NZHS E-CURRENT NEWSLETTER • NUMBER 61 • MAY 2022

NEW ZEALAND HYDROLOGICAL SOCIETY

E-CURRENT NEWSLETTER

INSIDE THIS EDITION

Richard Hawke, NZHS Executive Committee

MESSAGE FROM THE EXECUTIVE

Kia ora. Despite winter appearing in Wellington this week I am still believing it is summer ... and while anticipating the NZHS conference in Ōtepoti / Dunedin in December we can still celebrate our 60th Anniversary Conference, which was held at Te Papa in Wellington from 30 November to 3 December, 2021.

The Wellington conference theme was He kimihanga waiwaiā o te wai māori | An Essential Freshwater Odyssey, and we threaded the needle in terms of timing and covid.... The papers covered our water guardianship/management journey. We had about 175 attendees present at the conference and about 90 virtual attendees. A huge thank you to you, the Committee, OnCue (our Conference support) and Te Papa for making the conference a success.

I hope you enjoyed the Journal issue ("orange book") produced to celebrate our Society's 60th Anniversary, which was a follow on from the "red book" the Society published for its 50th Anniversary in 2011. I was pleased to receive a request to use some of the content of the book in an upcoming training manual.

The conference was a great opportunity to recognise several members for their contribution to NZ Hydrology. The recipients of the Outstanding Achievement awards were Murray Hicks from NIWA, Uwe Morgenstern from GNS and Liping Pang from ESR. All three of them are outstanding as you will see from the citations included. In February we had the opportunity to award William Dench, from WGA, the NZHS Early Career Scientist Award.

I do want to highlight a couple of items in Current. Michael Knopick's work on asbestros in New Zealand's urban water is an example of work the Society supports via its Project Fund and work presented at NZHS conferences. The Wellington conference also presented an opportunity to have a "modelling" workshop that had been delayed. Andrew Fenemor provides a synthesis of themes and commentary from the workshop. Current also includes updates from a number of organisations and thought-provoking articles.

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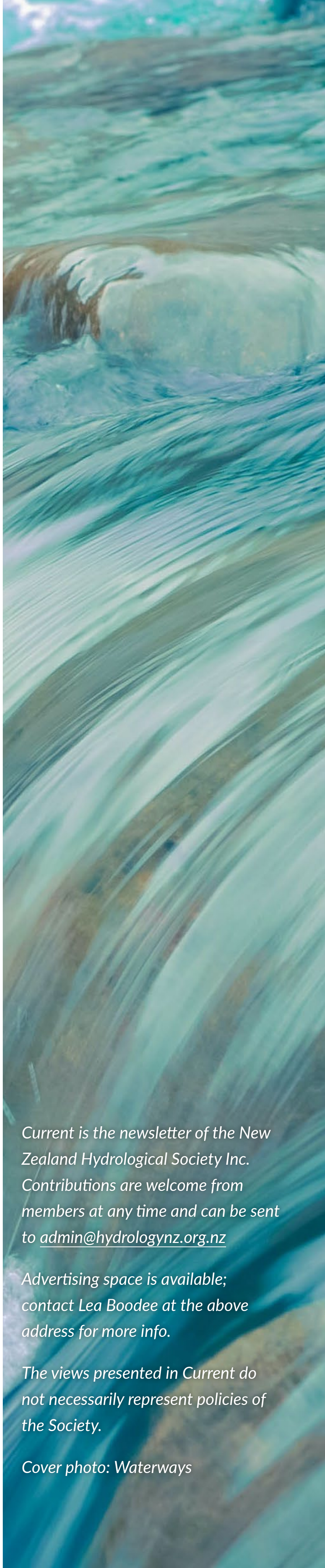

Current is the newsletter of the New Zealand Hydrological Society Inc. Contributions are welcome from members at any time and can be sent to admin@hydrologynz.org.nz

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

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

Cover photo: Waterways

UPCOMING EVENT

Our Water: A taonga in an ever-changing world

NZHSMSNZ
2022 JOINT CONFERENCE

6-9 DECEMBER ŌTEPOTI DUNEDIN

www.HydroMetSoc22.co.nz

The NZ Hydrological Society and the Meteorological Society NZ warmly welcome you to our joint conference at the University of Otago Ōtepoti / Dunedin campus.

The conference will be hosted within the St David Lecture Theatre Complex on the banks of the Ōwheo/Water of Leith and a short easy walk to a range of motel accommodation, cafés, bars and main street shopping.

Our theme for this year's conference "Our water: a taonga in an ever-changing world" reflects the value of water to Aotearoa New Zealand and we look forward to hosting a diverse range of delegates from across the motu.

Ngā mihi nui , the 2022 conference committee

SPONSORSHIP OPPORTUNITIES

Visit the conference website for more information

CALL FOR SPECIAL SESSIONS

Email your submission to tracy@on-cue.co.nz

CLOSES: 31 AUGUST

ABSTRACT SUBMISSIONS OPEN

Registrations also opening soon!

ARTICLE

Earl Bardsley

Could Lake Hawea be restored?

Earl Bardsley, Yasaman Karaminik – School of Science, University of Waikato

Figure 1: Flooded forest remnant, Lake Hawea. Source: www.wanderlusters.com/snapshots-lake-wanaka-lake-hawea

Introduction

Lake Hawea was raised 18 metres in 1958 to provide additional storage capacity for the Roxburgh power station. It remains the only controlled storage lake for the Clutha hydropower scheme, which today comprises the Roxburgh and Clyde stations and is operated by Contact Energy.

Raising Lake Hawea created significant shoreline environmental impacts. In particular, the native forests of the lower Hunter River were flooded. Remnant portions of some of the dead trees still protrude above the lake today (Fig.1).

Hydropower operation of the lake has also imposed a seasonal water level variation of up to 8 metres. This contrasts with the original natural fluctuations of about 1 metre and with much shorter duration. The seasonal hydropower water level cycle coupled with episodic wave erosion creates a form of erosional sluicing that produces unstable retreating shoreline cliffs in some localities (Fig. 2). A related but less obvious impact is the reduction of aquatic plant diversity compared to nearby unmodified Lake Wanaka (Clayton *et al.*, 1986).

Restoring Lake Hawea to its original natural level of 328 metres has never been seriously considered. This would have the effect of reducing the commercial viability of the Clutha hydropower scheme because some spring/summer lake inflows could no longer be held back for higher winter electricity prices. Also, removal of the 352 GWh energy storage capacity from Lake Hawea would reduce the already rather minimal national storage capacity of 4472 GWh.

Figure 2: Eroding shoreline, Lake Hawea.

However, there is now possibility for a dramatic shift in New Zealand's hydropower storage scene. At about the time that this issue of *e-Current* goes online, the New Zealand government will announce whether the Onslow pumped storage scheme will be considered for final feasibility investigations. This is in the context of creating up to 5,000 GWh of energy storage buffer to protect a future low-emission economy from a dry year.

Possibility for restoration

Onslow development could conceivably result in a total 5,352 GWh of energy storage capacity in the Clutha catchment, counting the small Hawea contribution. The question then arises as to whether the Hawea component is still needed for hydropower operation, as measured against the public good alternative of lake restoration.

It would be an admirable example of corporate good citizenship if Contact Energy were to permit restoration of the lake back to 328 metres. This would involve giving up the possibility of constructing a small power station at the Hawea dam. Of more importance would be loss of ability for controlled seasonal water release from Lake Hawea for power generation.

In fact, restoration of Lake Hawea and removal of its seasonal storage role is not such a dramatic move for commercial hydropower. This is because the Hawea catchment is drier and controlled lake water release provides only a portion of the Clutha River flow at the Clyde and Roxburgh stations.

As an illustration, a check on the vertical axes in Fig. 3 shows that the October to December Clutha flow at Clyde is considerably higher than the June to August flow. This applies with or without controlled storage at Lake Hawea. That is, the Clutha hydropower scheme is essentially a run of the river situation already.

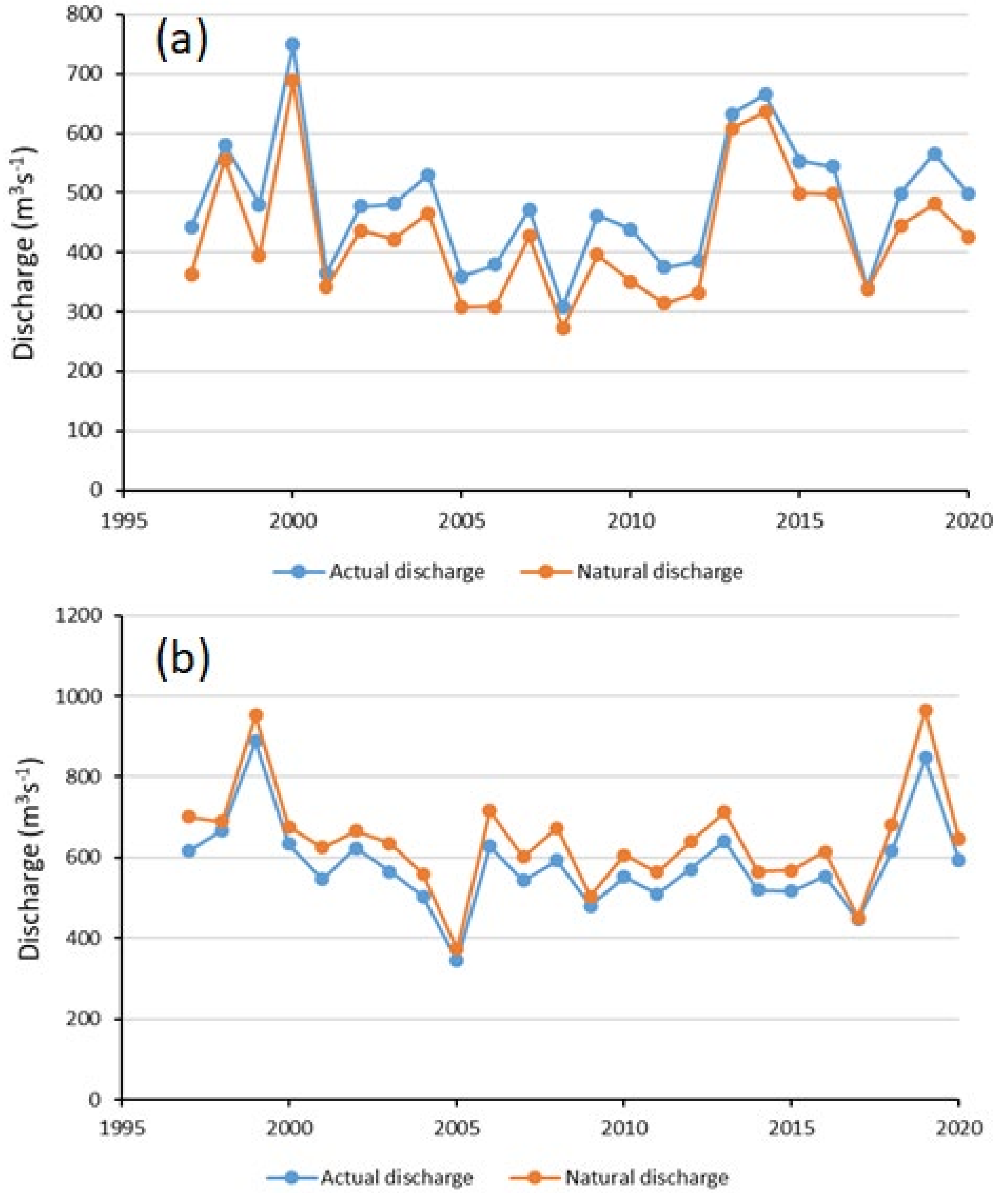

Figure 3: Mean Clutha flow (blue) as recorded at Clyde, and estimated natural Clutha flow at Clyde (orange) in the absence of Lake Hawea storage. (a) Mean flows for June, July and August, (b) Mean flows for October, November and December.

A commercial counterbalance to the loss of Lake Hawea seasonal storage will be the Onslow effect of flattening seasonal wholesale electricity price differentials, with winter prices decreasing (compared to the present) and summer prices increasing. Holding Lake Hawea water back for winter power generation is then no longer so important. Also, the higher summer prices will generate more electricity income from the high spring/summer Clutha flows. This might create economic viability for two further turbines at the Clyde Dam, which has inbuilt capacity for such expansion.

A restored Lake Hawea could still have a limited water storage role against brief inflow events. This would involve water level variations mostly within the original natural range, similar to the present operation of Lake Taupo.

The restoration process

Any major restoration project may raise concerns over associated environmental changes. One issue that is likely to arise with Lake Hawea restoration would be the possibility of groundwater bores drying up around Hawea township and Hawea Flat. This will depend on the extent to which bore water variations are driven by lake levels or by local rainfall recharge. If need be, arrangements could be made for provision of alternative water supply for irrigation and domestic use, which would seem a small price for lake restoration.

Figure 4: Lake Hawea as it would appear if restored to its original level. The green zones, presently underwater, are the main areas that were submerged when the lake was raised in 1958. Map source: LINZ.

The actual restoration, if it happened, would need to take place by separate increments of lake level lowering, to avoid dust issues and maintain shoreline stability. Most of the new land will be at the upper end of the lake (Fig. 4).

One feature of the restoration process would be the somewhat grotesque emergence of the skeletons of the sunken forest trees of the lower Hunter valley. Replanting the forest could start immediately and might be self-funding from carbon credits.

Conclusion

There is something of a mindset in New Zealand that past renewable energy developments should not be reversed, no matter how much environmental impact there may have been.

Hopefully, restoration of Lake Hawea would be the start of a new outlook. One thing we can be certain of is that if Lake Hawea was restored there would never be a call for it to be raised again.

Acknowledgement

All data represented in Figure 3 were kindly provided by Contact Energy, carrying no implication of Contact Energy agreement with any part of this article.

Reference

Clayton, J.S.; Schwarz, A.; Coffey, B. 1986: Notes on submerged vegetation of Lake Hawea. *New Zealand Journal of Marine and Freshwater Research 20(2)*: 185–189. https://doi.org/10.1080/00288330.1986.9516142

ARTICLE

Frederika Mourot

Groundwater can support resilience to climate change threats

Frederika Mourot, Rogier Westerhoff, Paul White and Stewart Cameron – GNS Science

Introduction

Adaptation to climate change threats has recently been at the centre of international and national discussions.

In late February 2022, the Intergovernmental Panel on Climate Change (IPCC) released its latest report, *Climate Change 2022: Impacts, Adaptation and Vulnerability*. This report looks 'at ecosystems, biodiversity, and human communities at global and regional levels. It also reviews vulnerabilities and the capacities and limits of the natural world and human societies to adapt to climate change' (IPCC, 2022).

In late April 2022, New Zealand's Ministry for the Environment published its first *Draft national adaptation plan* (open to consultation until 3 June 2022) to 'help Aotearoa New Zealand adapt to and minimise the harmful impacts of climate change' (Ministry for the Environment, 2022). This plan 'outlines the actions the government will take over the next six years to build climate resilience. It's a response to the priority climate-related risks identified in the National Climate Change Risk Assessment, released in August 2020' (Ministry for the Environment, 2020).

Our work

Early March 2022, the results of our work on groundwater and climate change were also published (Climate change and New Zealand's groundwater resources: A methodology to support adaptation) in an open-access international journal (Mourot *et al*., 2022): https://www.sciencedirect.com/science/article/pii/S2214581822000660

This research is timely with international and national interests and aims to highlight the crucial yet underrated role groundwater can play in building resilience to climate change threats. Aquifers are generally more resilient to hydrological changes than surface water bodies and buffer seasonal changes in temperature and rainfall (e.g. the Cardrona River and Wanaka Basin Aquifer in Otago; Fig. 1).

Figure 1: Drying reach of the Cardrona River in summer, Otago (Photograph: F. Mourot).

Our groundwater-related projections have been developed for an envelope of climate change scenarios and provide valuable insights to resource managers and communities to help build resilience to climate change threats in New Zealand.

The developed methodology uses national and sub-national datasets and models and is applied to two case study regions with contrasting climate change projections (Hawke's Bay and Otago). Its structure allows for future implementation in other New Zealand regions, which we expect to start from mid-2022.

Our paper is targeted at both scientists and policy audiences and covers:

- a detailed review introducing the basic knowledge needed to understand the issues and challenges of groundwater and climate change;
- some groundwater-related projections for two contrasted New Zealand case study regions;
- a comprehensive discussion on:
  - the limitations of the science of groundwater and climate change, challenges around uncertainty and identifying the unique effects of climate change (from effects of human activity and natural climate variability); and
  - the urgency that resource managers and communities initiate adaption actions.

Conclusion

The effect of climate change on groundwater is increasingly recognised, but a complete understanding of the processes and impacts on the resources remains limited in most countries, including New Zealand. However, groundwater can significantly support resilience to climate change threats if specific adaptation actions are taken now. For instance, focus on integrated approaches, embedding action effectiveness monitoring, and community engagement are recommended.

Acknowledgements

The authors also thank NIWA (A. Tait, P. Pearce and J.M. Woolley) for providing climate projection data. We also acknowledge the support from the Hawke's Bay (S. Harper, T. Farrier) and Otago regional councils (J. Rekker, M. Ettema, A. Levy, J.L. Payan and E. Gore).

The authors welcome comments and questions. Please address any correspondence to Frederika f.mourot@gns.cri.nz.

References and links

IPCC, 2022: *Climate Change 2022: Impacts, Adaptation and Vulnerability*. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. [accessed 2022 May 5]. https://www.ipcc.ch/report/ar6/wg2/

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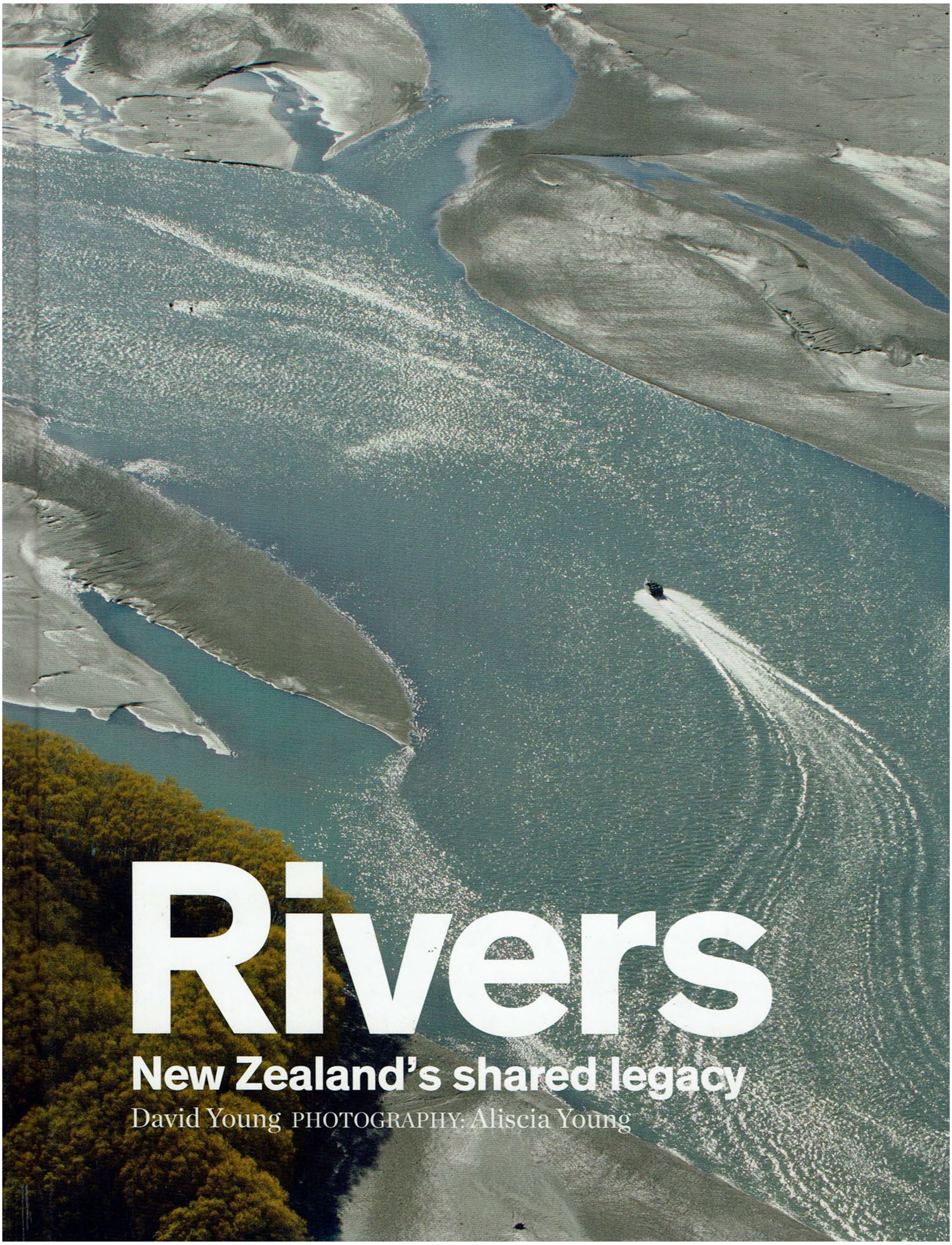
ARTICLE

Brian Kouvelis

Rivers – New Zealand's shared legacy



A small piece but important piece of history was missing from Richard Hawke's great publication documenting the last decade of the Society's activities and celebrating the 60th Anniversary of the Society in December 2021.

In my decluttering mode I came across my message below which I presented at the Society's Conference in 2013.. It sets out the Society's great support and sponsorship towards two iconic 'coffee table' books about New Zealand rivers written by my very good friend and author David Young.

I feel it is worth reproducing the message to that Conference for posterity's sake showing the generous support the Society has made to both of these iconic publications. Unfortunately, both are out of print but are well worth keeping an eye out for in second-hand book sales or Trade me if interested in obtaining copies. Last year, David Young published another very topical book with environmental/hydrological themes titled "Wai-Pasifika – Indigenous Ways in a Changing Climate". It is well worth checking this publication out. It is published by the Otago University Press, this time without any assistance from the Society.

Rivers - New Zealand's Shared Legacy

Message to the 2013 Rivers Hydrological Society Conference 2013 from Brian Kouvelis as sponsorship facilitator and technical coordinator for the book.

Journey of the book

Once upon a time, in 1981, the New Zealand Hydrological Society happened upon surplus funds from a well organised international conference. In November of that year these funds were put on term deposit at 15.5% interest rate! In July 1982 the Society established a "special publications" fund. After much deliberation as to what topic and form the first publication might be, assisted by the newly established fund, a contemporary book on New Zealand rivers was agreed upon. The belief was that the book would promote the aims and objectives of the Society for consumption by the great unwashed and uninitiated, about New Zealand rivers. The proposal by David Young for a book called "Faces of the River" was confirmed as the preferred publication in July 1983.

The writing, photography and publishing of the book was then developed as joint venture between the Hydrological Society and the Broadcasting Corporation of New Zealand - with agreement in principle between the two organisations established on 204 November 1984. The book was eventually published in February 1986 by TVNZ Publishing Ltd in association with the NZ Hydrological Society. The 5000 print run was sold out by February 1987. A real success story in itself!

In my view this original iconic coffee table book on New Zealand rivers, can still be regarded as contemporary in that it provided a view of how New Zealand rivers were perceived and managed at that particular point in time; the focus on the writing and anecdotal stories around the major rivers' flood protection schemes, the national hydroelectric power development schemes, mining and the emerging Iwi issues of the day.

Twenty five years on, I floated the notion at the Hydrological Society's 50' anniversary celebrations in December 2011 about the Society doing another similar book or updating "Faces of the Rivers" to pick up the changes in society's views on rivers and the change in focus on river management after 25 years. There appeared to be enthusiastic support for the idea. However, in terms of funding support, the Society indicated that it would not be able to contribute or commit to the same relative inflation adjusted level that it had back in 1984.

With the notion supported in principle by colleagues and undaunted about options on the funding aspect, I pursued the notion with my long-time friend and author David Young and photographer Bruce Foster. David was up for it, Bruce was already committed but would consider limited involvement to update photography and would supply his old plates. On closer analysis and given the developments in technology, it was agreed the photography needed to be fully updated as well as the writing. With a draft proposal in hand, we were then in search of a willing publisher. The proposal went into the melting pot of several publishers.

With inside assistance from my wife's relationship with Random House through her bookstore Popples and given the efforts by Random House rep Keith Bitchener, the book was selected eventually ahead of many other proposals for publication, much to our delight. The publication was scheduled to be in time for the 2013 Christmas market. David had a contract with Random House signed in November 2012. The issue of the photography needed to be resolved since Bruce Foster was not available within the allocated time frame. It was pleasing to see that Alicia Young, David's daughter, was selected as the preferred photographer from several others on the short list.

David and Alicia along with the publishers have done a brilliant job given timeframes and funding constraints.

Somehow, I inherited the tasks of sponsorship facilitator and technical coordinator for the book. This has been an interesting and challenging journey - but we've made it I! As with many projects these days there was scope creep and I undertook to bridge the funding gap through sponsorship which turned out to be a big ask in today's climate. The sponsorship side has been a mission and a journey in itself. I was thrilled that the Society after some deliberation by the committee, since we were out of sync with the special fund funding round, agreed to be part of the sponsorship programme and along with its logo and vision. These are displayed for posterity in the sponsors acknowledgement section at the end of the book.

The technical coordination of the appendices, mapping and editorial review was a privilege for me to be involved, albeit not without its moments. The major hydrological statistical appendix was facilitated by Jeff Watson at Horizons with his son Brent undertaking to update Maurice Duncan's original appendix, with the help of his counterparts in the Regional Councils across New Zealand.

There are many interesting comparisons to be made with 1986 summary hydrological stats table and the 2013 summary table 27 years on! g ; Manawatu mean flow 100cu.m/sec 1986, 116 cu.m/sec 2013; and Walau 103 cu.m/sec 1986, 97 cum/sec 2013 and the Clutha @Clydemax flood 2210 cum/sec @ 1986 cf 3450cum @2013

I note a number of low flow data have shown an increase in lowest flow on record from 1986 to 2013 - I haven't had a chance to follow up as to how this has occurred or can occur - presumably through reprocessing of earlier data or maybe application of Debroah Maxwell's data assimilation modelling ? There are also maximum flood flows scheduled in the 1986 appendix which have been decreased eg Waipaoa 3000 cum 1986 cf 2500 cum 2013 (post Bola) and Wanganui @Paetawa 6200 cum 1986 cf 4110 cum 2013

We had planned to have a water quality appendix but to establish this from scratch was not possible in the time frame we had. This aspect has been covered off in the appendicies by reference to the soon to be launched Land and Water Aotearoa (LAWA) website which will have flow statistics, water quality information and data, land use information and much more - mentioned by Michael McCartney yesterday. The official launch was to coincide with the launch of the book - unfortunately the it is delayed until March next year. The maps have been updated and an example of LiDAR technology has been included in the appendicies.

I strongly commend the book to you all. I trust you will enjoy it. It is timely and in my opinion, appropriately provocative in places. The book has already been nominated as a finalist in the NZ Post Book awards. Through David's research, interviews and writing, the book certainly demonstrates the marked change in emphasis and interest around our river systems.

The book includes comments on current public perception of rivers and identifies the new issues facing us in regard to river management. It is liberally peppered with anecdotal success stories in our new era of progress by collaboration.

Brian Kouvelis, Sustainable Futures NZ Ltd *9 November 2013*

ARTICLE

Michael Knopick

Asbestos in New Zealand's urban water mains: the impacts of aging infrastructure

Research update from Masters candidate Michael Knopick, University of Otago

Asbestos cement was a common construction material for water pipes during the twentieth century and my research investigated whether aging asbestos cement pipes, used for potable water distribution, are releasing asbestos fibres into New Zealand's municipal drinking water supplies.

The serviceable lifespan of an asbestos cement water supply pipe is estimated at 70 years but varies depending on water chemistry, trench backfill or water pressure, which may substantially reduce pipe serviceable lifespan. Most of New Zealand's source waters are soft (low calcium carbonate), making asbestos cement piping vulnerable to internal corrosion. Local predictive models of pipe lifespan due to deterioration range from 20 to 60 years, rather than the 70 years that is usual for piped networks overseas. Previous studies have estimated that 9000 km of asbestos cement mains in New Zealand will need to be replaced within the next two decades, with an estimated replacement cost in excess of 2.2 billion dollars. With such a large replacement cost looming, it is critical to discern which pipes are deteriorating and prioritisation for replacement.

This research used three key vulnerabilities that promote deterioration of asbestos cement pressure piping: the age and length of asbestos cement pipes that remain in use; the hardness of the potable water supply (aggressivity); and exposure to seismic ground disturbance. Christchurch experienced significant land deformation and intensive liquefaction associated with earthquakes in 2010–2011. As such, Christchurch has experienced considerable ground acceleration and cyclic loading that has (in some areas) adversely affected the integrity of the piped network. Since the earthquakes, much repair work has been undertaken on the piped network; however, desktop modelling indicates that 789 km of asbestos cement pressure pipes remain actively in use.

Methods

It was hypothesised that asbestos cement pressure pipe mains more than 50 years old are susceptible to corrosion and will release asbestos fibres into the potable water supply.

GIS analysis of the piped infrastructure was used to identify potential areas of pipe vulnerability. These data were combined with water age data provided by the Christchurch City Council and were used to delineate water exposure patterns to different lengths and ages of asbestos cement pipe in the network. From the desktop analysis, sampling locations were targeted to areas of potential concern: old pipes installed in areas that experienced liquefaction, as well as varying ages and lengths of asbestos cement piping. Hydrants and taps were sampled across most water supply zones from pipe networks older than 50 years (i.e., pre-1970s) to sample directly from the network and at end-use.

Twenty samples were collected from mains water supply via fire hydrants. Fifteen samples were obtained from households at domestic water taps (15 locations, 11 of which had first draw and flush duplicate samples).

Results from sampling were complemented with physical inspections of pipe conditions (deterioration measurements) and water aggressive index (AI) calculations. An AI was calculated for all hydrant samples where water quality parameters were observed (Ca hardness, pH, and alkalinity). The aggressive index was used as an indicator of

the tendency for calcium carbonate precipitate formation, which is known to form a protective deposit (scaling) on the interior of asbestos cement pipes. Without this scaling, a water supply is considered 'aggressive' and can cause the dissolution of the asbestos cement calcium matrix that bounds asbestos fibres in place, resulting in the release of fibres into potable water.

New Zealand does not currently have regulatory requirements for monitoring asbestos in drinking water, and our drinking water standards currently lack a maximum acceptable value for the contaminant. Therefore, this study employed an overseas accredited commercial laboratory to run transmission electron microscopy (TEM) under US-EPA protocols 100.1 and 100.2 to analyse for asbestos in drinking water. These are the most appropriate methods for analysing asbestos in drinking water and should be used when the best available analytical procedure is required. In a comparison to sampling completed in 2017 by the Christchurch City Council, our study indicated that polarised light microscopy (PLM) bulk analysis methods for detecting asbestos in building materials is not suitable for application to detecting asbestos fibres in drinking water and can produce false negatives.

Results

All of the hydrant samples (20) returned positive results for the presence of short chrysotile fibres asbestos fibres (> 0.5 µm) with an average concentration of 6.2 million fibres per litre (MFL). Short asbestos fibres (SAF) had the highest concentrations in drinking water samples, with five hydrant samples exceeding 5 MFL, including the highest concentration measured at 56 MFL. Nineteen (out of 20) of the hydrant samples showed long asbestos fibres (> 10 µm), with an average concentration 0.9 MFL. Asbestos fibres were detected in hydrant samples across all sampled pressure zones. The highest concentrations of fibres (as SAF) that exceeded 7 MFL were detected across Christchurch, and there is no discernable clustering at this scale of sampling. Additionally, 15 domestic water taps were also sampled and asbestos fibres were detected at 3 properties, averaging 0.2 MFL (> 10 µm) and 3.5 MFL (> 0.5 µm). There was no obvious spatial clustering to the positive detections in household water taps. Sampling was targeted to pipes installed from the 1930s to the 1960s and there was abundant evidence of fibres being released from pipes installed during this period.

The occurrence of positive samples and high fibre counts in our hydrants is significantly greater than what was observed in our end-use samples collected from household taps. It is possible that hydrant extraction, used to purge water from hydrant fittings, has mobilised fibres from asbestos cement pipe walls. However, consumer tap samples are not representative of the same degraded pipe lengths sampled from hydrants. This is because household samples across Christchurch were taken where permission to enter premises could be easily obtained. Further data are required to quantify the number of fibres reaching consumer taps, specifically in suburbs where hydrant samples have high fibre counts.

Project outcomes

The mains water supply in Christchurch is contaminated with asbestos fibres from decaying asbestos cement piping. However, the presence of asbestos fibre concentrations in Christchurch's drinking water is at present below the US-EPA (2015) guideline of 7 MFL pertaining to long fibres only (> 10 µm).

From this study it is evident that asbestos cement pipes are corroded by the soft (dissolved calcium average of 12 mg/L), highly aggressive municipal water supply, with mean lifetime corrosion rates of 0.20 mm a-1.

Municipalities should not continue to rely on aging asbestos cement piping, beyond its serviceable lifespan, because it will release asbestos fibres into drinking water.

Testing for asbestos fibres should be part of a long-term strategy for monitoring network integrity. It is recommended that all municipalities adopt monitoring of asbestos fibres from the reticulated water supply, especially as these pipes reach end of life. Asset managers should prioritise replacing pipes greater than 50 years in age, especially where high water pressures or land disturbance has occurred, to reduce the risk of water-carried asbestos being released into urban environments, and mitigate any risk of asbestos from ingested or re-aerosolised contaminated water sources.

Any future monitoring must ensure that samples are analysed using one of the standard TEM methods for the detection of asbestos fibres in drinking water. This will mitigate against false negative tests associated with other methods more suitable for bulk analysis.

This research was partially funded by a New Zealand Hydrological Society Project Fund and presented at the 2021 NZHS Conference in Wellington. My MSc thesis was submitted in January 2022. If you would like to hear more about this project, or have any questions regarding the work, you are more than welcome to contact me at:

Mknopick@engeo.co.nz

The findings of this research are also available to read online at: Water Supply

ARTICLE

Andrew Fenemor

Themes from the Modelling for Management workshop

New Zealand Hydrological Society conference, Te Papa, 2 December 2021

Organisers: Channa Rajanayaka[1], Joseph Thomas[2], MS Srinivasan[1], Julian Weir[3]

Facilitator: Andrew Fenemor[4]

[1] NIWA, Christchurch
[2] Tasman District Council, Richmond, Nelson
[3] Aqualinc Research Limited, Christchurch
[4] Manaaki Whenua – Landcare Research, Nelson

This is a synthesis of themes and commentary provided by presenters and workshop participants but is not a complete nor necessarily a consensus record of the views expressed at the workshop.

Workshop outline

Workshop Introduction and overview of NPSFM (Andrew Fenemor)

Te Mana o Te Wai – Rehabilitating Waterways, Working with Councils, and Thinking About Governance (Betsann Martin and Thompson Hokianga)

Environment Canterbury: Catchment Scale Models – which ones and why? (Carl Hanson)

Marlborough District Council: Wairau aquifer groundwater model (Peter Davidson and Eddie Wohling)

Greater Wellington Regional Council: Community limit-setting processes (Mike Thompson and John Bright)

Tasman District Council: Motueka-Riwaka groundwater model (Joseph Thomas and Julian Weir)

Waikato Regional Council: Integrated modelling for limit setting (John Hadfield)

Panel discussion (facilitated by Andrew Fenemor)

Context

Modelling is an informed attempt to predict future impacts of human activity, commonly through simulating a range of scenarios.

Important principles of integrated catchment management (ICM) include the non-unique nature of cumulative effects, and the need for collective action to achieve desired outcomes. Therefore, there is no single ‘right’ answer from modelling.

Models span simple (even qualitative) relationships between cause and effect right up to complex 3D spatio-temporal models of catchment processes and outcomes.

The NPSFM (2020) requires regional councils to set water take and water quality limits for all New Zealand catchments/FMUs by December 2024 (Otago Regional Council aims to complete this by December 2023). This is a huge undertaking very much reliant on good predictive modelling tools.

Among the big challenges are what might be described as the constraints of the Management Science or Policy Science: the methods and directives imposed by legislation and existing policy (e.g. environmental flow setting, Te Mana o te Wai (TMOTW), first-in first-served water allocations, water quality accounting, attribute monitoring against national limits, etc.) and consideration of how to transition from current policy to NPSFM-compliant future policy and rules.

'Adequate' models link system knowledge with the scale and scope of expected policy outcomes.

Te Mana o te Wai (TMOTW)

The NPSFM (2020) requires water management that provides for Te Mana o te Wai. TMOTW recognises that protecting the health of freshwater protects the health and well-being of the wider environment. TMOTW is about protecting the mauri of water bodies.

It is also about sharing decision-making about water between tangata whenua and other New Zealanders through six principles (NPSFM 1.3[4]): Mana whakahaere, Kaitiakitanga, Manaakitanga, Governance, Stewardship and Care & respect.

The challenge for policymakers, scientists, tangata whenua and modellers is how to practically implement the hierarchy of obligations in Te Mana o te Wai that prioritises (NPSFM 1.3[5]):
(a) first, the health and well-being of water bodies and freshwater ecosystems
(b) second, the health needs of people (such as drinking water)
(c) third, the ability of people and communities to provide for their social, economic, and cultural well-being, now and in the future.

Giving local iwi and hapū a voice will be fundamental for understanding and modelling the varied values and aspirations for water bodies within their rohe.

Iwi and hapū are being asked to develop statements of what TMOTW means to them.

Given the tight timeframes for limit-setting, it is desirable that we now get on with understanding values associated with TMOTW in partnership with manawhenua iwi/hapū.

Matauranga and tikanga are vital contexts: while modelling of holistic values such as mauri may be difficult, they need consideration; one place to start is mapping of mahinga kai, since that is a compulsory value for consideration under the NPSFM (2020).

Conceptual models

Simple representations of processes and connectivity help to understand system behaviour – these are the conceptual models that are the foundation for numerical models.

Most important is to have a sound conceptual model.

A focus should be on developing suitable conceptual models of cause and effect.

Modelling is useful in itself for helping the modellers and policymakers to understand the system.

System models are more than just the biophysical; they should also consider relevant economic, social and cultural values.

We need to consult early, especially with iwi/hapū partners, and recognise that they can contribute their own 'models' of Te Taiao, built on concepts such as matauranga, whakapapa and tikanga.

Data Needs

Good land use and land management datasets are needed for modelling water quality outcomes across catchments.

Good water use data is needed for modelling water flow and level outcomes.

Systematic water accounting methods are needed to be able to determine levels of under- and over-allocation from limits, and this is easier when regional councils have consistent templates to guide how they specify consent allocations and interpret existing consent formats.

Model boundaries may constrain a model domain artificially, so it can be worthwhile checking sensitivities to alternative boundary configurations (e.g. choices of model boundary conditions affecting cross-boundary temporal fluxes in groundwater systems).

Integration with flood and river channel management may be needed when modelling regional groundwater outcomes, especially if flood and riverbed levels drive groundwater recharge.

Climate change means the end of stationarity in hydrological data, which will increase modelling complexity.

Modelling changes in land use and other landscape parameters (e.g. riverbed levels) over time is necessary and is increasingly complemented by back-casting (modelling of historic extremes such as drought, peak dairy, pre-development land cover etc).

Uncertainty, assumptions and risk

Uncertainties of modelling are often hard for policymakers to understand and factor in (and can be hard to quantify anyway).

Explaining uncertainty can sometimes undermine model credibility when the model is actually the best predictive tool available – always ask yourself "what's a better tool or method?"

Often the uncertainties associated with our conceptual model far outweigh uncertainties across the datasets employed within our chosen model.

Calibration/validation of model results is vital.

Models are very useful for identifying primary drivers of the system, which may not all be obvious conceptually.

Be prepared to adjust your conceptual framing as new data and model calibration reveal alternatives.

Data limitations and non-quantifiable values

Model development should cease if progress is not being made with a particular approach. It is hard to make this type of decision.

Be aware of risk of staff burn-out especially with tight deadlines. Planning appropriate data collection and staging model development allows time for considered interpretation and validation, explanation, dissemination and translation of results for users.

Many attributes are not quantifiable, especially socio-cultural attributes and values, so recognise that decision-making is a political process informed by science knowledge, modelling and inferred values and attributes.

The modelling process

Models are most handy if you already have them, otherwise keep them simple, especially if under time and cost pressures.

Co-design of management modelling with policymakers and users is important; recognise that the modeller may think they know what's wanted, but they may also have only a partial or biased view of what's needed and possible.

Expert panels are useful when time constraints don't allow detailed modelling to be carried out.

Know your decision-makers to tailor results to their needs.

Continuity of personnel involved in modelling for management, whether science, policy or consultancy staff, is beneficial to avoid reinventing the wheel.

The process of modelling can itself be a brake on development, as users expect regulation or await information on likely policy direction (if there are opportunities to game the rules; it may, conversely, be a trigger for a gold rush, for example for water allocations before rules are tightened).

Water quality modelling, e.g., isotope modelling, can unseat flow calibration, but all forms of triangulation of different streams of evidence are useful to build consensus on the conceptual model underpinning numerical modelling.

Water quality modelling is proving much more difficult than flow modelling due to high variability in parameters, high complexity in water quality, ecological and isotopic processes, and uncertainties in important processes such as denitrification and the concept of limiting nutrients in receiving waters.

River–aquifer interaction needs more consistent policy approaches, e.g., to define the circumstances when and how depletion of river flows by groundwater pumping should be considered.

For easier explanation of modelling results, and rapid estimation of intermediate scenario outcomes, there is a role for Emulators (simplified representations of complex models).

Hypothesis testing and scenario simulations are useful strategies for testing conceptual models and management options.

Models as assets

Models for decision making differ from models for research.

Management models should be developed and treated as assets subject to ongoing improvement and maintenance.

Modelling consultants can become de facto holders of council IP, so part of their contracted role should be transfer, training and maintenance of the model as an asset.

Questions discussed in plenary

1. *Given the directive of the NPSFM in setting water take and quality limits on all catchments by 2024, what are characteristics of the most useful models for this task? What modelling, if any, would help in implementing Te Mana o te Wai?*
    - Models that identify primary drivers and 'choke points' for action
    - Models that are adequate, not necessarily highly detailed
    - Models that address desired outcomes, e.g., through scenario runs
    - Models that span all relevant values, not just those amenable to quantification
    - Talk to manawhenua about what models or views of Te Taiao make sense to them.
2. *What do regional councils and iwi most need from modellers to get the limit-setting task completed?*
    - Listening and explaining, co-development with outcomes continually in mind
    - Modellers should 'get out of the way' and not assume they know what's needed.
3. *What are the main uncertainties, assumptions and risks in decision making with models? How might these be addressed – what do the councils need to be comfortable these have been addressed?*
    - See notes above
4. *How could the New Zealanad Hydrological Society assist with 'modelling for management' over the next three years?*
    - Could be a liaison channel for MfE staff charged with providing guidance on limit setting
    - Be a forum for a follow-up workshop on the more detailed issues relevant to catchment limit-setting, including modelling.

Notes by Andrew Fenemor

Presented at the 2021 NZHS Conference

2021 NZHS award winner citations

Nomination for Murray Hicks — Outstanding achievement award

Murray Hicks is recognised as a national and international leader in the field of sediment transport and related geomorphic processes in river and coastal environments. Murray has made an outstanding contribution to the advancement of knowledge in this area.

Murray graduated from Otago University with a double major in engineering and geology and began working on sediment processes in 1977, starting his career at the Water and Soil Division of the Ministry of Works and Development (MWD). There he learnt the trade of suspended sediment and bedload sampling with George Griffiths and Mauri McSaveney, as part of the Alpine Processes research programme. In 1980 Murray was awarded a Fulbright Scholarship to complete his Ph.D. in Earth Science from the University of California at San Diego, where he specialised in coastal processes studying under Doug Inman, but also studied river geomorphology and sediment transport under Luna Leopold. In 1985 Murray returned to New Zealand to work for MWD, then DSIR, and transferred to NIWA when it was established in 1992. Murray has recently retired but during his time at NIWA he was Principal Scientist in River and Coastal Geomorphology. He managed the Sediment Processes Group, and then the Sustainable Water Allocation Research Programme which focused on understanding the implications of changes in flow regimes on river geomorphology and ecology.

Murray has written or co-authored more than 140 consulting reports and more than 90 scientific publications. His contribution to assessing sedimentation effects in catchments and on adjacent coasts undergoing hydropower or water abstraction investigations are considerable, including work on the Clutha, Waiau (in Southland and Canterbury), Waikato, Mohaka, Mokau, Kaituna, Mokihinui, Hurunui, and Lower Waitaki. His research has encompassed sediment studies across the complete range of environments in New Zealand, from the wildest parts of the Southern Alps to the most intensively used catchments for horticulture and urban development.

Murray's research has a considerable and ongoing impact on the understanding and management of New Zealand rivers. Murray helped establish a national sediment gauging programme, he co-wrote (with John Fenwick) the NIWA suspended sediment monitoring manual, and led development of the Suspended-Sediment Yield Estimator, a raster-based GIS tool for assessing the specific suspended-sediment yield from New Zealand's rivers and streams. Murray co-authored the book *Roughness characteristics of New Zealand Rivers* with Pete Mason in 1998, which continues to be widely used and has been reprinted numerous times to meet ongoing demand. Since 2000, a significant amount of Murray's time has been spent on braided rivers, notably the Waitaki and Waimakariri, and has involved helping pioneer the use of airborne LiDAR and digital photogrammetry to capture channel topography and morphological change. This developed into the use of 1D and 2D numerical models to predict reach- to basin-scale changes in bed levels, bed-material size grading, and coastal sediment exports as a result of dams and water diversions. Murray has also continued to contribute in the suspended sediment space in recent years, including developing national and regional empirical models predicting sediment yields, contributing to Ministry for the Environment studies to underpin the inclusion of sediment in the National Policy Statement for Freshwater Management and co-writing the National Environmental Monitoring Standards for turbidity and suspended sediment. His research expertise covers the full range from high quality data collection to process understanding to leading edge modelling approaches and management applications.

Murray remains a valued member of the New Zealand Hydrological Society and has been very generous in mentoring younger scientists in both NIWA and regional councils. I would like to nominate him for an Outstanding Achievement award in recognition of his contribution to hydrological science in New Zealand.

Nomination for Dr Liping Pang — Outstanding achievement award

We nominate Dr Liping Pang for her technical innovation, contribution to advances in knowledge, and outstanding achievements. Liping has successfully led the development of novel pathogen mimics and synthetic DNA tracers for water applications. She established an internationally widely used database of microbial removal rates in subsurface environments. As part of UNESCO's Global Water Pathogen project, Liping summarised current knowledge about microbial transport and removal in subsurface media into an outstanding reference book chapter ('Evaluation of subsurface microbial transport using microbial indicators, surrogates and tracers'). Liping's colloid-associated contaminant transport work and development and validation of new contaminant transport models have advanced our understanding of the processes and mechanisms underlying subsurface contaminant transport. The new tools and knowledge generated from her work have made a real difference towards better protecting freshwater resources and safeguarding drinking-water supplies.

Contribution to new knowledge

Liping devised a novel 'micro mimics' concept. She pioneered the development of novel surrogates using biomolecule-modified particles, and lately DNA-encapsulated food-grade biopolymer particles, to study pathogen removal and transport in subsurface environments and engineered water systems. The new *Cryptosporidium*, rotavirus, adenovirus and norovirus surrogates significantly outperformed existing surrogates, namely MS2 phage for viruses and unmodified beads for *Cryptosporidium*. Currently, they are developing surrogates for studying *Legionella's* mobility and persistence in the plumbing. This approach has opened new avenues for assessing pathogen removal in water systems. Pilot water treatment studies have revealed the inadequacy of turbidity for evaluating protozoan removal. Thus, New Zealand's drinking-water filtration systems can now be assessed for their protozoan and virus removal efficacies.

Liping has led the development of novel synthetic DNA tracers (free and encapsulated) for tracking water contamination. Twenty DNA tracers, which can be used concurrently to track multiple contamination sources and pathways, have been developed and validated in some field conditions. The technology could also be applied globally in food security, insurance, forensic, hospital and ecological investigations.

Liping developed a comprehensive and unique database of microbial removal rates in subsurface environments. It is frequently used in New Zealand and overseas to assess groundwater microbial contamination, determine setback distances (e.g., New Zealand guidelines) and select effluent disposal sites.

Nomination statement

Liping's teams have successfully developed novel pathogen surrogates for water applications. Studies in New Zealand and overseas have proven the usefulness of the new surrogates for mimicking pathogen transport and removal in aquifer media, water treatment processes, and wastewater land disposal. This work has increased research programme investment significantly, including two ESR Pioneer projects, two Marsden projects, one Health Research Council project, and international collaborations. Pilot studies with water industry have generated notable results that challenge the conventional use of turbidity and E. coli to assess microbial water safety. End-users remarked that this work could influence improvements in water quality standards internationally and help reduce drinking-waterborne infection risks.

The novel and versatile DNA tracers developed by Liping's teams are promising tools for concurrently tracking multiple water contamination sources and pathways. Research impacts will include better mitigation strategies for protecting freshwater resources locally and worldwide. Additionally, the technology can be applied across different sectors. The pathogen mimics and tracking tools have attracted interest from KiwiNet for potential commercialisation.

Liping developed a comprehensive database of microbial removal rates in subsurface environments, which has been used frequently by New Zealand and overseas end-users. Liping summarised the current knowledge in a book chapter for UNESCO's Global Water Pathogen project, titled 'Evaluation of subsurface microbial transport using microbial indicators, surrogates and tracers'. Her colloid-associated contaminant transport work, and development and validation of new contaminant transport models have contributed to a better understanding of contaminant transport processes and mechanisms in subsurface environments.

Liping's science excellence is demonstrated by her success at winning awards and highly contestable grants. She was awarded three Marsden Fund grants to explore viruses hitching rides on colloids in groundwater (2006), to mimic rotavirus transport in groundwater (2011), and to study Legionella in plumbing systems (2016).

While receiving her last Marsden Fund award in late 2016, she received an MBIE Smart Ideas grant to develop synthetic DNA tracers and an Health Research Council grant to assess New Zealand's drinking-water filtration systems using the new surrogate technology. Liping earned ESR's Science Excellence Awards in 2006 and 2017. She has published 58 peer-reviewed papers plus 22 technical reports (not in CV), and her publication on protozoan surrogates received ESR's Best Paper Award in 2013.

Liping has a national reputation for her work. Together with two other Marsden-funded women, Liping was profiled for Ada Lovelace Day in 2017. She featured in Our changing world on Radio NZ for her pathogen mimics work. She is an Associate Investigator at the Biomolecular Interaction Centre, University of Canterbury, and was an Honorary Fellow at the Department of Chemistry, University of Otago.

Liping's work has also gained international recognition. She was a keynote speaker at two international conferences. She was invited to co-author a book chapter for the UNESCO's Global Water Pathogen Project, contributed to Vienna University of Technology's Doctoral Programme on Water Resource Systems as a Guest Lecturer, and collaborated on several research projects and proposals with her overseas colleagues. In particular, her pathogen surrogate work has attracted international interest.

Nomination for Uwe Morgenstern — Outstanding achievement award

Uwe Morgenstern is an internationally recognised water dating expert who has produced a considerable amount of high-quality, rigorous scientific research over a substantial time period.

Uwe obtained his Ph.D. in isotope hydrology in 1992 at the University Bergakademie Freiberg, Germany. After a short stint of post-doctoral research and a lectureship in Germany, Uwe moved to New Zealand to join the tritium laboratory within the Institute of Nuclear Sciences of DSIR, working with Claude Taylor and Vanessa Trompettor (then Fox). The tritium laboratory became part of the Institute of Geological and Nuclear Sciences (GNS Science) after the disestablishment of DSIR in 1992.

Subsequently, Uwe took over leadership of the GNS Science Isotope Hydrology Team and Water Dating Laboratory in 1997. He has held these roles for more than 20 years. Over this time, he has pioneered the use of age tracers for understanding hydrology in New Zealand and overseas. He is a world expert in the measurement and use of tritium and silicon-32, along with other water age tracers including chlorofluorocarbons, sulphur hexafluoride and carbon-14.

Uwe's water dating work has generated significant scientific advances within the international hydrological community. In particular, Uwe's work with colleagues Mike Stewart, Roland Stenger, Jeff McDonnell, Laurent Pfister and Ian Cartwright showed how the tritium water dating technique could provide important new insights into the travel times of water through aquifer systems and within catchments. Since the 1990s, catchment travel times had been evaluated primarily using the stable isotopes, deuterium and oxygen-18, measured in stream flow. But using tritium dating, Uwe and his colleagues demonstrated that deeper groundwater contributes more to streamflow than had been previously understood from conventional stable isotope-based hydrograph separation. For example, application of these tritium water dating techniques in Toenepi Stream revealed significant variations in mean water transit time as a function of stream flow, from very old water (up to 160 years) at low flow rates to very young water (1–2 years) at high flows. These insights led to an international 'call to action' for hydrologists to start using tritium to gain important new understanding in the ways that catchments store and transmit water.

The impact of Uwe's research has extended well beyond the scientific community. Throughout his career, Uwe has collaborated closely with end-users, notably regional councils, to apply water dating to the management of groundwater and surface water resources. For example, his work showed that tritium dating could be used to measure the timeframes of nutrient input to Lake Rotorua, where water quality has declined significantly over the past 50 years despite recent efforts to halt the decline. The water dating results, combined with measurements of surface water and groundwater chemistry, showed that the nutrients causing eutrophication of the lake are nitrates from agricultural activities and phosphates from geological sources. The naturally high phosphate load reaches the lake continuously via groundwater-fed streams, and therefore the only effective way to limit algal blooms and improve lake quality would be by implementing land and water management approaches to limit the nitrate load. Uwe undertook similar work to assess lag times and 'load to come concepts' in the Lake Taupo catchment, which was fundamental to ground-breaking land-use management policy development by Waikato Regional Council. Such future scenario considerations in policy are now well-established in other regions.

Uwe's research into water dating to understand catchment processes naturally expanded into other areas of hydrological research. For example, Uwe's team has been instrumental in demonstrating the value of water dating in long-term water quality monitoring programmes, for instance to determine the baseline quality of natural waters. Uwe's water dating results are also being increasingly used in the construction and calibration of numerical groundwater models. In a world-first application, water dating is also used in New Zealand to assess the security of human drinking water supplies by assessing the fraction of young water.

Uwe's applied and scientific work has extended into a variety of other disciplines outside of hydrology. His scientific contributions also figure prominently in the reconstruction of past climates through dating calibration of timescales for sediment and ice cores, most notably in New Zealand's rapidly disappearing glacier resource, but also for cores collected in Tibet, the United States, Bangladesh, Russia and Antarctica.

Uwe's scientific achievements have been enabled by the world-leading low-level tritium analytical capability of his laboratory, originally achieved under the leadership of Claude Taylor. This analytical expertise is shown by tritium laboratory intercomparisons that have been conducted by the International Atomic Energy Agency (IAEA) every few years since 1965. The GNS water dating laboratory is consistently rated as first-rate, often being up to several times more accurate than the second-placed laboratory. Indeed, this analytical expertise has led to Uwe's ongoing involvement in training for other nations through a variety of IAEA programmes and projects.

Uwe has been a member of the NZHS since 2000 and is a regular presenter at Annual Conferences. Always focused on scientific rigour combined with practical applications for water management solutions, Uwe has a long and established track-record of outstanding contributions in hydrology befitting of the NZHS Outstanding Achievement award.

Nomination for William Dench — Early career scientist award

Thank you for contacting me to provide details to support William Dench for his nomination for the New Zealand Hydrological Society Early Career Scientist Award.

William has been working on hydrogeology projects associated with the Hekeao - Hinds Catchment in Canterbury since he started his Master Degree in Water Resource Management in 2015. His Masters thesis is titled:

Identifying changes in groundwater quantity and quality resulting from border-dyke to spray irrigation conversion (William Dench, 2017).

Following graduation from the University of Canterbury, William worked for MHV Water. During this period William gained valuable field work experience while implementing a groundwater and surface water monitoring program and carried out a research program to better understand groundwater age, flow and quality under the Hinds Plains. William was integral to the installation and monitoring of twelve small Managed Aquifer Recharge (MAR) sites across the Hinds Plains. He set up instrumentation and operated a testing regime to determine potential soakage rates over the twelve sites. William contributed to the preparation of the Hinds/ Hekeao Year 2 MAR report which documented the testing results. As part of this MAR project William was a member of the Hinds/Hekeao Managed Aquifer Recharge Technical Group.

William has been working at Wallbridge Gilbert Aztec (WGA) since August 2019 and during this time he has been developing his skills in groundwater modelling, pumping test analysis and other hydrogeological assessments. He has recently completed a complex groundwater model for an aquifer storage and recovery project in Melbourne. He has also worked on groundwater models in South Australia and has been supporting MAR projects across New Zealand.

William recently published findings from his Masters Thesis, taking annual leave to finalise the paper and respond to reviewers comments.

Dench W.E. and Morgan L.K. Unintended consequences to groundwater from improved irrigation efficiency: Lessons from the Hinds-Rangitata Plain, New Zealand. Agricultural Water Management Volume 245, 28 February 2021, 106530.

https://www.sciencedirect.com/science/article/abs/pii/S0378377420320771

William is dedicated, patient and thorough in his approach to hydrogeology research and modelling. He is building skills to become a well-rounded hydrogeologist with a broad range of skills and knowledge. It is my pleasure to support his nomination to reflect the dedication and discipline he has shown to persevere with getting his work published while still early in his career.

UPDATE

Compiled by James Griffiths

NIWA Update

Thermal imagery helps identify hyporheic seeps in the Selwyn River

NIWA is a key science provider on the MBIE Endeavour programme 'Subsurface processes in braided rivers' (being led by Lincoln Agritech). A key component of this research is understanding how river morphology influences water exchange, including hyporheic flows (water that flows through the gravels just below the surface). NIWA has developed a method of mapping hyporheic seeps (areas gaining flow from the subsurface) using a high definition thermal imaging camera (the FLIR T1010) deployed on a UAV (Unmanned Aerial Vehicle). Thermal infrared data are converted to water temperatures, highlighting temperature anomalies (Fig. 1).
By flying at first light on a cold morning, hyporheic seeps can be identified as areas of water warmer than the surface water in the river and warmer than the ground surface, as hyporheic water flows through the gravels which have retained heat from the previous day. By understanding surface water–groundwater exchange processes in braided rivers, we aim to answer questions about how river management influences groundwater recharge into some of New Zealand's most important aquifers. [Hoyle, Bind, Sutton, Kang, Measures]

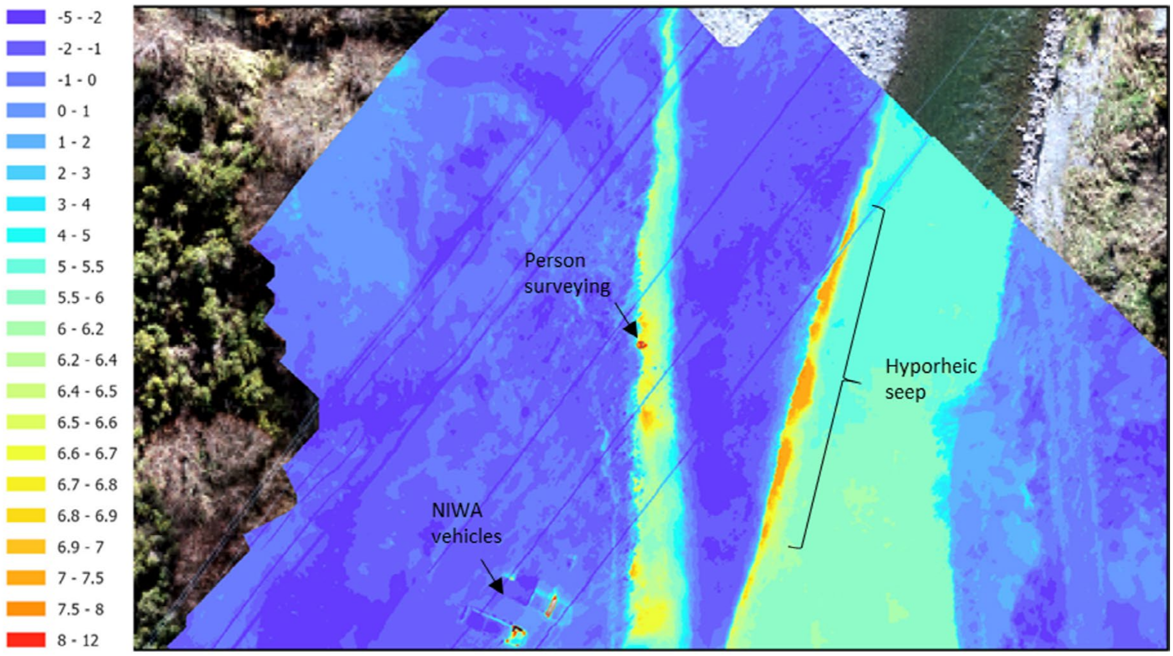


Figure 1: Thermal imagery from the Selwyn River showing a hyporheic seep through a gravel bar. Also visible are a person surveying and two NIWA vehicles. The scale to the left shows the temperature in degrees Celsius.

Flood forecasting support for West Coast Regional Council

During the West Coast flooding events experienced in February 2022, NIWA's operational flood forecasting team led by Céline Cattoën-Gilbert provided invaluable information to support the West Coast Regional Council's (WCRC's) emergency response team. Drawing on national and site-specific weather, sea-level and flood forecasting models and tools developed by NIWA, WCRC were provided with information on the timing and magnitude of peak flow and the likely areas of inundation. In particular, decisions to evacuate residents in the Westport township and mobilisation of resources further north were underpinned by probabilistic weather and flood forecasts from NIWA models. For this, NIWA analysed a combination of existing operational models (including NIWA's convective scale-based weather models shown in Fig. 2).

NIWA's field and environmental information teams also played a crucial role in securing real-time river gauge data quality and telemetry. This included the rapid mobilisation of the Greymouth field team to maintain and repair key stations that were damaged during the flood event. The floods highlighted the vital role NIWA plays in national-level flood forecasting and in supporting regional/local councils when the needs arise. The events, along with the July 2021 flooding, also highlighted gaps in current operating frameworks when it comes to national-level flood hazard risk forecasting, which the team are now working on. [Cattoën-Gilbert; Measures; Brandolino; Smart; Flanagan; O'Driscoll; Williams]

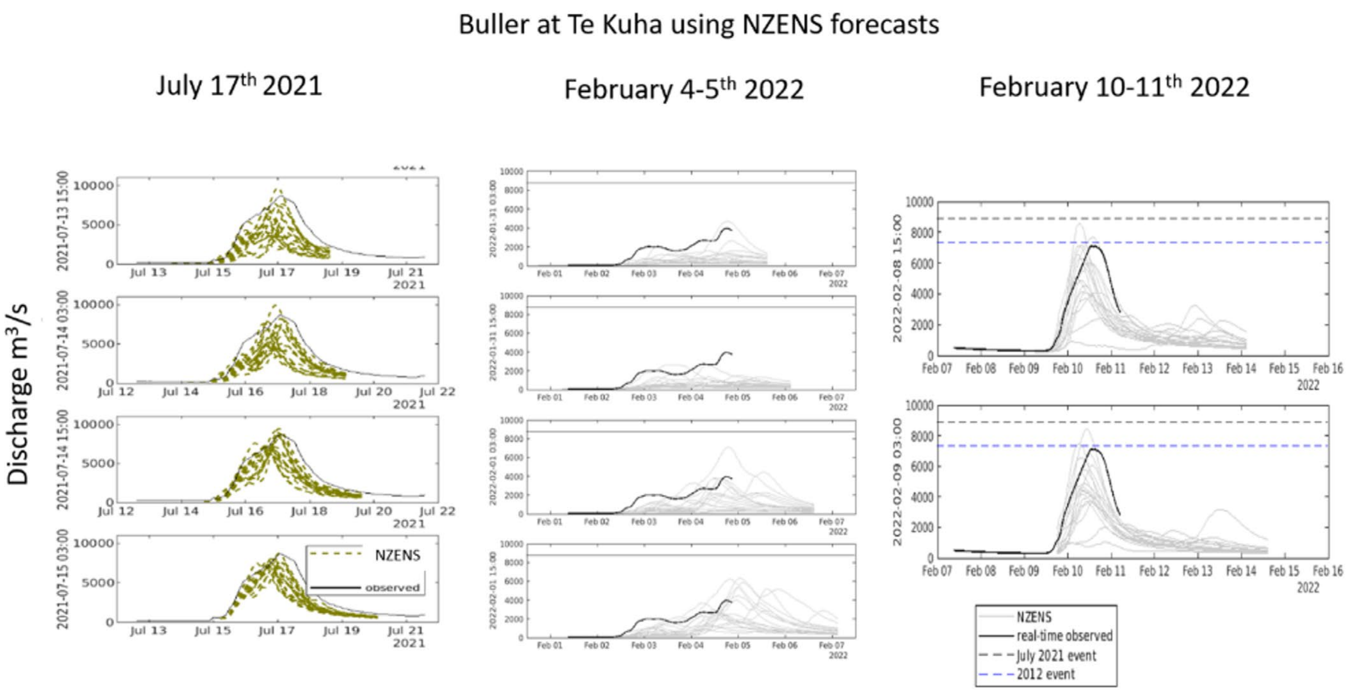


Figure 2: Example of NIWA's ensemble probabilistic flood forecasts showing the range of potential scenarios. Spaghetti plots are indicative of ensemble members.

Meta-modelling 'naturalised' groundwater levels across Greater Wellington Region

NIWA was contracted by Greater Wellington Regional Council to extend the naturalised groundwater levels across the region from 2007 to the present time. The naturalised groundwater levels were previously simulated using physically-based groundwater models, that assumed a no-abstraction scenario. NIWA have developed a meta-modelling approach based on stepwise linear regression to emulate the functionality of previously applied physical-based models, for the three primary aquifers in the region (Wairarapa Valley, Hutt Valley and Kapiti Coast). The inputs for the metamodels included precipitation, air temperature, and potential evapotranspiration, which represent land surface recharge into groundwater system, and river flow data, which represent the interactions between river and groundwater systems. The metamodels were calibrated and validated against the available naturalised groundwater level time-series data from previously developed physical-based models. The calibrated metamodels were then used to develop the naturalised groundwater levels from 2007 to 2021. Generally, the metamodels showed good simulation results in all three primary aquifers with model performances for 36 out of 47 wells classified from "Satisfactory" to "Very Good". [Yang, Rajanayaka, Daughney]

Bathymetry estimation from LiDAR – Flood Resilience Aotearoa MBIE Endeavour Programme

As a part of the production of hydrologically-conditioned digital elevation models (DEMs) for the Flood Resilience Aotearoa MBIE Endeavour programme, NIWA have been exploring approaches for estimating river channel (cross-sectional) depths in places where such measurements are unavailable. This will allow better representation of channels within conditioned DEMs and, in turn,

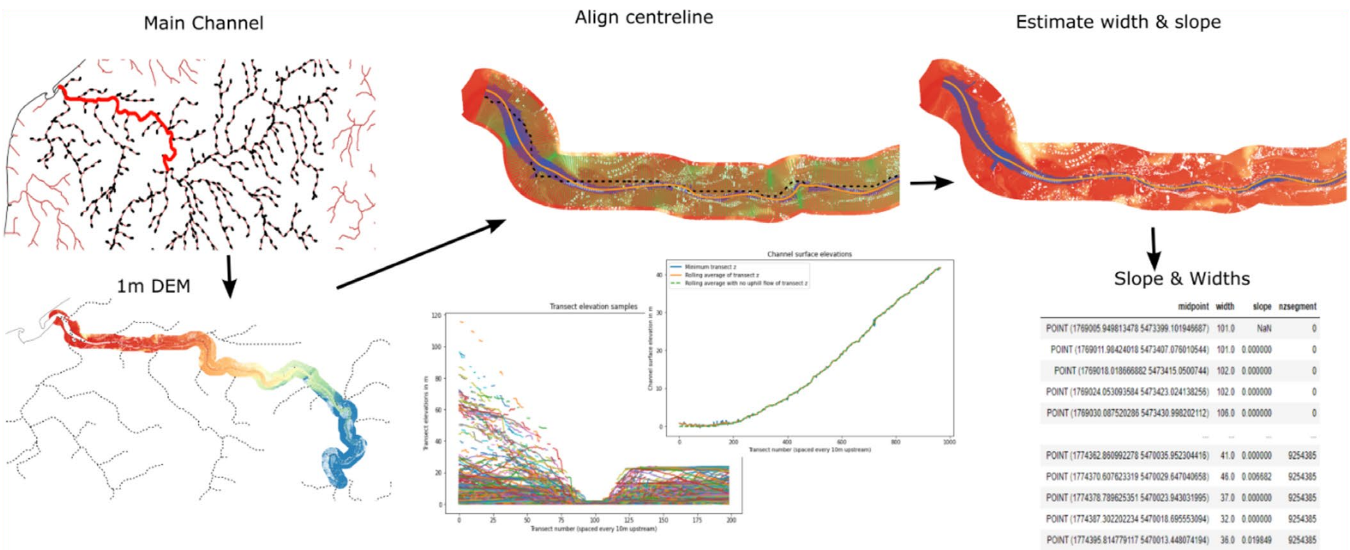


Figure 3: Automated workflow for estimating river channel depths. Flow and bed friction for each river segment are extracted from the REC; a 1m DEM obtained from LiDAR is aligned with the channel and used to calculate channel width and slope; the channel geometry is then inferred from empirical relationships.

improve the quality of the hydrodynamic model outputs. The approaches considered so far require an estimate of channel-forming flow, channel-bed friction, channel slope, and channel width. The bed friction and flows were estimated from the River Environment Classification (REC) and NIWA's Flood Statistics map, respectively, while the channel width and slope were estimated from LiDAR data. Channel depth was then estimated using empirical relationships that describe channel geometry. The process was automated following the workflow shown in Figure 3. Whilst the initial results validated against measured cross sections in the Waikanae and Westport catchments are promising, more robust validation are planned. [R Pearson, Wilkins, Lane]

Sub-surface forest flows

NIWA scientists visited Mahurangi Forest (Auckland) and TeHiku Forest (Northland) to assess the utility of Ground Penetrating Radar to characterise subsurface soil and geological structures. The results are looking promising as both sites exhibit quite distinct characteristics which should be relatively identifiable. Whilst on site, scientists responded to a request from Scion (who are funding the research under the Forest Flows project) to assess the utility of using the same equipment (albeit a different sized radar antennae) to identify the location and density of tree roots (Fig. 4 shows mark-out of measurement grid and measurement validation). Results from the investigation will provide scientists in the larger project with invaluable information for development of conceptual and numerical models of subsurface water and moisture movement. This information will in turn be used to assess the impact of forestry on water resources for different soil types (Woolley, Griffiths, Dudley).

Figure 4: Mark-out and validation of subsurface tree roots using ground-penetrating radar. (Photo Jim Griffiths)

Staff news

Jo Hoyle has been awarded the Wāhine Toa award by the New Zealand Rivers Group. The annual award recognises a female role model who is leading the way in the historically male-dominated professions of river engineering, management and geomorphology. Jo was recognised for her technical expertise, multi-disciplinary view of river management and inclusive/supportive behaviour. The award was announced in November and was due to be presented formally at the Rivers Group's conference in April 2022.

Lawrence Kees has joined the Hydrological Processes team in Christchurch, from Environment Southland where he was Water Resources Scientist. His previous experience includes snow surveys, low flow and groundwater modelling, ecohydrology and water allocation and policy. He has also been involved in traversing the Ross Ice Shelf as part of Antarctica New Zealand's deep field operations. Lawrence started his science career as a field technician at NIWA's Greymouth office some 15 years ago.

Jo Hoyle on location in the Rangitata River (left) (photo: Jochen Bind); and Lawrence Kees on location on the Crary Ice Rise, Antarctica (right) (photo: Raphael Kammlein-Cutler).

UPDATE

Compiled by Nimthara Udawatta

GNS Science Update

Staffing

Paul Oluwunmi joined GNS's groundwater modelling team in early May. Paul has a background in coupled (flow, thermal, geomechanical, geochemical and geophysical) processes. He previously worked as a research fellow at the University of Auckland's Science and Engineering faculties. His study during that time focused on the thermal-hydrologic-chemical-mechanical multiphase response of gas hydrate geological reservoirs to gas production and geological processes. At GNS, Paul will be working on methods to enhance the rapid development and deployment of numerical groundwater models. Initially, he will be looking at methodologies and modelling approaches to investigate the implications of saline water intrusion on groundwater aquifers in a changing climate.

Look out for the groundwater science-to-policy workshop August 2022

GNS Science and collaborators will be running virtual workshops in August on themes of groundwater science and policy. Policy development informed by science will help mitigate, manage and adapt to effects such as seawater intrusion and rising coastal water table.

The format of the workshop will be five two-hour workshops (one per week) on the themes of:

1. Managed retreat and climate change
2. Efficiency measures and water management
3. Groundwater and law
4. Records of engagement
5. Unintended consequences.

Please contact the organiser, Paul White, if you would like to attend any of these workshops.

Optimising operations for the national groundwater monitoring operations: assessment of the impact of a best practice change on sample preservation

In 2016, operations of the National Groundwater Monitoring Programme (NGMP) were reviewed using the Standard Methods for the Examination of Water and Wastewater, a joint publication of the American Public Health Association, the American Water Works Association, and the Water Environment Federation. The only operational change resulting from this review was the switch from an unpreserved filtered bottle collection for the analysis of ammonia-nitrogen to the use of a sulfuric acid (H2SO4) preserved filter bottle. This acid is used as a preservative for collecting water samples as it acts as a bacterial inhibitor and prevents salt formation with organic bases.

To investigate the impact of this change on measured ammonia-nitrogen concentrations, duplicate groundwater samples were collected by regional council staff over the NGMP network between May and December 2016. A selection of these duplicate samples (n=255) was analysed, encompassing a range of ammonia-nitrogen concentrations (<0.003 to 13.7 mg/L). The dataset was first reviewed as part of the Quality Assurance programme to identify non-valid analyses. Subsequently, the cleaned dataset was grouped under different conditions for comparison purposes (e.g., pair data ammonia-nitrogen; pair data, valid arrival temperature and valid sampling holding time). Finally, the paired datasets were analysed by graphical examination and tested for significant difference using the non-parametric sign ranked test. No statistical difference was observed between ammonia-nitrogen concentrations measured on unpreserved samples and the sulfuric-acid preserved samples.

Based on this data analysis, it is recommended to revert NGMP sampling to unpreserved samples, with consideration for cost-effectiveness in both the field and the laboratory. The design, methodology and statistical tests used to investigate the impact of change in sample preservation here are transferable to other operational changes. Groundwater quality data collected as part of NGMP can be accessed here.

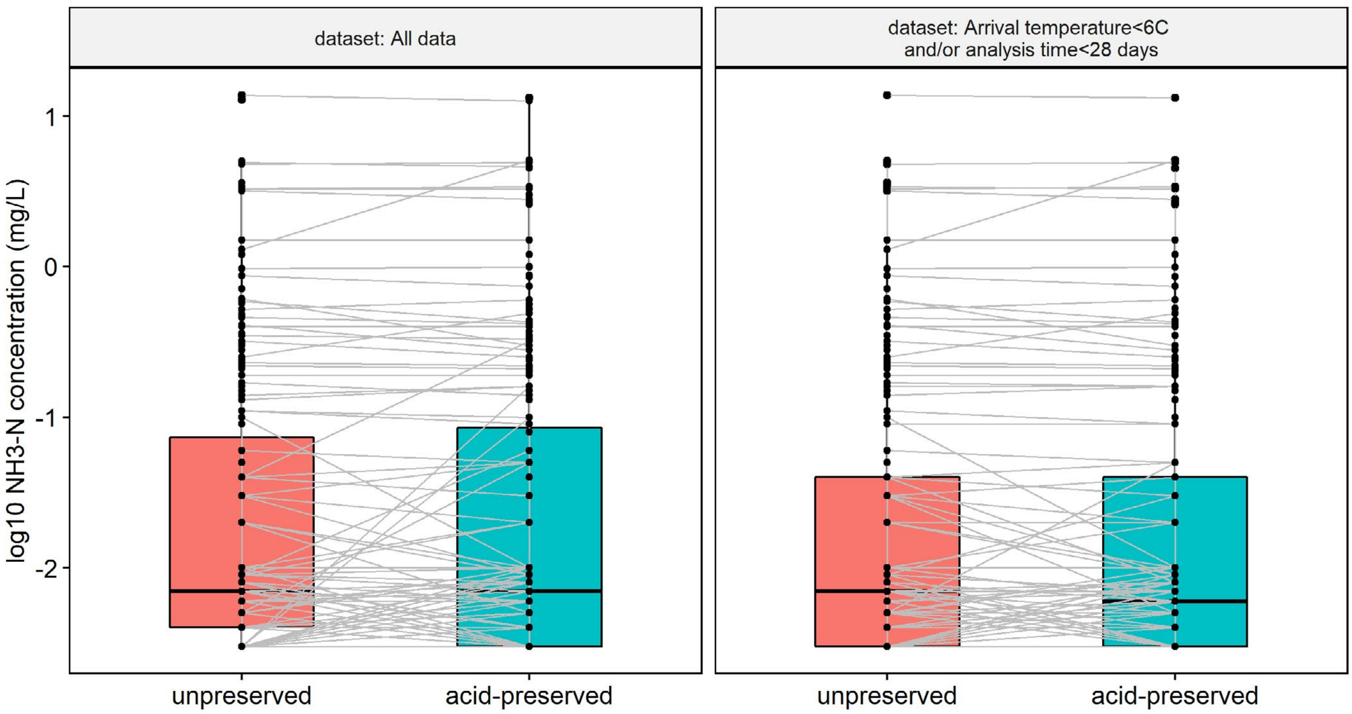


Figure 1: Boxplot of matched pairs of NH3-N concentrations for the full dataset (left) and the subset where arrival temperature and sample holding time fit the 2017 Standard Methods thresholds (right). Grey lines link samples collected during the same event at the same site.

For more information, contact: Estefania Santamaria or Magali Moreau

Santamaria Cerrutti, M.E.; Moreau, M. 2021: *Comparison of ammonia-nitrogen measurements between unpreserved and acid-sulfuric preserved groundwater samples*. GNS Science Report 2021/27, 15 p.

Effects of saltwater intrusion on groundwater microbial community diversity

The first assessment of the effects of seawater intrusion on groundwater microbial communities has now been released. Seawater intrusion may be induced by over-abstraction of groundwater or sea level rise due to climate change. Groundwater ecosystem services provided by microbial communities are essential for the maintenance of water quality. For example, nitrate contamination is a recognised health and ecosystem issue in most groundwater systems, often alleviated through microbial processes.

This pilot study used groundwater samples collected from sites in two regions, Waikato and Canterbury, exposed to a range of concentrations of chloride. The investigation into the impacts of seawater intrusion on the diversity and function of groundwater microbes demonstrates potentially harmful effects, particularly on the nitrogen cycle within groundwater. Identification of keystone species affected by saltwater in specific ecosystems will enable water management decisions about future abstraction limits and defences against sea-level rise to be underpinned by robust science knowledge about microbial community sensitivity to salinity.

For more information, contact: Karen Houghton

Houghton, K.M.; Fournier, M.; Tschritter, C. 2022: *Effects of saltwater intrusion on groundwater microbial community diversity*. GNS Science Report 2021/39, 52 p.

Te Whakaheke o Te Wai: radon sampling in Marlborough

In the first week of February 2022, a sampling campaign in the Wairau River was performed, covering nearly its entire length, between the coast and Dip Flat (Fig. 2). In collaboration with Marlborough District Council (MDC), 140 radon samples were collected to identify where the river interacts with the groundwater system, losing or gaining water. As a result, a very complex groundwater system discharging into the Wairau River in its lower reaches, where the confining layer is relatively thin and experienced liquefaction damage following the 2016 Kaikoura earthquake, was found. Up until now, very little was known about the natural discharge of the Wairau aquifer – an essential aspect for water resource management. This work is part of a collaboration between MDC and GNS's Groundwater SSIF programme to establish new techniques for water resource management, and the MBIE Endeavour programme Te Whakaheke o Te Wai to produce a national understanding of groundwater–surface water interactions.

For more information, contact Uwe Morgenstern

Figure 2: Wairau River, Marlborough (Credit: Uwe Morgenstern, GNS Science)

Predicting the impacts of sea-level rise on groundwater levels in South Dunedin

Predicting the impacts of sea-level rise on groundwater levels in South Dunedin as part of the New Zealand "SeaRise" project (https://www.searise.nz/), GNS is developing a modelling workflow in which the uncertainty of model inputs (parameters) is propagated to model outputs (predictions), to quantify the uncertainty of decision-relevant forecasts (i.e., groundwater levels in response to sea-level rise). The main intended outcome of this project is to provide coastal planners with the tools necessary to make better informed decisions in response to the risks associated with sea-level rise.

Specifically, the workflow involves the development of a highly parameterised (thousands of parameters) steady-state groundwater flow model of South Dunedin to systematically represent the inherent uncertainty of model inputs. History matching (calibration) to historic groundwater levels is implemented to condition model parameters and reduce the uncertainty of model predictions. The impact of sea-level rise is then assessed on a temporally and spatially variable basis through subjecting the calibrated groundwater flow model to IPPC Shared Socioeconomic Pathway (SSP) scenarios of sea-level rise and climate change, thereby estimating prediction uncertainty of groundwater levels in response to sea-level-rise. The potential groundwater hazard in South Dunedin can then be estimated (e.g., via the use of hazard informed maps) and decisions made.

The workflow is currently in the process of being written for publication, in addition to the development of python tools for the communication of the workflow and model outputs to the public.

For more information, contact: Lee Chambers

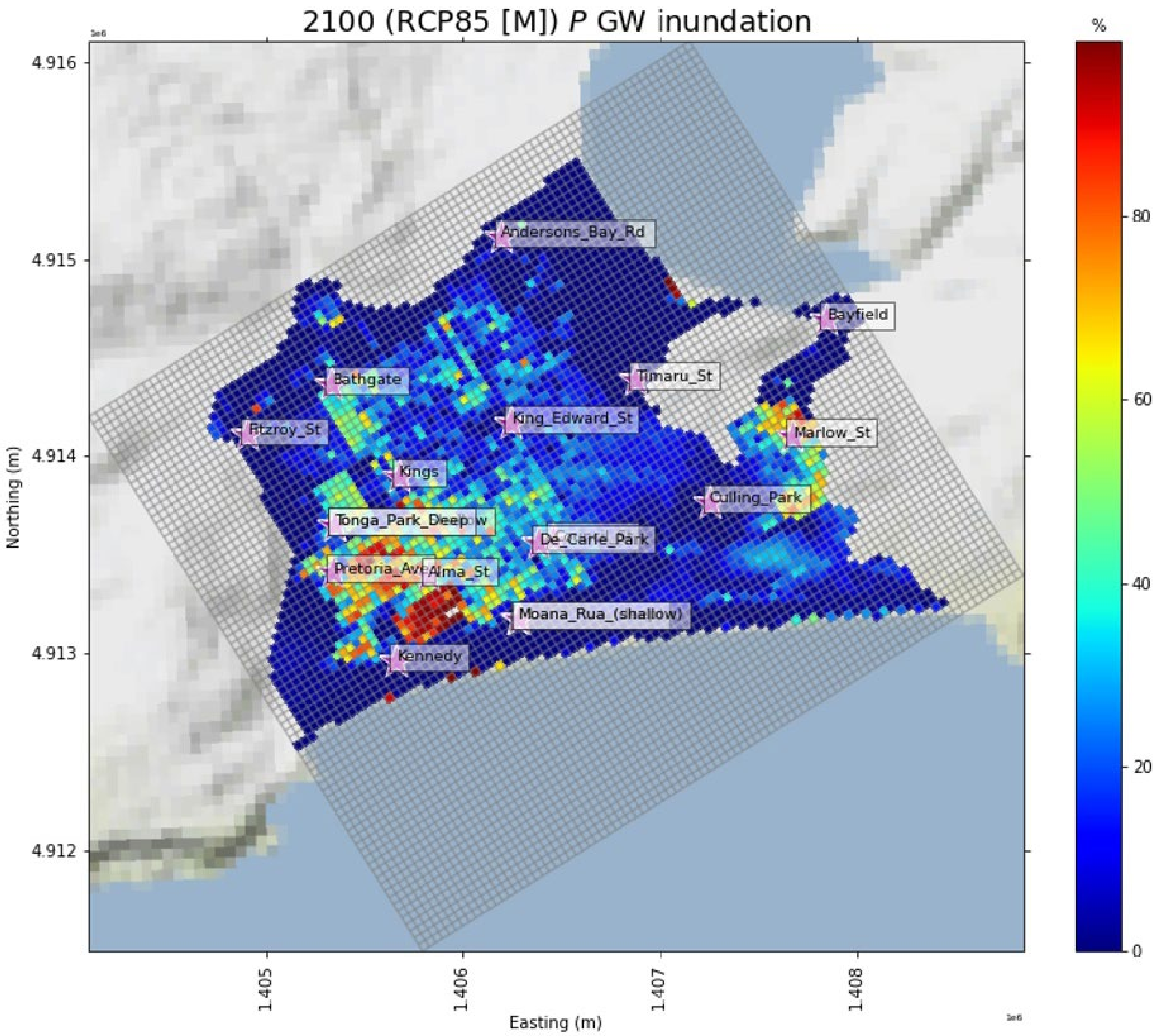


Figure 3: Estimated probability of groundwater inundation (i.e., groundwater levels exceeding the model top) in South Dunedin for RCP8.5 (median sea-level rise projection) in 2100.

Ruamahanga survey

Greater Wellington Regional Council (GWRC) was awarded a Provincial Growth Fund (PGF) grant in April 2020 to undertake an Airborne Electromagnetic (AEM) survey to deliver data that will contribute to improved knowledge and understanding of the Wairarapa's critical groundwater systems. These data are to be collected using SkyTEM technology and the survey is to capture the Ruamahanga Valley aquifers. Data from the survey will be used as a basis for further initiatives that enhance the understanding of the groundwater resource and develop and refine groundwater and hydrogeological models. This project was delayed for a few summers, due to COVID-related border implications, but is now planned for early 2023.

GWRC has engaged GNS Science to provide acquisition support, quality control, collation of supporting data, data processing, resistivity model development and associated workshops

For more information contact: Chris Worts or Richard Kellett

Upcoming Airborne Electromagnetic data acquisition in the Aupōuri Peninsula

The Airborne Electromagnetic (AEM) surveying of the Aupōuri aquifer is predominantly funded by Aqua Intel Aotearoa (AIA), a collaboration between Kānoa (Provincial Growth Fund) and GNS Science, with contribution from Northland Regional Council, Far North District Council, Ngai Takoto, and Te Aupōuri. The Te Hiku Water Study project team, representing iwi, the community, landowners and councils, has confirmed arrangements for a combination of aerial surveying and drilling of groundwater bores. Data from the survey will provide further knowledge and understanding of Aupōuri's groundwater system and service effective ways to balance environmental protection, demand for water, and natural disasters. The survey will be undertaken by SkyTEM Australia in November 2022.

For more information, visit https://www.aquaintel.co.nz/ or email.

UPDATE

Compiled by Juliet Clague

Lincoln Agritech Update

Critical Pathways Programme

The Hamilton-based Environmental team were out sweltering in the summer conditions, collecting core information and installing shallow (<10 m) wells (Fig. 1) in our Upper Piako study catchment. This information will help ‘ground truth’ the electromagnetic survey information (SkyTEM and t-TEM) and provide water table and groundwater chemistry data for the catchment models. The core information gathered includes standard soil description of colour, texture, mottling etc, and also tests for the presence of reduced iron (Fe^{2+}) using the Childs test reagent, which indicates reduced conditions in the subsoil (Fig. 2). Reduced conditions are important for understanding whether nitrate could be denitrified as it moves from the soil surface through the groundwater system and into surface waters.

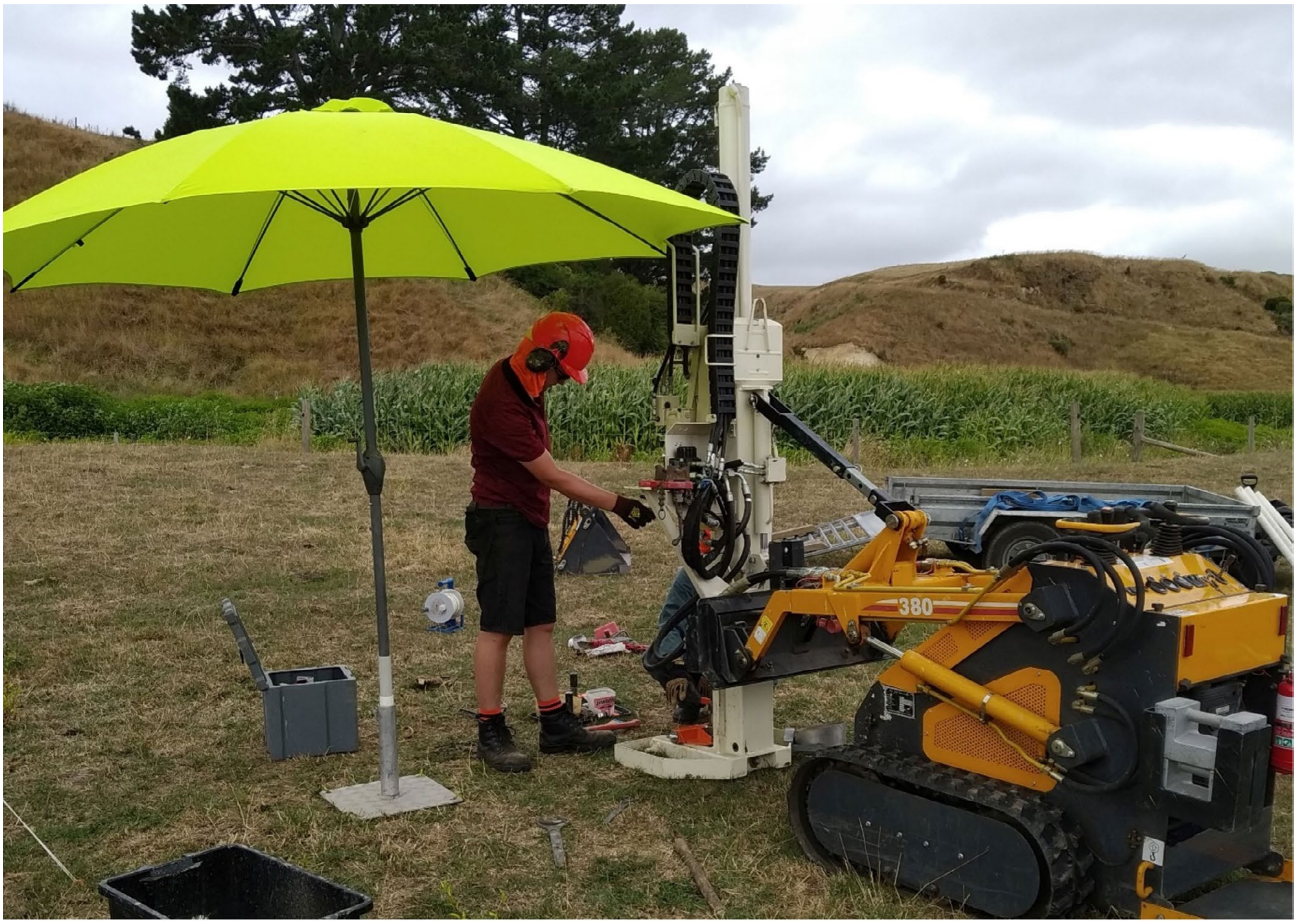


Figure 1: The drilling rig operated by James Owers in the Piako study catchment, January 2022.

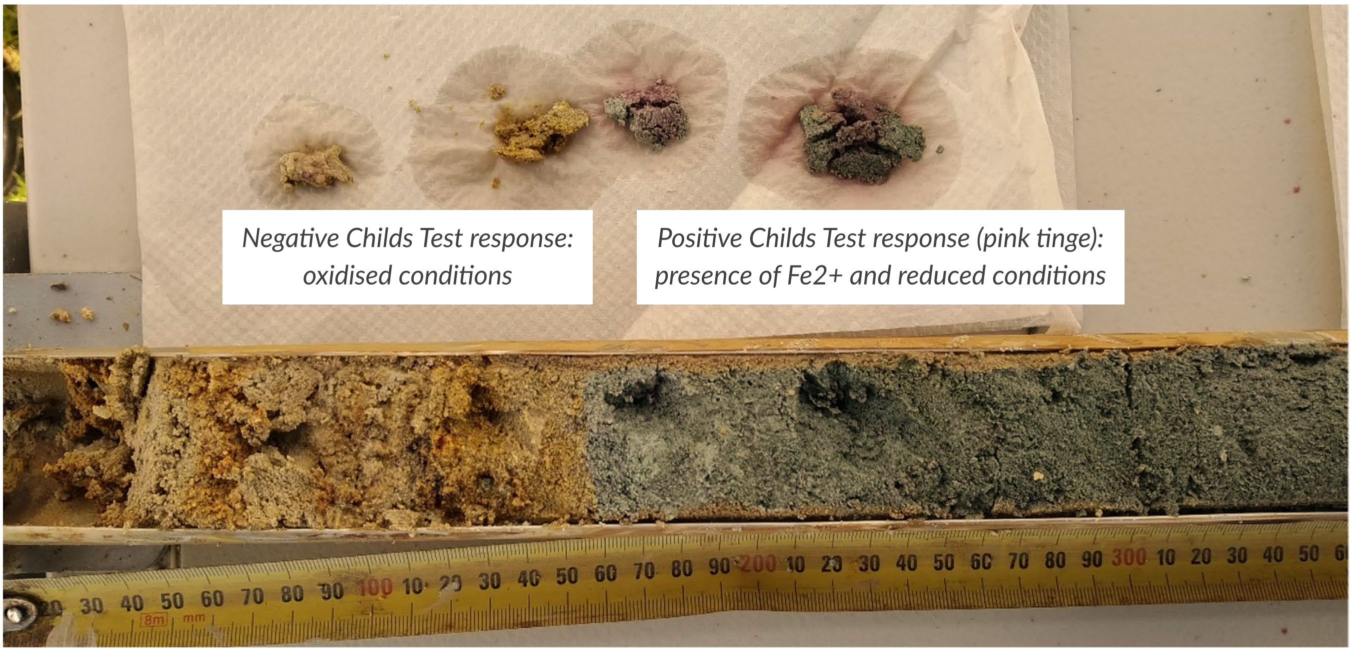


Figure 2: Testing for the presence of reduced iron (Fe2+) to indicate reduced conditions in the subsurface, January 2022.

The Hamilton office has also hosted two interns over the summer (Fig. 3). The Ngāti Hauā students are from Te Wharekura o Te Rau Aroha, which is just outside our Upper Piako study catchment. They have been learning about stream ecology and performing stream health assessments, so we introduced them to stream gauging and water quality sampling for some real-world science in action.

Figure 3: Te Wharekura o Te Rau Aroha interns Pare Wilson (left) and Reuben Gillett (right), January 2022.

Collection of reliable, continuous nitrate data from our NICO sensors has been problematic at some sites due to weed growth and subsequent sediment build-up in and around the deployment tubes, which are located on the stream banks. This has been a problem particularly at our Waiotapu Stream field site, as shown in Figure 5, where stream-bank access is difficult. A novel solution has been engineered by the team, using a boogie board as a floatation device for in-stream deployment of the NICO sensor (Fig. 4, Fig. 5). Fingers crossed this deployment option provides more reliable data and reduced maintenance.

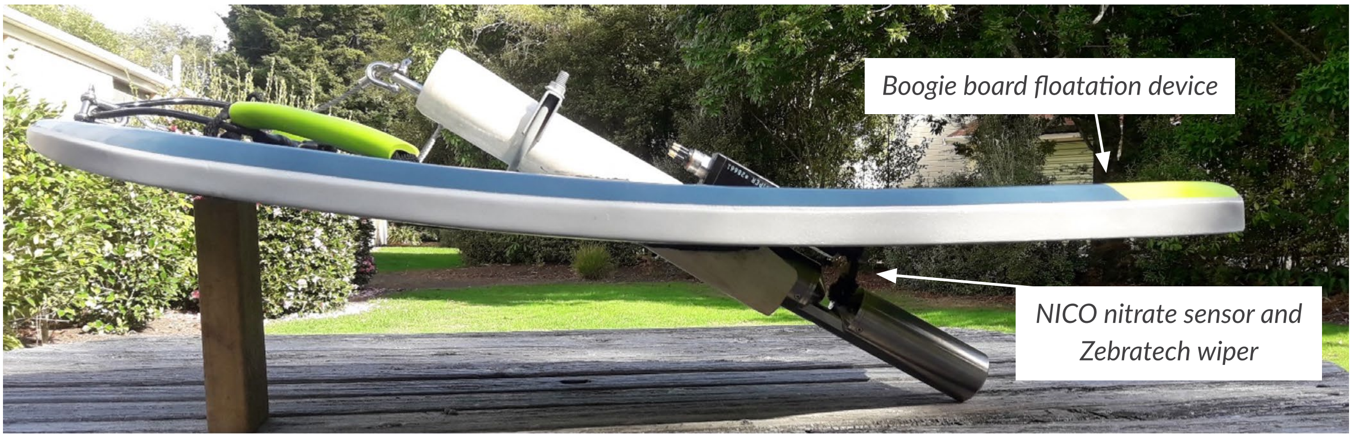


Figure 4: New boogie board deployment device with NICO nitrate sensor.

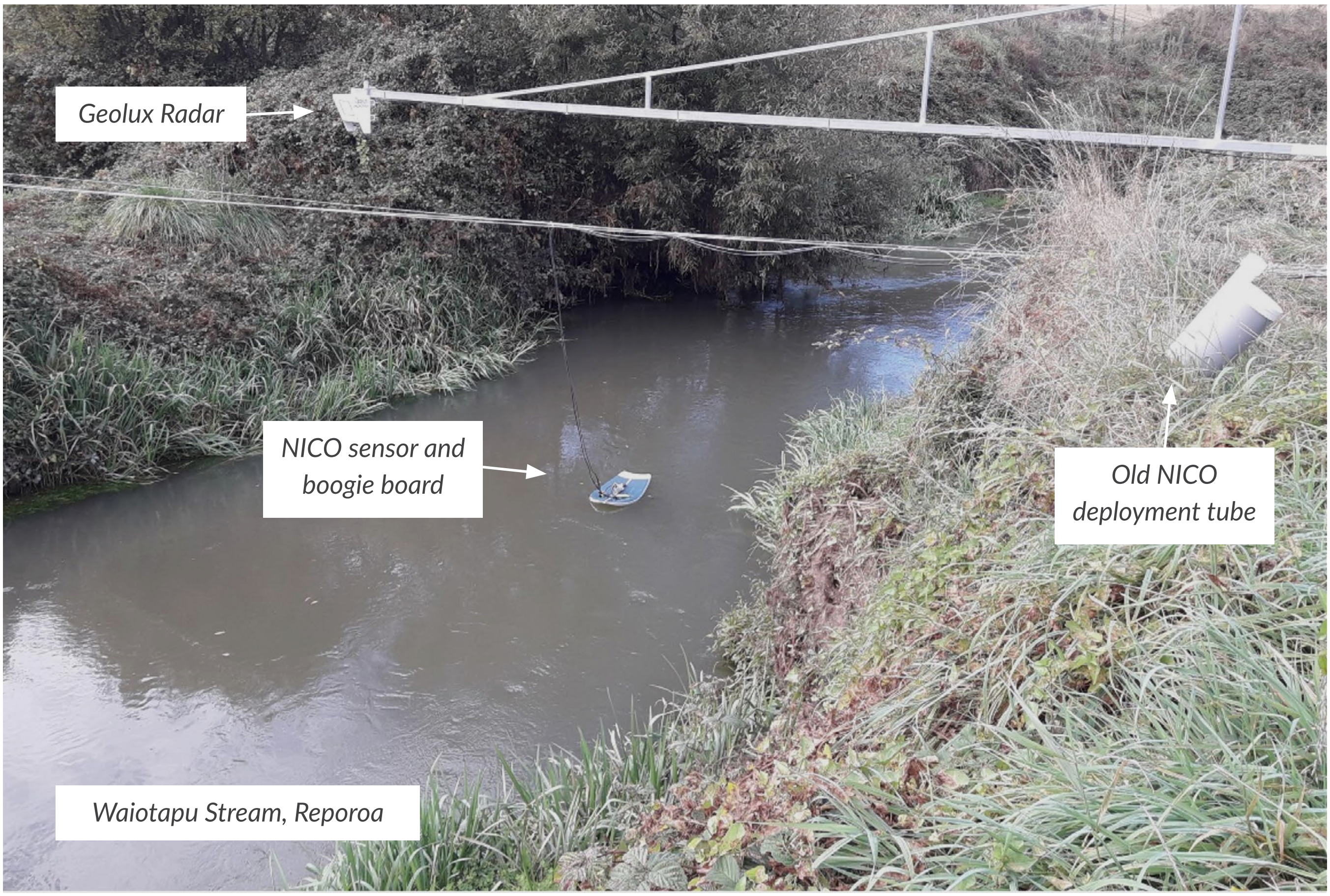


Figure 5: Waiotapu stream measurement site, showing Geolux radar, new in-stream NICO location and previous NICO tube location, attached to the bank. April 2022.

Figure 6: Shaun Kingsbury (left, LAL) and Mathias Østbjerg Vang (Aarhus University) configure the NMRI equipment at the Selwyn River field sites, April 2022.

Braided Rivers Programme

The Braided Rivers Programme has been using a variety of geophysical measurement techniques including a novel NMRI (Nuclear Magnetic Resonance Imaging) system (Fig. 6). In collaboration with our colleagues from Aarhus University in Denmark, we have used the device to quantify mobile water content in the subsurface to give an idea of lithology and aquifer layers in the reasonably shallow (<30 m depth) subsurface. The black coil is set up in a square and then connected to the control boxes, which then collect the data.

UPDATE

Compiled by Kate Mason

Aqualinc Update

New recruits

We have recently welcomed three new members of staff to the Aqualinc family.

Lucy Bennett, Graduate Environmental Scientist, joined the Water and Land team in November last year after graduating from University of Canterbury with a degree in Environmental Science and Geography.

Fletcher Frater, Data Scientist, joins the Research and Development team. Fletcher recently completed his Master of Science in Computational and Applied Mathematics at University of Canterbury.

Julie Clarke, Social Scientist, joins Aqualinc from Alexandra, Central Otago and will be the Aqualinc main contact in the lower South Island.

Research projects

N-Wise Irrigation field trial

The first season of our N-Wise Irrigation trial has been both challenging and fascinating.

The challenging aspect was the weather – it was exceptionally wet in December and February. This generated a lot of drainage, as can be seen in the cumulative drainage graph (Fig. 1). Each trace represents the drainage from a plot. There are eighteen in all. The amount of rainfall received essentially 'drowned out' differences in irrigation management between the plots.

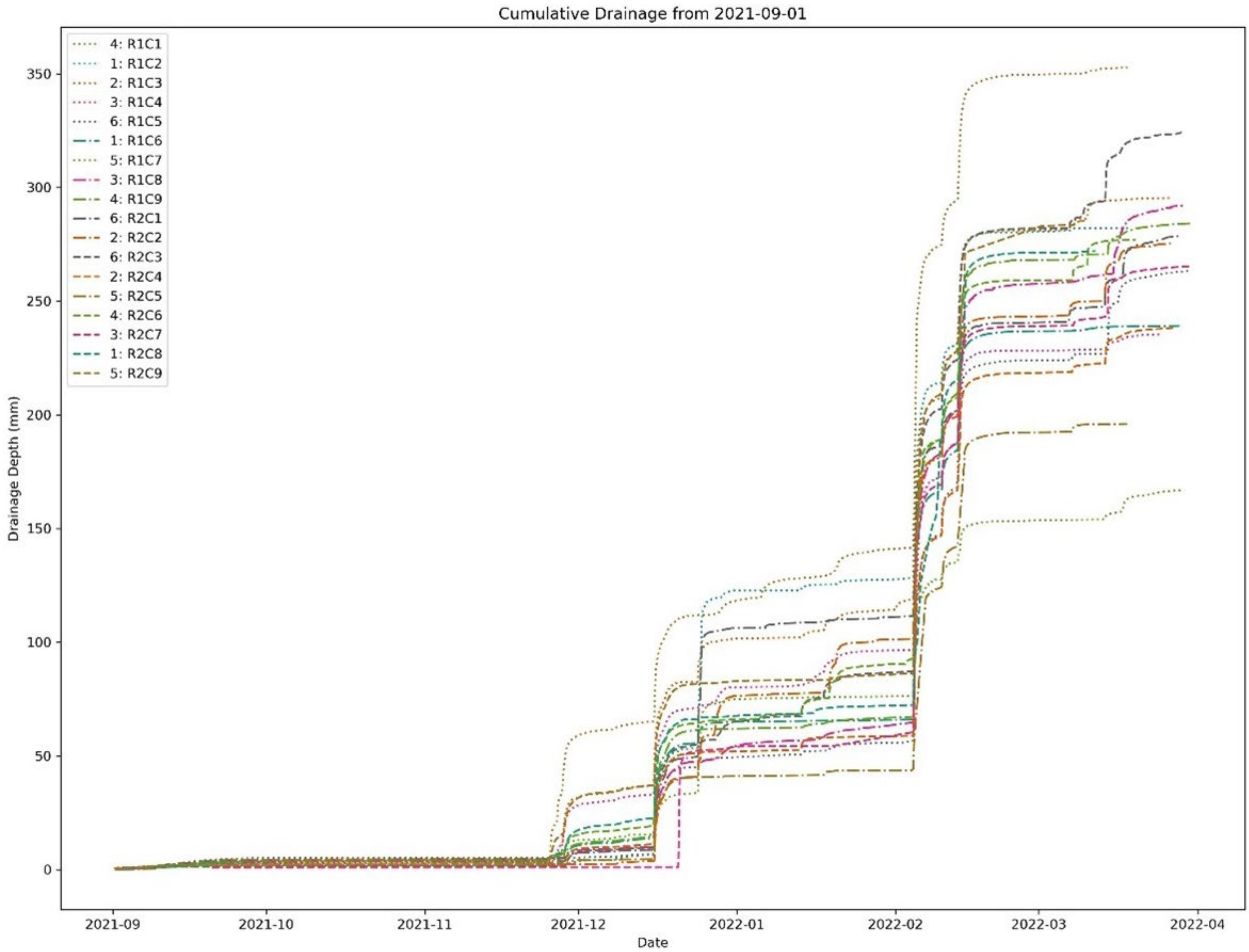


Figure 1: Cumulative drainage from 18 plots in the field trial, September 2021 to April 2022. Note: derived from raw, unaudited data.

It is fascinating how variable the drainage volume is, given that each received the same rainfall and very similar irrigation amounts. While the soil type across the 1500 m^2 area occupied by the trial is mapped as being the same (Lismore 2A1), we observed considerable variability in the stone content during the trial construction process. This would seem to be the reason for the variability in drainage. Future field work will involve soil texture and soil hydraulic property measurements across the trial site, to test this presumption.

The cumulative total nitrogen leached from each plot is shown in Figure 2. Unsurprisingly, this too shows considerable variability between the plots. In terms of grazing and fertiliser applications, all plots are managed in the same way.

The degree of spatial variability evident across the trial site highlights the challenges involved in modelling contaminant leaching at field and farm scale!

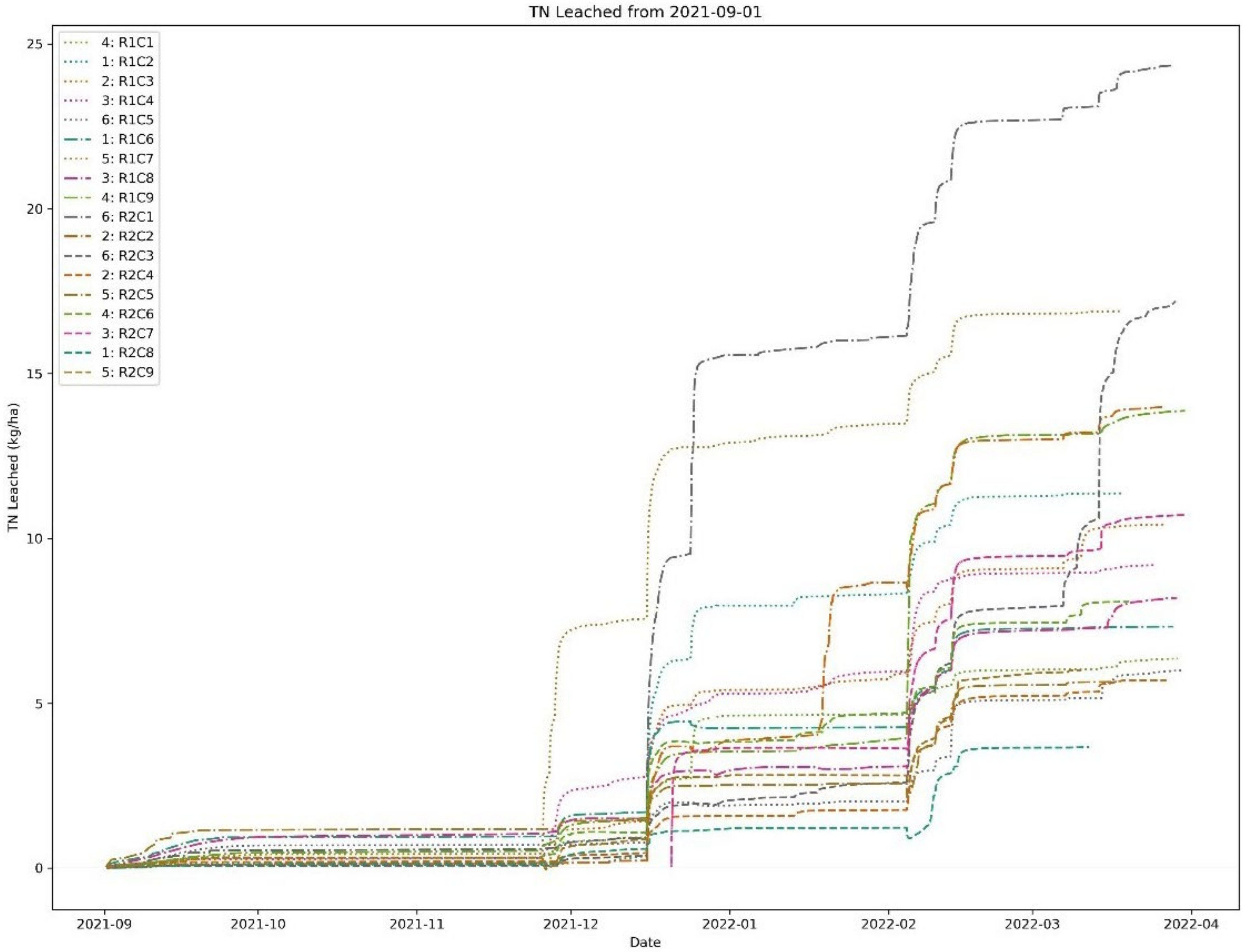


Figure 2: Total nitrogen leached from 18 plots in the field trial. Note: derived from raw, unaudited data.

Water Availability and Security (WAS) project

As mentioned in the last edition of *e-Current*, we modelled water availability and security on a national scale for the Ministry for Primary Industries. The key results are available on the MPI website. As a follow-up project, we analysed the sensitivity of these results to key assumptions about water allocation policy, climate change and water storage parameters. The results of this sensitivity analysis are currently being reviewed.

Remote sensing of soil moisture

Aqualinc field staff are working with University of Auckland researchers to obtain ground-based real-time soil moisture data for calibrating and validating novel soil moisture monitoring systems. We recently helped them install multiple soil moisture monitoring sites in Auckland and Northland. This is part of a project that is jointly lead by NASA, Air New Zealand and University of Auckland. Further information on the project can be found at https://www.nasa.gov/feature/goddard/2020/nasa-new-zealand-partner-to-collect-climate-data-from-commercial-aircraft. The soil moisture monitoring system we deployed is part of the SoilSCAPE programme, https://soilscape.usc.edu/.

Source water quality

There is a whole lot going on in the drinking water quality space at the moment, and Aqualinc are working on various projects. Earlier in the year, the revised National Environmental Standards (NES) for Drinking Water were released for public submission. A key issue in protecting drinking water is the need for clear guidance on delineating source water risk management areas (SWRMAs – previously referred to as source protection zones). The modelling and uncertainty guidelines included in the documentation to support the revised Drinking Water NES were developed by Aqualinc and GNS. This work highlighted numerous difficulties, including:

- balancing source protection against restrictions in land use, particularly for pre-existing land use activities, but with the priority of avoiding a SWRMA that is not sufficiently large to prevent water safety issues, and
- risk considerations and degree of complexity required for different prediction contexts. Whilst expert knowledge and site characterisation may be acceptable to develop a conceptual model for a small supply in a homogeneous aquifer, for a town supply in a heterogeneous alluvial aquifer system much more complex and robust modelling approaches are required.

Small suppliers

Under the Water Services Act, anyone who supplies water to more than their own household will become a small supplier and have responsibilities for ensuring the water they provide to others is safe. Aqualinc worked with Mackenzie District Council to identify potential small suppliers and provide them with information about how things are going to change. This was through a combination of talking to property owners and GIS analysis to identify properties where there was more than one building. Various small schemes were identified and options developed and costed for either connecting to the reticulated supply or putting treatment in place.

UPDATE

Compiled by Dr Leanne Morgan

Waterways Update

Update from Waterways Centre for Freshwater Management, University of Canterbury

The Waterways Centre for Freshwater Management is a teaching and research centre based at both the University of Canterbury (UC) and Lincoln University (LU). The Centre offers a Postgraduate Diploma, Masters and a PhD in water resource management, and teaches both undergraduate and postgraduate water papers at both universities. Now in its 11th year, the Centre is growing in academic staff, postgraduate students and research projects. It is also refreshing the water resource management postgraduate qualifications for 2023.

Among active research streams at the Centre is Dr Leanne Morgan's groundwater research group, focusing on coastal hydrogeology and groundwater–surface water interaction. Leanne is currently supervising research students looking at the impact of sea-level rise on groundwater (Irene Setiawan, PhD candidate, LU; Amandine Bosserelle, PhD candidate, UC), quantifying groundwater recharge

from braided rivers (Alice Sai Louie, PhD candidate, UC; Christy Songola, Masters candidate, LU) and understanding groundwater transport under heterogeneity (Connor Cleary, PhD candidate, UC). Another project, in collaboration with GNS, explores hindcasting a groundwater system to pre-European conditions incorporating indigenous records of natural conditions (Tara Forstner, PhD candidate, UC). Leanne is Principal Investigator for two MBIE Endeavour-funded projects: *Future Coasts Aotearoa* and *Subsurface processes in braided rivers*.

The Waterways Centre Director, Professor James Brasington, specialises in geospatial modelling of rivers systems. He has developed a state-of-the-art airborne lidar facility at Waterways, using the first sensors of their kind in the southern hemisphere. James supervises several students using geospatial data to model river processes, addressing issues such as the impact of flood harvesting on sediment processes (Justin Rogers, PhD candidate, UC) and the use of machine learning to model flood inundation (Martin Nguyen, PhD candidate, UC). He also supervises Postdoctoral researcher Justin Stout (UC) who is about to start on a two-year MBIE-funded project that aims to develop new lidar and image processing technologies to derive seamless, high-fidelity models of river and coastal systems. James is also leading work on another five-year MBIE programme (*Future Fish*) that aims to understand the effects of climate and land-use change on river dynamics and the associated impacts on both native and exotic fish communities. He is advertising for a new postdoctoral researcher and PhD student to work on this exciting project.

Dr Ed Challies works in the field of water policy and governance. Ed's work is currently funded through the Our Land and Water National Science Challenge, MBIE Endeavour Fund and Freshwater Improvement Fund. His work addresses catchment groups and community-based management in urban and rural contexts, and social-ecological feedbacks in freshwater management. His recent and current PhD supervision covers research in urban water governance (PhD candidates Rachel Teen and Tyler McNabb, UC), flood resilience (Unnathi Samaraweera, PhD candidate, UC), and social practices of water use (Julie Clarke, PhD candidate, LU).

Two new academic staff joined Waterways in early 2022. Dr Shelley MacDonell is a hydrological scientist whose work focuses on headwater catchments, aimed at better understanding water delivery to catchments, including timing and source contributions. Dr Issie Barrett completed her PhD in restoration ecology, investigating scenarios where communities remain in a degraded state following successful habitat and water quality restoration. Her passion is the practice of river restoration and Karina Kelly (Masters candidate, UC) will be undertaking her research in this area.

Other students and research projects are also underway in 2022, a reflection of the work being done by industry, academia and government to find answers to New Zealand's freshwater management issues.

UPDATE

Compiled by Bob Bower

WGA NZ Update

Wallbridge Gilbert Aztec (WGA NZ) are excited to announce that **Monica Jasper** has joined our team in our Christchurch office. Monica is an experienced GIS Analyst and Hydrologist with formal training in hydrogeology and hydrology with both undergraduate and graduate degrees covering geology, mathematics, and geographic information sciences in the USA. She has worked formally for the USGS, US Forest Service and Environmental Canterbury. She will be joining WGA to support our GIS Analysis team as well as provide hydrologic support.

WGA is also proud to share that **William Dench** received the Young Professionals Hydrological Society Award (2021) at a ceremony here in Christchurch in February 2022.

WGA New Zealand and Australia Activities 2022

The WGA water group continues to work on a diverse and interesting range of water projects across New Zealand. Projects of special mention include WGA's partnership with AQUASOIL INGENIEURE & GEOLOGEN GmbH (AquaSoil), which is based in Germany. Our collaborative global team has been assisting the Gisborne District Council's science team to develop both a geologic and a FeFlow numerical groundwater model for the Poverty Bay Flats. This complex coastal groundwater system, consisting of several distinctive confined and unconfined aquifers, is showing signs indicating pressure from abstraction as well as changing water quality conditions. The model has been developed to model both water quantity and quality as it relates to the current allocation regime and the predicted effects of climate change on a coastal aquifer system. The groundwater modelling process has included participation by community stakeholders and Treaty Partners in model training sessions and workshops. This rewarding process has allowed modellers, hydrogeologists, GDC staff and Treaty Partners to learn from each other and incorporate the cultural values and knowledge into the GDC groundwater model. Exploratory scenario modelling has incorporated a variety of climate change hydrological parameters including increasing soil moisture deficits, increasing frequency and severity of drought and implications for sea-level rise relative to saline intrusion.

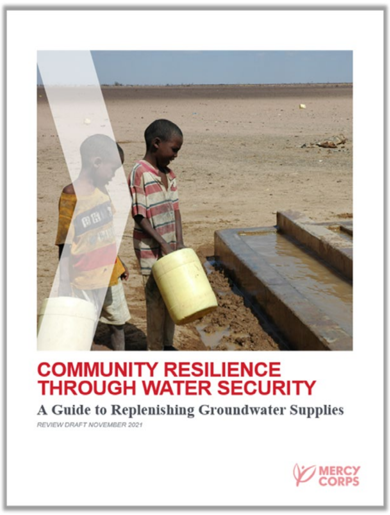
WGA also continues to expand our projects across the wider Australasian region with numerical models being developed for Managed Aquifer Recharge (MAR) programmes in Australia. These models are looking for the scheme-level development of Aquifer Storage and Recovery (ASR) bore fields to use recycled and stormwater runoff to manage water security and scarcity. WGA has also been involved in other hydrogeology-related projects including transport tunnel de-watering and modelling, and mining water management programmes.

WGA International Activities 2022

As the Covid pandemic and travel restrictions have eased in 2022, WGA has had the opportunity to participate on the international stage in North America and the Middle East. WGA is currently working with the first nation - ***Yakama Nation: Confederated Tribes and Bands*** located in the central Cascade Mountains of Washington State, USA. This project was fostered on WGA's international reputation for working with indigenous peoples to help them develop treaty-related water management strategies. The Yakama's are developing a groundwater replenishment programme to offset the impacts of climate change and improve their water security and salmonid species protection for the next seven generations.

WGA staff Bob Bower (Christchurch) and Russell Martin (Adelaide) travelled to Longbeach California in April 2022 to help lead this year's International Symposium on Managed Aquifer Recharge (ISMAR 11 – ISMAR11.net). Bob (ISMAR Conference Co-chair) was recognised with a 'Lifetime Achievement Award' from the International Association of Hydrogeologists (IAH) for his contributions to the MAR technical community over his career.

WGA staff have also been working on water aid programmes in the developing world through projects with the USA-based **Mercy Corps** (www.mercycorps.org). Bob Bower authored the Mercy Corps' CREWS guide, which helps guide field aid workers to identify and develop groundwater replenishment projects for at-need communities (see inset). As climate change and water scarcity are at crisis levels in much of Africa and the Middle East, Bob also has been working with the Mercy Corps Engineering team in Jordan to develop two MAR projects with a recent field visit to the potential project sites (see inset). The projects are located in the southern Jafr region, which is considered a hyper-desert and one of the driest places on earth.



Mercy Corps staff field guide authored by Bob Bower (WGA)

Right: On-site for Jordan's first ASR Bore – Jafr Basin, Southern Jordan

Below: Bob Bower (WGA) with Jordan Engineering Team, Amman May 2022