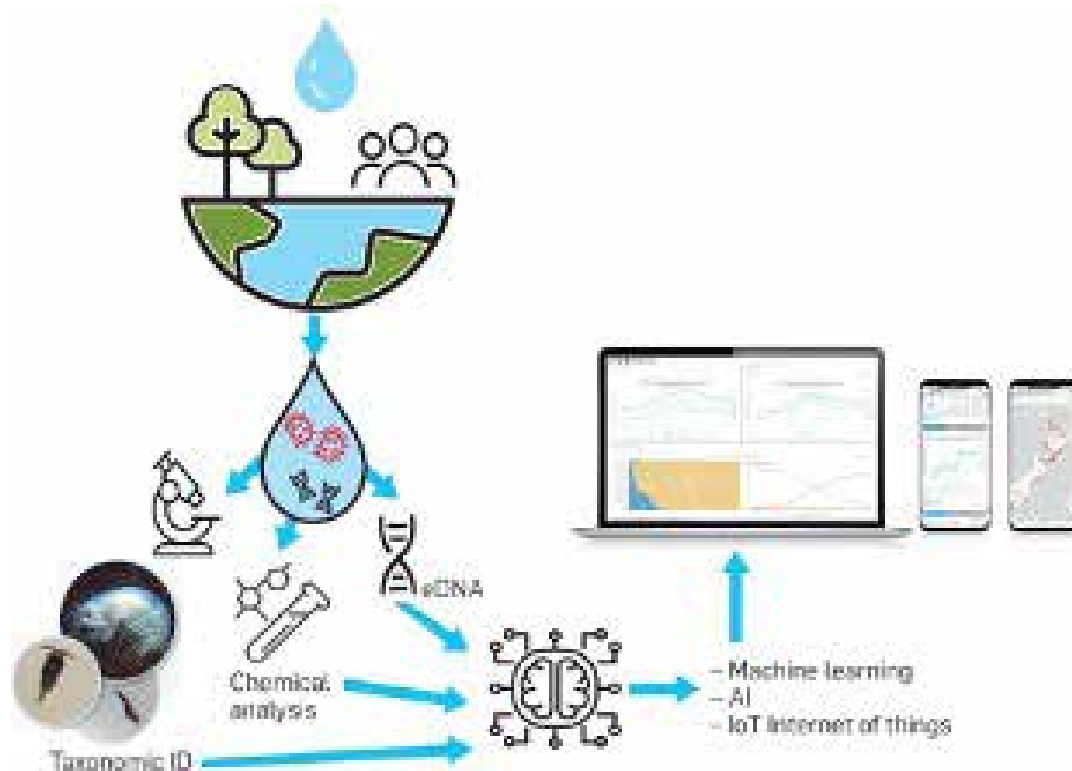


Figure 7: Top figure provides a schematic of the project, from data collation to machine learning and AI that is being used to develop a predictive model platform and a biosensor. Bottom left image shows Hayden Masterton (PHFS) fishing for Stygofauna with Rob van der Rajj (GWRC). Bottom right image shows Panan Siththirit and Hayden Masterton (PHFS) preparing to filter groundwater for eDNA sampling.

From our ongoing studies we can now see that distinct biomes exist in our different aquifers. Most of this difference in the biomes is linked with the aquifer chemistry. We have a priority list of taxa proposed as indicators of contamination or change to a system. We have developed a proposed tiered health index framework that is being developed further that can be included in future groundwater policies.

Recent publications and outputs

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Weaver, L., Webber, J., Bolton, A., Sitthirit, P., Abraham, P., Masterton, H., Close, M. (2024). Groundwater Ecosystems: Preliminary Biodiversity of Uncommon

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UPDATE

Lincoln Agritech

Compiled by Juliet Clague



Farewell and Best Wishes to Alice Sai Louie

The team from Lincoln Agritech are sending their best wishes to Alice Sai Louie who has just finished her fixed term contract. Alice will be heading to France in November to start a post-doctoral position at Géosciences Rennes (CNRS/University of Rennes) working with The Rennes Water Resources Group. Building on her PhD research, Alice will continue advancing active-distributed temperature sensing (A-DTS) to quantify groundwater fluxes at high spatial resolution. This will include developing and testing new fibre-optic tools in collaboration with partners at Université Gustave Eiffel (Paris) and INRS Québec. This approach is expected to have strong implications for improving flow and transport modelling and groundwater remediation.



Alice Sai Louie

Emerging Climatic Pressures Programme

We'd like to highlight one of the PhD projects funded by our Emerging Climatic Pressures Programme by introducing Ksenia Trifonova from Lincoln University. Ksenia is working with water and sediment samples taken from Lake Karapiro (Waikato River) in mesocosms and is supervised by Niklas Lehto, Naomi Wells (both from Lincoln University) and Adam Hartland (Lincoln Agritech).



Collecting water samples for the mesocosm experiment.

The aim of this mahi is to understand how climate change may affect the role of river sediments as a sink or a source of nutrients and trace elements to the overlying water bodies. Sediments store large quantities of nutrients and trace elements that regulate algal growth and affect water quality. By altering CO₂ levels in the headspace of the mesocosms, Ksenia can mimic different climatic conditions and scenarios. This research will determine if future climate conditions could trigger the release of these substances that would potentially fuel harmful algal blooms, affecting mahinga kai and recreation, and resulting in the release of hazardous metals like arsenic into the awa.



Ksenia and the mesocosms containing Waikato River water and sediments.



Introducing the latest addition to our water quality monitoring team

This remote-controlled ¼-scale jet boat (built by Jettec in Kaiapoi) is equipped with a multi-parameter sonde which will enable us to capture water quality data along transects and in difficult-to-access locations of the Waikato River. The sonde will provide continuous

information on many important attributes such as pH, temperature, conductivity, dissolved oxygen and CO₂ levels, to help build up a picture of the variability along the length of the river.

OBITUARY

Dr. Bruce Hunt

1941-2025

Dr Bruce Hunt, a brilliant engineering lecturer and mathematician, passed away on 18 April 2025 in Whakatane, aged 84 years. Bruce moved from the USA to NZ in 1973 to teach fluid mechanics and groundwater flow in the Civil Engineering Department at the University of Canterbury until his retirement in 2006.

Bruce's extensive groundwater research is well known internationally, and the analytical solutions he developed for groundwater quality and quantity problems are widely applied. Bruce coded his mathematical solutions into VBA macros in Excel, which made them accessible to a wide range of people including those less mathematically inclined.

Bruce was born in Pennsylvania. His mother, who taught mathematics, convinced him to study engineering and he continued on to gain a Masters and PhD. His move to New Zealand was influenced by a love of fly fishing and he continued to enjoy fishing, including surfcasting, in his retirement. Bruce's daughter Lauri recalls when she was young seeing his blackboard at the University of Canterbury scrawled with calculus, and how in the evenings he would go to bed early with a ream of paper to write more calculus. Former students still treasure his beautifully handwritten notes and equations.

Haijing Wang taught fluid mechanics alongside Bruce in her first academic job and fondly remembers his kind encouragement and generous help in her early career. She sat in his fluid mechanics lectures several times and recalls: "His speech was clear and precise, with no word of redundancy. His writing on the blackboard was always beautiful and tidy, exactly a full board by the end of the lesson. These were the best lectures I have ever attended in my life. I already knew then that I would never be able to reach the height of his lecture art, I do not believe many people would."

Bruce supervised the postgraduate research of a number of past and present NZHS members including Julian Weir, Liping Pang, Alan Pattle and Hilary Lough

and taught and collaborated with many others including David Scott, Catherine Moore and Peter Callander. His teaching has significantly influenced the development of New Zealand expertise in groundwater. His students remember him for his patience, kindness and clear communication of complex mathematics. His warmth extended to inviting his students and colleagues for dinners with him and his wife Sandra, and he was always keen to share his beautifully crafted fishing lures.

In 2006, Bruce was pleased to receive an award from Environment Canterbury in recognition of the outstanding contribution he made to the understanding of groundwater in Canterbury.

Bruce leaves a strong legacy in the understanding of groundwater nationally and internationally and the ongoing application of his valuable research.

