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NEW ZEALAND HYDROLOGICAL SOCIETY

CURRENT NEWSLETTER

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MESSAGE FROM THE EXECUTIVE

After more than a decade, the New Zealand Hydrological Society annual conference will be returning to Christchurch. When we last met in Christchurch for the annual conference in 2006, YouTube and Twitter had just arrived, and the iPad was non-existent. The Three Gorges Dam in China was still seven years away from becoming operational. The fourth IPCC (Intergovernmental Panel on Climate Change) report was yet a year away, and 91 octane was $1.57/L. Prior to the seismic events in 2010 and 2011, the city of Christchurch was a very different place to what it is today.

Today, Christchurch city is standing up tall and proud, and ready to welcome hydrologists and meteorologists to the New Zealand Hydrological Society and the Meteorological Society of New Zealand joint annual conference. The main conference will be held at La Vida Conference Centre in Upper Riccarton, from Tuesday 4th to Friday 7th December 2018. The conference theme is "The Hydrological Cycle in Changing Times". The reception to the conference has been overwhelming, with submission of more than 250 abstracts. The current programme has more than 190 oral and 60 poster presentations on topics ranging from climate and cryosphere to bush fires, the complete hydrological cycle, policy, infrastructure and governance. The much anticipated conference dinner is to be held at the Art Gallery, in the city centre on 7 December – and has a "Black Tie / Sunday Best" theme. A diverse range of fieldtrips have been planned, including an insider view into the Central Plains Irrigation Scheme; an informative trip around Christchurch City focussing on drinking water and flood mitigation, in the context of climate change and natural hazards; and a leisurely visit to the International Antarctic Centre. On behalf of the conference committee, I would like to warmly welcome you to the 'Garden City' of Christchurch Ōtautahi and to the conference, and I look forward to making the conference a success.

MS Srinivasan

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Taihoro Nukurangi

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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@hydrology.org.nz
Advertising space is available; contact Helen Kinaston at the above address to find out more.
The views presented in Current do not necessarily represent policies of the Society.

Photo on front cover: Figure 2. Southern end of the present Lake Onslow reservoir (photo: Mohammed Majeed).

Earl Bardsley, University of Waikato

ARTICLES

Pumped storage for reduced emissions?

As part of a recent report on transitioning to a lower emissions economy (Productivity Commission, 2018), a case was made for electricity from expanded renewable sources to replace fossil fuel usage in industry, with concurrent adoption of electric vehicles (EVs).

However, as was noted by Transpower in a submission to the Report, a move toward more reliance on renewables gives increased risk of impact from future dry seasons. We would certainly look foolish if some future dry period resulted in enforced EV carless days.

The Report nonetheless is strong in its advocacy of a shift to EVs:

A rapid and widespread transition to a very low emissions light vehicle fleet is essential for New Zealand to achieve a long-term emissions reduction target.

It is also noted in the Report, as well as in recent television advertising, that Norway is some way ahead in terms of transitioning to EVs with renewable energy supply. However, Norway has much greater hydro storage capacity than New Zealand, including the world's largest pumped storage scheme by energy measure.

The Report sidesteps the issue of detailing specific mechanisms to offset future dry years and seems to have faith that a "voluntary market for firm energy" will provide the necessary security of future electricity supply in a low-emissions economy. Pumped storage is mentioned only to the extent of being dismissed as having high capital cost and probably being "environmentally and economically infeasible".

One alternative might be to simply permit a greater degree of drawdown of existing hydro lakes. However, power generated in this way is likely to be expensive in the electricity market and there would be a gamble on having a subsequent period of higher than average inflows to bring the lakes back to their normal operating range. Also, given the shoreline damage already present at our main hydro lakes from seasonal operation, it is concerning that the Report even raises the drawdown option as a possibility. Battery storage against dry years is not practical but one alternative might be maintaining a large stockpile of coal at Huntly. However, the present two 250 MW Rankine units there are nearing the end of their operational life and can't be relied on into the future without expensive upgrades.

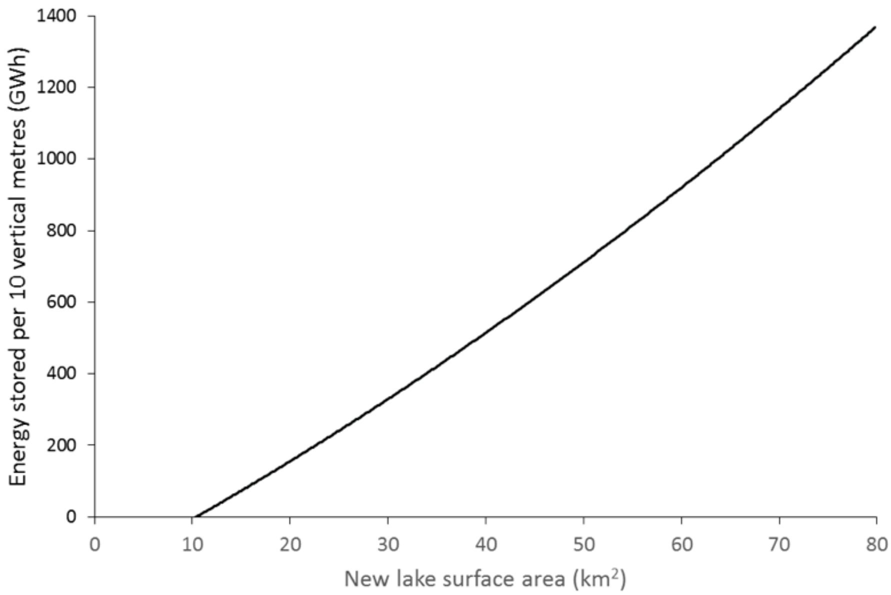

Figure 1. Energy storage from an expanded Lake Onslow as a function of lake surface area. A lake of surface area 80 km2 has ≈ 1,400 GWh of gravitational potential energy over a 10-metre elevation change.

If pumped storage is to be a viable dry-year buffer in a low-emissions economy then considerable energy storage is required, implying a significant engineering scheme. Any such scheme cannot be considered in the abstract and can only be evaluated with respect to the hydrology of a specific site.

The Onslow basin in Central Otago has been noted previously as having potential for large-scale pumped storage, with Lake Roxburgh acting as the lower reservoir (Bardsley, 2005). In fact, the scheme considered in that paper was huge and would have been the world's largest by energy storage. The economics were probably never going to be viable and the large surface area of the upper reservoir might have resulted in a net water loss to evaporation.

However, smaller versions of the scheme can also be considered, each with its own energy-hydrology operating mode and economics. In each case, about 1,300 MW of installed capacity is envisaged, with a 20 km rock tunnel linking the upper and lower reservoirs (Lakes Onslow and Roxburgh, respectively). Figure 1 shows the energy storage capacity of the Onslow basin as a function of the extent to which the existing Lake Onslow is expanded beyond its present size of about 10 km2. Figure 2 shows the landscape around the southern end of the present lake.

The plotted function in Figure 1 gives the amount of energy, E, that would be released by lowering an expanded Lake Onslow by 10 metres, as a function of lake surface area, A:

$E = 0.058 A2+14.43 A -150.1$

where E is in GWh and A is in km2. In reality, the achievable E would be a little less because of inevitable inefficiencies in the pump storage cycle.

The increase of E with A is derived from both the increased lake surface area and the fact that a larger lake area implies a higher lake level elevation. A lake area of 50 km2 corresponds to a dam height of about 50 metres at the Teviot stream outlet, while an 80 km2 lake would require a dam slightly more than 100 metres.

Figure 2. Southern end of the present Lake Onslow reservoir (photo: Mohammed Majeed).

Whatever expanded lake surface area might be decided on, the most passive mode of operation is maintain it as an apparent natural lake, to be utilised only in the event of a dry season. This use is analogous to a stand-by thermal station but would have the advantage of no emissions.

A higher level of utilisation would be to operate the lake continuously to buffer short-period wind power fluctuations. Again, the expanded lake would hardly differ in appearance from a natural lake for most of the time, but would serve the useful additional purpose of allowing significant expansion of wind power without risking grid instability.

The maximum level of utilisation would be to include use of Onslow pumped storage as an active South Island seasonal hydro lake. This would also reduce the frequencies of extreme wholesale electricity prices during times of power supply issues. At the time of writing (late October 2018), average wholesale electricity prices have been in excess of $300 per MWh because of a combination of low hydro lake inflows and gas supply issues.

An interesting variation of the seasonal theme is to maintain the Waitaki lakes (Tekapo and Pukaki) at around their mid-levels through the year, shifting their seasonal hydro storage roles to the expanded Lake Onslow. A current PhD study at the University of Waikato indicates that seasonal pumped storage operated in this way would create net positive energy output on average because of reduced spill loss from the Waitaki power scheme (Majeed, 2018). Onslow seasonal operation linked to the Waitaki scheme would have the further economic advantage of making available up to 100 m3s-1 of extra Waitaki water for summer irrigation.

Evaluating whether Onslow pumped storage is “economic” is therefore a complex process which must take into account many factors, depending on scheme size and its mode of operation. Economic advantages might include including enabling expansion of wind power, reduced frequency of high electricity prices, more Waitaki summer irrigation water, and maintaining EVs and electricity-intensive industrial activity during extended dry periods.

The extent of environmental impact of Onslow pumped storage also depends on its mode of operation. As just a dry-year reserve with wind power support, for most of the time an expanded Lake Onslow would appear as a larger version of the present lake. Introducing seasonal use inevitably has environmental impact from lake level fluctuations. However, a major engineering project is the best time to carry out ecological mitigation from the outset. For example, an expanded Lake Onslow might be converted in part into an ecological tourist attraction by way of constructing an intricate maze of open channels among floating wetland islands.

Whatever its mode of operation, Onslow pumped storage construction would require a long lead time. Quite apart from consents and impact evaluations, even filling an expanded lake would have to be done in time-spaced increments. Pumped storage may or may not play a role in reducing our future emissions but detailed economic and environmental evaluations should start soon so that informed decisions can be made.

Bardsley, W.E., 2005. Note on the pumped storage potential of the Onslow-Manorburn depression, New Zealand. Journal of Hydrology (NZ) 44, 131-135.

Majeed, M., 2018. Evaluating the potential for a multi-use seasonal pumped storage scheme in New Zealand’s South Island. PhD thesis, University of Waikato (submitted).

Productivity Commission, 2018. Low-emissions economy.

ARTICLES

Jeremy Bulleid (NIWA)
Thomas Wilding (Hawke's Bay Regional Council)

Automatic Discharge Measurement of Lowland Weedy Streams

Introduction

In this article we describe our progress with the development of a practical tool to improve the reliable measurement of water flowing in lowland weedy streams. This is part of an MBIE Envirolink Tools project being carried out in collaboration with regional councils. We are using air bubbles and Artificial Intelligence (AI) to realise a technology that shifts the paradigm of conventional flow measurement.

Limitations of conventional measurements

Conventional methods for continuous flow monitoring require a surrogate (water level), translated to discharge using a rating curve. The presence of aquatic vegetation makes this relationship insensitive and unstable, often resulting in 'difficult-to-impossible' measurement conditions.

The Rising Bubble Method

Because there is no current technology that can easily, accurately, directly and continuously measure discharge in weedy streams, we are developing an idea to transform the Rising Bubble Method (RBM) into standard measuring equipment. The principle, as summarised in Figure 1, is to release a bubble from the stream bed. The bubble is displaced downstream by the flow as it floats to the surface. The downstream displacement integrates velocity throughout the water column.

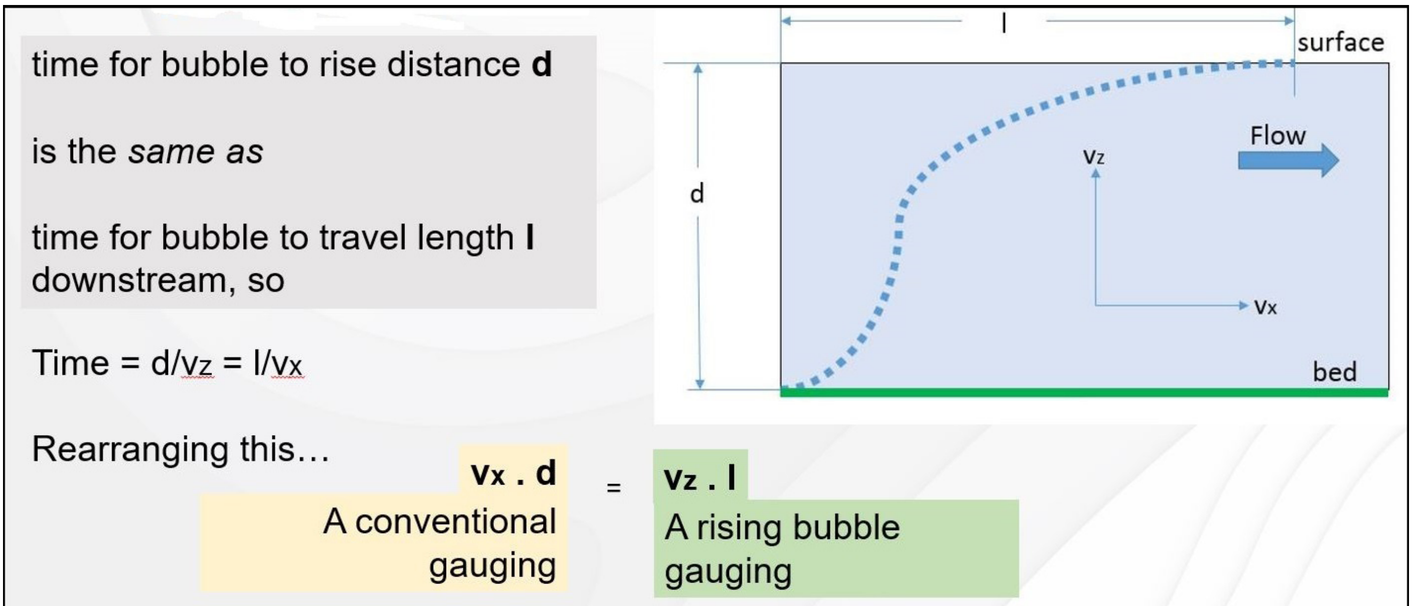

Figure 1: The rationale for, and difference between conventional gauging and RBM gauging, showing the path of a single bubble. Vz is the same as rise velocity but emphasises the direction (z axis).

This principle can enable us to measure flows 'where we need to' not just 'where we can'. This will produce more impactful knowledge

Our bubble injector module injects bubbles with the precise diameter needed to achieve constant rise velocity (Vr). A bubble is injected simultaneously from each of the injectors spanning the streambed. Previous research has proven that the bubbles intrinsically integrate the downstream displacement as they rise to the surface. The horizontal distances, from the line of bubble injectors (the origin) to where the bubbles break the water surface, are directly proportional to discharge. We need to accurately determine this bubble Just-Surfaced location, from video taken of the water surface. We have transformed the conventional measurement domain (the stream cross-section) to the water surface.

Tool Overview

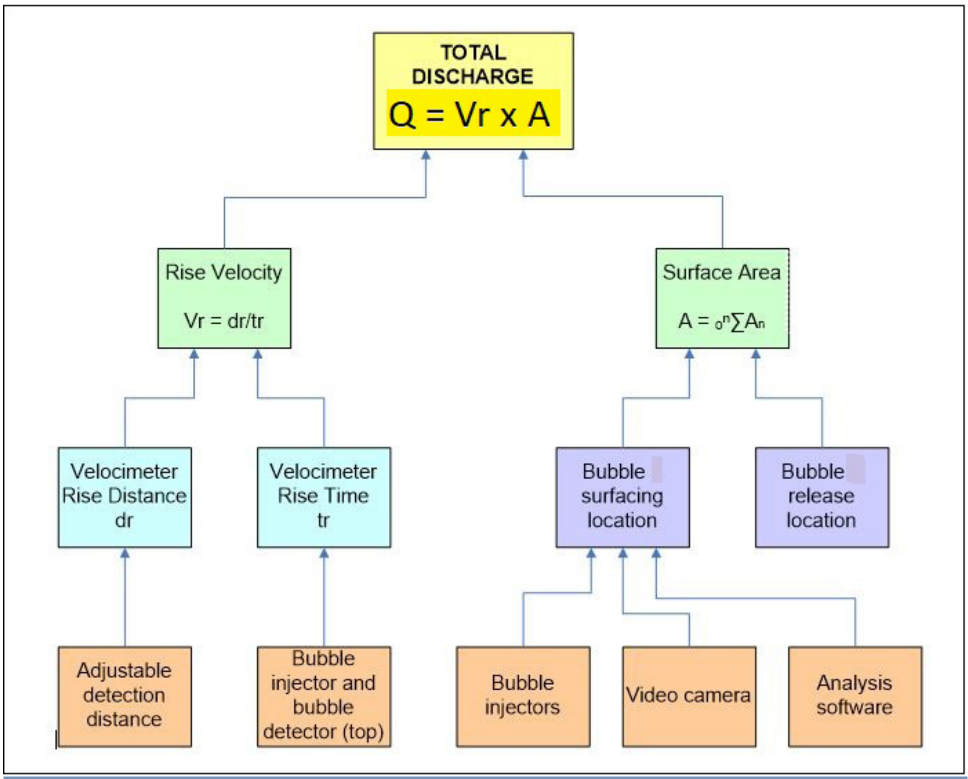

Figure 2: The overview of the process we are using, where there are n bubble injectors. The surface area A is the displacement area.

Artificial Intelligence – stage 1

Because it is not humanly possible to differentiate a Just-Surfaced bubble from other classes (Background, Just-Surfaced, On-Surface and Burst), instantaneously, across a line of bubbles, we need a faster, flexible and more insightful method... video, and Artificial Intelligence (AI).

An AI Neural Network (NN) was created and taught to recognise a Just-Surfacing bubble, by training it with 600+ images of each of the other classes. When tested with images it has never seen before, the NN now routinely exceeds 99% accuracy from 200 diverse validation images.

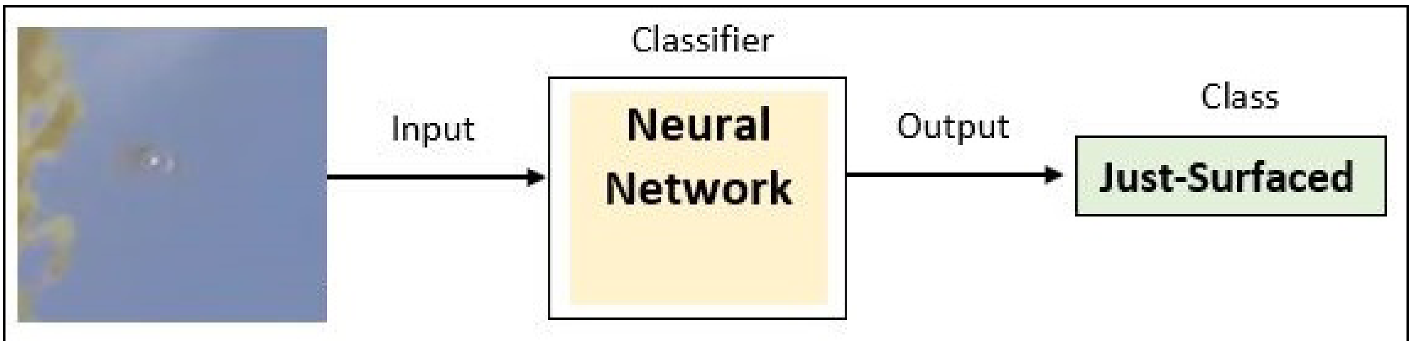

Figure 3: The AI classifier correctly identifies input images from four different classes.

Calculating Q

Q = Vr x A. So how do we measure these?

Measuring Rise Velocity (Vr)

The Velocimeter measures Rise Time. The characteristics of the bubbles released in the Velocimeter are the same as those released at the streambed so have the same rise velocity. The uncertainty in Vr translates directly to uncertainty in Q. We have met the uncertainty target we needed for Vr (< 1%) to meet our 5% uncertainty target in Q.

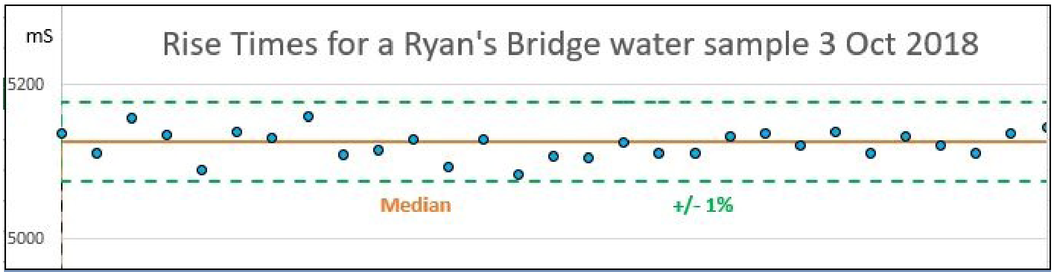

Figure 4: Rise times (Halswell River) measured in the version2 Velocimeter. The Vr calculated from these data is 0.207 m/s (calculated uncertainty is 0.36%)

Figure 5: Velocimeter

Measuring Displacement Area (A)

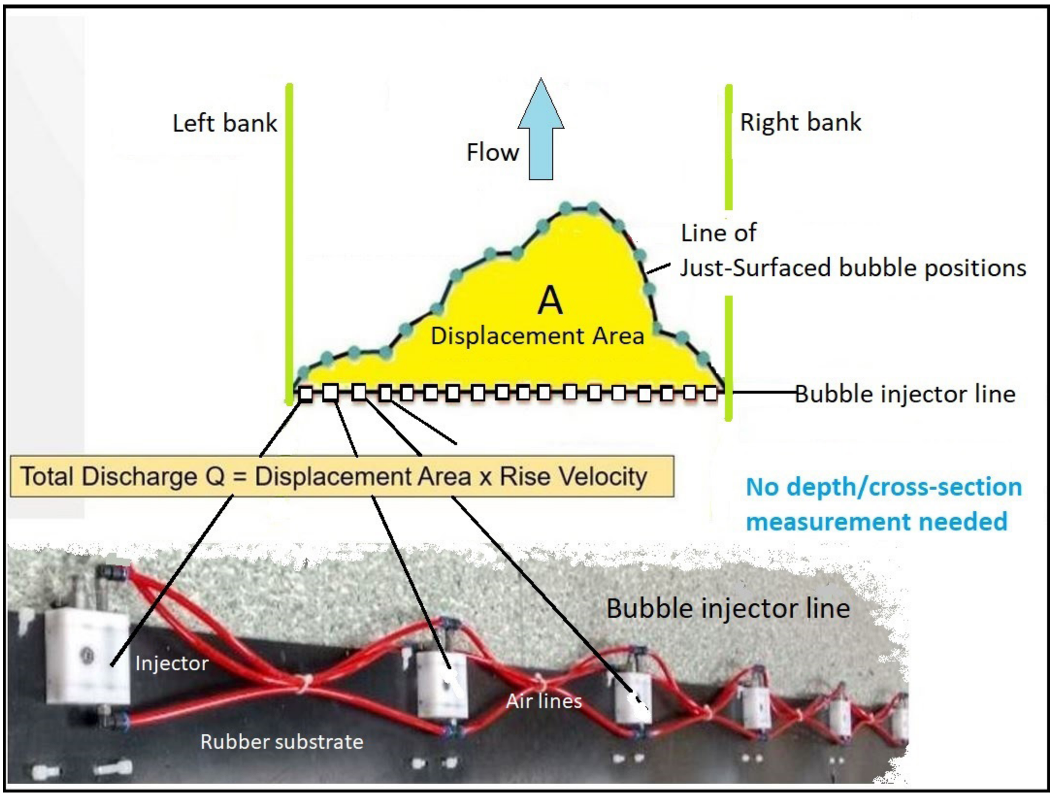

Figure 6: This 13-point prototype bubble line is easily rolled up. The injectors are mounted 0.4 m apart on a rubber substrate with a flat lead diver's weight under each injector to provide stability.

An early field trial at the reference ECan site

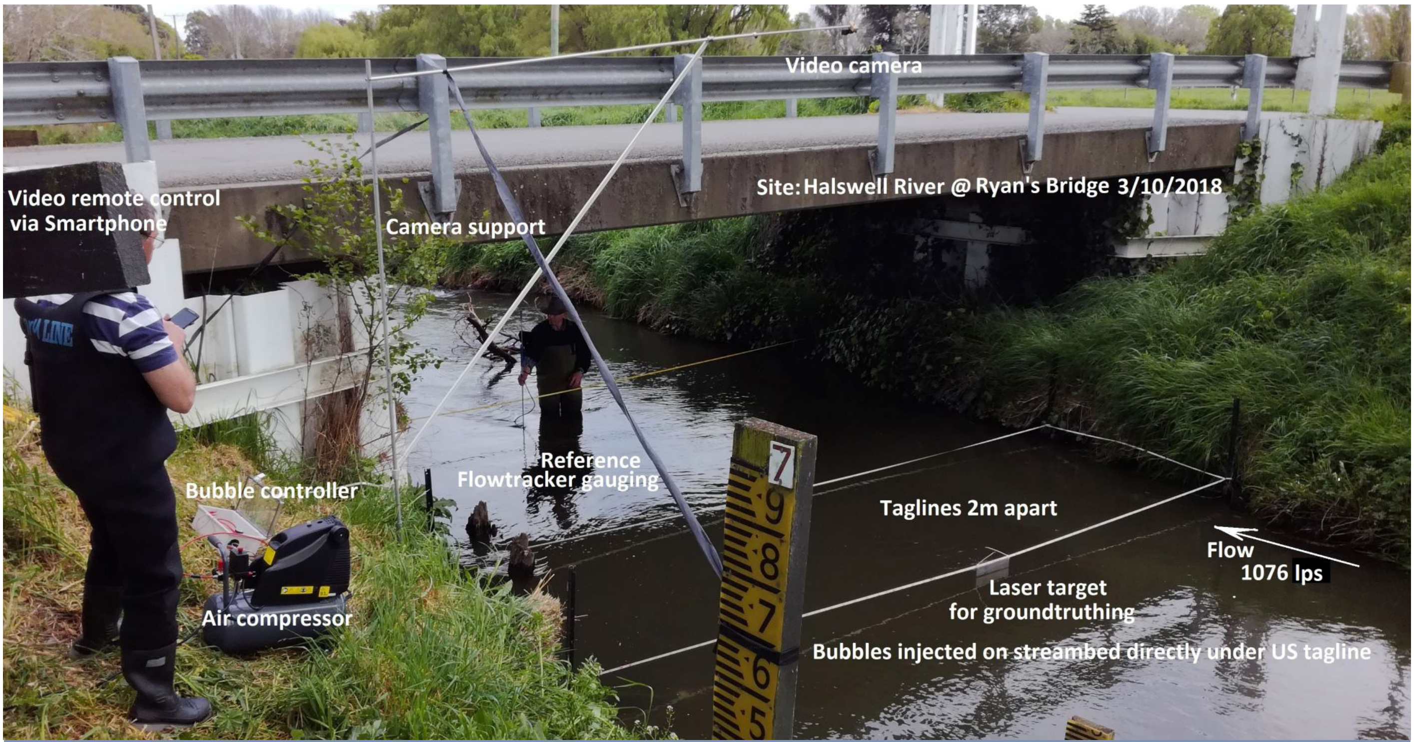

Figure 7: This is how we laid out the site for the trial on 3 October 2018. The water was flowing at over 1000 litres per second (lps) and was quite turbid, so the bubble line is not visible.

Post-processing of the video, frame-by-frame, yielded a credible result. The Just-Surfaced location of each bubble was identified: the downstream displacement of each bubble determined by manually measuring the on-screen image, from the origin to each Just-Surfaced position, then scaling. When tracking a bubble sequence manually frame-by-frame, it's easy to verify that the Just-Surfaced position has been correctly identified... although rather tedious. Here is the result (U is uncertainty, D depth):

	Q (lps)	U_Q (%)	U_Q (95% CL)	Horiz. points	Vert. points
Rated	1162		8	-	-
Flowtracker	1076	1.3 (stats)	5.9 (ISO2007)	23	0.6 D avg.
Rising Bubble	1074	2.9	5.8	13	Integral 0 to D

AI – stage 2; from manual to automatic

We're now developing a second NN to work at stream-width scale. This will incorporate the stage 1 NN and will be trained to locate Just-Surfaced bubbles across the full stream width. When complete, we'll compile the AI model, add operational functions (e.g., start video) and run it as a standalone software application, on-site. To enable automatic calculation of Q it will scan a few seconds of video, frame-by-frame, 'look' for and locate the position of Just-Surfaced bubbles, 'join the dots', calculate the area (A) displaced from the origin and multiply A by Vr.

Acknowledgements

MBIE Envirolink (for funding)
Hawke's Bay Regional Council
Environment Canterbury (Bruce Digby)
NIWA

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ARTICLES

Seasonal Streamflow Forecasting Based on Ensemble Streamflow Prediction Technique: A Case Study in New Zealand

Long term streamflow forecasts are essential for optimal management of water resources for various demands, including irrigation, fisheries management, hydropower production and flood warning. New Zealand currently does not have a centralized, comprehensive, and state-of-the-art system in place for providing operational seasonal to interannual streamflow forecasts to guide water resources management decisions.

As a pilot effort National Institute of Water and Atmospheric Research (NIWA) have currently implemented and evaluated an experimental ensemble streamflow forecasting system based on the familiar, probabilistic forecast framework, Ensemble Streamflow Prediction (ESP) technique (Fig. 1). The basic assumption in ESP is that future weather patterns will reflect those experienced historically. Hence, past forcing data (input to hydrological model) can be used with the current initial condition of a catchment to generate an ensemble of flow predictions.

The pilot study employs the ESP-based approach using the TopNet hydrological model with a range of past forcing data and current initial conditions. An ensemble stream flow predictions that provide probabilistic hydrological forecasts (Fig. 2), reflecting the intrinsic uncertainty in climate, with lead time up to three months is presented for the Rangitata, Ahuriri, and Hooker and Jollie catchments in South Island, New Zealand (Fig. 3). Verification of the forecast over the period 2000-2010 indicates a Ranked Probability Skill Score of 23% to 69% (over¬ climatology) across the four catchments (Fig. 4). In general, improvement in ESP forecasting skill over climatology is greatest in summer for all catchments studied. The ESP-based forecast exhibited higher skill for a greater percentage of the forecasting period than climatology. As a result, the ESP forecast can provide better overall information for integrated water resources management purposes. ESP-based forecasts using the TopNet hydrological model have potential as tools for water resource management in New Zealand catchments.

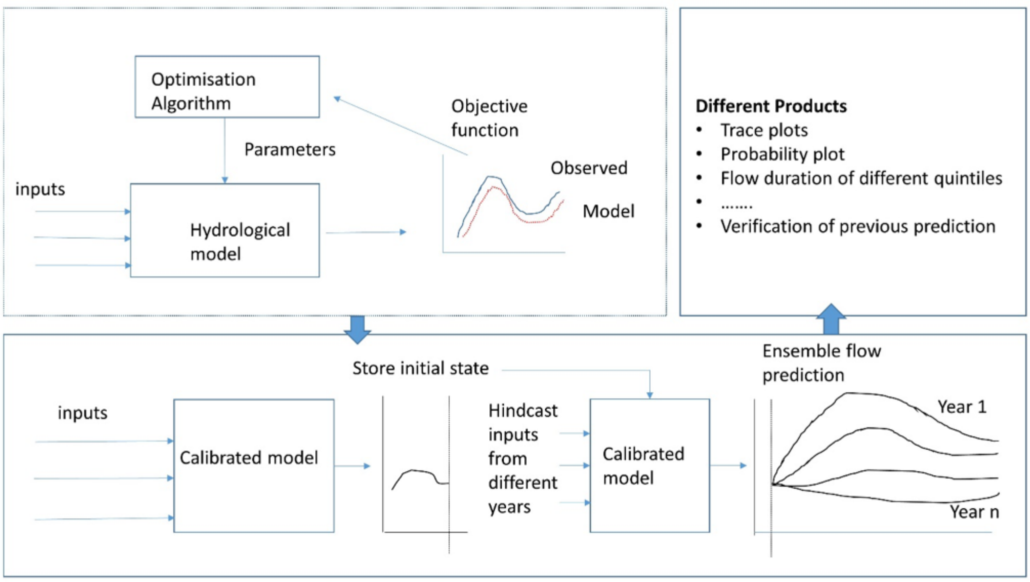


Figure 1 Schematic representation of the ensemble stream flow prediction system

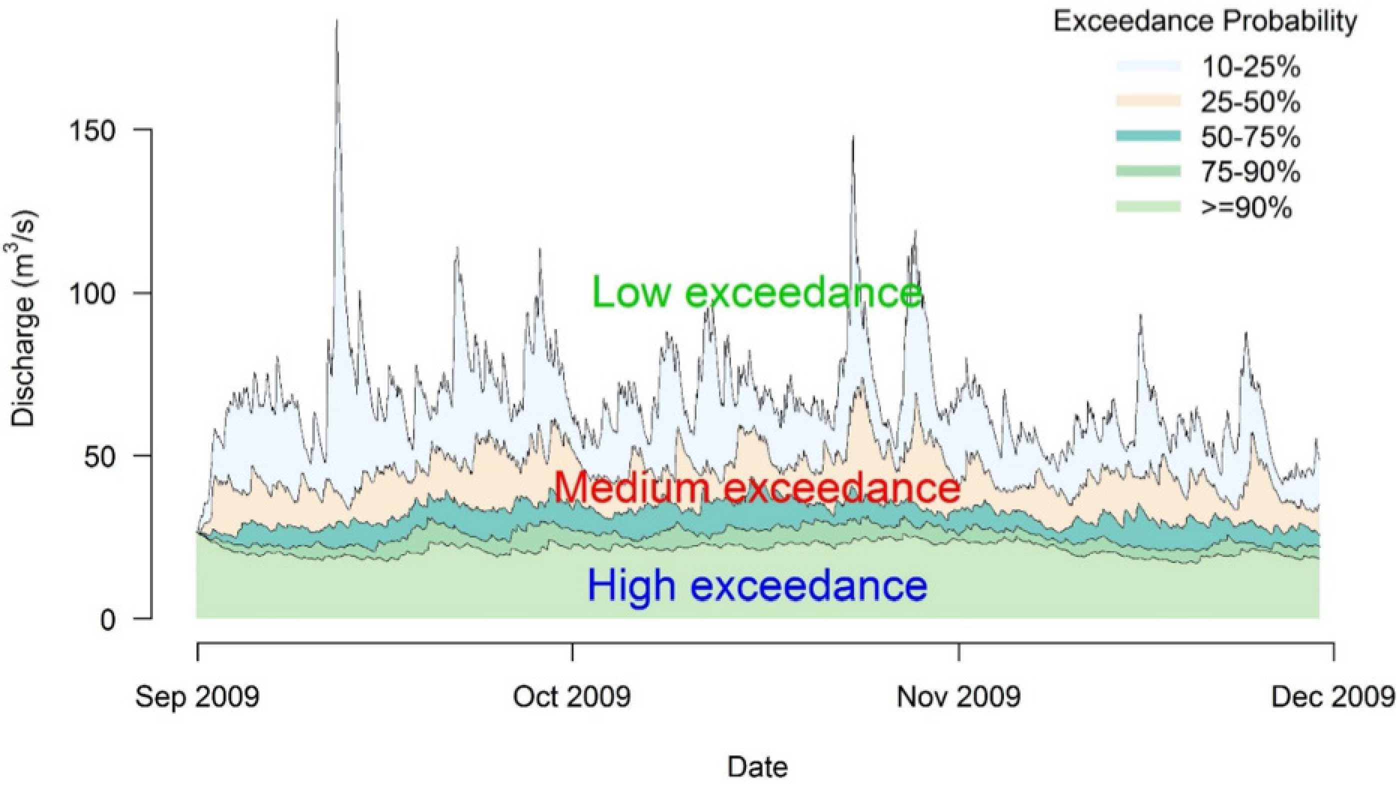


Figure 2 An example probabilistic forecast indicating low, medium and high exceedance forecasts

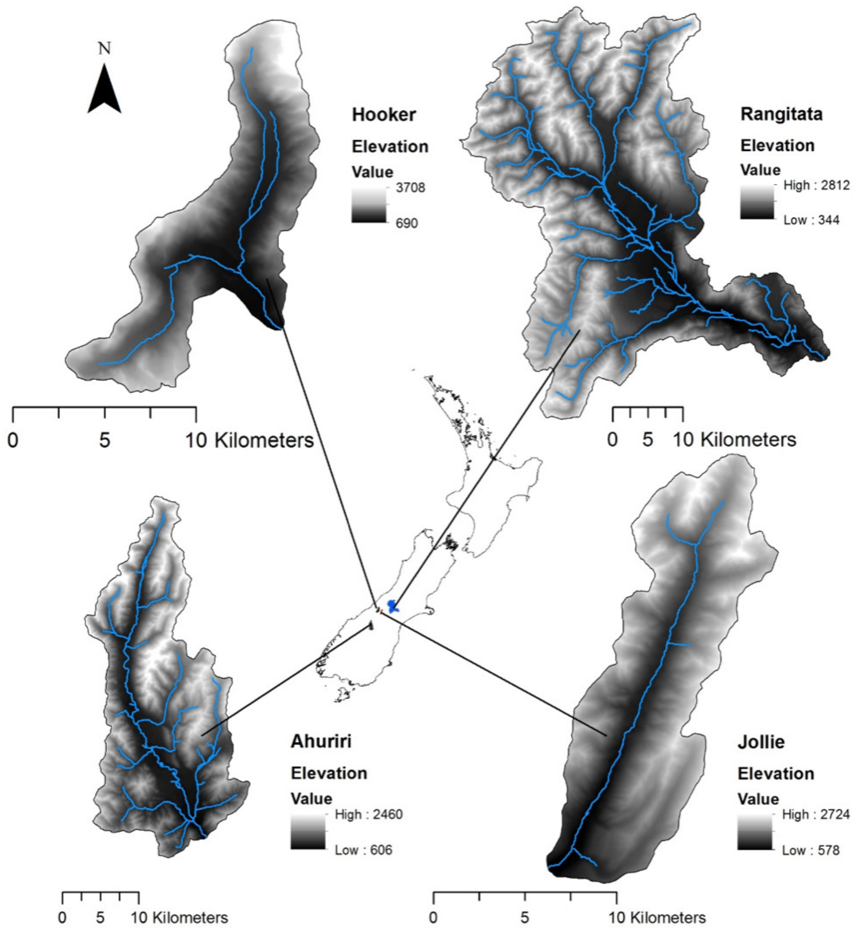


Figure 3 Study area indicating the four selected catchments located in the South Island of New Zealand (top) and close up views of each of the test catchments with the river networks and elevation (bottom)

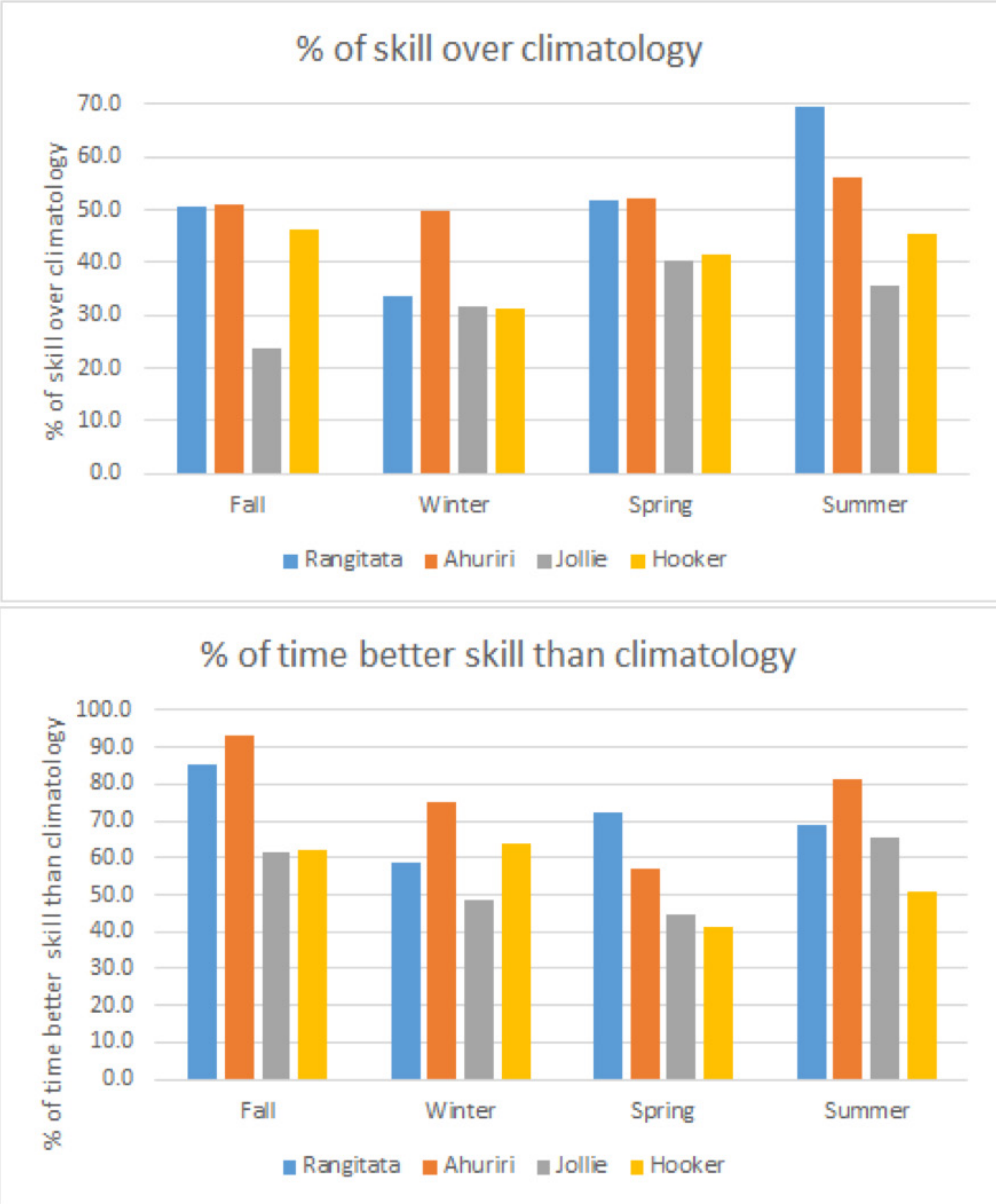


Figure 4 Average perccentage increase in ESP skill (in terms of RPSS) over climatology (Top) and average percentage of the forecast period for which ESP exhibited higher skill than climatology for all the four cacthments and seasons (Bottom) (Average was over forecast period February 2000 to February 2010)

UPDATES

Particulate Organic Matter, Suspended Sediment and Turbidity: Research update from Doctoral candidate Christina Bright and her recent conference activities.

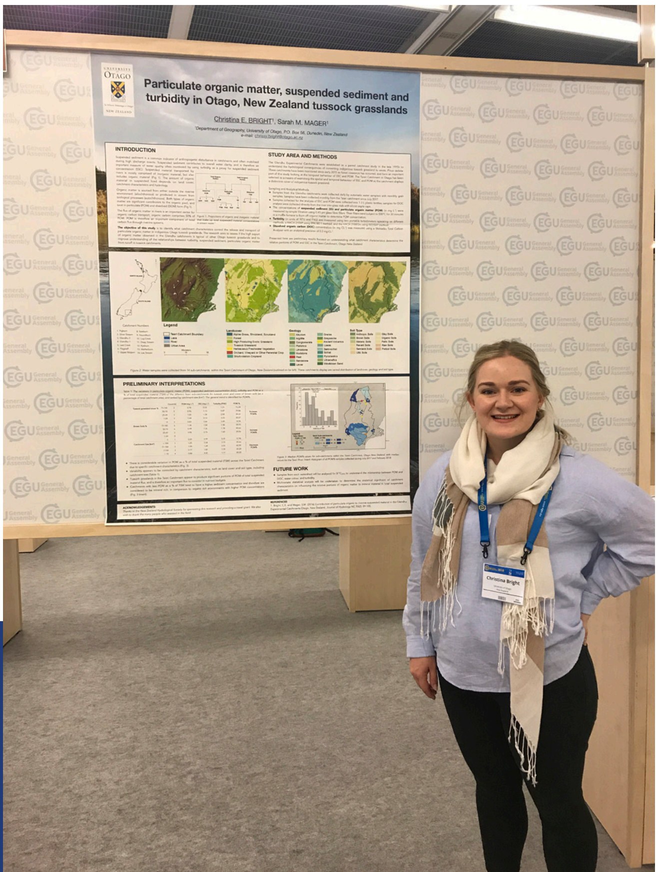
Understanding the behaviour of suspended sediment and particulate organic matter has been the focus of my doctoral research, with a specific focus on what environmental characteristics determine the relative proportion of these particulates in stream flow and how these in stream particulates relate to turbidity. My primary research interests are related to understanding the behaviour of both inorganic and organic suspended material, as the erosion of soil and sediment is considered one of our greatest water quality threats. The effective measurement of these instream particulates is crucial to our process-based understanding of water clarity degradation, and the determination of sediment yields used to understand the environmental consequences of certain activities. To address these broad research interests, my doctoral research is divided into two projects.

Soil Sampling Rock n Pillar Range

The first project focused on determining the relative proportions of suspended sediment and particulate organic matter as components of riverine suspended material and understanding the environmental characteristics that control the ratio of mineral suspended sediment to particulate organic matter. Part of this research identified the influence that fouling from organic matter and different particle properties of suspended particulates has on the determination of nephelometric turbidity (see: Bright & Mager, 2016 in the NZ Journal of Hydrology). Two commonly reported interferences with turbidity measurement are the effect of water colour, or colour dissolved organic matter (CDOM), and interference from particle size of the suspended fine particulates. Both of these affect the way in which the optical sensors in turbidimeters respond to materials suspended in a fluid. Interesting results are coming from these assessments, and further work is being carried out to understand how the bias caused by these measurement interferences affects sediment ratings.

The second research project focused on understanding where particulate organic matter and sediment is sourced from in a catchment with varying land cover, in an effort to link high riverine concentrations of dissolved organic carbon and particulate organic matter with organic-rich land cover types in the catchment, or areas prone to erosion of organic material. The experiment utilises the sediment source tracing technique of biotracers (Compound Specific Stable Isotopes (CSSI)) to link sediment collected from stream flow or depositional areas at the bottom of the Taieri Catchment with sources from outside the fluvial environment in the sub-catchments.

At the beginning of 2018 I was fortunate enough to travel to Europe and have the opportunity to present my research at two conferences. I travelled to Tuebingen, Germany and met with some of the Environmental Science team that part of the 'Catchments as Reactors' CAMPOS Research Group at the University of Tuebingen, and was invited to attend their conference, 'Integrated Hydrosystem Modelling'. Many of my conversations at this conference were related to the use of proxies, like turbidity supported by other environmental data (heavy metals and other environmental pollutants), to better understand sediment and contaminant fluxes, in particular particle facilitated transport.



Christina at EGU in Vienna

From there, I travelled to Vienna where I attended the European Geosciences Union General Assembly. The week I spent in Vienna was highly rewarding with such a diverse and interesting conference programme. I presented a poster in the session titled "Chemical weathering, soil formation, and organic carbon mobilization across spatial and temporal scales". My attendance at the workshop and General Assembly was possible thanks to funding from the New Zealand Hydrological Society by means of a Project Grant and Conference Grant that has supported my doctoral research and my recent international travel. Without the support of the New Zealand Hydrological Society this research would not have been possible and I would have missed the highly rewarding experience of travelling to international conferences. If you are interested in hearing about this work further, I will be attending the annual NZHS conference, or contact me directly at: christina.bright@postgrad.otago.ac.nz.

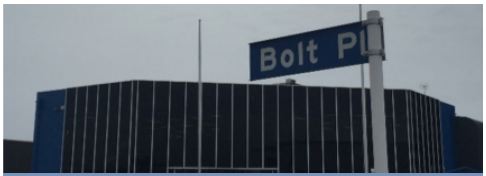
AQUALINC RESEARCH LIMITED

UPDATES

News from Aqualinc Research Limited

New Christchurch Office

Aqualinc has relocated to a newly refurbished offices at 1 Bolt Place, Christchurch Airport. The new office has allowed us to have the whole of the Christchurch based team in one location. The office is just around the corner from where we were and if you are passing by call in and say hello.



New Christchurch Office

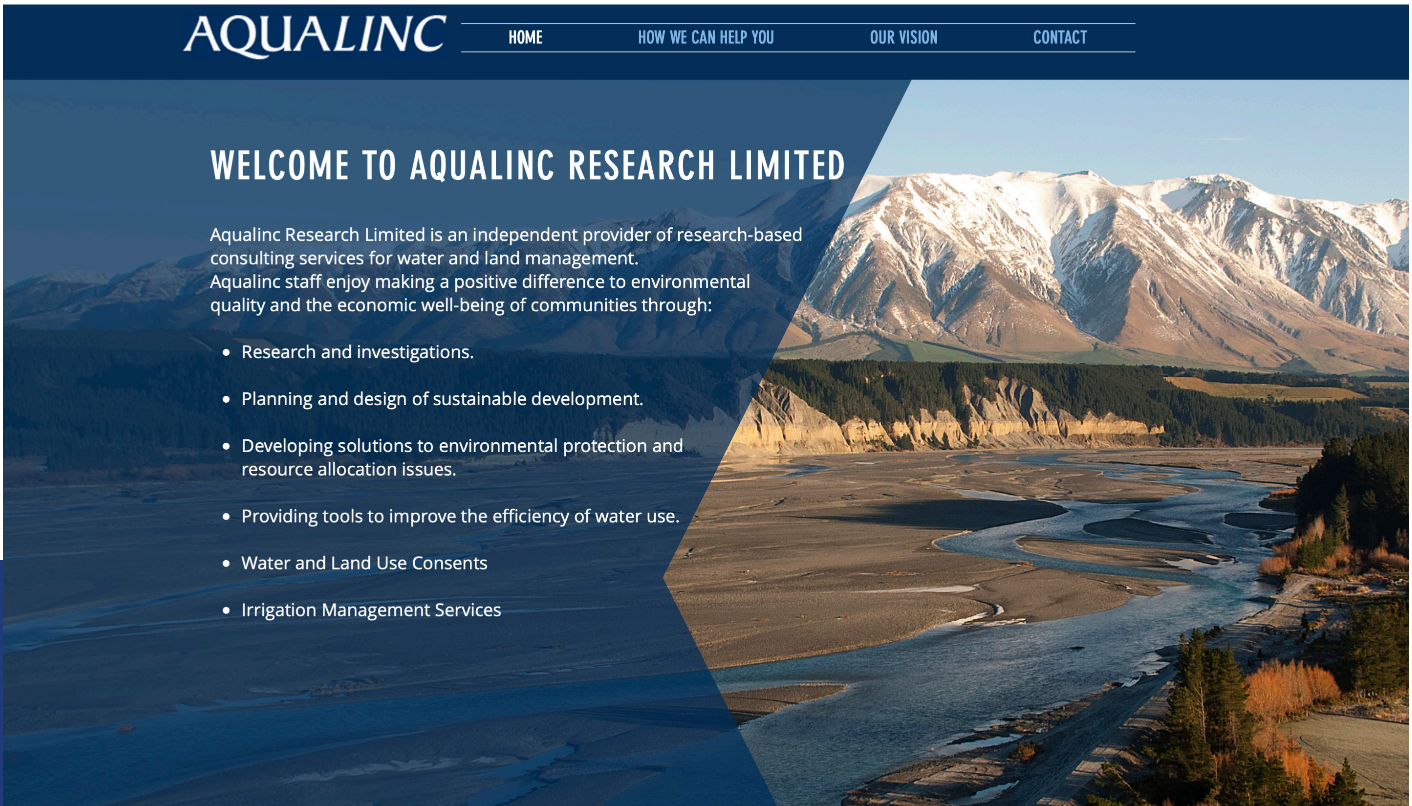
New Aqualinc Website

We are in the process of upgrading our web site! Wayne Hawkins our IT Manager is leading the development of the new-look web site. It is now super easy to find out about our services and to find our contact details. Keep an eye out for the changes and any feedback would be great.
The web address is : www.aqualinc.co.nz

Amanda Brown

Ashburton Office Grows

A warm welcome to Amanda Brown who has joined the Aqualinc team at our Ashburton office. Amanda is a Natural Resources Engineer with a background in Water Resources and River Engineering. Amanda joins our Resource Management Team.



Updated Aqualinc Website

Wellhead and source protection services

Ross Hector and Julian Weir have been providing assistance to a number of our clients reviewing and assessing drinking water wellhead protection status, and using modelling to delineate source protection zones. This has included wellhead inspections, backward particle tracking using numerical groundwater models, and assessing potentially contaminating activities within source protection zones.

Nutrient loss reduction from efficient irrigation has been quantified

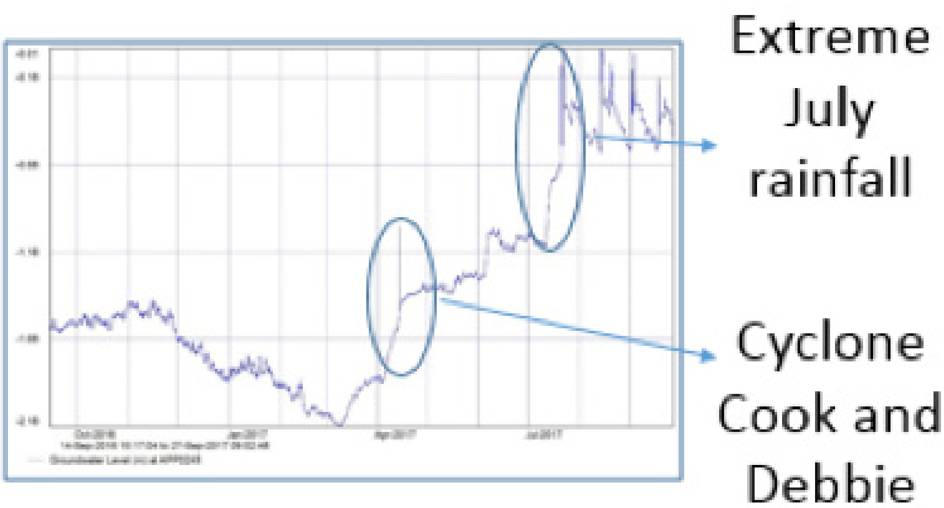
Approximately 27% less nitrogen loss to water, without any change in pasture production, may be achieved through improved irrigation efficiency. This was the primary finding of Dr John Bright after investigating optimal soil moisture triggers and irrigation application depths on modelled nutrient budgets for 12 Canterbury Dairy farms. The research was funded by the Fertiliser Association and the report is available here.

Soil and Water Assessment Tool (SWAT)

Dr Aroon Parshotam has implemented a national SWAT model to estimate soil loss to freshwater, sediment transfer from freshwater to coastal water and sediment deposition in coastal waters. This study of national-scale sediment modelling provides a bench-mark against which future changes can be assessed.

Shallow groundwater monitoring in Christchurch

With earthquake imapcts and potential imapcts from sea level rise across Christchurch, there has been keen interest in the dynamics of shallow groundwater, and the processes that drive groundwater level change. Dr Helen Rutter has been working with the data of 250 shallow groundwater level sensors. Initially installed to assist with land damage assessment post-earthquake, the high-resolution data have proven to provide insight into the variability of shallow groundwater levels, and the drivers of groundwater level change.



Hydrograph illustrating the response of shallow groundwater to rainfall recharge.

Kaikōura Earthquake Recovery

One of the lesser-known impacts following the 2016 Kaikōura earthquake, has been the emergence of springs and waterlogged areas across the Kaikōura Plains. Ian McIndoe and Helen Rutter have started to investigate the causes of the springs, and looking at mitigation options of any negative impacts.

Climate Change Impacts

Dr Andrew Dark and Dr John Bright have been investigating the likely impact of proposed water resource limits under projected climate change for abstractions from several river sources. Unlike most common climate change assessments, the investigation also included both water supply and water demand changes in parallel. The key findings are that the combination of projected reduced stream flows and increased demand would lead to reductions of between 6-18 % of the supply/demand ratio by the 2090s. Most of this reduction occurs irrespective of proposing water limits.

Groundwater Modelling

Julian Weir and Mark Flintoft continue to develop new groundwater flow and transport models for various clients. Aqualinc has and ever-increasing area of New Zealand for which we have prepared three-dimensional integrated surface water- groundwater models.. Most models were originally set-up to understand water flow and nutrient transport, however as they evolve and grow they are increasing being used for many more varied purposes, including assessing the impacts of climate change and sea level rise, using particle tracking for source protection zone assessment, and evaluating land use change impacts on water quality.

Aquifer Testing

Through the winter months, Dan Farrow, Olivia Cranney and Ross Hector have been busy undertaking tests on groundwater wells to check that impacts of pumping are within regional council guidelines. Within Canterbury, this is a crucial step that is required before consents can be approved for use of a new well. The primary purpose is to ascertain how pumping affects other nearby wells and surface water courses, and predict the impacts of pumping over an irrigation season.

Soil Moisture monitoring season has begun

Phil Neill, and the Field Services Team, are hard at work as the seasonal monitoring of soil moisture with neutron probes and telemetered soil moisture readings. The Field Services are passionate about providing timely and accurate moisture measurements to our nationwide clients. To ensure efficient water use the team also undertake irrigator calibration, to ensure the correct amount of water is being applied, water holding capacity checks and EM Scans.

A centre-pivot irrigator about to pass over a row of application depth calibration vessels.

UPDATES

News from DHI Water and Environment

Te Pourepo o Kaituna Wetland Creation Project

As part of the Te Pourepo O Kaituna Wetland Creation project, Bay of Plenty Regional Council (BoPRC) aims to convert up to 80 ha of farmland to a new wetland in the lower Kaituna area, adjacent to the Kaituna River, Lower Kaituna Wildlife Management Reserve and Tauranga Eastern Link Road. BoPRC has commissioned DHI Water and Environment to develop a numerical model of the wetland. The primary objectives of this project are:

- Build and calibrate an integrated numerical model to represent the hydrological processes of the existing wetland enclosed by the Diagonal Drain, the Kaituna River and the Tauranga Eastern Link, including hydrogeology, surface water, and interactions with vegetation and climate. The model will assist with design and optimisation of the newly constructed wetland and preparing an Assessment of Environmental Effects to assist with obtaining a resource consent for this wetland extension.
- Testing options as changes to the existing environment in the model so that parameters can be assessed, and potential effects reported on.
- Determine what rate of inflow from the Kaituna River is required to maintain the optimum average operating water level range within both the new and existing wetland. This includes estimation of seasonal variation due to varying evapotranspiration or other hydrological processes, considering the increased retention of groundwater caused by blocking some outflowing pumped drains.

Proposed wetland image courtesy of Bay of Plenty Regional Council

- Assess the potential or actual adverse environmental effects of the existing wetland and drainage systems for farmland surrounding the wetland. Consider and recommend any measures required to avoid, mitigate or remediate any negative impacts.
- Determine the potential water quality in the new wetland with emphasis on salinity, temperature and dissolved oxygen. Recommend any avoidance, mitigation or remediation measures to negate impacts and ensure no negative impacts within existing wetland (e.g. no increase in overall salinity).
- Consider the effect that climate change may have on water and salinity levels in the wetland area (existing LKWMR and new wetland extension) and what wetland design considerations should be incorporated to allow adaptation of the wetland's operating regime to the likely or predicted effects of climate change on the wetland.
- Determine inflow (and outflow) structure options that are required to maintain the minimum inflows identified, including an initial assessment to understand the current level of efficiency of the existing inlet structures and floodgates. Assistance from an experienced hydraulic structures engineer will be provided by BOPRC.
- Determine how the new and existing wetlands could be connected to achieve desired water levels and maximise throughput/refresh rate.

Integrated catchment management for Southern New Zealand

A recent Case Story outlines the project DHI undertook with Environment Canterbury. The challenge that was faced included changing irrigation practices, over-abstraction of groundwater and piping of irrigation and stock-water distribution races which had contributed to declining groundwater levels on the Canterbury Plains in the Hinds/Hekeao catchment.

Apart from a sophisticated tool for modelling groundwater and surface water, Environment Canterbury was also looking to build capacity in their organisation so that they would not have to outsource in the future.

Read more about the Signature Project here.

Staffing: New team members join DHI.

2018 heralds in a new engineers and scientists for the team. In Water Resources, Environmental Engineer Alois Denervaud and Intern Shubhneet Singh have arrived in Auckland and Wellington respectively with the appointment of Senior Groundwater Scientist Patrick Durney into the Christchurch team. In the Urban department, Marion Foglia returns as a Graduate Engineer following the completion of her studies, and Fatima Bashir joins her in Auckland as an Urban Engineer. Florian Monetti joins the Marine team as a Coastal Engineer in the Auckland office. Finally, Hema Kumar is now located in Auckland as Software Specialist.

Alois Denervaud joins us in the Water Resources Team in Wellington as an Environmental Engineer.

Urban Engineer Marion Foglia returns to the Urban team as a new Graduate Engineer and Coastal Scientist Florian Monetti is now in the Auckland-based marine team.

Patrick Durney has joined the Christchurch branch of DHI Water and Environment as a Senior Groundwater Scientist.

(L-R) Water Resources intern Shubhneet, Software Specialist Hema, and Urban Engineer Fatima.

UPDATES

Environment Canterbury Collaborative Hillslope Project

How do groundwater recharge and nutrients move through soils containing loess? That is a question that has been puzzling the groundwater scientists at Environment Canterbury. So, we're talking to some experts to help us work it out.

What is loess and why does it matter?

Loess deposits, those hardpan layers of windblown dust (Figure 1), are widely distributed from Marlborough to Southland over the eastern and southern downlands, hills, and plains. Soils containing loess cover an area of more than 1 million hectares.

The occurrence of perched water tables and ponding on the land surface are clear evidence of restricted water infiltration through loess. Water that cannot infiltrate is diverted sideways to the surface water system rather than becoming groundwater recharge.

A few years ago, Environment Canterbury completed a desktop review of the hydrogeological significance of loess in Canterbury (Poulsen, 2013). We found there are many knowledge gaps, such as: the volume and timing of recharge to groundwater; the transfer of nutrients through and out of the soil; and the influence of irrigation on water and nutrient fluxes. This uncertainty impacts the models we use to estimate groundwater recharge and contaminant losses.

Poor understanding of how water moves through loess soils presents challenges for trying to set sustainable limits for groundwater usage and nutrient loads, especially when a significant area of loess soil in the South Island, and Canterbury, is used for productive farmland. Loess soils also impact on irrigation behaviour, where irrigation design, application rates and return periods required to irrigate low-infiltration rate loess soils can be at odds with our assumptions of irrigation efficiency.

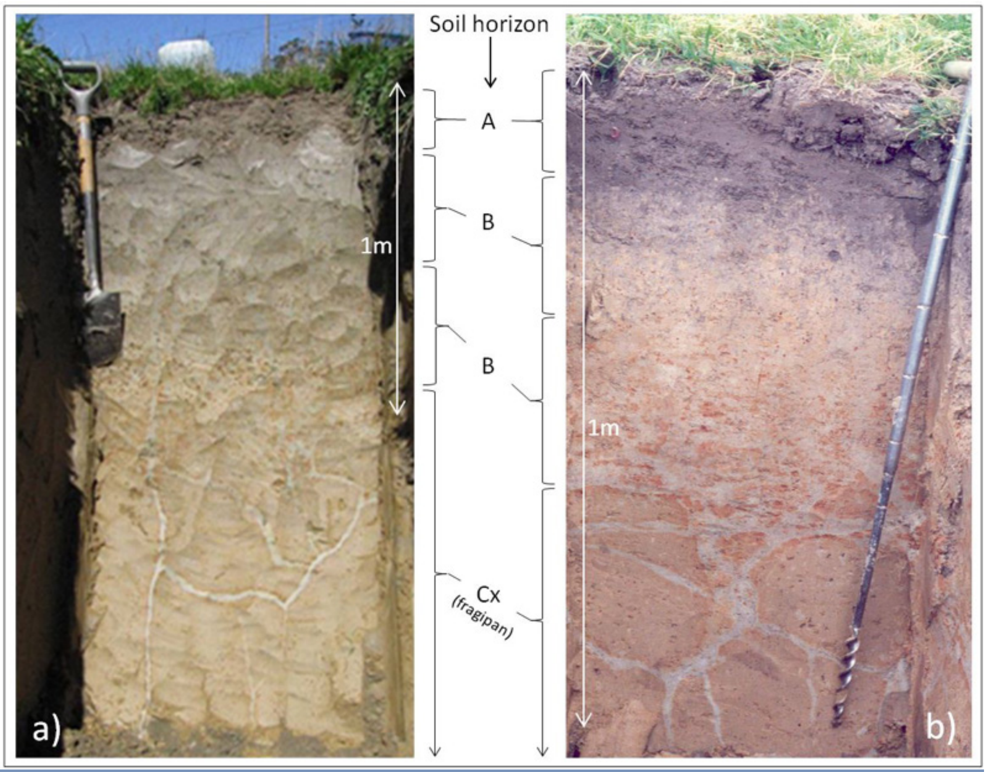


Figure 1: Loess soil profiles (photo: Trevor Webb, from Poulsen, 2013)

A collaborative effort – a loess research catchment site

Environment Canterbury is working on a collaborative project to investigate groundwater recharge and irrigation efficiency under loess soil conditions. Over the past six months we have been holding several workshops and talking to researchers from institutions with interest and knowledge in this field, including AgResearch, Plant and Food Research, NIWA, Manaaki Whenua - Landcare Research and Lincoln University.

From these discussions, we have agreed to work together to set up a field research site. Work has begun on selecting a small (approx. 2 ha) loess-covered irrigated catchment in South Canterbury that can be instrumented to monitor various components of the water balance, such as rainfall, soil moisture river flow and groundwater levels over the next five years (Figure 2).

Once operational, the site will be available for researchers to conduct experiments through co-funded research projects that help to develop our understanding and modelling of these systems. We envisage that the basic monitoring setup for the trial site can also be piggybacked off by external agencies where more detailed monitoring or modelling is needed to address further research aims.

Figure 2: GIS study site selection and photograph of one of the candidate sites

The project is being managed by Abigail Lovett of Earth & Environmental Science Ltd. Environment Canterbury staff involved include Matt Dodson, Fouad Alkhaier, Philippa Aitchison-Earl and Tom Johns.

Poulsen, D. 2013: The hydrogeological significance of loess in Canterbury, Environment Canterbury Technical Report R13/60.

https://api.ecan.govt.nz/TrimPublicAPI/documents/download/1853775

Productivity Commission, 2018. Low-emissions economy.

E/S/R Science for Communities

UPDATES

Update from ESR Groundwater Group

Compiled by Liping Pang

The following reports on the major activities occurring in ESR's Groundwater Group between October 2017 and September 2018.

Enhanced Mitigation of Nitrate in Groundwater

ESR is carrying out a research programme, together with Lincoln Agritech, Aqualinc Research, Southern Geophysical, and University of Canterbury, to develop and demonstrate effective groundwater mitigation methods for oxic alluvial aquifers that will reduce the amount of groundwater nitrates impacting rivers, lakes and streams. The approaches include Biogas Induced Denitrification in groundwater and denitrifying Permeable Reactive Barriers. These are being coupled with aquifer characterisation using advanced shallow depth geophysics to enable the effective design, delivery and implementation of these mitigation tools.

We are focussing on alluvial gravel aquifers as these are important for NZ's primary productivity, vulnerable to nitrate contamination, and have little capacity for denitrification. The fast and heterogeneous groundwater flow patterns in these aquifers present significant challenges for the development, design and implementation of mitigation options. The selected mitigation techniques are:

- Denitrifying Permeable Reactive Barriers (PRBs): Woodchip as the carbon source is added in trenches through the aquifer, so that nitrate-contaminated groundwater is intercepted and the carbon stimulates denitrification by bacteria which converts nitrate to inert di-nitrogen gas (N2).
- Biogas induced groundwater denitrification (BID) aims to reduce groundwater nitrate by promoting denitrification in the aquifer through saturation of groundwater with biogas to act as a carbon source for the microbial community. This technique will be a world-first groundwater field application.
- A bioreactor using woodchips as the carbon source has been designed and is being evaluated to provide enhanced removal of nitrate from high-nitrate shallow groundwater as it emerges in artificial drainage systems. This option could provide a very cost-effective method for removal of nitrate before it impacts receiving waters.

A suitable site has been selected for the PRB field trial on Waimakariri District Council (WDC) reserve land near Kaiapoi, Canterbury. It has the advantages of a shallow groundwater table, moderately high levels of nitrate in the shallow groundwater, the required alluvial gravel hydrogeologic setting, close proximity to Christchurch, and keen support from the land owner (WDC). Characterisation of the site has been undertaken using a combination of shallow geophysics, well drilling and groundwater sampling to provide information for the resource consent applications and to determine the best location for the PRB. Resource consents have been obtained following consultation with the local iwi, the Zone Committee, the Waimakariri District Council, and Environment Canterbury.

Lee Burbery and **Phil Abraham** have been investigating hydrogeological conditions at PRB site in the Silverstream Reserve. Working with Southern Geophysical they have been applying hydrogeophysical methods to examine groundwater flowpaths and determine groundwater velocities at the field site. The aquifer test at the site, that involved drawdown measurements made in 34 observation wells, also kept the pair busy and was made possible through support provided by the University of Canterbury

Waterways Centre, Environment Canterbury, Aqualinc Research Ltd and Pattle Delamore and Partners, who all kindly loaned pressure loggers for the job.

A field site for the drainage bioreactor has been selected in the Waikato region and the bioreactor was designed and installed in June 2017. The bioreactor volume is around 60 m3 and is filled with untreated woodchips. Flows through the bioreactor are continuously monitored and the inlet and outlet waters are proportionally sampled and analysed for carbon and nitrogen species to assess the effectiveness of the bioreactor and for other species to assess any detrimental side effects. The artificial drainage has high nitrate input concentrations (between 6 and 9 mg N/L) and the outlet concentrations indicate > 99% removal of nitrate. There was some initial flushing of organic carbon and phosphorus from the woodchips but this decreased to near background levels after 3-4 pore volumes. The results from the first year's drainage season have been presented at 3 conferences.

Contact **Lee Burbery** or **Murray Close** for more details.

MBIE-funded Transfer Pathways Project

Throughout the winter, **Lee Burbery** and **Phil Abraham** have been working in the lowland, coastal Silverstream catchment, North Canterbury. With support from Environment Canterbury they have been working to commission a second, automated, continuous groundwater nitrate monitoring station in this catchment. The monitoring station complements one already in operation and that has been running since March 2018. At the monitoring stations, groundwater nitrate concentrations are measured daily at up to five different depths within the local groundwater system. The observations are providing insight to the dynamics of nitrate transport in the groundwater system and understanding of how this governs water quality in Silverstream. Contact Lee Burbery for more details.

Figure 1: Phil Abraham (ESR) and Annette Bolton (ESR) sampling at one of the sites.

Groundwater ecosystem sampling in Takaka

The groundwater group (under Groundwater Health Index SSIF) secured a medium advice Envirolink grant ($20K) with Tasman District Council (TDC). The grant developed a sampling plan for TDC to sample their groundwater for microbial and macroinvertebrate diversity as an extension to their water quality monitoring. As part of this Envirolink project we secured additional ESR funding to visit a catchment in order to test sampling strategies with TDC. The catchment chosen was Takaka (including wells in the Arthur Marble Aquifer which supply water through to the renowned Te Waikoropupū Springs).

The area sampled included a site of special scientific interest but has been sampled sparsely (and only the springs and river) and so the baseline for any assessment of future impacts of land use activities is severely lacking. This has been highlighted in the current water conservation order hearings to protect Te Waikoropupu Springs. The effects of further abstraction in the catchment, land-use changes and maintenance of the special nature of the springs to iwi and to maintain the optical clarity of the springs are matters that the Special Tribunal is considering. The Te Waikoropupū springs are deemed to be the purest (in terms of clarity) in the Southern Hemisphere. However, there is a lack of data for the groundwater ecosystems in the aquifers that service the springs.

Samples were taken for assessment of water chemistry, and microbial and macrofauna abundance. We used a variety of techniques, including netting for macrofauna, pumping large volumes of groundwater for microbial and macrofauna abundance and diversity assessment. We measured the field parameters at each well and took samples for a complete suite of water chemistry parameters. To monitor the attached microbes, we placed in-situ biofilm bags within wells which will be sampled at a later date. We were able to sample seven bores and a spring in the catchment. The data obtained from the sampling will add to both local knowledge of groundwater ecosystems and to a national database of groundwater ecosystem diversity. This will increase our understanding of the vital roles biological systems play in maintaining pristine water in groundwater environments. We would like to thank TDC staff and Karen Shearer (Cawthron Institute) for their time and assistance in sampling. Contact **Louise Weaver** for more details. Also see http://www.envirolink.govt.nz/assets/Uploads/1861-TSDC143-Sampling-considerations-and-protocols-for-assessing-groundwater-ecosystems.pdf

MBIE Smart Ideas project on tracking water contamination using synthetic DNA tracers

In this project, we have developed a novel and environmentally friendly DNA tracer technology which can be used to concurrently track multiple water contamination source locations and pathways. The new DNA tracers are produced as either naked DNA molecules, or DNA molecules that are encapsulated within microparticles of a food-grade biopolymer. In collaboration with Environment Canterbury and Waikato Regional Council, we have validated these DNA tracers (total of 20 different DNA markers) in groundwater, soils and surface water, and results are promising. With trace amounts of DNA tracers applied, we were able to detect these tracers in surface water as far as 1 km downstream without the need for concentrating the water samples. The microencapsulated DNA tracers showed significantly less reduction as they are protected from environmental stress. Contact **Liping Pang** for more details.

Health Research Council project on assessing pathogen removal in water filtration systems using micro mimics

This project tests our newly developed surrogate technology for assessing the efficacies of protozoan and virus removal in drinking-water filtration systems typically used in New Zealand. In collaboration with Invercargill Water Treatment Plant, we have conducted 85 challenge tests with Cryptosporidium surrogate in pilot-scale filters of anthracite, pumice sand and ceramic sand under typical operational conditions. The pilot trials have generated statistically robust information on the surrogate removal efficiencies of different filter media. Research findings challenge the current practice in using turbidity as a measure of system performance for protozoan removal. We are currently evaluating various point-of-use domestic filters for their efficacies in removal of rotavirus, adenovirus and norovirus. Research outcomes will support decision making on future water treatment practices in New Zealand and overseas for preventing drinking-water borne illness. Contact **Liping Pang** for more details.

Marsden Fund project on mimicking Legionella in the plumbing

We aim to develop novel surrogates that could mimic the mobility and persistence of Legionella pneumophila in the plumbing systems under the influence of residual disinfectants. So far surrogate DNA-encapsulated microparticles have been synthesized using a food-grade biopolymer. The surrogate microparticles have been optimised to mimic the size, rod shape, surface charge and hydrophobicity of L. pneumophila. Our next step in the study is to validate the surrogates' mimicry of L. pneumophila in simulated plumbing systems with commonly used water pipe materials and residual disinfectants. We will compare the sequestration of L. pneumophila and the surrogates in biofilms and within amoebae. We will determine the attachment/detachment kinetics of L. pneumophila and the surrogates to/from the EWS pipe materials and their persistence under the influence of different residual disinfectants over a range of concentrations. Contact **Liping Pang** for more details.

Figure 2: Louise Weaver (ESR) and Annette Bolton (ESR) sampling the bore. Louise is taking field measurements and Annette is sampling for Stygofauna.

UPDATES

Update from GNS Science

Compiled by Conny Tschritter

Staffing

Peter Johnson joined our groundwater modelling team at the beginning of October, increasing the numbers to six dedicated groundwater modellers. He has recently completed his postgraduate studies. Since 2015, Peter has worked with the Computational Earth Sciences group at Los Alamos National Laboratory in the US where he studied multiphase thermal-hydraulic-mechanical interactions in salt surrounding nuclear waste, unsaturated zone dynamics in porous media with changing porosity, hydrologic disturbances in volcanic settings, and gas contaminant transport in unsaturated media. In addition, he has been a contributing developer to the numerical porous flow simulator Finite Element Heat and Mass (FEHM).

Smart Models for Aquifer Management (SAM) – Programme

The Smart Models for Aquifer Management (SAM) research programme is a GNS Science-led collaboration with multiple organisations. The programme is funded by MBIE and co-funded by Waikato Regional Council, Greater Wellington Regional Council, and Environment Southland. The primary aim of the SAM programme is to identify optimal groundwater-surface water flow and transport models to address large scale, real-time, specific environmental management problems, that use data at hand, and can be used to inform targeted data collection to optimise them. This work will provide a methodology to support judgements of what modelling strategy is most useful in any given data and decision-making context, and to identify the gains and/or diminishing returns achieved with more data or more complex models. Programme duration: 2015-2018; Contact: Cath Moore c.moore@gns.cri.nz.

July 31 was a big day in the SAM program calendar: The groundwater modelling team and collaborators from NIWA, ESR, Victoria University, LandWaterPeople, University of Waikato and Market Economics presented results and progress to project stakeholders from Environment Southland, Greater Wellington Regional Council and Waikato Regional Council.

In September, Tess op den Kelder successfully defended her master thesis titled: Using predictive uncertainty analysis to optimise data acquisition for stream depletion and land-use change predictions. In this study, Tess used the Data Worth Method to determine which type of data, collected where and when will be the most valuable for both water quality (nitrate concentrations) and water quantity (low-flow) predictions. The worth of both existing and new, yet to be acquired data is explored. Next to that, the impacts of spatial parameterisation simplifications were investigated. The study was performed on the mid-Mataura catchment located in Southland. The results showed that spatial parameterisation is needed when performing a data worth study for stream depletion predictions; however, a more detailed parameterisation than pilot-points does not provide significantly more information. The spatial data worth patterns when predicting low flows mainly depend on if the predictions are integrating or discrete in nature. Lastly, the data worth patterns when predicting change in nitrate concentration, as a result of land-use changes, depend on the proximity of the prediction location to the denitrifying areas. Tess will present the study at the NZ Hydrological Society Conference in December.

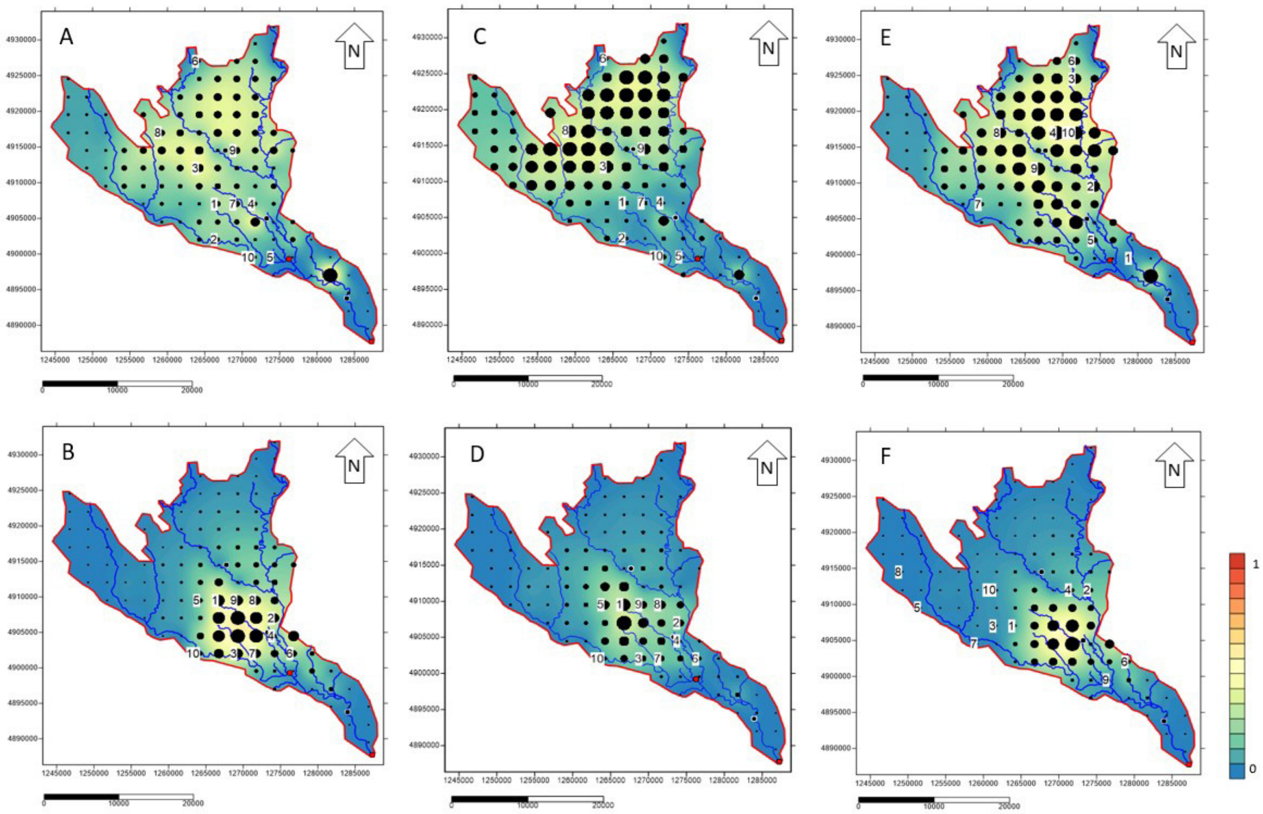


Figure 1. Proportional reduction in uncertainty after addition of the new groundwater telemetry wells in the mid-Mataura catchment, Southland. The colours are on a scale from 0 (blue) to 1 (red) and the same scale is used for all figures. The black dots show the location of the new additional well and the size of the dots are proportional to the reduction in uncertainty and are prediction specific. The numbers show the order of the next new observation that will reduce the uncertainty the most. The black dots with white circles around them are the additional wells and the red dots are the prediction locations. A) Difference in days below Q95 at Gore, B) Difference in days below Q95 at McKellar Stream, C) Difference in number of consecutive days below Q95 at Gore, D) Difference in number of consecutive days below Q95 at McKellar Stream, E) Magnitude of stream depletion at Gore, and F) Magnitude of steam depletion at McKellar Stream.

Op den Kelder, A.M. (2018). Using predictive uncertainty analysis to optimise data acquisition for stream depletion and land-use change predictions (Unpublished master thesis). Stockholm University, Stockholm, Sweden.

Te Whakaheke o Te Wai - understanding of flow sources, pathways, and lags of groundwater

GNS Science's bid Te Whakaheke o Te Wai was successful in the latest MBIE Endeavour round and will receive funding of $9.5 million over five years. This programme aims to optimise water management based on understanding of flow sources, pathways and lags, and develop the world's first nationally continuous maps of groundwater age, origin and flow paths, useable for all institutions involved in water management. New Zealand lacks this knowledge, so current water management strategies cannot prevent land use degradation of rivers and aquifers, impacting cultural values, drinking water supplies, agriculture and tourism. We will derive the whakaheke of groundwater and baseflows in New Zealand's 200 major aquifer systems and the rivers that drain them. We will measure age tracers, which integrate all flow velocities (of water and contaminants) above any measurement point. We will use complementary hydrogeological, chemical and isotope data to understand origin of recharge and flow pathways, effects of geology, seasonality and stream order. New modelling approaches will integrate the tracer and other data across scales. Working with hapū, iwi and national Māori partners, we will incorporate mātauranga-a-iwi/hapū into our models alongside the tracer and other related data. Programme duration: 2018-2023. Contact: Catherine Moore c.moore@gns.cri.nz and Uwe Morgenstern u.morgenstern@gns.cri.nz

Heretaunga Plains aquifer system study

The GNS Science report on the groundwater dynamics of the Heretaunga Plains aquifers has been completed. This study shows unprecedented detail of groundwater sources, mixing, flow rates, and hydrochemical processes as inferred from age and chemistry tracer data. This was a collaborative study between Hawke's Bay Regional Council, Hastings District Council, Napier City Council, and GNS Science, to enable sufficient understanding of this complex groundwater system that was involved in the outbreak of gastroenteritis (Campylobacter) that took place in Havelock North in August 2016.

Morgenstern, U.; Begg, J.G.; van der Raaij, R.W.; Moreau, M.; Martindale, H.; Daughney, C.J.; Franzblau, R.E.; Stewart, M.K.; Knowling, M.J.; Toews, M.W.; Trompetter, V.; Kaiser, J.; Gordon, D. 2018 Heretaunga Plains aquifers: groundwater dynamics, source and hydrochemical processes as inferred from age, chemistry, and stable isotope tracer data. Lower Hutt, N.Z.: GNS Science. GNS Science report 2017/33. 82 p.

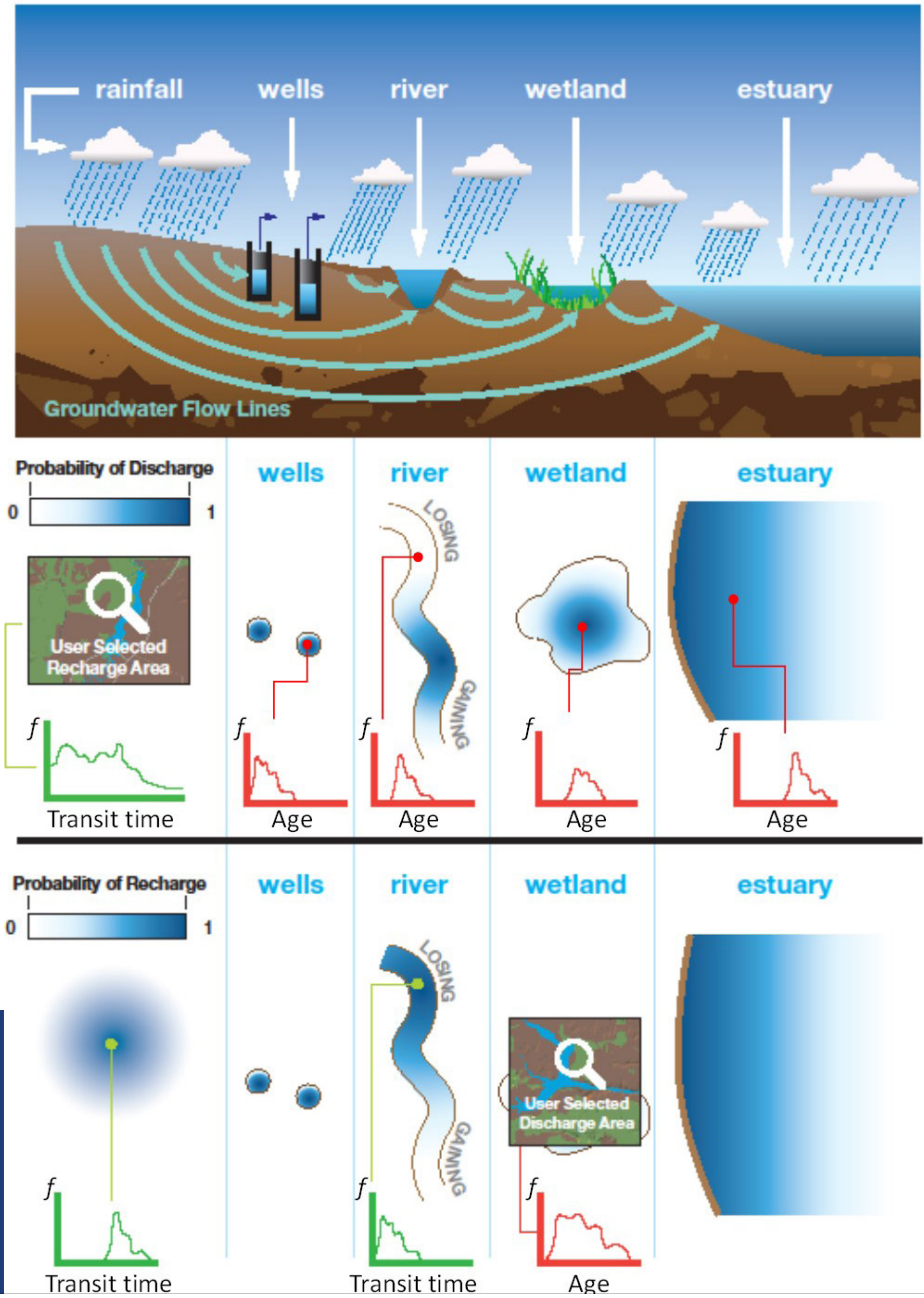


Figure 2. Conceptualisation of Te Whakaheke o Te Wai: origin, age, flow paths and destination of groundwater moving through an aquifer system. Top panel: Cross-section through a schematic aquifer showing distributed recharge from rainfall and groundwater flow paths to different discharge points (wells, river, wetland, estuary). Middle panel: map view that traces groundwater flow from a user-selected recharge area, with green graph showing transit time distribution to reach the multiple discharge points (f is fraction of water). Blue shading indicates probability of discharge at different locations, with red graphs showing groundwater age distributions at indicated points. Bottom panel: map view that traces groundwater flow from a user-selected discharge area back to its multiple points of recharge. Graphs, colour and shading are as in middle panel.

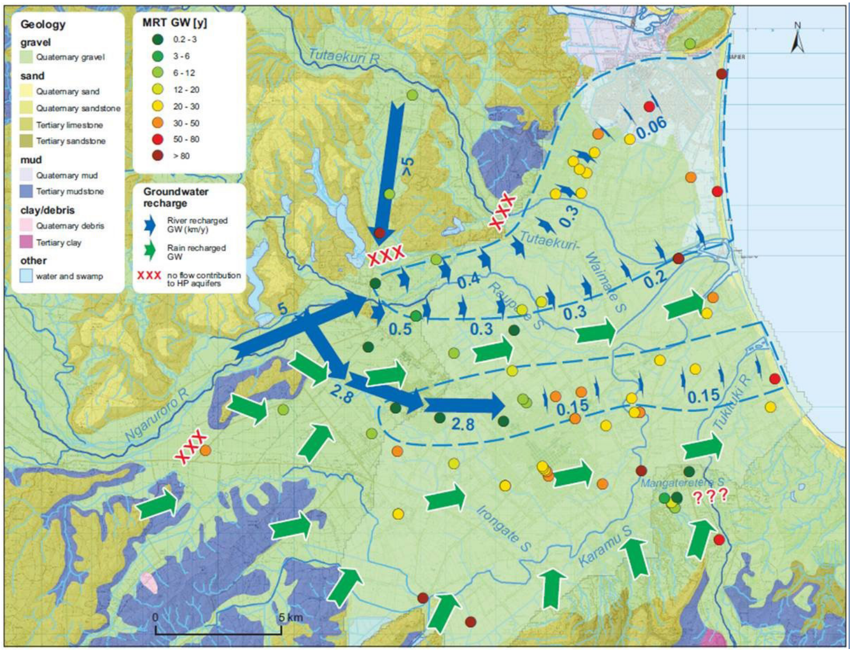


Figure 3. Water dynamics in the Heretaunga Plains hydrologic system inferred from groundwater ages (circles). Blue arrows indicate river recharged groundwater flows, with the length of the arrows proportional to the groundwater flow velocity (numbers in km/year). Green arrows indicate rain recharged groundwater flow direction in general, without information on flow velocity. Red crosses indicate no connection of potentially lost surface water to the main aquifer. Red question marks indicate unknown contribution of the river to the main aquifer due to lack of data. The two areas indicated by blue dotted lines are the areas of clear Ngaruroro River-recharge signature. The light green in the area of Quaternary gravels indicates the area of confined aquifer.

Geological and hydrological development of the Upper Waikato catchment in 3D

Geological and hydrological development of the Upper Waikato River (UWR) catchment in the last two million years was represented by four 3D models. Pre-historic lakes in the young TVZ 2 epoch probably developed behind an impoundment of the Waikato River located at Ongaroto Gorge. Sedimentary deposits in these ancient lakes, including Lake Huka that was located in the Reporoa Basin, are key features of hydrogeology of the UWR as they provide confining zones to groundwater and geothermal flow.

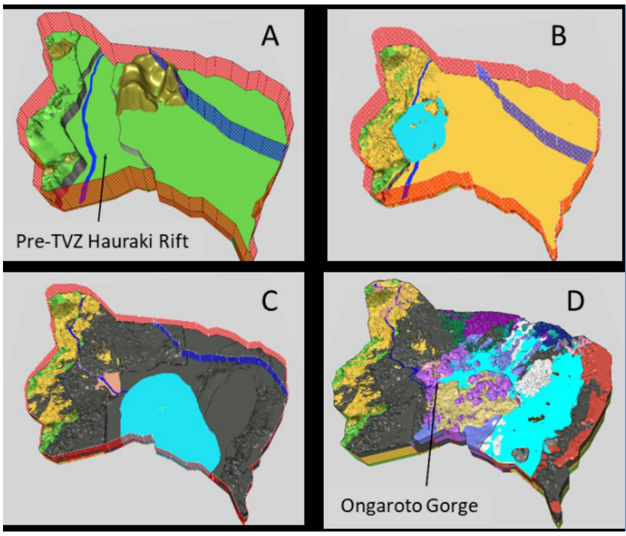


Figure 4. Geological evolution of the TVZ in the UWR catchment described in four epochs: A) pre-TVZ; B) 'old TVZ'; C) young TVZ 1; and D) young TVZ 2. Hydrological features include: the Waikato River (royal blue), the northern UWR catchment boundary (blue fence) and possible pre-historic lakes (teal).

White, P.A., Moreau, M., Reeves, R.R., Rae, A., Tschritter, C. 2018. Evolution of geothermal-groundwater circulation systems and geology in the Quaternary Taupo Volcanic Zone: example of the Upper Waikato catchment, New Zealand. 40th Geothermal Workshop,14 – 16 November, Wairakei

horizons REGIONAL COUNCIL

UPDATES

Auto Salt system from Fathom Scientific

Horizons Regional Council recently purchased a standalone Auto Salt system from Fathom Scientific. The system comprises 2 x 4-20mA pressure tranducers, a Fathom AQ control box and 2 self logging EC-T probes.

The system was not purchased to be installed at a particular site, but to prove the methodology and accuracy of dilution gauging and as such was installed at a stable stream site with an established rating. The installation equipment was built to be transportable and a 500L tank was purchased for the salt solution.

Injection Site on Kumeti at Te Rehunga weir Site consists of:-

500L sealed water tank — In-tank pump to mix solution
Fathom AQ control box — CR300
Inline flow meter (to record the amount of solution injected).
Pressure transducer in tank (to monitor solution level)
Pressure transducer in river (to record water level)

We set up the system so that it conformed with the current Horizons equipment and communications by connecting the AQ logger to the CR300. At this stage the AQ box controls the premixing of the solution and the injection rate and time; however, we will remove this from the setup and control all functions from the CR300.

Salt Dilution Tank

Kumeti at TeRehunga Weir

Down Stream Site – approximately 150m downstream of injection point.

Site consists of :-
2 EC-T probes on each side of the river to confirm adequate mixing of the salt solution
Standalone CR300 logger with 4G modem comms and solar power are connected to Horizons Base.

The system is currently run remotely. Firstly, the downstream site is set to record at a 5 sec interval to establish the base EC level. The top site is then activated. Premix is started followed by the injection of 1 litre of solution per 1 m3/s into the river. The downstream site is set to record for around 10 minutes which allows enough time for the solution to have passed the site and the EC level to return to the base level.

The data is currently remotely downloaded and entered into an Excel spreadsheet that calculates the flow. A number of parameters need to be considered and calculated within the spreadsheet, i.e., river water temperature, EC probe calibration factor and actual salt mass injected.
We are in the process of automating the calculation of flow but there may always be some manually inputted data to obtain the flow reading.

We have currently run about a dozen injection gaugings and they have all been within 3-7% of the rating or the gauging completed at the same time.

150 DS Weir

What next?

This particular site is difficult to gauge at high flows, so we will complete the dilution gaugings at higher stages. We will also make comparisons of gaugings on rising and falling limbs to check for loop ratings. Once we have gained sufficient data from this site we will install the Auto Salt Systemon a larger river and start looking at the limitations of the volume of solution, distance required for complete mixing etc.

Fine tuning

We are looking at adding an EC probe inline at the injection point and also modifying the flow meter that measures the injection volume. With the current system we test the solution EC and then assume that it does not change. If we log the volume and EC of the solution at the time of injection we may be able to completely automate flow calculation in the office.

Where can this type of gauging equipment take us?

First impressions of the system are very favourable. I can see its use both in permanent sites that are difficult to gauge, but also as a very valuable tool to generate a solid rating over a very short space of time at a newly established site. The ability to set the system running remotely or based on stage height is a major benefit. The reduction in man hours completing manual river gaugings is considerable and makes the initial expenditure of equipment financially viable.

UPDATES

Lincoln Agritech Ltd update

Compiled by Juliet Clague

Our Environmental Research team has been successful in the most recent MBIE Endeavour Fund round, leading the 'Critical Pathways' research programme and contributing to a NIWA-led mitigations programme.

Critical Pathways: unravelling sub-catchment scale nitrogen delivery to waterways

To better manage freshwater pollution we need to understand the pathways by which nitrogen travels from land to waterways; how fast it travels and how much nitrogen is naturally removed by microorganisms as it moves from the soil through the groundwater into a waterway. At present, there is little understanding of nitrogen pathways and removal processes at the sub-catchment scale (10's of km2), i.e., the scale dominated by streams which feed into our rivers. However, it is at this scale that we have the best management and mitigation options available to reduce nitrogen delivery to waterways. This problem has been recognised by farmers, iwi, industry and councils as they try to work out land use, land management, and mitigation options that allow achievement of community-mandated water quality goals under the National Policy Statement for Freshwater Management, with all councils required to have policy for water quality management in place by 2025.

In this collaborative project, we will use multi-scale measurement, data analysis and modelling to cohesively link transect, sub-catchment and catchment scale hydrogeophysical information. Airborne and ground-based transient electromagnetic surveys in two contrasting catchments located in the Waikato will collect 3D resistivity/conductivity information which will then be used to identify hydrogeophysical units using numerical, machine learning and statistical methods. Ground and surface water monitoring along transects within these catchments will then provide data to help unravel and model the transfer of N at the sub-catchment scale. The economic implications of landuse management and mitigation strategies will also be investigated.

We look forward to working with our research partners over the next five years: Aqualinc Research, Manaaki Whenua Landcare Research, Lincoln University, GNS Science, AgFirst, and Ian Kusabs and Associates, supported by Waikato, Hawkes Bay and Taranaki Regional Councils, and Dairy NZ.

New technologies to double the effectiveness of on-farm diffuse pollution mitigation

Lincoln Agritech is also collaborating closely with Aqualinc Research and the University of Waikato in this NIWA-led project, which aims to develop a range of Interceptors, to reduce the impact of agricultural activities on the surrounding freshwater environment. This work will focus on surface and subsurface drainage systems which short-circuit natural attenuation processes during passage through soils and riparian zones, generally making them the dominant conduit for nutrient run-off into waterways. Lincoln Agritech Ltd will be heavily involved with the field-scale performance testing of enhanced woodchip bioreactors, utilising the bioreactor we have already operating on the Hauraki plains (Fig. 1).

Recent publications:

Singh, S.K., and Stenger, R. (2018) Indirect methods to elucidate water flows and contaminant transfer pathways through meso-scale catchments – a review. Environmental Processes. DOI:10.1007/s40710-018-0331-6

Woodward, S.J.R., and Stenger, R. (2018) Bayesian chemistry-assisted hydrograph separation (BACH) and nutrient load partitioning from monthly stream phosphorus and nitrogen concentrations. Stochastic Environmental Research and Risk Assessment. DOI:10.1007/s00477-018-1612-3

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Figure 1: Denitrifying woodchip bioreactor in Hauraki. The high number of sampling wells allows the reaction progress within the bioreactor to be examined.

NIWA Taihoro Nukurangi

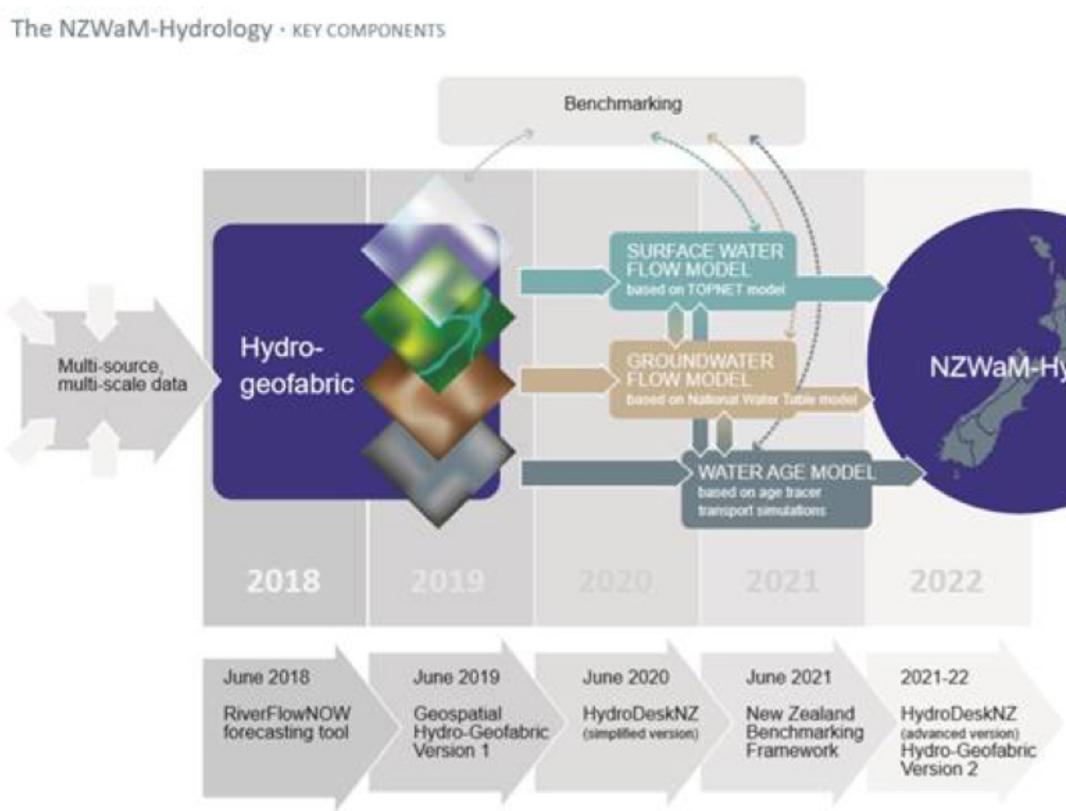
UPDATES

News from NIWA

Compiled by James Griffiths

New Zealand Water Model – Hydrology (NZWaM-Hydro)

NZWam-Hydro is a partnership of NIWA (lead), GNS Science and Manaaki Whenua - Landcare Research, and the regional councils of Southland, Horizons and Gisborne over the period 2016-2022 (formerly referred to as the National Hydrology Project (NHP)). The aim of the NZWaM-Hydro is to allow prediction of hydrological processes from the national to sub-catchment scale (and thus of relevance to the National Policy Statement for Freshwater Management). NZWaM-Hydro will combine surface water and groundwater models with a new 'water-age' model (see figure below). The project also includes the development of a geospatial database (or 'Hydro-geofabric') to facilitate transferable, scalable and cost-effective model development and application. The resulting improved accuracy of the river flow simulations will enable communities to develop more sustainable patterns of water-resource use, and better prepare for flood and drought. A special session on NZWam-Hydro will be convened at the NZHydroSoc conference in Christchurch in December.



Supporting local iwis

MS Srinivasan and Graham Elley have been working with NIWA Instrument Systems and Te Kuwaha teams to establish a field monitoring site at Omaio, Bay of Plenty. The project is funded by Deep South National Science Challenge and aims to examine ways of supporting and enhancing the management and utilisation of land and water resources by local iwi. The NIWA team has been working with Te Rau Aroha Trust who are interested in converting their corn fields into high yielding horticultural land. The NIWA field team from Rotorua has installed climate and soil moisture monitoring sites in the Omaio region and have delivered training in water quality monitoring. On 23 June, the NIWA team held a hui at Omaio, explaining the whenua of the science and monitoring work in the region, and how this can contribute to better land and water management. The hui was attended by about 25 people, including people from other nearby iwi who are interested in land use change.

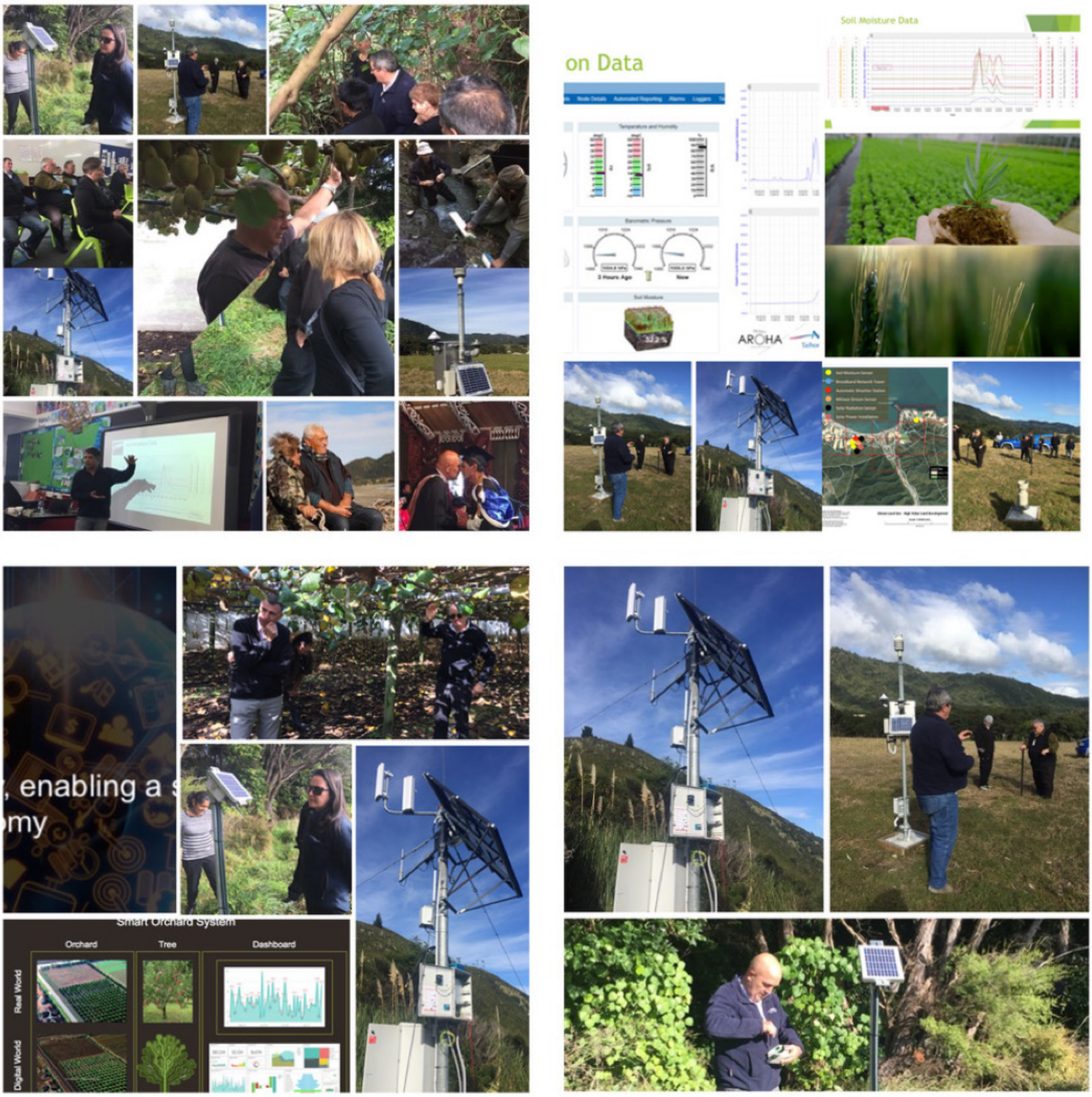
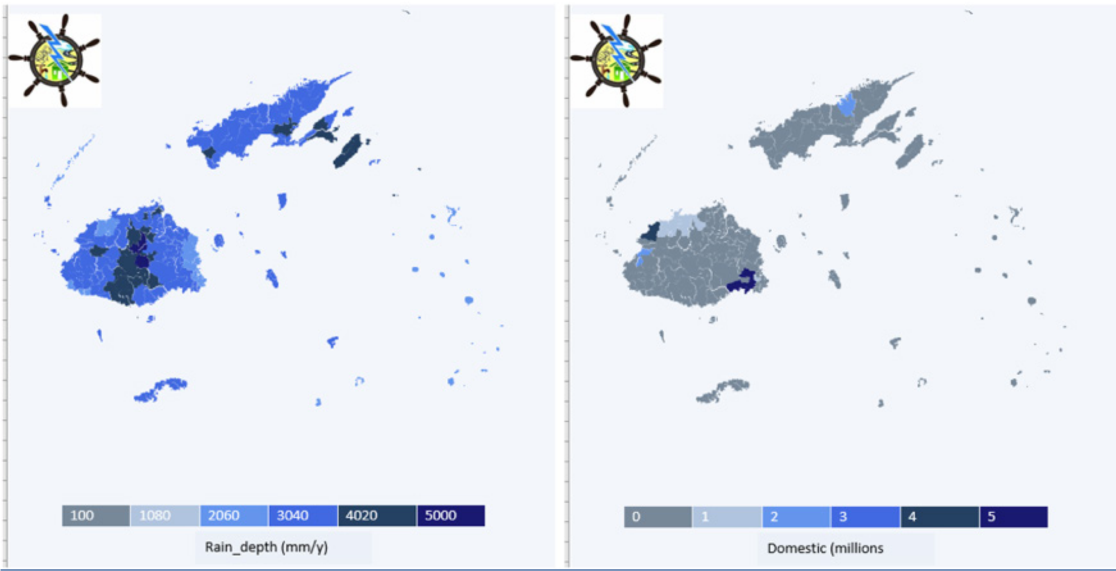


Photo credit: Karamea Insley, Te Rau Aroha Trust

FijiWAT accounting Tool

Fiji is generally wetter than New Zealand, with an average 2.9 m rainfall per year (2010-2015) compared to NZ's 2.1 m/year. Like New Zealand, however, water use in Fiji is a relatively small fraction of total water flux (< 2%). Even so, issues of spatial and temporal water availability and associated water quality are of concern. In response, NIWA has developed 'FijiWAT', a water accounting tool for Fiji that allows visualisation of regional water fluxes and water uses on an annual and monthly basis (see figures below). Key data include interpolated monthly rainfall, evapotranspiration, soil moisture storage and rainfall excess (runoff and recharge combined). These are derived from Fiji Meteorological Service data holdings using a tool based on the New Zealand Virtual Climate Station Network concepts and the Porteous soil water balance model. Additional data were supplied by other Fijian Government agencies, including annual hydro-electric power generation, water bottling data, and estimates of domestic water use based on the Fiji census. At present the tool uses existing administrative boundaries, but these do not relate to hydrological catchments. Subsequent versions of the tool would aim to develop a digital stream network for Fiji, together with an appropriate rainfall-runoff model. [**Shankar, Srinivasan, Henderson**].



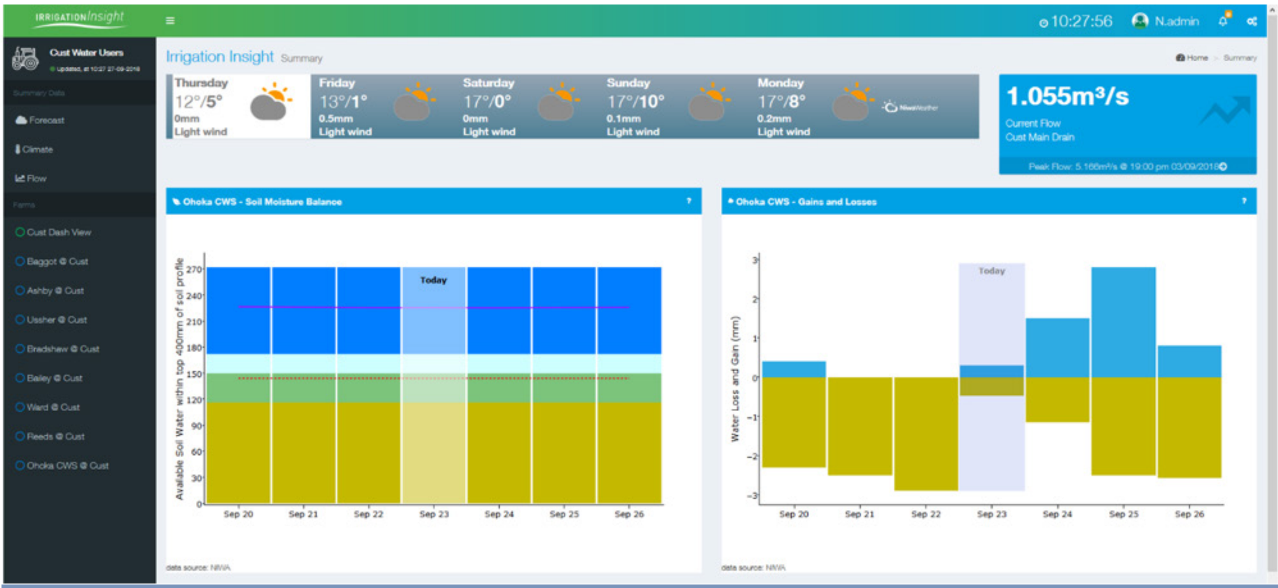
FijiWAT visualisation tool illustrating annual rainfall (2010), and domestic water-use (2010) in millions of m3/year.

Singapore PUB analytics

An ArcGis Add-In for automated catchment delineation at monitoring stations has been developed and tested. The Add-in is now in a suitable form for implementation on the Public Utilities Board (PUB) of Singapore's ArcMap system. It will be implemented in conjunction with the 'event identification system', currently being developed by Niwa. The add-in provides the ability to quickly generate new upstream catchment boundaries when new stations are added to the network. Catchment boundaries provide a means for estimating the amount of rainfall falling on a catchment during an event. [**Shanker, Singh, Schmidt, Bargh**]

IrriMate web portal

The NIWA-led Irrigation Insight programme has launched a new on-line data portal for displaying current and forecast climate, hydrology and pasture growth data for on-farm irrigation and drainage management. The web portal is designed to be a one-stop shop for a range of environmental and on-farm data that are relayed and displayed in real-time to the users. The focus of the portal is to make data easily accessible and readable for informed decision-making. Data displayed include soil moisture, soil temperature, irrigation, rainfall, 2 to 6 day weather forecast, satellite-sourced pasture growth (from LIC), river flows (from ECan) and on-farm surface and ground water use. The web portal can be accessed at https://i2.niwa.co.nz/ If you need access to the portal, contact programme manager [**MS Srinivasan**].



A screenshot of IrriMate web portal

New staff

Duncan Macpherson (Tekapo Field Team) joined the team in May 2017, jumping the ditch from Aquamonix Ltd, Brisbane. Originally from New South Wales, Duncan brings a decade of hydrologic network monitoring experience from previous positions with Manly Hydraulics Laboratory and Water NSW. **Elliot Bowie** (Dunedin Field Team) started in June 2018, moving from Environment Southland, Invercargill. Originally from Nelson, Elliot gained valuable experience from starting his hydrology career with Tasman District Council. **Adrian Aarsen** (Alexandra Field Team) was appointed to a full-time position with the Alexandra Team in September 2018 and adds some excellent practical field skills to this region.

Staff Retirement

Martin Robertson (Alexandra Field Team). Initially starting at the Ministry of Works Green Island Sediment Lab back in 1974, he moved to Alexandra in 1978 and completed 40 consecutive years of work primarily in field hydrology in the central Otago region for NIWA, serving as Field Team Leader for the last 4 years. Martin also led the development and installation of dozens of NEON irrigation monitoring systems for small open-channel flow allocations, throughout the area.

JACOBS

UPDATES

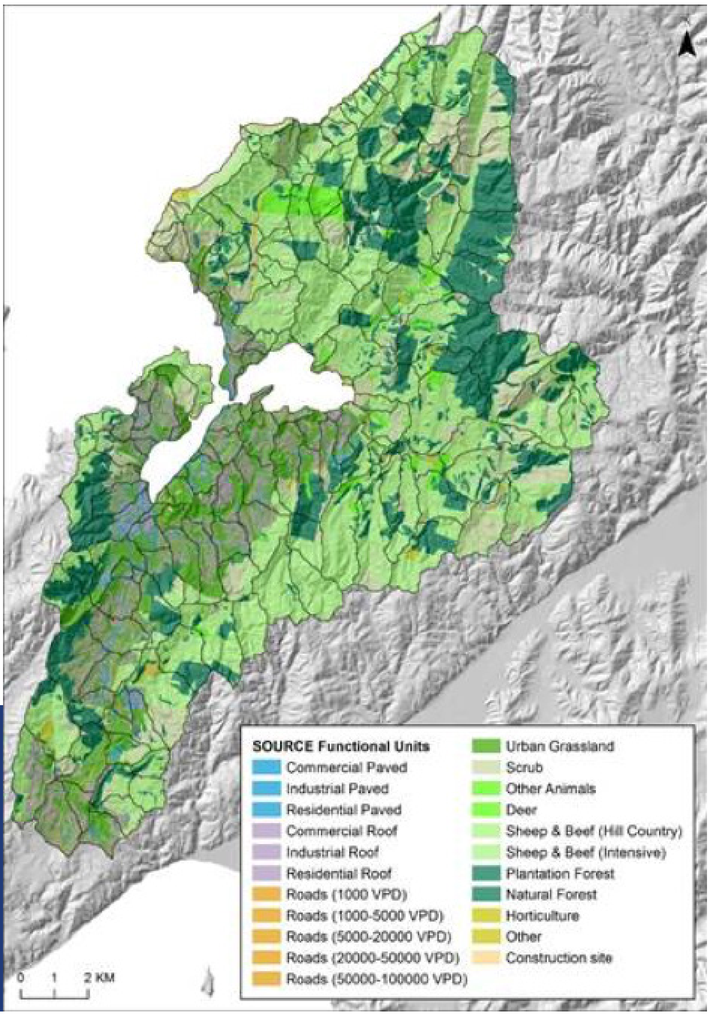
Update from Jacobs

The Jacobs Water Resources Team, based in the Auckland, Hamilton, Wellington, and Christchurch Offices, comprises 13 staff with skills over a range of disciplines, including Hydrogeologists, Hydrologists and Water Resource Scientists. Some of the key projects the team have been working on over the last year are outlined below:

Catchment Modelling and Assessment of Background In-stream Nutrient Yields

Some of our team of water resource scientists and hydrologists in Wellington, James Blyth, Kate Clay, Stu Easton and Laura Keenan, have been working with Greater Wellington Regional Council (GWRC) to aid them in setting freshwater objectives for in-stream nutrients across the Ruamahanga and Porirua catchments as part of the regional Whaitua processes.

This work has involved building, calibrating, and validating baseline hydrological and water quality models in the Ruamahanga and Porirua catchments. These models have then been used to undertake scenario modelling of landuse change options within the catchments, including water sensitive urban design, stock exclusion, wetlands, pole planting, and retirement (to name a few). The outputs from the scenario models are now being used to set freshwater objectives and nutrient load limits/targets which will eventually be integrated in the Proposed Natural Resources Plan (PNRP). Image to the right shows different functional units for the Porirua catchment model.



Groundwater Modelling

Members of our Groundwater Modelling team, Dr Mauricio Taulis and Gillian Holmes in conjunction with our Australian Principal Groundwater Modellers, Brian Barnett and Dr Phil Hayes, have been working with Bay of Plenty Regional Council (BoPRC) to construct two regional groundwater models. These models have covered the Kaituna-Maketu-Pongakawa and the Rangitaiki-Tarawera-Whakatane Water Management Areas.

These models were developed to provide BoPRC with tools to further understand the groundwater flows in the study areas and to simulate the impact of seasonal variations in groundwater as well as assessing the effects of groundwater abstraction. This will enable BoPRC to increase their understanding of the potential effects of abstraction on groundwater levels and base flow across the aquifer from the point of view of allocation.

This work involved reviewing the existing information across the WMAs, developing a conceptual understanding of the hydrogeological processes that the groundwater model needs to include or replicate, including: groundwater flow directions, hydraulic connection between groundwater and surface water bodies, recharge and discharge, the spatial distribution of hydrogeological units and their properties; designing and constructing a groundwater flow model based on the conceptual model; calibrating the model using the current and historical groundwater take data and groundwater and surface water level data.

Wetland Hydrology & Hydrogeology

Some of our team of water resource scientists, hydrologists, and hydrogeologists in Wellington, **James Blyth, Stu Easton** and **Tim Baker**, have been involved in a number of wetland projects around New Zealand, including hydrology and water quality investigations. These wetland projects are focussing on restoring natural wetlands by first understanding their hydrological regimes which will help inform restoration designs. In addition, we have been involved in a number of hearings presenting technical hydrological and hydrogeological evidence and are also designing and building a number of constructed treatment wetlands for stormwater and agricultural runoff.

Emerging Contaminants in Groundwater, Surface Water and Soils

Our groundwater team are involved in a number of PFAS and Emerging Contaminant studies across NZ. These range from PFAS investigation and remediation jobs for both private and government clients to the investigation of Emerging Contaminants in aquifers suppling municipal groundwater supplies. We are fortunate to have several HAZWOPER qualified and ultra-trace low flow (EPA 1669) trained staff able to undertake this field work. One such investigation, completed by **George Hampton, Tim Baker** and **Kevin Tearney** investigated the presence of Emerging Contaminants in the Waiwhetu Aquifer in Lower Hutt. The widespread presence of Bisphenol A (BPA) was surprising and is subject to ongoing investigation.

Photo below shows typical set-up for ultra-trace groundwater sampling.

WSP-Opus

UPDATES

Environmental Division – Water Resources Team

Compiled by Lizzie Fox

Staffing

There have been several changes within the Water Resources team over the last year, the first being we are now part of WSP! **Matt Balkham** continues to lead the team as Work Group Manager, providing expert engineering advice alongside **Dr Jack McConchie**, the Technical Principal of Hydrology and Geomorphology.

Two additional Modelling Engineers joined the team this year: **India Eiloart** and **Leila Sadeghi**. They work alongside **Franciscus (Kos) Maas, Louise Algeo, Daniel McMullan** and **Ana Serrano,** who have specialities in fluvial and coastal modelling and design.

We had to say goodbye to **Sheryl Paine**, who has gone overseas for two years for her OE. With her departure, we welcomed **Courtenay Bremner** who joins the other Water Resource Scientists, Groundwater Scientists and Hydrologists: **Samwell Warren, Ella Boam, Lizzie Fox** and **Kirsty Duff. Lennie Palmer** has also come on board as a Senior Hydrologist, based in the Tauranga office.

Claire Gray has come on board as our Water Quality specialist, with experience in conducting water quality analysis and site assessments. Her work is supported by the Water Resources Scientists and Modellers, allowing us to increase our Water Quality expertise.

This brings the Water Resources team to 15 individuals, who are located across Wellington, Palmerston North and Tauranga.

Projects

The team works on a variety of projects, specialising in hydrology, geomorphology, coastal dynamics, hydraulic engineering, and modelling. Below are some key projects which the team has worked on over the last year, that highlight the diversity of the team's expertise.

Drought Security

To assist in the planning of future security of supply, the client required a daily water storage model. This was to help our client assess whether or not it would accommodate future water demand scenarios. Multiple scenarios were modelled, including population projections out to 2100, daily demand increases, and alterations to the consents; including minimum discharges downstream. The project required detailed analysis of available hydrometric data, updating and modifying a previous hydrological model, and discussing resilience options moving forward. Figure 1 demonstrates the outputs of some scenarios, comparing maximum monthly water demands to 2053 (2b), average monthly demand to 2100 (3a) and maximum monthly demand to 2100 (3b) for a theoretical dry period with no demand management.

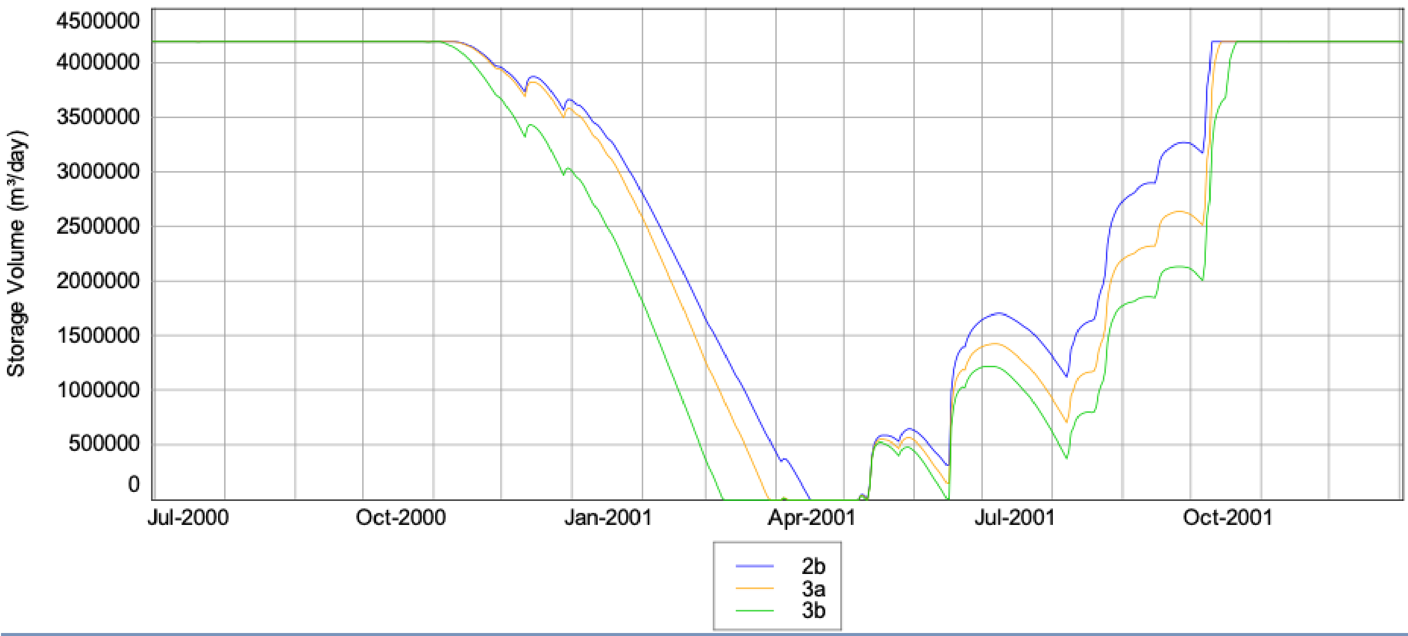


Figure 1:Examples of available storage in the dam, assuming a maximum capacity of 4.2 Mm³; and various demand scenarios.

Skid Failures - Marlborough

Several slope failures in the Marlborough Sounds were investigated to determine the probable cause, and contributing factors, of the failures. This information could then be used to aid in future management of the slips, particularly around earthworks in the area. The analysis showed that the failures were triggered by a relatively small rainstorm, though the primary cause of instability was a combination of poor drainage design and maintenance, and inadequate control of forestry-slash and side-cut material for roads. This study highlighted the importance of considering multiple streams of analysis i.e. rainfall, geology and geomorphology assessments to determine the cause of failure.

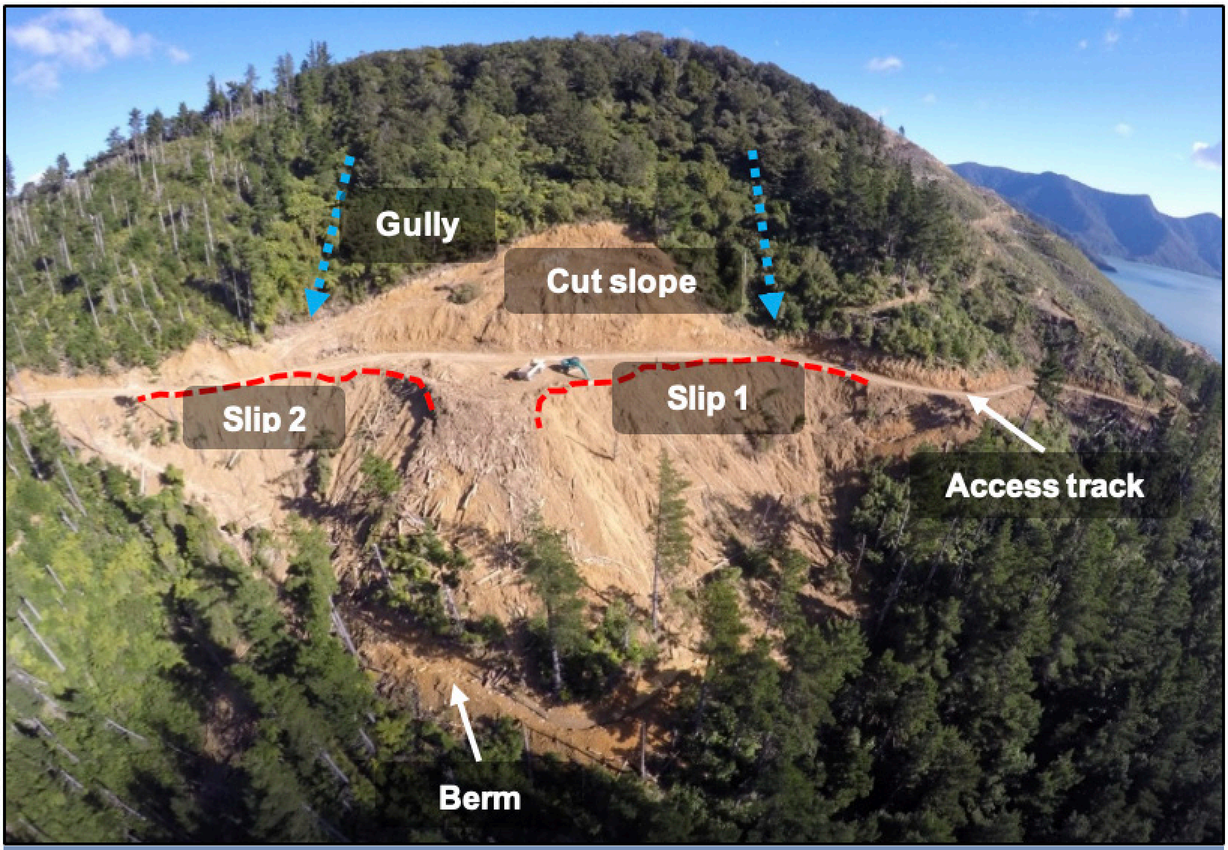


Figure 2: Characterising the two slips in Marlborough that were investigated for failure mechanism.

Coastal Flooding & Erosion – Cyclone Fehi

In February 2018, New Zealand was hit by ex-tropical cyclones Fehi (1st February 2018) and Gita (20th February 2018). Inundation and debris forced temporary closures of sections of the state highway network. Damage to infrastructure has required many months of work to restore the full transport function. WSP Opus provided expert technical opinion to support the emergency response and designed and supervised construction of subsequent repair works. The findings from this work will be presented at the New Zealand Coastal Society 2018 Conference, with a focus on the lessons learned and opinions on the implications for master planning for our coastal communities.

Figure 3: Coastal engineers out on site at Punakaiki, February 2018.

Figure 4: He Ara Kotahi Walkway and Cycle Bridge across the Manawatu River, October 2018.

Hydraulic Bridge Design – WSP-Opus are the lead consultants on the He Ara Kotahi walkway in Palmerston North. This is a new shared pathway and bridge for cyclists and walkers that will link Palmerston North City, Massey University, and Linton Military Camp. The Water Resources Team have been heavily involved in the hydraulic modelling, scour analysis and protection design for the He Ara Kotahi and Turitea Bridges; the former crossing the Manawatu River, and the latter over the smaller tributary about 1.5km downstream. This was a collaborative project across the Water Resources Team and multiple disciplines within the business, including stakeholder and community engagement throughout the process. Figure 4 shows the construction progress of the He Ara Kotahi Bridge as of October 2018.