NZHS E-CURRENT NEWSLETTER • NUMBER 59 • MAY 2021

NEW ZEALAND
HYDROLOGICAL SOCIETY

E-CURRENT NEWSLETTER

INSIDE THIS EDITION

Dr Helen Rutter, NZHS Executive Member

MESSAGE FROM THE EXECUTIVE

Well, it's been a bit of a whirlwind couple of years, with reforms, new standards, policy statements, etc., mixed up within a worldwide pandemic, all whilst the effects of climate change are increasingly being felt. The annual conference, 'Weathering the Storm', was aptly named, given the many challenges faced both at home and abroad in 2020. The conference was very well attended, being a joint conference with the Freshwater Sciences Society and Rivers Group, but it felt a little odd to be in such close proximity to so many people after lockdown! Congratulations and thanks to OnCue for managing to organise it, given the constant fear of further lockdowns. Congratulations also to the many prize winners, including Chris Daughney for the Best Overall Presentation and Lawrence Keys for the Gumboot prize!

Over the past couple of years, the government has been moving forwards with freshwater reforms and an overhaul of the water supply (plus stormwater and wastewater) sector. The Essential Freshwater package (including the NPS-FM, Freshwater NES, and changes to the Resource Management Act 1991) is intended to set New Zealand on a new pathway regarding freshwater management. The package is guided by the concept of Te Mana o te Wai, which acknowledges the fundamental importance of water and recognises that protecting the health of freshwater protects the health and well-being of the wider environment and the people living within it. The challenge for us will be implementing ways to make the improvements needed to give effect to Te Mana o te Wai, with limited data and tools, all whilst maintaining New Zealand's economy. There is some great innovative thinking going on, for example, research to improve irrigation practices to reduce nutrient losses, using airborne geophysics to characterise our aquifer systems, and improving the connection between western science and mātauranga Māori. We need to keep thinking innovatively and find ways to better inform our decision making.

At the same time, driven by the Havelock North water contamination disaster, the water supply industry is facing an overhaul. A new drinking water regulator – Taumata Arowai – has been established and the Water Services Bill is going through Parliament. The bill proposes a new regulatory regime for managing drinking water supply, and the obligations on drinking water suppliers are more onerous than those under the existing Health Act. One of the interesting aspects of the bill is that anyone supplying water to more than their own household becomes a small water supplier, must register as such, and must then comply with the requirements of the bill. Currently, it is not known just how many of these small suppliers there are, but this will be another challenge for many rural landowners. Part of the new requirements will also be the development of source protection zones and the need to consider how land use should be limited within these. Lots of thorny problems ahead of us it seems!

As Terry Pratchett said: 'The phrase "may you live in interesting times" is the lowest in a trilogy of Chinese curses that continue "may you come to the attention of those in authority" and finish with "may the gods give you everything you ask for."' Like it or not, we live in interesting times. They are times of uncertainty, but this presents great opportunities for creativity and innovation.

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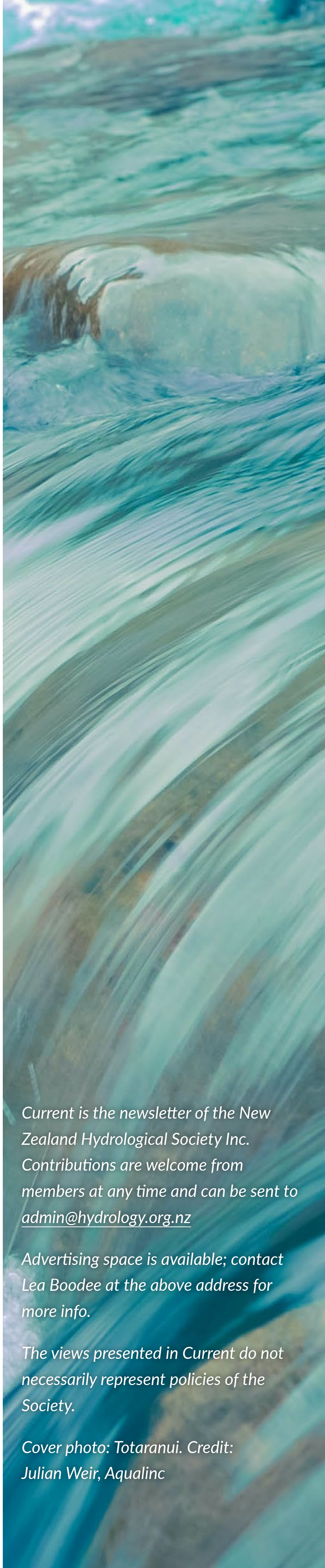

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Cover photo: Totaranui. Credit: Julian Weir, Aqualinc

RECENT EVENT

Karen Wilson, 2020 Conference Chair

2020 Conference Report

Tēnā koutou,
Greetings!

It was great to see so many society members attending and presenting at the joint NZHS, Rivers Group and NZFSS conference held in Invercargill in December. We had more than 370 attendees with an additional 81 virtual registrations from across the world, making it a true hybrid conference. The diverse programme included 225 oral presentations, 14 of which were virtual, more than 50 posters, the opportunity to engage with a variety of trade stands, and fieldtrips to the wider region. With so many interesting talks packed into five concurrent sessions over three days, it's been great to be able to watch recordings of the oral presentations so that no one misses out on seeing the presentations. We were also fortunate to have three outstanding keynote speakers and 300 of us also enjoyed an atmospheric conference dinner in Invercargill's Transport World.

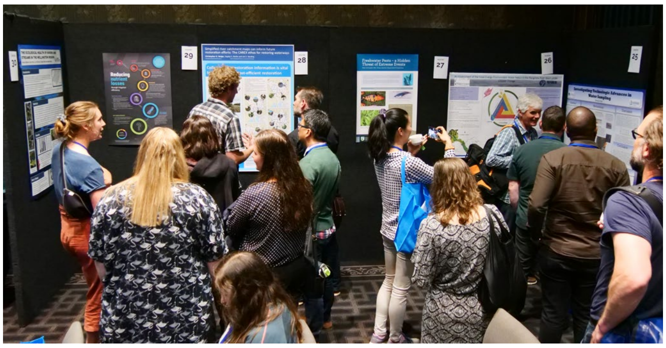
2020 was an extraordinary year, with a global pandemic having an impact on all of our lives. The conference theme, Weathering the Storm, turned out to be particularly apt! Organising a conference in such uncertain times provided plenty of challenges, including needing to do scenario planning for three possible Covid alert levels. Tracy Young and her team at OnCue were rockstars at adapting to changing circumstances and guiding us through.

Thank you to our generous sponsors for their support, the organising committee and OnCue for their hard work, and everyone who attended and presented for their commitment to ensuring the 2020 conference was a success. Due to a higher than expected in-person attendance, we were able to make a surplus to contribute to NZHS income for the year.

I look forward to seeing you at the 60th NZHS conference in Wellington in November.

Noho ora mai
All the best,

Karen Wilson
2020 Conference Chair
On behalf of the organising committee




TEXACO

RECENT EVENT

Matt Hope, 2021 Workshop Organiser

2021 Technical Workshop Report

There was a strong feeling of déjà vu as this year's technical workshop date got closer and the country was either in Covid level 3 or 2. Even though we were prepared to host the workshop under level 2, there was a sigh of relief when the levels changed on the Friday before.

Operating under level 1 meant we could all gather in one room rather than having to split the workshop to keep numbers under 100. Networking with our peers has a part to play at the workshop so it was great we could all come together and meet face-to-face.

Day One

This year's workshop was held at the Rydges Latimer in Christchurch from Tuesday 9th March. Our opening speaker was Helen Shaw from Environment Canterbury, who set the scene for us under the theme "Rising to New Challenges & Changing Conditions".

The day consisted of presentations from a cross-section of the hydrological industry and set us up for the field day on the Wednesday. All presentations were also streamed live so that members and guests who couldn't make the event could watch at home. I'm told that this was very popular so this option will more than likely become a standard in future workshops.

The day ended with presentations from our exhibitors which lead into the social function which meant that everyone could catch-up in a less formal setting.

Day Two

Our field day was held at the Silverstream Reserve in Clarkville where we had the opportunity to again compare our stream gauging instruments. A couple of drones and fixed cameras even made an appearance this year so that surface velocity methods could also be compared.

There were also demonstrations of groundwater monitoring techniques and different nitrate sensors where trialed to compare results.

As NIWA's rating tank was only a short drive away, everyone was invited throughout the day to visit it. This gave everyone the opportunity to see how meters are verified and calibrated firsthand. Thanks to Alec Dempster for running this.

The day ended with demonstrations on periphyton monitoring techniques and discussions around this.

Thanks to Phil Downes and his team for organising the day and to Evan Baddock for putting a video together.

Day Three

Day three consisted of more technical presentations throughout the day and the opportunity to discuss technical details with our 13 exhibitors during breaks.

The day wrapped up with the workshop dinner which was also held at the Rydges.

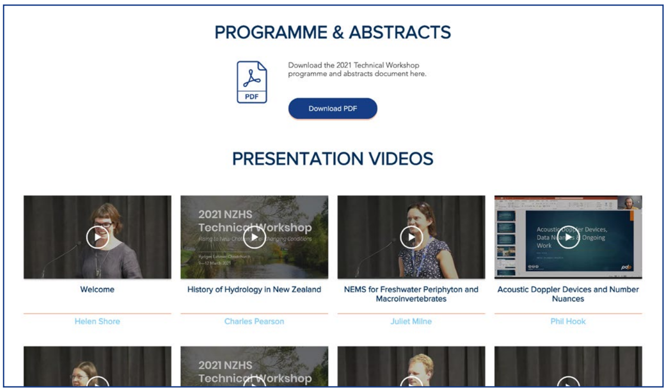
Day Four

Our final day took us through to mid-day where we ended with prize giving. Congratulations to Amber Taylor from Waikato University for winning this year's young presenter award. This will enable Amber to travel to the Australian Hydrographers Association conference once travel restrictions are lifted.

Thanks to Mike Ede, Nick Holwerda, Evan Baddock and Phil Downes for delivering another great event.

Workshop Videos

Link 1: Field Day Video – Credit Evan Baddock (click the image above or the url below to go the link).
www.youtube.com/watch?v=BXfXstdfhJY



Link 2: Presentation Videos (click the image above or the url below to go the link).
www.hydrologynz.org.nz/2021-technical-workshop

ARTICLE

Katie Coluccio, University of Canterbury

Groundwater Seepage to Coastal Lagoons: Its Role in Lagoon Hydrology and Water Quality

Research update from Doctoral candidate Katie Coluccio

My PhD research has focused on exploring questions around groundwater processes in coastal lagoons. Direct measurement of groundwater seepage to surface water bodies can be challenging, so its contribution to hydrological processes in coastal waters is often under-estimated or poorly understood. An increasing number of studies have shown that groundwater can play a significant role in contaminant transport to coastal areas, even when the proportion of groundwater inputs in water budgets is relatively small.

This project has several key research questions:

1. How is groundwater discharge to coastal lagoons distributed spatially?
2. What is the quantity of groundwater seepage discharging to a coastal lagoon in Canterbury, New Zealand?
3. What are the seepage sources to a coastal lagoon in Canterbury, New Zealand?
4. How does groundwater discharge to lagoons affect nutrient loads?

These questions have been explored at an iconic coastal lake/lagoon in Canterbury – Te Waihora/ Lake Ellesmere. It is a large (~150 km^2), shallow (mean depth ~1.4 m), brackish lagoon with high turbidity and wind speeds. Te Waihora is the site of extensive restoration efforts by a number of groups to improve its water quality, which has declined significantly in recent decades.

This project has involved extensive data collection in the field, with the initial stage of research involving large-scale surveys of the lagoon to map the spatial distribution of groundwater seepage locations. We hired a Cessna to fly a thermal infrared imaging camera over the lagoon during summer to locate cold areas of water that could indicate groundwater inflow. We paired this with data collection by boat measuring radon-222 (a radioactive gas and natural groundwater tracer), water temperature, electrical conductivity and dissolved oxygen during summer and winter. We mainly found signs of groundwater seepage on the margins of the lagoon. While in some locations this evidence was confounded by nearby confluences of groundwater-fed streams, in other locations signs of groundwater inflow did not coincide with surface inputs. We expect this pattern of groundwater seepage concentrated around the lagoon margins to be largely controlled by factors such as the shallow lagoon bathymetry and fine lakebed sediments creating a confining layer that inhibits groundwater inflow from underlying artesian aquifers.

Figure 1: Sampling radon on the fly in Te Waihora/Lake Ellesmere with two RAD7 radon detectors on board.

We also set out to quantify the total groundwater input from seepage through the lagoon bed, which was a daunting task for such a large water body. We chose a broad-scale method (a radon mass balance) so that we could draw conclusions across the site and compare our estimates to previous seepage meter measurements. We accounted for all radon inputs and outputs to the lagoon such as tributary inflow, radon degassing and diffusive radon inputs from bed sediments. We also incorporated complex factors like interactions between the lagoon and the gravel bar (Kaitorete Spit), the occasionally open outlet to the ocean, and variable wind speeds. Part of this mass balance included estimating a radon endmember in adjacent groundwater, which is often one of the more difficult parts of these types of models to constrain. We found that degassing of radon to the air was the most influential component of the mass balance, which was unsurprising given how windy this site can be. We also found that the model was less sensitive to changes in lagoon levels. Overall, the radon mass balance estimates of groundwater seepage to Te Waihora were 1–2 orders of magnitude higher than the seepage meter estimates.

The final component of this project is ongoing and involves resolving groundwater sources to Te Waihora and examining their role in nutrient transport to the lagoon. We carried out a sampling campaign in late 2020 analysing major ion chemistry, oxygen-18 and deuterium isotopes, and nutrients in nearby groundwater wells at varying depths, porewater at the lagoon margins, springs and surface water from the lagoon. Defining clear endmembers for groundwater tracers on the Canterbury Plains can be a tricky task, and this study has not proved to be an exception. However, based on early data analysis, some interesting findings regarding water sources and nutrient transport are emerging.

Figure 2: Sampling shallow groundwater on Kaitorete Spit

This research was funded in part by a grant from the New Zealand Hydrological Society. Without this support, this project would not have been possible, particularly the extensive field data collection. I am grateful for the various opportunities and support that the Society provides to students, including a platform to present research at the annual conferences, project and travel grants, and publications.

Provided the NZHS Conference Committee has not tired of hearing me present on this project, I will present the final results of this research at the 2021 NZHS Conference in Wellington. I plan to submit my PhD thesis in April/May 2021. If you would like to hear more about this project, or discuss opportunities for new projects, you can contact me on katie.coluccio@pg.canterbury.ac.nz.

Recent Publications:

Coluccio, K.; Santos, I.; Jeffrey, L.C.; Katurji, M.; Coluccio, S.; Morgan, L.K. 2020: Mapping groundwater discharge to a coastal lagoon using combined spatial airborne thermal imaging, radon (222Rn) and multiple physicochemical variables. *Hydrological Processes 34(24)*: 4592–4608. https://doi.org/10.1002/hyp.13903

Coluccio, K.; Santos, I.R.; Jeffrey, L.C.; Morgan, L.K. 2021: Groundwater discharge rates and uncertainties in a coastal lagoon using a radon mass balance. Manuscript under review with *Journal of Hydrology*.

ARTICLE

Jeremy Bulleid and Daniel Clements, NIWA

Autonomous Intel for War on Waterway Weeds

In an ideal world alien bio-invaders would not impact our freshwater environments. But in the real world they do, often competing aggressively with and displacing native species, posing a serious threat to the long-term function of freshwater aquatic ecosystems in New Zealand. As a result of human activity, introductions of invasive aquatic weeds threaten environmental, social and economic resources and represent a significant management problem to the economy and natural environment. If left unchecked, dense infestations of aquatic weeds cause significant habitat alteration, impact on recreation, cultural values, navigation and hydroelectric generation, and compromise agricultural productivity by impeding water delivery.

In the absence of control of aquatic weeds, the impacts on New Zealand aquatic environments will increase and further spread is likely. Prevention and early intervention are recognised as the most cost-effective means to manage invasive species that pose a biosecurity risk. Effective detection and surveillance strategies are key to achieving eradication, so that control strategies can be enacted.

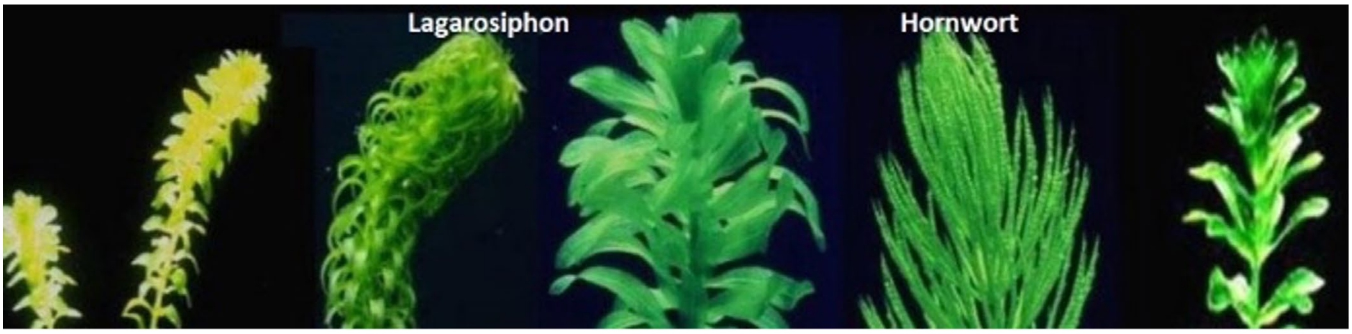


Figure 1: Five introduced underwater weed species currently present in New Zealand waterways. Lagarosiphon and hornwort are currently under significant active management programmes.

Current surveillance strategies are partially effective and have paved the way for new options. Diver surveys have been heavily relied upon and are now complemented with surveys carried out by autonomous boats, which collect video and hydroacoustic data. These methods generate hours of video recordings, and while these capture a picture of part of a particular lake or river at a particular time, it leaves us with a practical problem.

The Video Conundrum

What should we do with these enormous video files? Transferring and storing thousands of hours of video, shot at typically 30 frames a second, is problematic. And how might we process the raw imagery into useful, verifiable intel? The human resourcing that would be needed to post-process video on that scale is prohibitive.

The solution must come in the form of automation. In principle this could remove much of the need for human processing. But even if automation were attainable, this would not solve the mass video archival problem. And, to enable us to map the target species, we would have to detect and locate the targets in real time, from an autonomous boat travelling at a speed of perhaps 2 m/s.

And a Resolution

Fortunately, we found a way to resolve both the mass storage and processing conundrum at the same time, by replacing human eyes and brain with 'computer intelligence'. We explored and applied an **Artificial Intelligence (AI) Deep Learning (DL)** approach to detect the target species. Once trained, the detector 'looks' for the target in the video, frame by frame. Then, if a video frame contains one or more detections, we simply record the GPS location and choose whether to discard the video frame.

Hence, using a well-trained AI approach we can build a very small file containing only GPS locations, ready for input to a mapping app such as ArcGIS or Google Earth, to enable control methods to be implemented. This approach optionally avoids the problem of having to deal with large video files. We would, however, still retain a few still images to verify target detection.

Arming with Artificial Intelligence

There are three parts to the AI process we are using:

1. Designing the AI network,
2. Training the network (Figure 2) to create a detector, and...
3. Using the detector (Figure 3).

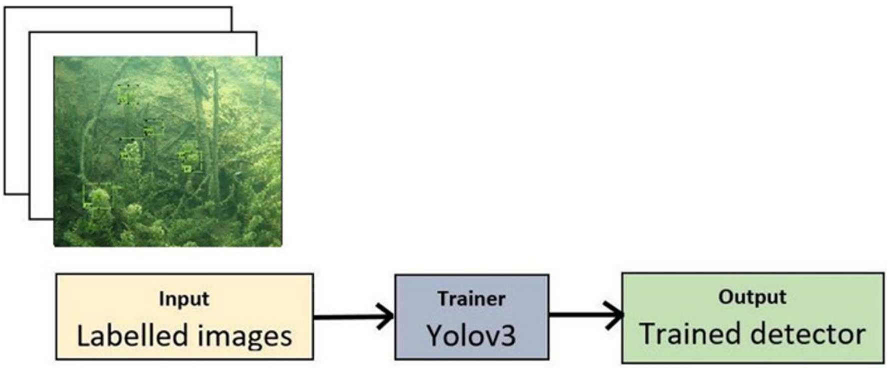


Figure 2: Training a detector

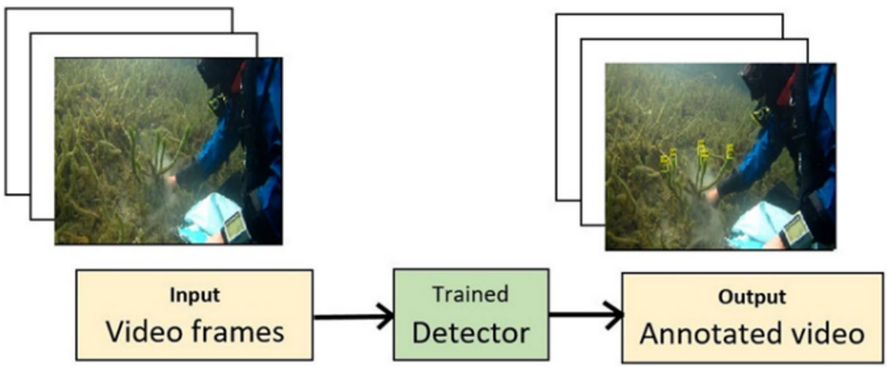


Figure 3: Using the trained detector

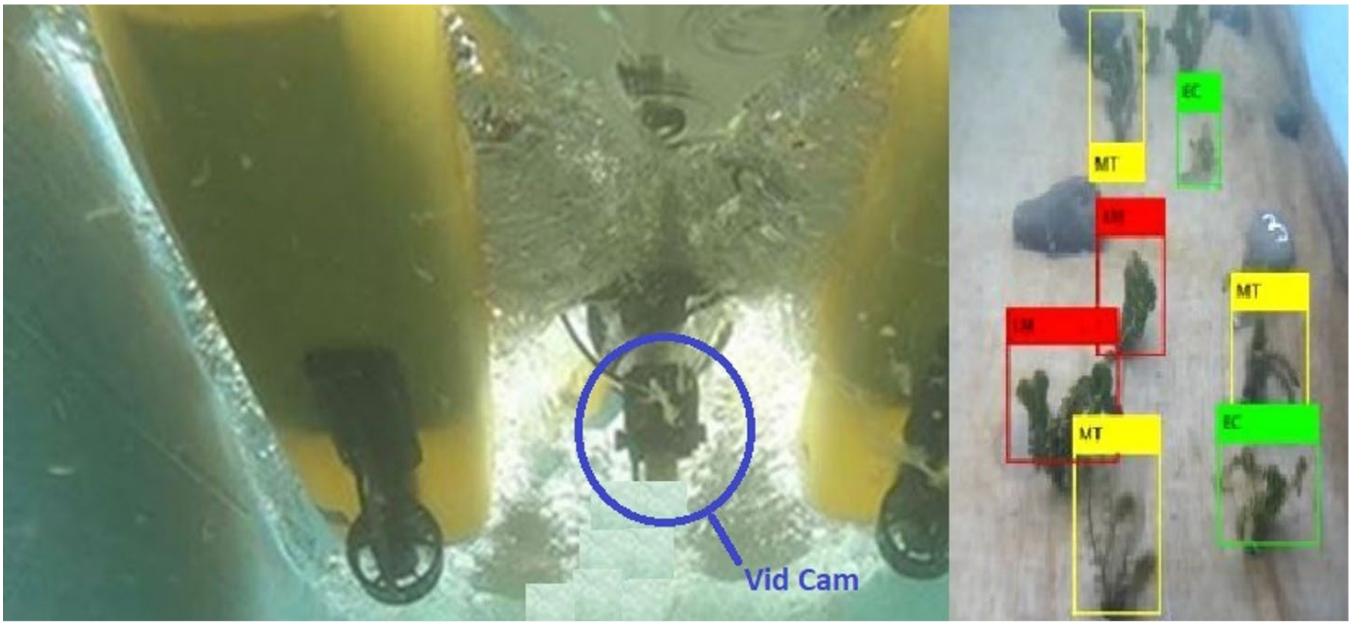


Figure 4: (Left) Autonomous boat with GoPro camera mounted underneath. (Right) Annotated detections: Red – Lagarosiphon (LM), Yellow – Myriophyllum (MT), Green – Elodea (EC).

Preliminary AI Trials

We are currently refining the development of this AI DL detection system. We carried out our first trials in a mesocosm environment, a hydraulic flume, where we planted out three underwater plant species common in New Zealand, including the target species *Lagarosiphon*. Post-processing the video, shot from the boat, has produced encouraging results (Figure 4).

In subsequent tests, we post-processed in situ video footage from both South and North Island lakes (Figure 5). This yielded surprisingly good results considering the modest amount of training currently available. We will continue to train the detector until we achieve sufficient accuracy and enable it to work in a range of waterways and environmental conditions.

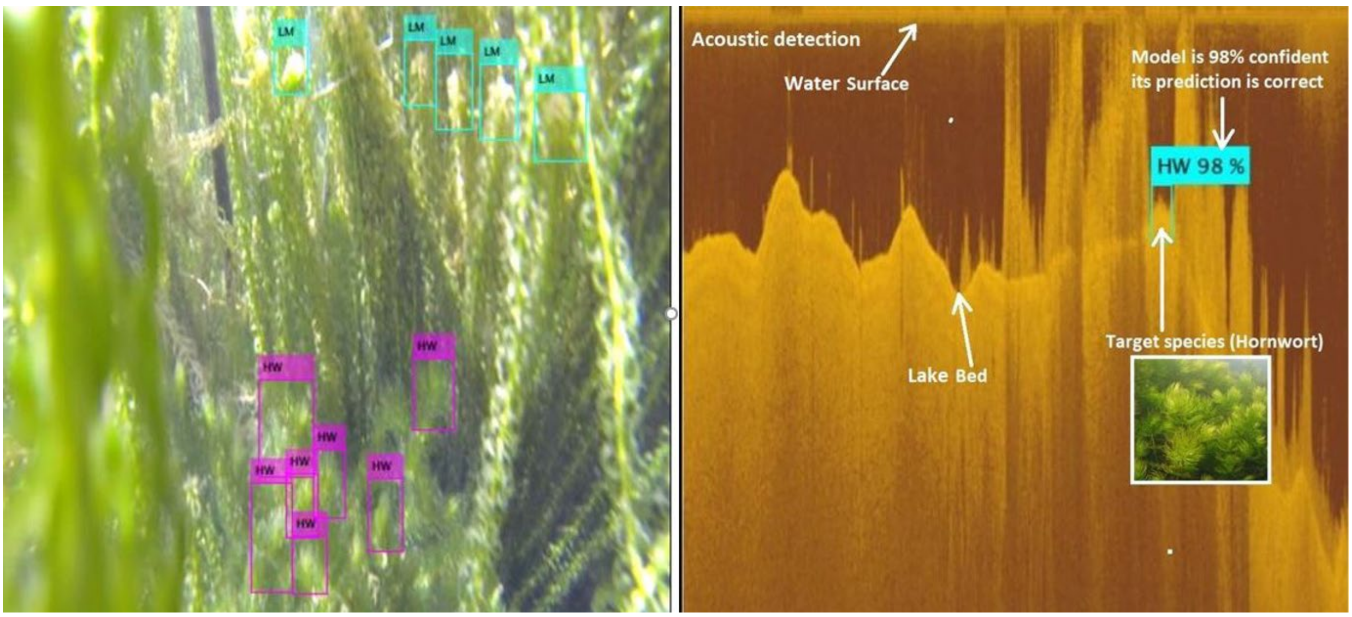


Figure 5: (Left) Detecting Lagarosiphon apical tips (LM) and hornwort (HW) in Lake Ōkataina. (Right) Detecting hornwort in Lake Rototoa – from hydroacoustic (for low-visibility) images.

From Disparate to Deployable

We have now pulled the 'component parts' together and developed a prototype module that can be easily strapped to a boat (Figure 6). It contains a 'detector' that can be taught 'what to look for', whether we are targeting invasive weed species, fish, or invertebrates. It will log the GPS locations and send them to NIWA's Neon telemetry server for archiving and export to a mapping programme for benchmarking or planning mitigation, eradication, and control strategies.

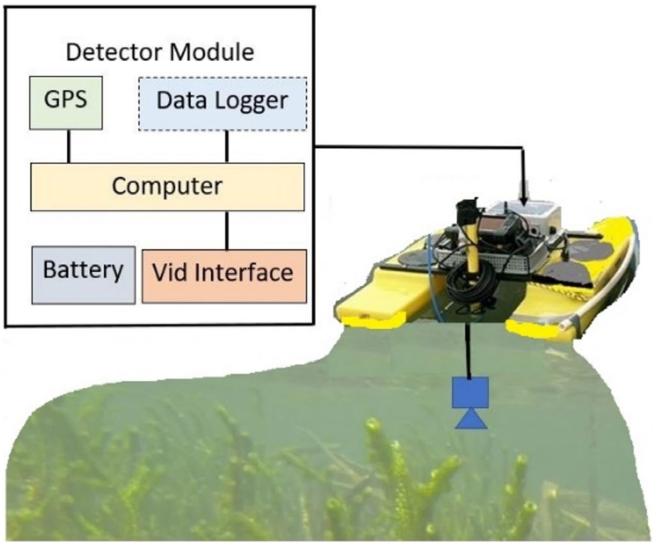


Figure 6: The prototype detector module.

Desired Outcome in Sight

We are currently in the early phase of the research cycle and further field training data collection, integration of the AI DL into the module, and testing to optimise the system is required. These modules will enable faster, more cost-effective and extensive surveillance, and provide early warning of existing and emerging threats to our freshwater ecosystems.

Detection modules will be replicable, deployable on a wide range of surface craft and may be operated by different agencies or citizen scientists nationwide. The module has a high-tech inner core, but with a low-tech outer shell it will require only minimal skills to set up and operate.

Contacts

For further information, contact Jeremy.Bulleid@niwa.co.nz or Daniel.Clements@niwa.co.nz

ARTICLE

Simon Cox, GNS Science

Sometimes Research, Like Wine and Other Good Things, Matures Over Time

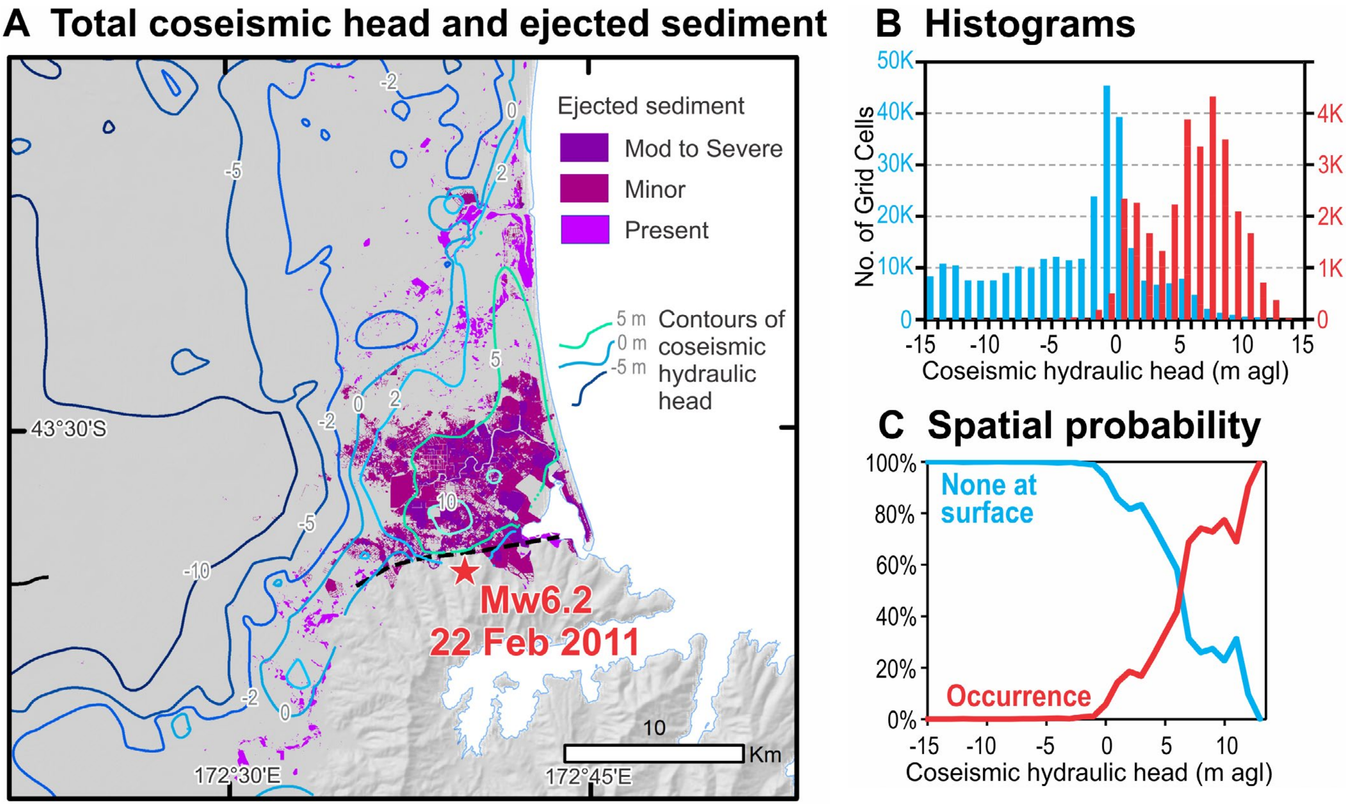
Figure 1: 'Haywire hydrology' as seen from an earthquake reconnaissance flight on 4 September 2010. Offset on the Greendale fault disturbed the flow of Hororata River. Photo: Richard Jongens/GNS Science.

As they flew along the newly formed Greendale Fault in September 2010, there were many things that Dr Simon Cox and his GNS Science colleagues could see were clearly awry during the first aerial reconnaissance. But among the offset roads, bent hedgerows and fences, torn and cracked fields, and damaged houses, there was one curiosity that specifically caught Simon's attention: many of the wells now had groundwater flowing out of them where normally it would have been at least 40 metres underground. Having worked on the formation of quartz veins and exploration of gold deposits, which are developed by earthquakes deep in the earth's crust, here was a real-life example of processes he had studied for his PhD and worked on for years but never actually observed as they happen deep in the earth's crust. Not only that, but he was seeing it in full realisation there would be many recordings of what had happened in monitoring bores all over the Canterbury plains. While there was much to do initially for earthquake recovery, this was a serendipitous opportunity for new science that rarely comes along.

Figure 2: An irrigation channel dammed and partially offset by the Greendale Fault, as seen from an earthquake reconnaissance flight on 4 September 2010. Photo: Richard Jongens/GNS Science.

The weird things that seemed to happen to groundwater during the earthquakes also caught the attention of Dr Helen Rutter from Aqualinc, as well as many people from Environment Canterbury and regional councils throughout New Zealand. Emails quickly brought collaborators together and observations gathered. One of the first things that seemed apparent was the earthquakes generated a rapid increase in groundwater pressures immediately during the shaking, followed by a drop in the deeper aquifer levels and rise in shallow aquifers immediately after the earthquake. In many places there had been an upwards flow that coincided with emergence of new springs and a pulse of water flowing down the rivers. The effects were also far-reaching, affecting aquifers throughout New Zealand including over 1000 km away in Northland. In a paper in the *New Zealand Journal of Geology and Geophysics*, which won the New Zealand Geophysics Prize in 2012, Cox and his colleagues postulated that release of artesian groundwater pressure and groundwater flow also played pivotal roles in Christchurch liquefaction (Cox *et al.*, 2012). Some of the groundwater level changes lasted for years after the earthquakes. These were documented along with differences in pre- and post-earthquake aquifer testing for a paper published in *Water Resources Research* (Rutter *et al.* 2016).

With support from the Royal Society Marsden Fund and the Natural Hazards Research Platform, their portfolio of 'Earthquake Hydrology' research began to grow. The expertise of Sjoerd van Ballegooy and other engineers from Tonkin & Taylor was enlisted in 2014, and the team contributed maps of the water table position to help inform rebuilding of Christchurch. One of the first challenges for understanding liquefaction was to map out exactly what happened within, across and between the aquifers throughout the earthquake sequence. They found groundwater in aquifers beneath Christchurch locally rose in pressure an equivalent of > 5 m in hydraulic head during the Mw6.2 earthquake (22 February 2011), which added



Graphic 1: (A) Map of the occurrence of liquefaction as ejected to the surface after the 22 February 2011 Mw6.2 earthquake, overlain with coloured contours of total coseismic hydraulic head in aquifers. (B) Histograms of the number of 50 x 50 m grid cells of ejected sediment occurrence (red, left scale) and not observed (blue, right scale) within 1 m intervals of aquifer hydraulic head. (C) Spatial probability distributions for ejected sediment 'occurrence' and 'not observed' derived from the relative proportion of classified grid cells within each 1 m groundwater level in the study area. Reproduction of Figure 4 from Cox et al. (2021).

substantially to the +5–10 m 'above ground' pressures that were normally contained by the overlying impermeable aquitard layers. The spatial correlations also appeared very clear: much of the worst liquefaction and surface flooding coincided with the areas that experienced highest groundwater pressures. But 'correlation is not proof of causation'; initial reviews of the work were critical that spatial relationships could have been coincidental because the highest pressures were also where the greatest thickness of liquefaction-prone sandy-silt were found. The science was still premature and a new approach was needed.

Enlisting the expertise of statistician David Harte, the team began unpicking the relationships between the geotechnical tests carried out by engineers on liquefaction vulnerability, actual observations of liquefaction during the earthquakes, and groundwater pressure changes that had occurred in aquifers about 20–40 m below each site. The first approach had analysed regional-scale relationships between liquefaction and groundwater, deliberately including areas of the Canterbury Plains to the west of Christchurch to span a wide range of aquifer pressures, potentially resulting in non-causative covariations in the data. The re-analysis looked only within the Christchurch urban area, where there is less variation in aquifer conditions but lots of geotechnical data. When tests were grouped on the basis of liquefaction vulnerability and soil strength, irrespective of location, places where 'minor' and 'moderate–severe' liquefaction occurred during the 22 February 2011 Mw6.2 earthquake had distinctly higher aquifer pressure than sites where liquefaction was not observed. Now with immediate relevance to engineering, a series of manuscripts were written and rewritten for the journal *Engineering Geology*.

Figure 3: Liquefaction at Kirsten Place as a result of the Mw6.2 Christchurch earthquake, 22 February 2011. Photo: Alun Davies/ simplicitywebdesign.co.nz.

'It was an incredibly frustrating and long road that was bad for morale at the time,' says Simon Cox, 'but ultimately a process that greatly strengthened the science. Although it took a decade from initial observations, developing the hypothesis then teasing all the details out, it now seems unequivocal that in that earthquake caused leakage of artesian groundwater that contributed to the near-surface liquefaction-induced ground damage.'

The final paper was published on the 10th anniversary of the February 2011 Canterbury earthquake (Cox *et al.*, 2021). It argues leakage and upwards flow from artesian aquifers promoted the ejection of liquefied sediment in Christchurch. It showed that hazard assessments need to consider hydrogeological setting and conditions, that Christchurch may have been one of the worst-case examples ever experienced, and there is a need to re-evaluate other examples of liquefaction worldwide. The paper can be downloaded for free from https://doi.org/10.1016/j.enggeo.2020.105982.

References

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ARTICLE

Kolt Johnson, Auckland Council

Covid-19 Lockdown Effects on the Parakai Geothermal Aquifer

Parakai is a township at the mouth of the Kaipara River, approximately 50 kms north of Auckland City, and is a popular recreational destination for thermal hot water pools. The Parakai geothermal aquifer lies within fractured Waitemata Group sandstones. Over 90 production wells tap the geothermal field, with the bulk of the consented water abstraction supporting commercial hot pool complexes. The annual fluctuation of groundwater levels in the Parakai geothermal aquifer is significantly influenced by groundwater abstraction. The lowest groundwater levels generally occur over winter when abstraction for hot pools is at its highest.

Groundwater levels were significantly affected by Covid-19 travel restrictions. The onset of Level 4 restrictions on 26 March 2020 coincided with a total cessation of water take by the largest spa pool complex, resulting in a sharp increase in groundwater levels in Auckland Council's monitoring bore #86 (Figure 1). This continued throughout Level 4 and Level 3, with groundwater levels exhibiting an asymptotic recovery response. Leading up to the close of Level 3 on 14 May 2020, the spa pool complex resumed pumping, which lowered groundwater levels. A lowering of groundwater levels continued throughout the year until the second Level 3 restriction on 12 August. As with the first period of restrictions, groundwater levels rose sharply, then dropped again with the lifting of Level 3.

These events provide valuable data showing the direct link between groundwater levels and pumping in the Parakai geothermal aquifer. The data may also be of use to support efforts to manage groundwater levels in the aquifer.

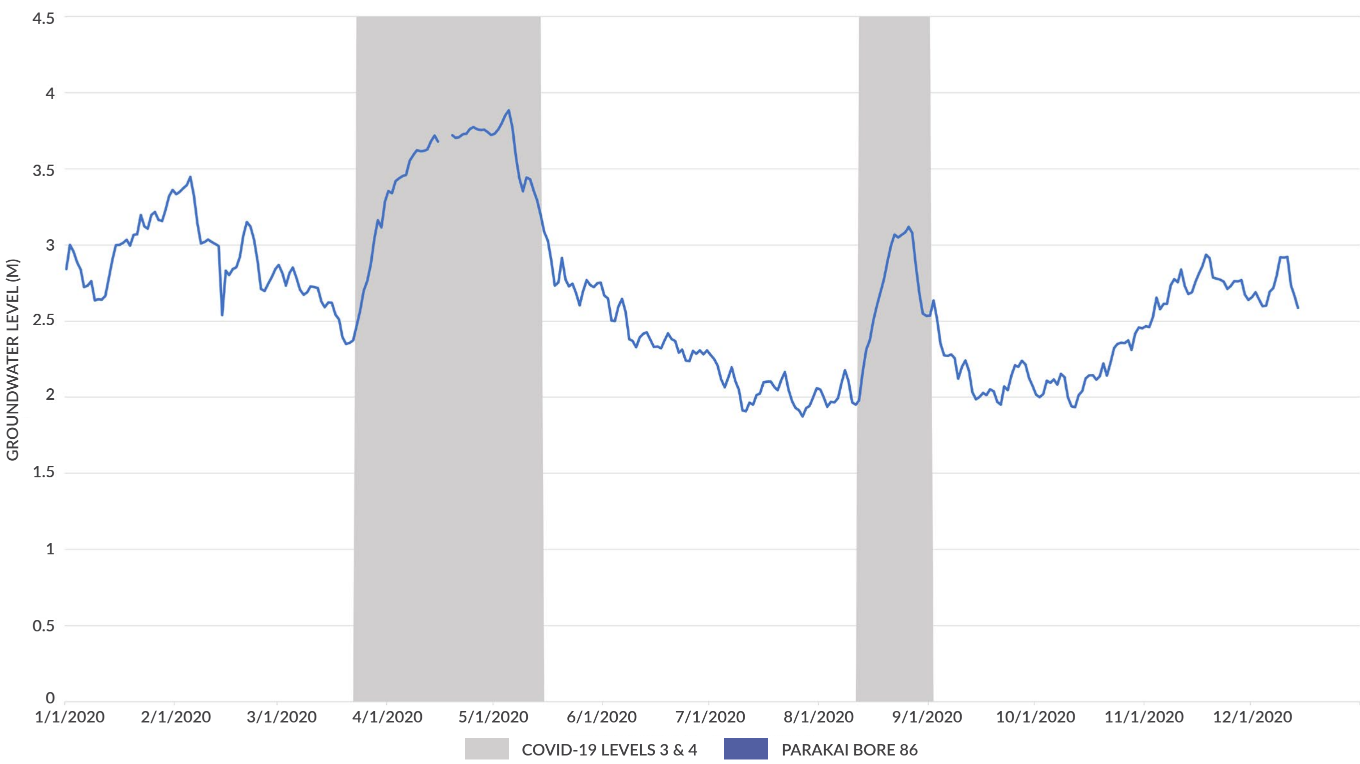


Figure 1: Groundwater level hydrograph for Parakai Bore 86 and periods of Covid-19 Level 4 and 3 restrictions.

UPDATE

James Grifiths

NIWA Update

As usual at NIWA, the summer period has been a busy one for fieldwork and related activities. As we head into winter there is still much ongoing fieldwork, but we are gradually scaling back the larger campaigns. This gives plenty of opportunity for hydrologists to spend more time in the office and at the computer screen. The following stories have been picked to reflect the mix of a much larger number of new and ongoing projects that NIWA hydrologists are currently involved in.

Hydrological Flow Path Explorer

Under the SMARTer Edge-of-field Mitigation Strategies project **Shailesh Singh** and **Julian Sykes** have developed a tool from the hydrological flow 'splitter' first developed under the Our Land and Water National Science Challenge (Sources and Flows programme). The 'Hydrological Flow Path Explorer' tool enables delineation of different hydrological flows for any river segment in New Zealand (surface water, groundwater, unsaturated lateral flow, tile drainage, etc). This is achieved using the HYPE hydrological model and can be used for a range of applications, e.g., riparian and constructed wetland buffer design and guidance. This tool can be accessed using following web link: https://gis.niwa.co.nz/portal/apps/webappviewer/index.html?id=8202f2d938724a118b0706584372e7d4.

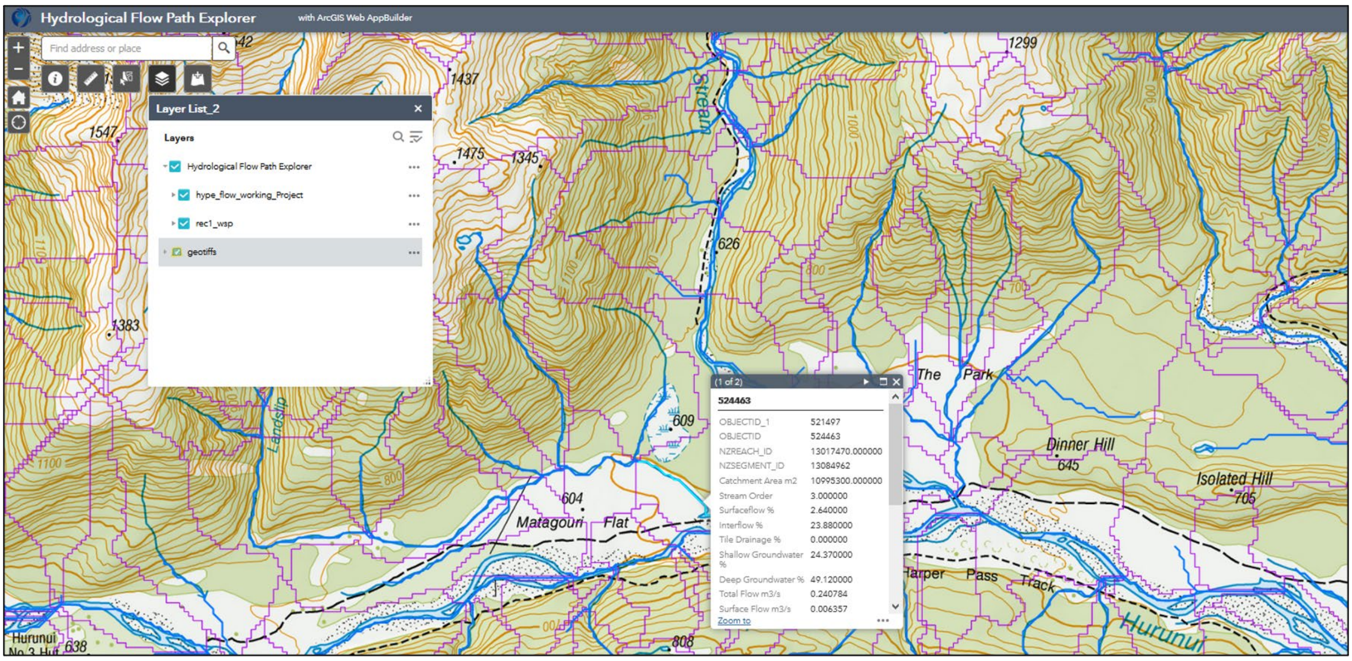


Figure 1: Screenshot of user interface for Hydrological Flow Path Explorer (illustrating reach-scale information for the Hurunui).

Climatology of Atmospheric Rivers

Atmospheric rivers are thin streams of water vapour that stretch for thousands of kilometres and deliver vast amounts of rainfall to mountainous areas of New Zealand. They pose both a hazard through flooding and a benefit through supplying water for hydro-electricity and agriculture, but until now, no objective classification of these events had been undertaken, limiting our ability to prepare and respond to events. A paper published in the Journal of Climate reports on a new study led by University of Otago and co-authored by **Jono Conway**, which provides the first climatology of atmospheric rivers for the New Zealand region, describing the frequency and severity of the events along with the rainfall delivered during events. The ability to automatically detect and understand the severity of atmospheric rivers before they make landfall is a promising tool for reducing the impacts of these storms, particularly on the West Coast of the South Island where these events are common but not always hazardous.

Water Accounts to 2020

Stats NZ Tatauranga Aotearoa asked NIWA to provide an update of the New Zealand Water Accounts to July 2020 to supersede the last report compiled by NIWA in 2015. The accounts include annual and seasonal averages of water flow and storage from 1995 to 2020 for each region in New Zealand. Water flows include precipitation, evapotranspiration and river flow (to the sea and between regions), whilst water storage includes snow, ice, soil moisture and lake and reservoirs. Account was also taken of how much water is used in hydropower generation. Led by **Christian Zammit** (who also led national-scale hydrological modelling), the project required use of GIS analysis to summarise data (**Ude Shankar**), summary of snow and ice survey data (**Drew Lorry**) and analysis of lake and hydropower data (**Roddy Henderson** and **Shailesh Singh**). In addition to a summary report (compiled by **Jim Griffiths**), new R and python code for derivation of summary statistics from GIS coverages were developed by **Matt Wilkins**. The new report is expected to be released by Stats NZ in the coming months (www.stats.govt.nz/topics/fresh-water).

Soil Moisture Forecasting Using Machine Learning

As a part of NIWA's Irrigation Insight MBIE Endeavour programme, a group of NIWA researchers, led by **MS Srinivasan**, are exploring various machine learning approaches to forecast soil moisture based on current soil moisture and forecast weather conditions. NIWA and NeSI researchers have discussed various methods that can be used and are worth further investigation. Once identified, the machine learning model will be integrated into NIWA's IrriMate tool for operational soil moisture forecasting for irrigation and drainage management. The developed models are location specific but can be built for any location where training data are available. This will allow NIWA to develop tailor-made products that add value to primary sector services.

Wet Weather Sampling

NIWA will assist Christchurch City Council with the implementation and operation of a stormwater sampling project within targeted drain networks in eastern Christchurch. The project run by **Jenny Gadd** and **Marty Flanagan** includes operation of seven autosampler stations, three Nalgene samplers and two flow stations and will involve the Christchurch Field staff targeting three rainfall events in which samples will be collected from 11 urban stormwater drain locations. Samples will be dispatched to the Christchurch City Council lab for analysis. The project is expected to operate to June 2021, or until three rain events have been successfully sampled.

Forest Hydrology

NIWA's activities led by **Bruce Dudley** on the (MBIE Endeavour funded) Scion-led Forest flows project is gathering pace with the culmination of many months of planning across four field sites (in Canterbury, West Coast, Northland and N. Auckland). The multi-year project involving numerous NIWA scientists and field technicians will look at the movement and characteristics of water through forested catchments. Field monitoring installations currently underway include meteorological stations, rainfall gauges, throughfall collectors, isotope collectors, groundwater monitoring wells, lysimeters and stream gauges. One of the aims of this project will be to allow validation of remote sensing data relating to forest canopy and hydrology over larger areas, but we're hoping to develop plenty of additional insights into the hydrology of New Zealand forested catchments along the way.

Figure 2: Under-canopy rain and isotope collectors (left), compact weather station (middle), and groundwater monitoring well installation (right).

NZWaM HydroDesk Tool

HydroDesk is new web-access tool that allows users to run the New Zealand Water Model (NZWaM) in a catchment of their choice from their desktop (hdesk.nzwam.nz). The tool was demonstrated at the HydroSoc Conference in Invercargill and attracted considerable interest. Whilst not using all the functions of the NZWaM, the tool allows users to get a taste of how the modelling framework can be employed and provides greater access to, and visualisation of, model outputs. In addition, the platform is also being used to demonstrate a revitalised version of NIWA's Cumulative Hydrological Effects Simulator (CHES) (more about that in the coming months). If you have any questions about the HydroDesk tool, feel free to contact **Christian Zammit** or **Matt Wilkins**.

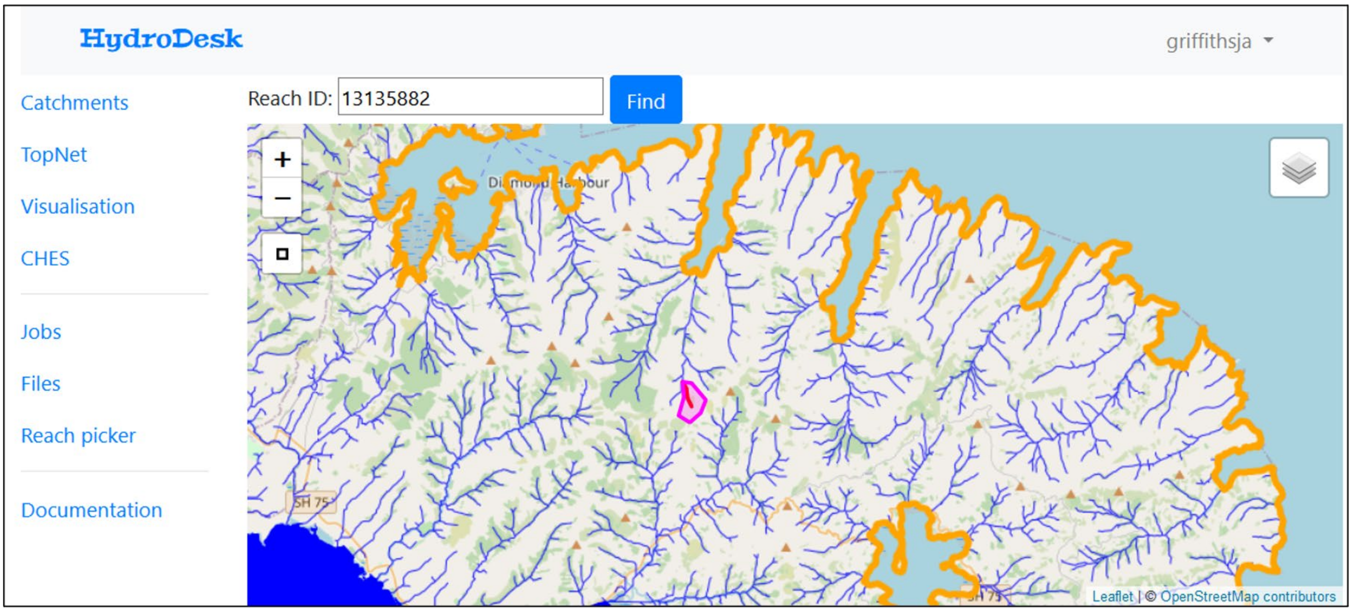


Figure 2: Under-canopy rain and isotope collectors (left), compact weather station (middle), and groundwater monitoring well installation (right).

New Lysimate Variant

NIWA's in-soil water sampler, Lysimate, has undergone significant adaptations to enable better sampling from multiple levels, and thus focuses on in-situ measurement of nutrient movement in the water that flows freely downward through soil (**Graham Elley**, **MS Srinivasan**, **Andrew Starr**). To achieve this, the original Lysimate has been adapted to include an in-situ nitrate analyser to enable near real-time and remotely monitored nutrient analyses. The water samples are drawn directly from water moving through the soil. The time and volume of the sample is recorded, on a Unidata NRL datalogger, along with the nitrate/nitrite concentration measured by a TriOS spectroscopic analyser. The revised sampling arrangement allows sampling and analysis from multiple depths. Near real-time data can then be accessed on the Neon Server. This adaptation will enable answers to questions such as 'how quickly are nutrients moving through soils, how much nutrient is retained and consumed, and how much is being flushed away as a potential pollutant?'

Staff News

Augusta Castela Soares, an intern from Timor L'Este, has returned to her studies at Lincoln University after a 10-week internship with the Hydrological Processes Group in Christchurch. In her time with NIWA Augusta developed learning materials for processing hydrological data in QGIS. **Alice Hill** has joined NIWA on 2-year Rutherford Foundation Fellowship looking at the role that meltwater plays in water quantity and quality forecasting to downstream water supplies in the Canterbury Plains (through case studies in the Rangitata, Waimakariri, and Hurunui basins). **MS Srinivasan** has been seconded to MPI as a technical lead of Water Availability and Security project, a part of MPI's Fit for a Better World programme. MS will continue to spend 50% of his time at MPI for the next few months. Finally, we will welcome **Kelsey Montgomery** back from maternity leave in mid-June.

UPDATE

Nimthara Udawatta

GNS Science Update

Figure 1: New staff members at the Wairakei site: Maïwenn Herpe, Nimthara Udawatta, Wes Kitlasten and Estefania Santamaria

Staffing

During the last six months the Hydrogeology Group at GNS has expanded substantially. We have welcomed six new members into our teams:

Groundwater Modelling Team

Wes Kitlasten is a senior groundwater modeller who was previously employed by the USGS as a groundwater modeller. Wes has a diverse background including groundwater modelling, forest hydrology, soil erosion and metamorphic petrology. At GNS, Wes is involved in developing a modelling framework to facilitate generation of groundwater models ranging from local to national scales. These models will be generated from consistent datasets using FloPy (a Python package for creating MODFLOW-based models). Uncertainty analysis will be evaluated using PEST++ and pyEMU.

Lee Chambers is a groundwater modeller / hydrogeologist who was previously employed by the University of Strathclyde (Scotland) as a post-doc on the Scottish Government's Climate Justice Fund: Water Futures Programme, primarily working on developing sustainable groundwater supplies in Sub-Saharan Africa (Malawi), using techniques such as stable isotopes, borehole forensics and improved drilling practices. Lee has a background in using environmental tracers (e.g. noble gases, CFCs, SF6 and tritium/helium dating) to reduce uncertainty in groundwater flow and transport models of circum-Himalayan groundwaters (Mekong delta – Cambodia). At GNS, Lee is working on inundation forecasting in the context of sea level rise (groundwater flood forecasting) using MODFLOW and the PEST software suite – model independent uncertainty analysis.

Figure 2: New staff members at the Avalon site: Susana Guzman and Lee Chambers

Susana Guzman is a groundwater modeller who previously worked as a research assistant at the Engineering Faculty of the University of Auckland. During that time, her research focused on inversion and uncertainty quantification of geothermal models. In March 2020, Susana graduated from the University of Auckland with a PhD in Mathematics. Her research interests include multiphysics modelling and inversion, high performance computing, and numerical methods. At GNS, Susana is engaged in the development of groundwater recharge modelling methods and stochastic geological modelling.

Hydrogeology and Geophysics Team

Estefania Santamaria is a hydrogeologist holding a master's degree in geology from the National University of Cordoba (Argentina). During Estefania's final project at university she worked for the Environmental Mining Department in Cordoba province, monitoring and evaluating Environmental Impact Reports of local mining projects. At GNS, Estefania is working on the SSIF National Aquifer Mapping Project in the Aupouri Peninsula, Northland, to understand the hydrogeological system better.

Nimthara Udawatta is a hydrogeologist. Nimthara was completing her master's in Environmental Science at Victoria University of Wellington and joined GNS Science during the midst of it. At GNS, Nimthara is working alongside Paul White on the SSIF National Aquifer Mapping. She is currently focusing on the Quaternary gravel depositions of Ngaruroro River, Heretaunga Plains, which will involve producing a lithological model using DGI EarthVision Version 9.1 modelling software.

Maïwenn Herpe is a hydrogeologist holding a MSc in Geophysics from EOST, Strasbourg University (France). Maïwenn previously worked in the oil and gas industry in Europe specialising in seismic interpretation. At GNS, Maïwenn works on multiple projects, including the SkyTEM project in the Hawke's Bay region, managing the hydraulic testing aspects of drilling phase.

Towards Implementation of Robust Monitoring Technologies Alongside Freshwater Improvement Policy in Aotearoa New Zealand

The NPS-FM and Essential Freshwater Package describes that New Zealand needs to "stop further degradation of New Zealand's freshwater resources and improve water quality within five years" and "reverse past damage and bring New Zealand's freshwater resources, waterways and ecosystems to a healthy state within a generation". Land and water stewards need to be confident that mitigation actions (e.g., wetland restoration, development of riparian buffers, stock exclusion) will be effective and that improvements can be identified robustly. However, critical knowledge gaps have been identified in monitoring that improvement, specifically in the design and technologies for such monitoring networks. Previously, monitoring in New Zealand largely consisted of monitoring state and trends at the catchment or regional scales (State of Environment monitoring), but not so much monitoring the effect of mitigation actions that takes place at multiple scales by multiple stakeholders.

We have recently completed an Our Land and Water (OLW) National Science Challenge project, 'Monitoring Technologies', led by GNS Science. The 9-month project identified the knowledge gaps by developing tools to better identify current and novel technologies that monitor the effects of freshwater improvement/mitigation measures. The current developed tool consists of a large inventory of monitoring technologies in an SQL database that can be interrogated in various ways, e.g., an R-shiny interface. This project involved collaboration between 13 scientists from central government, regional councils, iwi, consultancy, CRIs and universities.

Phase 1 of this project will likely be followed by larger Phase 2 project which will integrate with other OLW monitoring projects to develop GIS-based tools. This will be useful for end users (e.g., councils) to address the following questions at the catchment scale:

1. How well can current networks detect the effect of several mitigation actions?
2. What monitoring networks and technologies are needed to improve that the detection?
3. What is the cost of implementing such networks and technologies?

More questions on this project, please contact:

Rogier Westerhoff (GNS Science) or
Olivier Ausseil (Aquanet Consulting)

Westerhoff, R.; McDowell, R.; Brasington, J.; Hamer, M.; Muraoka, K.; Alavi, M.; Muirhead, R.; Lovett, A.; Ruru, I.; Miller, B.; Hudson, N.; Lehmann, M.; Herpe, M.; King, J.; Moreau, M.; Ausseil, O. Towards Implementation of Robust Monitoring Technologies alongside Freshwater Improvement Policy in Aotearoa New Zealand. Submitted to *Environmental Science and Policy*.

Te Whakaheke o Te Wai Endeavour Programme – Heretaunga Hui

The Te Whakaheke o Te Wai project team from GNS, Victoria University, collaborators from Lincoln Agritech's Braided Rivers project, and project partners from Ngāti Kahungunu and Hawke's Bay Regional Council, enjoyed a productive and engaging two-week hui in Heretaunga, Hawke's Bay. The broad aims of the Endeavour-funded Te Whakaheke o Te Wai research programme are to explore the origin and duration of water flow pathways, and how we use insights into water age and origin for better water resource management at a range of spatial scales (well-scale to national). With a rich history of local knowledge and a comprehensive water age dataset, the Heretaunga Plains provides an important project case study. The Heretaunga hui included various hikoi and kōrero, exchanging conceptual system understandings and knowledge, and identifying and mapping features and indicators in the Heretaunga Plains that hold significance to local iwi.

Key topics of discussion were the changes that have occurred in the Paritua Stream. Photos from the 1990s showed people swimming and cooling off in the stream, which is in stark contrast to the dry stream bed witnessed the day the team visited the site. The timing and frequency of the dry stream bed occurrences and the physical conditions that lead to them are currently being investigated. Highlights of the hui included a stimulating pōwhiri at the Mangaroa Marae followed by presentations and discussions.

Figure 3: Spring/Puna site visit (credit: Catherine Moore)

Decision Support Groundwater Modelling

1. Improved Workflow

Our Groundwater Modelling Team continues to develop and apply numerical techniques to support decision making. A recent paper published in Frontiers in Earth Science details an improved workflow for decision support groundwater modelling with a case study example from the Wairarapa. The workflow raises the priority of conducting uncertainty quantification when modelling to support decision making. The paper advocates for undertaking uncertainty quantification prior to the often time-consuming and expensive task of model history-matching (calibration). Prioritising and revisiting uncertainty quantification in the decision support modelling context can provide relatively early guidance on the appropriateness of undertaking further history matching, and even justification for forgoing history matching altogether. This work was funded through the Smart models for Aquifer Management (SAM) Endeavour research programme and the GNS SSIF Groundwater Programme.

Hemmings B.J.C.; Knowling M.J.K.; Moore C.R. 2020: Early Uncertainty Quantification for an Improved Decision Support Modelling Workflow: A Streamflow Reliability and Water Quality Example. *Frontiers in Earth Science 8*. https://doi.org/10.3389/feart.2020.565613

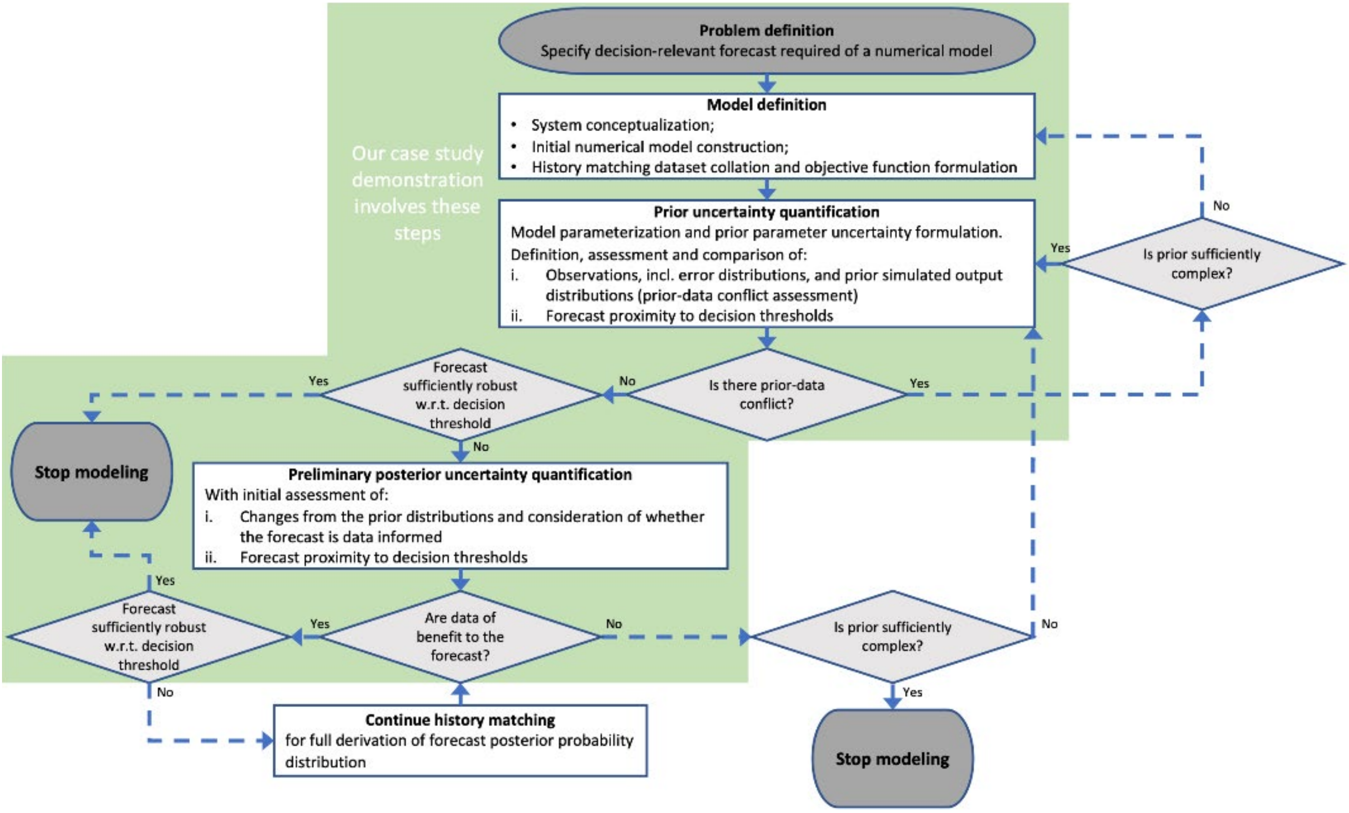


Figure 4: Proposed decision support modelling workflow with early uncertainty quantification (from Hemmings et al., 2020)

2. Software Development

GNS, in collaboration with USGS, University of Adelaide and Intera, continues to develop tools and software to aid the use of numerical models in decision support. This paper, supported through GNS' Groundwater SSIF and other aligned research programmes, provides a demonstration of script-based tools for circumventing the often-laborious construction and deployment of numerical models for use with PEST parameters estimation and uncertainty quantification software. The model-independent methods are available, open-source, as part of the pyEMU python library (https://github.com/pypest/pyemu).

The paper steps through a worked example that can also be accessed in a jupyter notebook at https://mybinder.org/v2/gh/pypest/pyemu_pestpp_workflow.git/feat_binder. Users are welcome to test, adapt and provide feedback on the GitHub site, or directly to lead-developer Brioch Hemmings.

White, J.T.; Hemmings, B.J.C.; Fienen, M.N.; Knowling, M.J.K. 2021: Towards improved environmental modelling outcomes: Enabling low-cost access to high-dimensional, geostatistical-based decision-support analyses. Environmental Modelling & Software 139. https://doi.org/10.1016/j.envsoft.2021.105022.

For more information contact: Brioch Hemmings

UPDATE

Juliet Clague

Lincoln Agritech Update

Figure 1: A Geolux Radar has been installed on the Wharepapa Stream sub-catchment in our Waiotapu study catchment to provide continuous flow data. A NICO sensor will shortly be installed to give continuous nitrate data.

Critical Pathways Programme

The MBIE-funded Critical Pathways Programme (CPP) aims to unravel the different pathways of contaminant transfer at the sub-catchment scale. The Lincoln Agritech Ltd (LAL) team has been busy preparing sites for continuous flow and nitrate monitoring (Figure 1), installing pressure sensors in selected streams to monitor water levels over time and performing summer low flow gauging at pressure sensor locations.

As part of our Vision Mātauranga commitment, we held a much-appreciated wānanga with members of Ngāti Tahu – Ngāti Whaoa at various sites in the Waiotapu Stream catchment and at Matārae Marae. Tribal members used their kaupapa Māori phone app, which was recently expanded with support by our programme (Figure 2), while we demonstrated how stream gauging and water chemistry sampling was performed (Figure 3). As our stream water chemistry dataset gradually builds up, we envisage carrying out more comparisons between our chemistry results and the assessment of the water's condition from a te ao Māori perspective. We will also be hosting community workshops in each catchment in the next quarter to share our knowledge and results gained thus far.

Figure 2 (above): Members of Ngāti Tahu – Ngāti Whaoa demonstrate their Mahinga Kai app.

Figure 3 (right): Stream gauging in the Waiotapu catchment using a RiverSurveyor.

Figure 4: TriOS NICO sensor before and after cleaning with oxalic acid.

By the end of this quarter, LAL will have five NICO (nitrate) sensors installed across our two study catchments. We have found that despite being installed with a wiper to clear biofilms, in some locations they are prone to inorganic fouling, likely caused by high concentrations of iron and manganese in the water. After a couple of months in the stream, the sensor is covered in black/brown precipitate that does not rub off. In consultation with HyQuest Solutions (the distributor for TriOS sensors in New Zealand) we have found that a quick dip in an oxalic acid solution cleans them up beautifully (Figure 4).

LuWQ2021 Postponed Until 12-15 September 2022

LuWQ 2021 (International Interdisciplinary Conference on Land Use and Water Quality), to be held in the Netherlands, has now been postponed until 12–15 September 2022. More information available on the website: www.luwq2021.nl

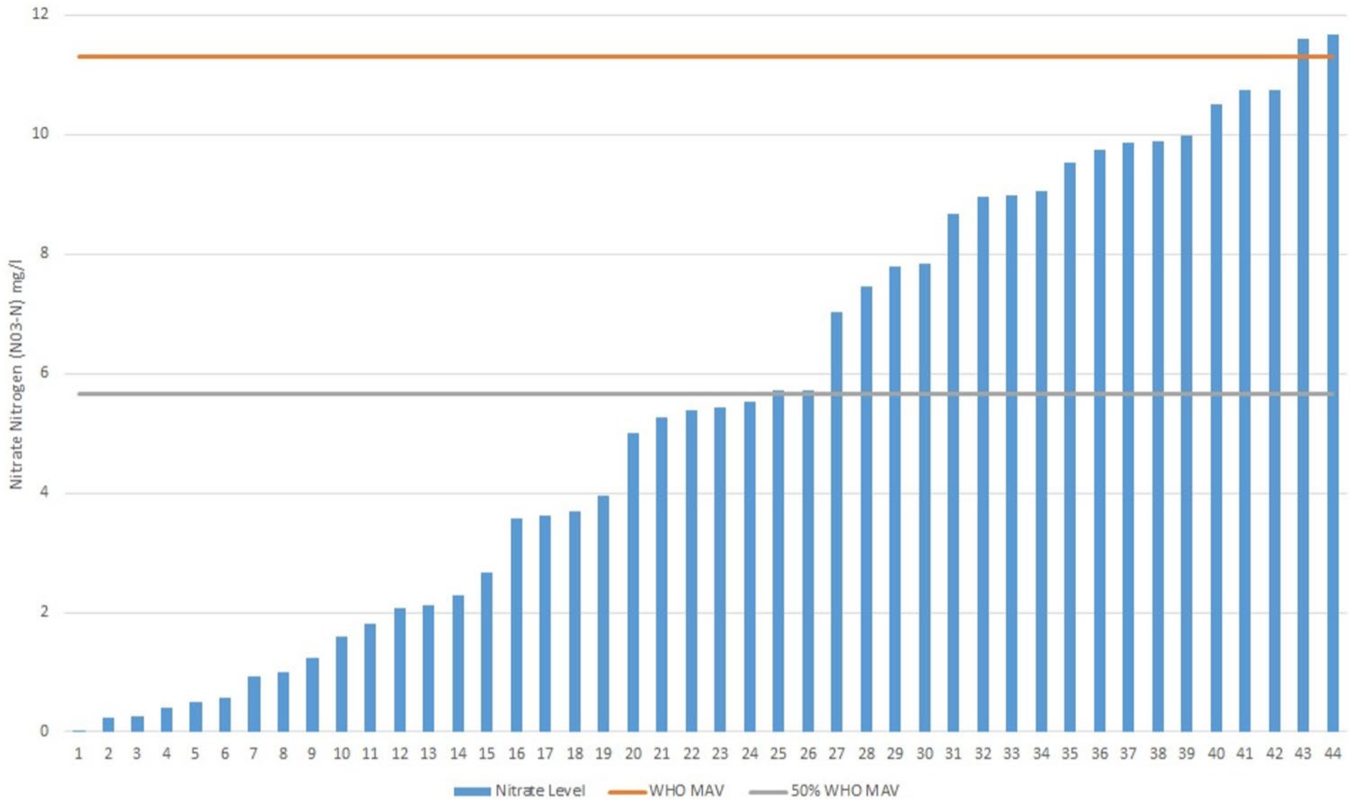
Here's hoping things have settled down by then!

HydroMetrics Nitrate Water Testing Events

HydroMetrics is a division of Lincoln Agritech Ltd. Our sensors offer real-time groundwater monitoring and puts the tools into the hands of land owners and businesses so they can become environmental guardians of their land and water.

To demonstrate the effectiveness of the sensors, HydroMetrics ran a two-hour public event on campus at Lincoln University and set up a nitrate water testing station. This event attracted many Selwyn locals who wished to test their rural well supply.

Fifty-nine water samples from local drinking water wells were measured for nitrates. Of those, 44 well owners kindly agreed to allow us to share the results anonymously so others in the region could understand the potential issues.



Graph 1: Public Nitrate Testing Day, Lincoln, February 12th 2021.

The team recorded two samples that exceeded the World Health Organization (WHO) Maximum Acceptable Value (MAV) (orange line on the graph); however, you can see there was a large number of wells with results more than 50% of MAV (thick grey line on the graph).

The 11.3 mg/L Nitrate Nitrogen (NO3-N) limit is recommended by the WHO and is currently adopted by the New Zealand Government in the Drinking Water Standards.

The HydroMetrics nitrate water testing station proved to be so popular that the team decided to repeat the event at the South Island Agricultural Field Days in Kirwee. For a gold coin donation, members of the public were able to get their water tested. The monies raised from the event was then donated to Farmstrong charity to support mental health of rural sector.

For more information visit www.hydrometrics.co.nz.

Recent Publications:

Barkle, G.; Stenger, R.; Moorhead, B.; Clague, J. 2021: The importance of the hydrological pathways in exporting nitrogen from grazed artificially drained land. *Journal of Hydrology 597* 126218. https://doi.org/10.1016/j.jhydrol.2021.126218

Gosses, M.; Wöhling, T. 2021: Robust data worth analysis with surrogate models. *Groundwater*. https://doi.org/10.1111/gwat.13098

UPDATE

Dr Helen Rutter

Aqualinc Update

New Recruits

Aqualinc have welcomed two new members of staff recently, with **Ed Fairclough** joining the Land and Water business unit and **Jane Alexander** joining the Research and Development business unit. Both are Canterbury University graduates: Ed has recently completed his BE (Hons) in natural resources engineering, and Jane has submitted her PhD thesis in civil engineering. Our new team members are contributing to a variety of projects for Central Government, Councils and the private sector.

Fletcher Frater, an MSc student from Canterbury University who has previously been a summer intern at Aqualinc, is working alongside aside us, with input from John Bright and Andrew Dark, on project called 'Optimising the use of multiple water storages under various water supply reliabilities'. This project is funded by a Callaghan Innovation Fellowship.

Canterbury Groundwater Levels

As we knew six months ago, there had been little winter recharge in 2020. This was reflected in little groundwater recovery through the winter and now, with a warm, dry summer, some record low groundwater levels (Figure 1).

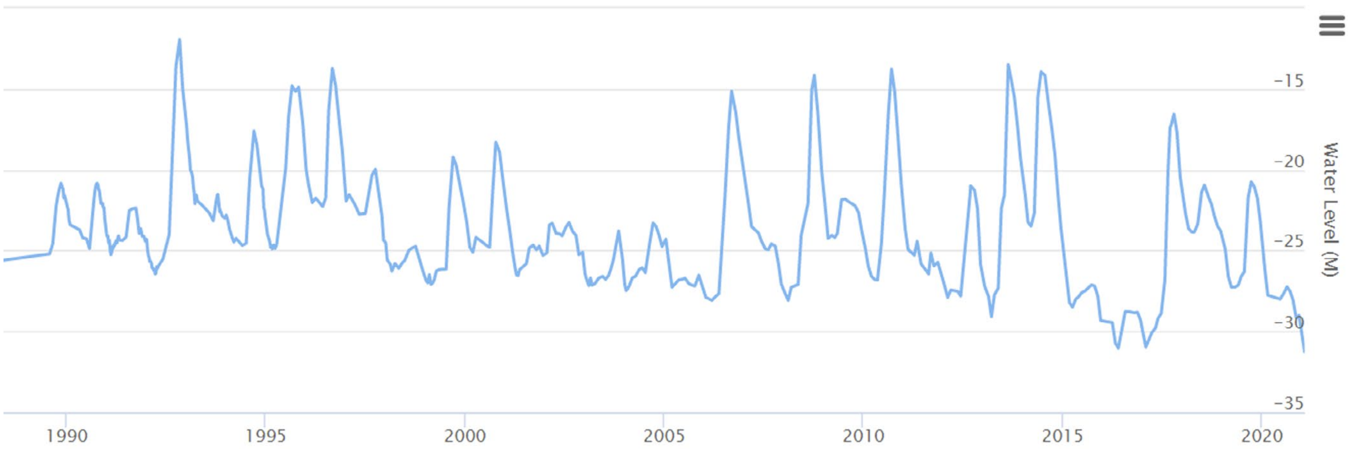


Figure 1: M35/5696 at West Melton, showing record low groundwater levels at the end of January 2021.

Shallow groundwater also shows a lack of recharge in recent times. We have been keeping an eye on data from the Christchurch City Council shallow monitoring network (inherited from EQC). The extreme high levels that were observed in 2017 and 2018, partly in response to ex-tropical cyclones Debbie and Cook followed by heavy winter rainfall, just don't appear to have occurred in 2019 and 2020 (Figure 2). This valuable dataset continues to provide us with insight into the dynamics of shallow groundwater under Christchurch.

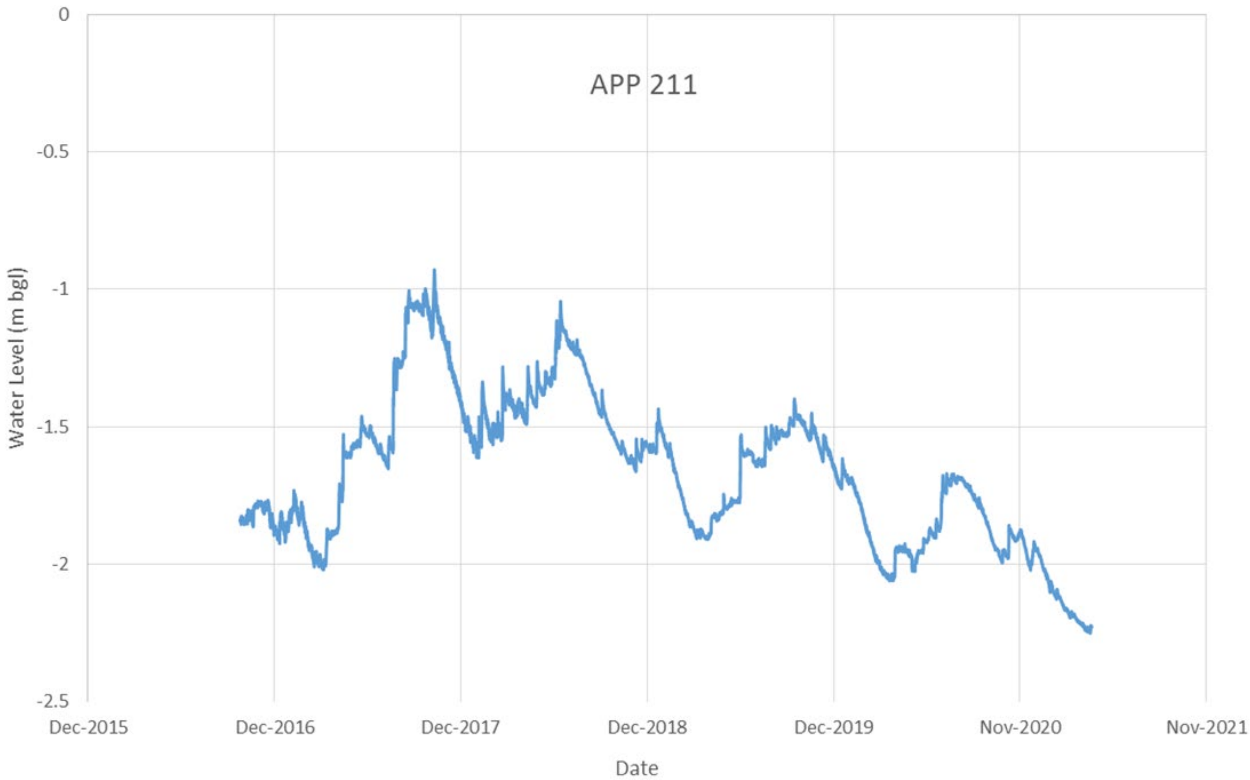


Figure 2: Shallow groundwater at APP083, showing the absence of groundwater responses to recharge in 2019/2020.

Irrigation Management

Given the warm, dry conditions and low groundwater levels, our field services team have been busy helping farmers optimally manage their water, through soil moisture monitoring and irrigation management. Conversations at field days have not only included irrigation management but also reflected the many upcoming challenges for the rural community, including changes to drinking water regulations, freshwater reform and land management.

Figure 3: Aqualinc's stand at the South Island Field Days, with soil moisture measurement instrumentation on show.

Publication of Work

Older projects are seeing the light of day. Aqualinc's work for the Christchurch City Council on the impacts of earthquakes and sea level rise on shallow groundwater levels has been received by the Council's Three Waters and Infrastructure. The investigation used a combination of analysis of data from the Christchurch shallow piezometer network and groundwater modelling, partially using Aqualinc's Canterbury Groundwater model. The work forms part of Christchurch City Council's multi-hazard study to inform floodplain management.

A recent paper, based on work in 2014 by Simon Cox, Helen Rutter and others, has been published. As described in the article 'Sometimes research, like wine and other good things, matures over time' (this edition of eCurrent, page 17) it explores the potential impacts of deep artesian groundwater under Christchurch on the liquefaction that occurred during the 2010/2011 earthquake sequence.

Figure 4: John Bright receiving the Irrigation NZ Innovation Award from Ballance (award sponsors) Science Extension Officer Jessica Hollever.

Irrigation New Zealand Innovation Award

In November 2020, Aqualinc was awarded the Irrigation New Zealand Innovation in Irrigation Award for 2020, in recognition of our work for the Fertiliser Association of New Zealand on N-Wise irrigation strategies. This work demonstrated that by changing irrigation management practices an average 27% reduction in modelled nitrogen loss to water is achievable, with minimal impacts on average annual pasture production.

As mentioned in the last eCurrent, we are conducting further work at a field trial site in Central Canterbury, funded by Ministry for Primary Industries' SLMACC programme, to test N-Wise irrigation strategies on a commercial dairy farm under realistic conditions of water-supply uncertainty. The site is now established, with lysimeters, irrigation systems, monitoring and telemetry all in place. Testing of different irrigation strategies will commence in earnest in the 2021-2022 irrigation season.

Figure 5: Aerial view of the field trial site under establishment.

UPDATE

Bob Bower

WGA Update

WGA NZ Welcomes New Staff

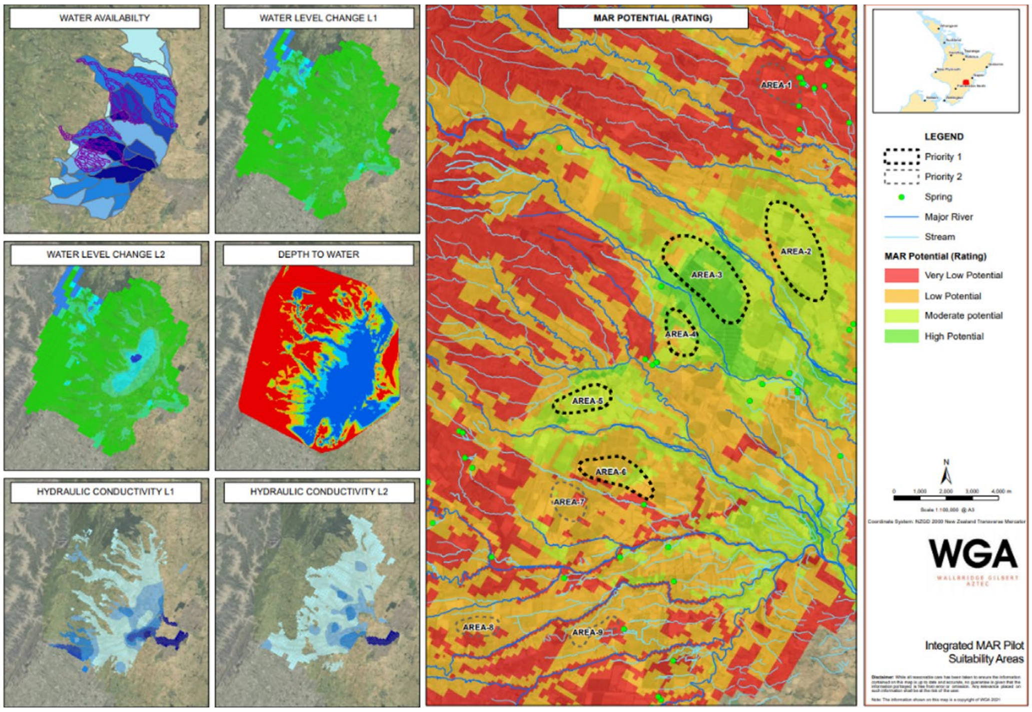
Wallbridge Gilbert Aztec (WGA NZ) are excited to announce that Francis Smith and Michelle McKeown have joined our team and are based in our Christchurch head office at Saltworks in the CBD.

Francis Smith is a senior hydrologist with international consultancy experience in the water science and engineering sector across Africa, Asia, Europe, New Zealand and North and South America. Francis specialises in the measurement, evaluation, and interpretation of surface water hydrology and meteorology, including application to environmental and climate change impact assessments, consent applications, engineering design and feasibility studies. Combining practical field experience establishing and maintaining innovative monitoring networks in remote and challenging environments across the world, with extensive experience conducting detailed hydrological and hydraulic investigations, Francis works closely with clients, councils, and other specialists to provide practical solutions to complex hydrological challenges.

Michelle McKeown is a wetland scientist with a PhD in Freshwater Systems and over a decade of research experience in Ireland, Fiji, and New Zealand. Michelle has developed an extensive skillset, which cover a broad range of biophysical sciences including ecology, hydrology, geochronology, microbiology, and climate change. Her knowledge is grounded in the interaction of microorganisms, plants, groundwater, climate, and human-environmental interaction. Her knowledge and experience bring a holistic understanding of the physical, hydrological, and ecological functioning of wetlands to projects. Michelle now works with various partners to develop solutions to environmental degradation and wastewater treatment, from constructing wetlands (that mimic natural wetland functioning through innovative design) to developing innovative options to re-animate natural wetland sites.

Central Hawkes Bay Managed Aquifer Recharge (MAR) Pilot

Managed Aquifer Recharge is a tool for the purposeful recharge of water to aquifers to support New Zealand's sustainable catchment management programmes. Nationally water security planning efforts are facing a growing need to develop opportunities to enhance natural groundwater storage to help safeguard water supplies and enhance and protect environmental baseflows. Similarly, the rising pressures from climate change are threatening our freshwater supplies such longer droughts and sea level rise which influences saline water intrusion in coastal aquifers. One of these WGA key projects is in Central Hawke's Bay (CHB) aimed at developing a MAR Pilot site as part of the Hawke's Bay Regional Council's Regional Water Security Programme. Field activities includes MAR Pilot site verification testing using pit investigations and soakage testing is helping to help quantify the variability of the shallow sub-surface vadose zone beneath an alluvial terraced site. As part of integrated catchment efforts, WGA has also developed an approach catchment-scale mapping MAR suitability specific to the goals of improving natural groundwater storage and targeting key resource management concern areas. This suitability mapping was conducted working with the HBRC science team and our colleagues at Williamson Water Land Advisors.



Conferences

WGA is a sponsor for the global International Symposium for MAR (ISMAR) 11, which will be held in April 2022 (Longbeach, California, USA). **Bob Bower** is leading the Young Professionals and International Technical Programmes.
https://www.ismar11.net/

Michelle McKeown is co-hosting the Trans-Tasman Quaternary Conference in July 2021.
https://aqua.org.au/

UPDATE

OXFAM

NZHS Administrator

Oxfam Update

The New Zealand Hydrological Society is proud to continue it's support of Oxfam New Zealand and the FLOW Project.

Upon confirming our continued support of this project, the society recieved the following message of thanks from Oxfam:

"Please pass on a huge big thank you from me and the rest of the Ox-whānau, for the generosity and commitment we receive from the NZHS members in support of FLOW... We are so happy to have NZHS with us as part of this journey!"

FLOW is Oxfam's four-year project based in the Henganofi district, Eastern Highlands of Papua New Guinea (PNG). FLOW stands for Fostering Lasting Opportunities in WASH (Water, Sanitation, and Hygiene).

FLOW's overarching goal is to improve health, resilience, and quality of life for remote and vulnerable communities, particularly women and children, in rural PNG.

Oxfam also wrote to inform the society that the FLOW Project is being absorbed within a new 5-year, multi-country Programme, called Kōtui. As well as FLOW in PNG, there will be projects in Timor Leste, the Solomon Islands and Tuvalu. You can find out more about Kōtui by reading the Programme Overview here:

www.oxfam.org.nz/wp-content/uploads/2021/04/Kotui-Progamme-Overview-country-projects.pdf

Kōtui is a five-year programme spanning four countries in the wider Pacific region. It is a Negotiated Partnership between Oxfam Aotearoa and the New Zealand Aid Programme.

60th Annual Conference

NZHS 2021

30 Nov – 3 Dec

Te Whanganui-a-Tara | Wellington

He kimihanga waiwaiā o te wai māori
An Essential Freshwater Odyssey

EARLYBIRD REGISTRATIONS OPEN 18TH MAY

PROGRAMME AT A GLANCE

Tuesday 30th November

DAY EVENTS | Powhiri, Keynote Speaker, Concurrent Sessions

EVENING EVENTS | Welcome Function

Wednesday 1st December

DAY EVENTS | Keynote Speaker, Concurrent Sessions

EVENING EVENTS | Society AGMs, Social Function

Thursday 2nd December

DAY EVENTS | Keynote Speaker, Concurrent Sessions

EVENING EVENTS | Conference Dinner

Friday 3rd December

DAY EVENTS | Field Trips

KEY DATES

Abstract Submissions
NOW OPEN

Earlybird Registrations
OPEN 18TH MAY

Abstract Submissions
CLOSE 9TH AUGUST

Earlybird Registrations
CLOSE 15TH OCTOBER

Conference Dates
30TH NOV - 3RD DEC

More Info: www.nzhsconference.co.nz

UPCOMING EVENT

NZHS Administrator

2022 Technical Workshop Announced: Napier Conference Centre 29 March – 1 April 2022

Cape Kidnappers, Hawkes Bay. Photo: Gary Lisbon

Save The Date!

Be sure to save the date in your calendar and keep an eye out for future announcments regarding the 2022 Technical Workshop. We look forward to having you join us in Napier!

Napier Conference Centre

NOTICE

Stew Cameron, Paul White and Rob Reeves

Obituary: Dr Michael Rosen

It's with sadness that we convey the news of the passing of Dr Michael Rosen. Michael was a Groundwater Chemist with GNS Science from 1993 to 2001. Many people from the New Zealand groundwater community will remember Michael's kindness, sense of humour and excellent scientific mind.

While at GNS, Michael was responsible for developing the National Groundwater Monitoring Programme, which continues to this day as a recognised Nationally Significant Database. In addition, he developed the first set of groundwater quality sampling standards for New Zealand. He was a co-editor of the book Groundwaters of New Zealand, and authored chapters on groundwater quality; this book is still in use by many New Zealand hydrogeologists.

Michael made major contributions to investigating land use effects on New Zealand groundwater systems. His strong research interest in lakes led to his involvement in the early days of the Lake Taupo Protection Project (LTPP). From these beginnings, the LTPP grew into an approximately $120 million effort by government (central, regional and district) and the local community to protect Lake Taupo water quality from the effects of land use.

Michael left GNS Science in 2001 to work in various research roles specialising in groundwater and surface water quality for the United States Geological Survey based in Carson City, Nevada. His passion for lakes continued with research on Lake Mead and Lake Tahoe. Michael's prodigious scientific output included three further books and many papers; he also chaired the International Association of Limnogeology. Mike is survived by his wife Laura and children Nick and Emma.

NOTICE

NZHS Administrator

Membership Renewals – Thank You for Your Continued Support

NIWA Taihoro Nukurangi

Society Sponsor

We would like to take this opportunity to say thank you for your continued support over the last year. It's time again for our annual membership renewals, so a friendly reminder to check your inbox for your invoice this week.

As part of your membership, you receive:

- Journal Hydrology (NZ) – Two issues per year and for 2021, the 60th Anniversary Edition. You can review past pubished jounals on the NZHS website here: www.hydrologynz.org.nz/journals.
- eCurrent, the official NZHS online newsletter, containing Society news and informative news on hydrological happenings in New Zealand and overseas – Two issues per year. You can view past issues on the NZHS website here: www.hydrologynz.org.nz/publications.
- Member discount to the NZHS 60th Anniversay Conference, Technical Workshop and other educational events – the 2021 60th Anniversay Conference is being held in Wellington at Te Papa from 29th November–3rd December.
- Regular e-news via email to keep you informed of current events within the industry.
- Free job vacancy listing on the NZHS website (valued at $70). You can view job listings on the NZHS website here: www.hydrologynz.org.nz/jobs.
- Access to and information about activities from other similar scientific and industry groups.
- Access to books on topics relevant to NZ hydrologists.
- Knowledge and information sharing amongst peers.

Your subscription supports projects and conference travels undertaken by NZHS members.

Annually the Society awards more than $10,000 as project and travel grants to its members.