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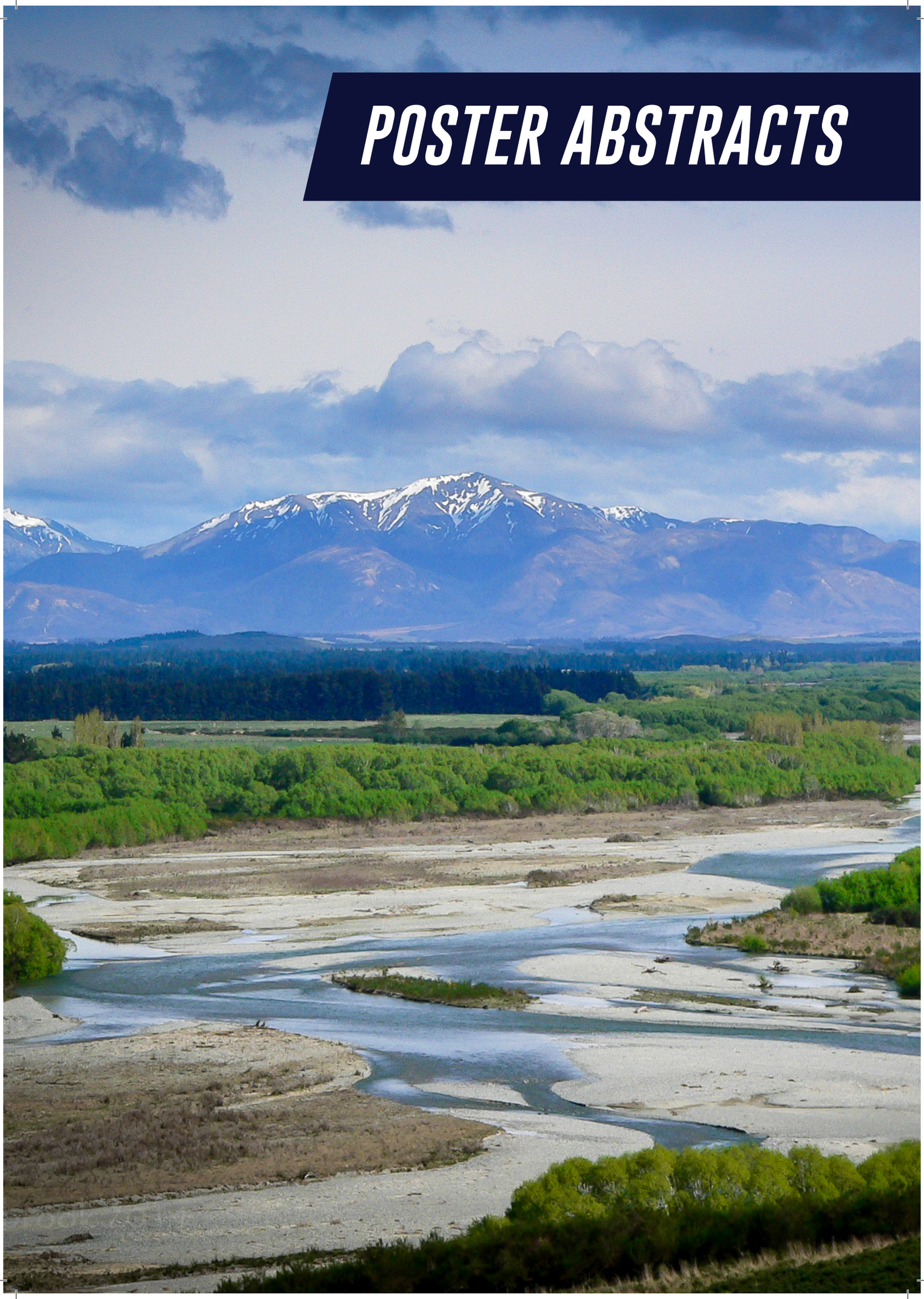

POSTER ABSTRACTS

A COUPLED HYDRODYNAMIC-ECOLOGICAL MODEL OF INFLUENCE OF NATIVE BI-VALVE POPULATIONS OF KAAEO (FRESHWATER MUSSELS) ON WATER QUALITY OF LAKE OHINEWAI

Allan, M.,[1] Clearwater, S.,[2] Hofstra, D.,[3] Thompson, K.,[3] Barnhart, C.,[4] Brown, R., [5] Stott, R.,[3] Hopkins, A.,[6] Nikau, T.[7]
[1] Waikato Regional Council
[2] Te Papa Atawhai
[3] National Institute of Water & Atmospheric Research Ltd (NIWA)
[4] Missouri State University
[5] Manaaki Whenua
[6] AM2 & Associates
[7] Matahuru Papakainga Marae

Freshwater mussels are a keystone species in lakes and influence lake trophic state through filter feeding, biodeposition and nutrient cycling. The most common mussel in New Zealand waters Hyridella menziesii is listed as being in gradual decline, likely due multiple stressors such as eutrophication, habitat loss and lack of recruitment. The present study used lab and field experimentally derived mussel feeding and excretion related parameters within whole lake models to simulate the role of freshwater mussels in a shallow lake. The model was used to indicate mussel biomass required to have an impact on lake ecosystem function including nutrient concentrations and water quality. The model showed that mussel-mediated decreases in phytoplankton biomass were highly sensitive to model parametrization of mussel clearance rates.

QUANTIFYING AND REDUCING NITROGEN LEACHING UNDER INTENSIVE VEGETABLE PRODUCTION IN TEMPERATE REGIONS

Avendano, F. A.,[1] Horne, D. J.,[1] Singh R.,[1] Cichota, R., [2] Bloomer, D., [3] Palmer, A.[1]
[1] Environmental Sciences, School of Agriculture and Environment, Massey University
[2] The New Zealand Institute for Plant & Food Research Limited
[3] LandWISE Incorporated

Practices that increase N use efficiency and mitigate N losses are receiving increasing attention from growers, regulators and scientists. Developing these require a sound understanding of N losses and its flow pathways from vegetable production fields to the receiving water bodies. However, there is currently little measured data available on the quantification of N leaching from vegetable production systems in New Zealand. Data is particularly lacking for the Arawhata Catchment near Levin, where most of the fresh vegetables consumed in the lower North Island are grown. High N levels in the Arawhata stream and Lake Horowhenua have been found. The main objectives of this study are to quantify the range of N leaching rates under vegetable production in the Arawhata, and to develop in-field and edge-of-field strategies that can reduce N losses to the stream and lake. This will be achieved through a three stages approach. Firstly, actual N losses are being measured at two local farms under different crop rotations and fertilizer treatments. The results from these trials will then help to calibrate and validate the APSIM model, which simulates N dynamics under crops at the paddock scale. APSIM will be then used to investigate the ability of different management practices to reduce N losses under intensive vegetable farming in the region. In the third stage, a catchment-scale model will be used to simulate the effects of placing a range of N loss mitigation strategies, including the in-field practices identified with APSIM and edge-of-field techniques, across the landscape to help minimise N losses into the stream and lake.

A SCIENCE-TO-CITIZEN PATHWAY FOR MONITORING USING ENVIRODIY.ORG MAYFLY STATIONS

Baisden, T.W.,[1] Murray, R.,[1] Dare, J.,[1,2] Jarman P.[1]
[1] University of Waikato
[2] Bay of Plenty Regional Council

Low-cost Arduino equipment customized by EnviroDIY.org provides an accelerating pathway for using high-quality sensors. Initially evolving through a US National Science Foundation funded Critical Zone Observatory at the Stroud Research Centre, the customised Mayfly boards provide a robust, low cost option for sensor stations. A significant advantage is the international non-commercial model complete with a code repository (on Github) and web-enabled cloud upload technology. We have so far demonstrated basic conductivity-temperature-depth and more capable stations with turbidity, dissolved oxygen, temperature and conductivity, and telemetered data deployed at streams of interest flowing in the Rotorua Te Arawa Lakes. Ongoing science-driven development is focussed deploying a growing array of stations with varying capabilities dispersed to multiple points in catchments. At the same time, we demonstrate a pathway to enable community volunteers to adopt the technology.

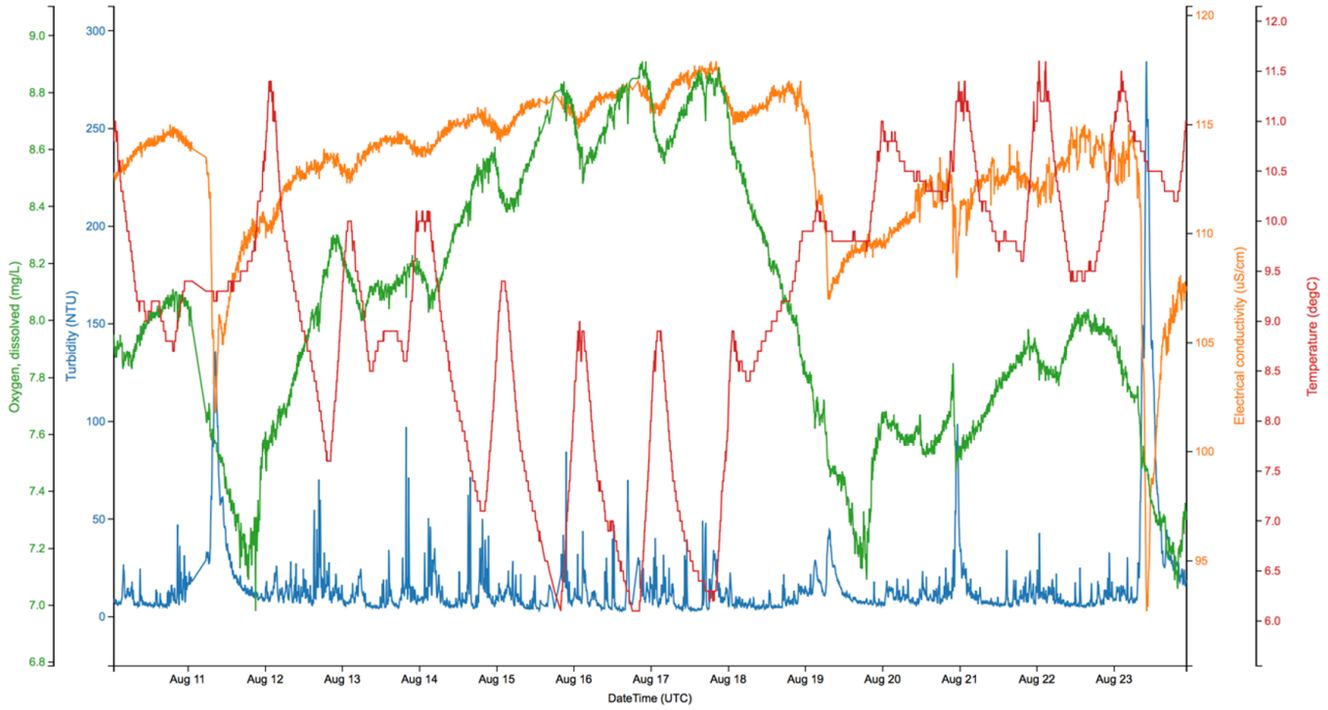

Figure 1. Example of cloud-based output from a Mayfly station at the Ōkaro stream.

TOXICITY OF COMMON URBAN AND RURAL FRESHWATER CONTAMINANTS TO JUVENILE FRESHWATER CRAYFISH (*PARANEPHROPS PLANIFRONS* OR KŌURA).

Albert, A.M.,[1] Thompson, K.,[1] Bell, S.,[1] Clearwater, S.J.,[2]
[1] National Institute of Water and Atmospheric Research
[2] Department of Conservation

The North Island's largest freshwater crustacean, crayfish *Paranephrops planifrons* (kōura), is a resident of rural and urban streams and in lakes and is a traditional food resource. We know little about the sensitivity of this tāonga species to environmental contaminants and it is not among the species used to derive the Australia New Zealand Guidelines (ANZG) for the protection of freshwater aquatic species. The sensitivity of juvenile *Paranephrops planifrons* (kōura) to several common freshwater contaminants zinc, copper and total ammonia-nitrogen (TAN) was investigated using toxicity testing. We also tested the herbicides glyphosate and Aquathol K in order to increase our knowledge of the susceptibility of this native species to products used adjacent to or in waterways. A method of obtaining and maintaining large numbers of similarly aged juvenile kōura for toxicity testing was developed. Kōura were exposed to the contaminants for 14-days, in low dissolved organic carbon (DOC) and low hardness waters so that the data would be of sufficient quality for potential inclusion in ANZG updates. Using standard ecotoxicology methods, toxicity endpoints (e.g., NOEC and LC_{50} values) for juvenile kōura were derived for exposure durations from 1 to 14 days. Juvenile kōura were relatively insensitive to copper, zinc and TAN exposures, compared to current water quality guidelines. Our data indicate Aquathol K is non-toxic to kōura at the standard application rate used in New Zealand. Water quality guidelines and toxicity endpoints are useful for the management of contaminants to protect aquatic biota.

ECOSYSTEM HEALTH IN LOWLAND STREAMS: EFFECTS OF RIPARIAN VEGETATION ON TEMPERATURE, DISSOLVED OXYGEN, AND MACROINVERTEBRATE COMMUNITIES.

Booth R. A.[1,2]
[1] University of Waikato
[2] Waikato Regional Council

Intensifying agriculture and an increasingly variable climate pose a growing threat to the structure, stability and functioning of freshwater macroinvertebrate communities. Intensive agriculture imposes a range of physical and chemical changes to streams, such as increased nutrient loading, sedimentation, plant growth, and temperature extremes. These changes influence stream macroinvertebrate species composition and ecosystem functioning, such as litter decomposition and dissolved oxygen dynamics. Additionally, agricultural streams are faced with increasing frequency of extreme climatic events, such as heat waves and drought, which may further exacerbate physical impacts on aquatic ecosystems. Riparian planting has been suggested to ameliorate impacts of agricultural intensification and climate change by moderating nutrient runoff and sedimentation, as well as buffering daily fluctuations in temperature and dissolved oxygen. We aim to investigate the importance of riparian vegetation in lowland streams for moderating the detrimental effects of rising temperatures on agricultural landscapes in the Waikato region. To do this, we are conducting macroinvertebrate sampling and decomposition assays in agricultural streams that have varying degrees of riparian vegetation, as well as monitoring key environmental variables such as dissolved oxygen, light and temperature. Using these data, we will determine how riparian vegetation modulates interactions between temperature, light and dissolved oxygen that influence macroinvertebrate community structure and ecosystem functioning. By advancing our understanding of the multifaceted effects that riparian vegetation can have on lowland streams, our research will determine how riparian restoration could help macroinvertebrate communities to persist in a changing climate.

MOVEMENT PATTERNS OF EELS (*ANGUILLA* SPP.) RELOCATED PRIOR TO DREDGING AN URBAN WATERWAY

Burrell, G.P.,[1] Brown, M.G.,[1] Webb, C.J.,[1]
[1] Instream Consulting

Sea level rise will put pressure on local governments to reduce flooding risk by dredging rivers. This will in turn place pressure on aquatic ecosystems from the effects of dredging. One of the direct impacts of dredging is physical destruction of fish and aquatic habitat. Fish capture and relocation prior to dredging is an option for avoiding impacts on fish, but few studies monitor the fate of relocated fish. This paper summarises the movements of eels (*Anguilla* spp.) tagged with Passive Integrated Transponder tags prior to being relocated as part of a dredging operation in the Ōpāwaho / Heathcote River, New Zealand. Analysis of tagging data indicates a recapture rate of 24% for shortfin eels (*A. australis*) and 31% for longfin eels (*A. dieffenbachii*). Most (94%) of eels were only recaptured once or twice. The median distance travelled between release and recapture locations was 1.9 km for shortfin eels and 1.7 km for longfin eels. Median daily distances travelled between release and recapture were 36 m per day for shortfin eels and 24 m per day for longfin eels. The median number of days between release and recapture was 51 days for shortfin eels and 64 days for longfin eels. Overall, tagging data suggest that trapping and relocation is a viable method for avoiding dredging impacts on eels. However, further monitoring, including analysis of growth and survival, is recommended to confirm this.

NGĀ AWA RIVER RESTORATION RESEARCH STRATEGY AND ON-LINE RIVER RESTORATION HUB

Clearwater, S.,[1] West, D.,[1] Miller, R.[1]
[1] Department of Conservation

The Department of Conservation (DOC)-led Ngā Awa River Restoration programme aims to collaboratively implement river restoration that is enduring, catchment-scale and enhances climate change resilience in 14 river catchments in New Zealand. The co-management relationship between DOC and the Treaty Partner(s) in each catchment is integral to the programme, and Nga Awa supports a River Restoration coordinator at each catchment (see presentation by R. Miller).

Ngā Awa aims to advance our understanding of best practice restoration at a catchment scale - and we invite collaboration. The suite of conservation challenges that impact Ngā Awa include climate change, engaging and influencing a wide variety of stakeholders, influencing water infrastructure investment and management, water quality and quantity reductions, habitat destruction and pest species. Ngā Awa is strongly aligned with Te Mana o Te Taiao, the trajectory of recent National Policy Statements for Freshwater Management (NPS-FM), and other initiatives such as Jobs For Nature. A trans-disciplinary approach to understand the socio-economic drivers of river health, and responses to river restoration, offers opportunities for research partnership.

Ngā Awa's 2020-2023 Research Strategy themes are: 1) Incorporating **climate change resilience** into river restoration 2) Working with **river geomorphology** to support enduring outcomes; 3) Using **socio-economic knowledge** to support aquatic biodiversity protection and restoration; 4) Developing **monitoring strategies and techniques** for river catchments to support adaptive management.

We are also developing an **on-line River Restoration Hub** to make the latest Aoteoroa-relevant river restoration research more accessible for uptake. We are seeking contributors and links to pre-existing resources.

DEVELOPING CONTAMINANT CRITERIA PROTECTIVE OF SENSITIVE LIFE STAGES OF THE NATIVE FRESHWATER MUSSEL *ECHYRIDELLA MENZIESII*.

Clearwater, S.J.,[1,2] Albert, A.M., [2] Thompson, K., [2] Bell, S., [2] Williams, E.K., [2]
[1] Department of Conservation
[2] National Institute of Water & Atmospheric Research

Freshwater mussels (Unionida) are among the freshwater invertebrates most sensitive to the ubiquitous aquatic contaminants copper (Cu) and ammonia (or Total-Ammonia-Nitrogen (TAN)). For example, the 2007 US Environmental Protection Agency Water Quality Criteria has more conservative Cu thresholds for water bodies where freshwater mussels are present. In 2014 we demonstrated that the short-lived larval life-stage (glochidia) of the New Zealand native freshwater mussel *Echyridella menziesii* were relatively tolerant of Zn, but that they were the native aquatic species most sensitive to Cu by a factor of 2-3, and the species 2nd most sensitive to TAN (out of 16 species of native invertebrates and fish) (Clearwater et al. 2014 Arch. Env. Contam. Toxicol. 66). Back then we were unable to culture or collect sufficient juvenile freshwater mussels to directly evaluate their sensitivity to contaminants. Instead based on comparison to a significant body of international data on both life-stages (but different mussel species), we predicted the sensitivity of *E. menziesii* juveniles to Cu and TAN. Now we have begun to reliably mass-produce juveniles and have completed the first round of 96-hour static-renewal toxicity tests. Our toxicity endpoints for juveniles align with predicted values for Cu but indicate that juveniles are slightly more sensitive to TAN than we predicted. The new endpoints will also be compared to the updated ANZECC water quality guidelines with a view to better understanding whether future toxicity testing of other contaminants using the accessible glochidia, will provide data sufficiently protective of the longer-lived juvenile life stage.

I HAVE LIVED HERE A LONG TIME – I HAVE NEVER SEEN A FLOOD LIKE THIS EVER

Connell, R.

Residents often say after a flood disaster, "I have never seen a flood of this magnitude before after living here for the last, 20, 30 or even 50 years".

This paper addresses how often this should occur. I have looked at the question, "How often does a flood significantly larger than the any event in the first 50 years occur?"

For this analysis, I used two 50 year periods. Using random numbers, I calculated the return period of the largest flood for the first 50 year period and compared with the largest flood in the second 50 years of record. To obtain probability that this will occur, I calculated a normalized discharge for these floods using the expected type of flood distribution in New Zealand. I used. the percentage of rivers that are EV1, EV2 and EV3, (omitting the TCEV and other distributions). From these results, I calculated how often a flood that is significantly larger in size than the largest in the first 50 years.

What is a flood that is significantly larger?

I have examined using the criteria of 1.3 times, 1.5 times, 2 times and 4 times the size of the largest flood in the first 50 years as a flood that is significantly larger.

From this I have estimated how often each criterion should occur in New Zealand.

Finally, I discuss the issues with the analysis and areas for further research.

GLUTTONOUS ALGAE AND THEIR APPETITES

Daly, O.,[1] Kuczynski, A.,[1] Lewis, C.,[1,2] Kilroy, C.[1]
[1] National Institute of Water and Atmospheric Research
[2] The University of Birmingham, United Kingdom

Nuisance and toxic periphyton cause environmental and health problems in rivers in New Zealand and worldwide. For example, some Microcoleus strains produce neurotoxins and ingestion of these has resulted in numerous dog deaths. Periphyton biomass and growth rates depend on multiple factors including light, temperature, and nutrients. Nutrients (nitrogen, N and phosphorus, P) are the primary drivers of growth rates and the most common management target. Simple empirical relationships between nutrient concentrations and periphyton biomass can help guide broad management strategies such as setting regional nutrient limits. However, development of more realistic mechanistic models that accurately simulate periphyton growth, leading to better informed management actions, has been hampered by lack of data. The objective of this project was to improve understanding of nutrient uptake in periphyton under different conditions. Cell growth is often simulated as a function of nutrient concentrations in water (Michaelis-Menten kinetics) but nutrient uptake is also mediated by cellular storage of excess N and P (Droop kinetics). The effect of nutrient storage has been seriously understudied in periphyton. We conducted experiments in controlled laboratory conditions to quantify nutrient uptake rates for Microcoleus and filamentous green algae. Each assemblage was exposed to gradients of external N and P concentrations and aged periphyton were used to conduct experiments across a gradient of internal N and P concentrations (cell quotas). Taxon-specific N and P uptake rate equations were derived with respect to cell quota and external nitrogen and phosphorus concentrations.

DIRECT PUSH SAMPLING OF GROUNDWATER IN NEW ZEALAND

Gardner, P.,[1] Curtis, J.[1]
[1] GNS Science

A low-cost and easy to use direct-push method is presented that allows groundwater sampling for age dating and hydrochemical analysis with high depth resolution and a final depth up to 30m.

This direct-push method allows for two types of groundwater sampling: First, soil cores are taken from the unsaturated zone (up to 10m) via a steel corer driven by a hydraulic hammer. Following collection, the moisture is extracted from the soil using our recently developed soil distillation system and can be analysed for tritium and isotope data.

Second, a sampling probe with an exposed sampling screen enables water sample collection at multiple depths within the saturated zone without retrieving, cleaning, and re-driving. Previous studies have indicated that hydrochemistry, stable isotope, and age dating results obtained using the direct push method are comparable but with better resolution compared to those obtained from multi-level nested wells.

As percussive force is supplied by a hand operated hydraulic hammer, the direct push method offers the potential for a cost-effective system that is mobile and can therefore be applied to the study of groundwater in areas where no wells exist. The main limitation is the depth to which the probe can be inserted which is itself dependent on the geology of the sampling site. In materials like sand or pumice the method is very effective and the probe can quickly be drilled down to significant depths. Gravels are generally not suitable for the use of this probe as it cannot penetrate these layers. Possible applications are the study of geochemical gradients, groundwater age determinations and investigations into recharge processes in unconsolidated aquifers.

TRACE METAL LIMITATION OF PHYTOPLANKTON GROWTH IN LAKES OF THE TAUPO VOLCANIC ZONE

Dengg, M.,[1] Stirling, C.,[1] Reid, M.,[1] Seyitmuhammedov, K.,[1] Letho, N.,[2] Safi, K.,[3] Verburg, P.[3]
[1] Centre for Trace Element Analysis, Department of Chemistry, University of Otago
[2] Faculty of Agriculture and Life Sciences Lincoln University
[3] National Institute of Water and Atmospheric Research (NIWA) Hamilton

The Taupo Volcanic Zone (TVZ) in the North Island of New Zealand was formed and shaped by rhyolithic volcanic activity more than 2,000 years ago. Due to its volcanic past, the TVZ is characterized by extremely low concentrations of trace metals in soils and lakebeds. We hypothesize that these low trace metal concentrations (mostly below the parts-per-trillion [ppt] level) limit phytoplankton growth, as iron, manganese, zinc, cobalt, and other 'bioactive' metals, are required to support enzymatic processes in phytoplankton and enable nitrogen-fixation in cyanobacteria.

A one-year survey of Lakes Taupo, Okataina and Rotorua was conducted from August 2018 to August 2019 to examine the relationships between trace metal concentrations, trace metal bioavailability, and phytoplankton growth. Water samples were collected from the surface water layer of each lake on a monthly basis, and from the entire water column in February 2018 when the lakes were stratified and August 2019 when the lakes were well mixed to account for seasonal differences in trace metal concentration and bioavailability. Each water sample comprised the dissolved, particulate and total trace metal fraction. Chemical pre-concentration techniques and sector-field ICP-MS (SF-ICPMS) were used to quantify trace metal concentrations at the sub-ppt level. Dissolved gradients in thin films (DGT) were deployed in parallel to allow the 'bioavailable' fraction of key trace metals to be modeled and quantified.

Here we present first results of this one-year long survey, with an emphasis on metals that are most important for phytoplankton growth, and their bioavailability during different seasons.

IDENTIFYING THE IMPACT OF NON-NATIVE BROWN TREE FROG, LITORIA EWINGII, ON NEW ZEALAND POND SYSTEMS.

Earl, B.C.,[1] O'Regan, R.,[1] McIntosh, A.R.,[1] Warburton, H.J.[1]
[1] University of Canterbury, Department of Biological Sciences

Australian brown tree frogs (Litoria ewingii) have been spreading across New Zealand for decades. Their tadpoles have been observed in many ponds, but their effects on New Zealand pond ecology are unknown. New Zealand has few anurans and none with aquatic tadpoles, so the presence of a large generalist herbivore, often at high densities, could potentially have strong effects. Moreover, the faunas of the temporary or semi-permanent ponds likely occupied by L. ewingii tadpoles are also vulnerable because of increased magnitude drying events associated with climate warming. We surveyed ponds ranging from temporary to permanent, and those with fish present and absent, in the Cass Basin, Canterbury, to identify the types of ponds used by L. ewingii tadpoles. They seem to be opportunistic colonizers, as they were found in high densities in fishless temporary ponds. To determine the functional role of tadpoles, we also carried out a mesocosm experiment with tadpole presence crossed with predatory invertebrate presence (2x2 factorial design with 7 randomized blocks). Tadpoles significantly affected algal and organic matter abundance and grazed down macrophytes, but there were no effects of predatory invertebrates. Therefore, tadpoles are likely to have large influences on ecosystem processes like nutrient cycling in small lentic habitats, and due to their grazing of aquatic plants, could fill a functional role not currently occupied. Therefore, the spread of these frogs in New Zealand may need to be more carefully considered, especially in light of other influences on temporary pond ecosystems due to climate warming.

HOW CONNECTED ARE WAIKATO RIVER FRESHWATER MUSSEL POPULATIONS?

Fenwick, M.,[1] Hofstra, D.,[1] Richie, P.,[2] Lee, C.,[3] Longmore, J.,[3] Hopkins, A.,[4] Clearwater S.[5]
[1] National Institute of Water and Atmospheric Research
[2] Victoria University, Wellington
[3] University of Waikato
[4] AM2 and Associates
[5] Department of Conservation

Echyridella menziesii (kaaeo in the Waikato-Tainui rohe) is one of three species of freshwater mussel's native to Aotearoa-NZ. This species once formed extensive beds in lakes and rivers throughout Aotearoa-NZ and is still locally common in some places. However, E. menziesii are ranked as At Risk – Declining in the New Zealand Threat Classification System. The decline of freshwater mussels both nationally and internationally has been attributed mainly to the loss and degradation of suitable habitat through changes in land and water management, and the loss of host fish species upon which the completion of their life cycle depends. In addition, a recent Climate Change Vulnerability Assessment revealed emerging climate-related threats to E. menziesii where it ranked as being 'highly vulnerable'.

The propagation and translocation of endangered species is increasingly being considered in Aotearoa-NZ to support improvements in biodiversity and ecosystem health. Some of these methods hold great potential for the restoration of freshwater mussel populations. However, despite the ecological value and conservation status of this species there is little information available regarding their genetic diversity at a population level.

Here we present two genetic analyses: (1) an analysis of variation in a short section (500bp) of the cytochrome oxidase 1 mitochondrial gene (mDNA) from freshwater mussels sampled over a wide geographic range; and (2) the preliminary results from a focused study of freshwater mussel mDNA sampled from the Waikato River catchment between Taupō-nui-a-Tia and Te Puuaha (Port Waikato).

We are pleased to report on the success of new non-lethal methods of freshwater mussel DNA tissue collection using swabbing methods. The results will inform guidance for eco-sourcing and translocating freshwater mussels for restorative purposes to best manage genetic diversity.

IMPLEMENTING NEW FRESHWATER POLICY: A TIMELINE THROUGH TO 2026 AND BEYOND

Forsyth, K.[1]
[1] Ministry for the Environment

In 2020 the Government's most recent round of freshwater policy reforms was announced, including:

- an updated National Policy Statement for Freshwater Management (NPS-FM)
- new National Environmental Standards for Freshwater (NES)
- new regulations under section 360 of the Resource Management Act 1991 (RMA)
- amendments to the Resource Management (Measurement and Reporting of Water Takes) Regulations 2010
- amendments to the RMA to provide for a new freshwater planning process and to enable mandatory and enforceable freshwater modules of farm plans.

This package of freshwater reforms includes immediate actions to stop declines in freshwater, medium-term changes, and measures to make ongoing improvements for future generations. In this poster we'll present a time line for when the different parts of the package take effect, and what this will mean for freshwater management.

DROUGHT MONITORING TOOLS AND DROUGHT MANAGEMENT IN THE MIDDLE EAST AND NORTH AFRICA REGION

Fragaszy, S.E., Jedd, T., Wall, N., Knutson, C., Belhaj Fraj, M., Bergaoui, K,. Svoboda, M., Hayes, M., McDonnell, R.

The Middle East and North Africa (MENA) region experiences severe socio-economic, environmental, and political impacts during droughts, and it faces increasing drought risk in future climate projections. To mitigate these effects, environmental monitoring and early warning systems aimed at detecting the onset of drought conditions can facilitate timely and effective responses from government and private sector stakeholders. The UN Office for Disaster Risk Reduction's Sendai Framework and the International Drought Management Programme provide a global standard (a "norm") to manage droughts through natural hazard risk reduction approaches.

This study uses multistage, participatory research methods across more than 135 interviews, focus groups, and workshops to assess the following in the MENA countries of Morocco, Tunisia, Lebanon, and Jordan:

1. Extant drought monitoring and management systems, including whether drought risk management norm diffusion has taken place;
2. key cross-sector drought impacts; and
3. drought monitoring and management needs to embed hazard risk management norms.

Drought monitoring needs include technical definitions of drought for policy purposes; information-sharing regimes and data-sharing platforms; ground-truthing of remotely sensed and modelled data; improved data quality in observation networks; and two-way engagement with farmers, organizations, and end-users of drought monitoring products. The analysis reveals incomplete drought hazard risk management norm diffusion. Stakeholders subscribe to relevant values, but national policies and implementation do not fully reflect the norm. Process tracing reveals that availability of drought early warning data is a key barrier to risk reduction. Further, a drought early warning system would not be feasible or sufficient for the purpose of risk reduction unless paired with policy measures and financial mechanisms to reduce the political and economic costs of a drought declaration.

This study is informing and shaping the ongoing development of drought early warning systems and drought management planning in each country, and the broad stakeholder engagement can help foster the emergence of effective environmental monitoring coalitions.

Sources:

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PREPARING A TUNA RESEARCH STRATEGY IN PARTNERSHIP WITH TANGATA WHENUA

Funnell, E.[1]
[1] Department of Conservation

Tuna/longfin eel (*Anguilla dieffenbachia*) are a significant taonga species for tangata whenua. They are classified as 'At Risk – Declining' due to concerns with the trends in their population status[1]. Tuna are vulnerable to impacts from loss of habitat, loss of connectivity for migrations between the sea and freshwater habitats, changes in water quality, and harvesting. Due to their migratory life cycle, these species require landscape-level management to ensure they can access and utilize the full range of habitats needed during their lives. To address this issue the Department of Conservation is implementing a new programme that is working towards an ultimate future state of 'all migratory and marine species have a representative network of secure, stable or increasing sub-populations'. The three freshwater migratory species selected to focus on were: shortjaw kokopu (*Galaxias postvectis*), inanga (*Galaxias maculatus*) and tuna/ longfin eel (*Anguilla dieffenbachia*). To improve implementation of tuna management strategies, key knowledge gaps need to be addressed. Maori have extensive knowledge of tuna and have been actively practicing mātauranga Māori for centuries[2]. Therefore, to address gaps in knowledge and improve co-management, the Department is seeking to integrate Māori interests through co-development of a tuna research strategy. The strategy will identify and prioritise the research needed to be able to restore tuna populations and support kaitiakitanga.

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EXPLORING THE APPLICATION OF ECOLOGICAL PROCESSING INDICATORS IN NEW ZEALAND RIVERINE ENVIRONMENTS: A META-ANALYSIS

Gault, A.,[1] Harrison, E.,[2] Clapcott, J.,[2] Petherick, L.[3]
[1] Victoria University of Wellington
[2] Greater Wellington Regional Council
[3] Cawthron Institute
[4] Victoria University of Wellington

Broad-scale assessments of ecosystem 'health' are often based on correlative relationships between catchment land-use categories and structural components of streams, often neglecting measures of ecosystem processes. Recent research has demonstrated the importance of including complimentary functional indicators to assist in describing the integrity and function of underlying ecosystems. In some recent exploratory studies, organic matter processing has been one of those potential indicators.

The newly standardized cotton-strip assay quantifies the inherent capacity of ecosystems to process organic carbon. It does so by measuring their decomposition potential, whilst integrating the influences of microbial community structure and environmental factors, predominantly nutrient availability and temperature, on microbial activity represented by cellulose breakdown rates.

Previous New Zealand based studies have considered regional-scale application of cotton-strips alongside traditional monitoring strategies, with focus on spatial, temporal, and varying land-use scales. However, these studies are often limited by region.

In a New Zealand meta-analysis, we look to further elucidate the consistency of ecological processing via cotton strip breakdown across differing land-use gradients and focus on nutrient and temperature responses from samples collected by Waikato, Horizons, Hawkes Bay, Otago and Southland regional councils within the last 12 years. Here, I will present preliminary results and next steps of this study.

ROBUST EVALUATION OF DATA WORTH FOR THE WAIRAU AQUIFER USING SURROGATE MODELS

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Aims

A numerical groundwater model of the Wairau Plain Aquifer has been developed to make several predictions useful for groundwater management by the Marlborough District Council (Wöhling et al. 2018). A topic of interest has been the estimation of uncertainty associated with these model predictions, along with the potential of data to reduce these uncertainties. Unfortunately, long model run times impede these analyses, especially when taking into account parameter non-uniqueness in the process, because they require in the order of 102 – 104 model runs.

Methods

We address these challenges by combination of two different solutions:

- application of (faster) surrogate models instead of a complex benchmark model, and
a. coupling of linear predictive uncertainty estimation with efficient Null-space Monte Carlo methods to a robust data worth analysis.

The methods are tested by comparing results from the complex benchmark model of the Wairau Plain Aquifer with those from two different surrogate models: a spatially and parametrically simplified version in MODFLOW (Niswonger 2011), and a projection-based surrogate model utilizing proper orthogonal decomposition (POD). We estimate worth of data in relation to predictive uncertainty computed by the linear methods presented in the PEST toolbox (Doherty 2016), differentiating between data existing in the calibration dataset (existing data), unknown or validation measurements ("future" data) and potential knowledge of model parameters ("parametric" data). Parameter non-uniqueness is taken into account by computing the variability of the data worth estimates from multiple calibrated model parameter sets, generated by applying PEST's Null-space Monte Carlo methods.

Results

The robust data worth method produces reasonable estimates for existing, "future" and "parametric" data for different model predictions of the complex benchmark model. Both surrogates perform well in reproducing these results for existing data. The simplified MODFLOW surrogate struggles to reproduce "future" data worth for some predictions and fails to accurately estimate "parametric" data worth. This is due to its simplification in parameter space. In contrast, the data worth estimates of the POD model are in good agreement with the benchmark results for "future" and "parametric". High variance associated with some data worth estimates suggests the necessity of accounting for parameter non-uniqueness as we did in the robust data worth method presented here.

References:

Doherty, J., 2016. PEST: Model-Independent Parameter Estimation - User Manual. Watermark Numerical Computing, 6th Edition.

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TRIALLING GROUND PENETRATING RADAR FOR DETECTING NEAR SURFACE CONCENTRATED FLOWPATHS ON A TOENEPI DAIRY FARM

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[1] NIWA, Hamilton
[2] NIWA, Auckland

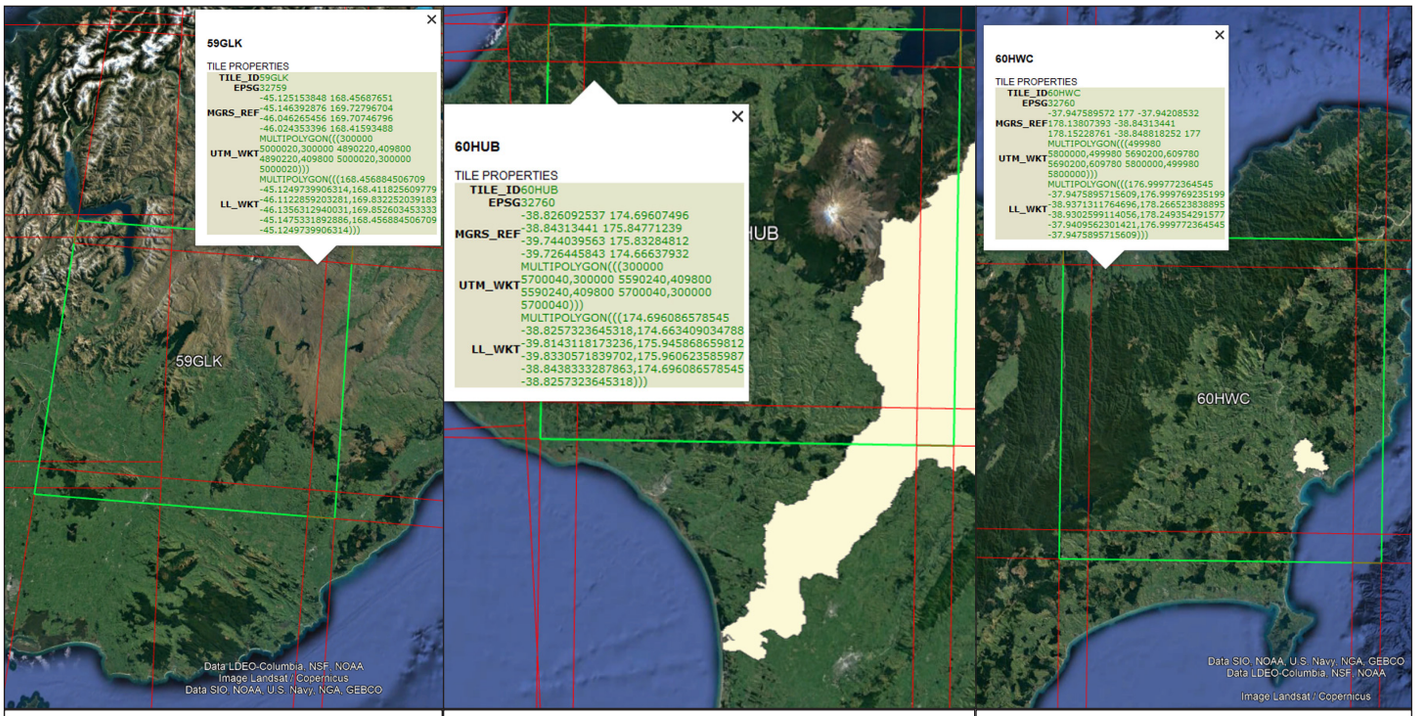
Vast networks of underground channels, springs, and drains provide preferential flowpaths for nutrients and faecal microbes from agricultural land to surface water. These shallow flowpaths are often hotspots for contaminant delivery that bypass riparian or edge-of-field mitigations. Mapping the structural features that preferentially transport diffuse pollution from the land is a challenging but crucial step to guide precision mitigation, whereby farmers can target the right mitigation tools at the right locations for their farm environments to improve downstream water quality.

We trialled a 160 MHz Mala GroundExplorer ground penetrating radar (GPR) to image buried soil layer boundaries, farm water and drainage infrastructure, and other near-surface features that influence preferential contaminant transport on a 4-ha dairy paddock in the Toenepi catchment, Waikato. The paddock featured a gently undulating hillslope with well-drained, Kiwitahi silt loam which sloped to a flat stream valley with two surface drains over a very poorly-drained Topehaehae clay loam. The GPR antenna was towed along transects spaced at 10-m intervals parallel from the stream edge to the hilltop paddock boundary and also along 25-m intervals perpendicular to the stream. GPR data was processed in GPR-SLICE v7.MT and used to identify the locations and depths of subsurface tile drains, old surface drainage channels, coarse tree roots, and shallow groundwater springs to approximately 6 m. Results from this scoping study indicate GPR can be used to pinpoint near-surface structures and concentrated flowpaths that can be targeted for diffuse pollution mitigation on farms, even in water-logged and poorly drained soils.

USE OF REMOTE SENSING DATA FOR HYDROLOGICAL MODEL VALIDATION

Griffiths, J.A.,[1] Singh, S.K.,[1] Zammit, C.[1]
[1] NIWA, Christchurch

Remote sensing data have the potential to supply spatial and temporal data at an appropriate scale for application in catchment-scale hydrological models for water resource applications. By contrast many conventional data related to hydrological observation are represented by point measurement. Satellite data can therefore be used to improve the definition of soil and land cover at the watershed, by improving definition of infiltration, evapotranspiration and runoff coefficients. In this study, we highlight that most widely available remote sensing data that can improve hydrological modelling in New Zealand. To do this, a range of readily available satellite data sets were used to generate land surface hydrological variables for use in hydrological modelling (e.g. Sentinel and Landsat data, see Figure 1 and Figure 3). This study compared estimates of soil moisture made using the New Zealand Water Model (TopNet) and the Soil Moisture active Passive L3 product for surface and deep soil moisture (SMAP) in three different catchments (see Figure 2). Model based soil moisture dynamic matches well with SMAP data.



Tile: 59GLK	Tiles: 60HUB; 60HVB; 60GVA; 60GUA	Tile: 60HWC

Figure 1. Sentinel-coverage for NZWaM test catchments in Southland (Mataura), Horizons (Rangitikei) and Gisborne (Taruheru).

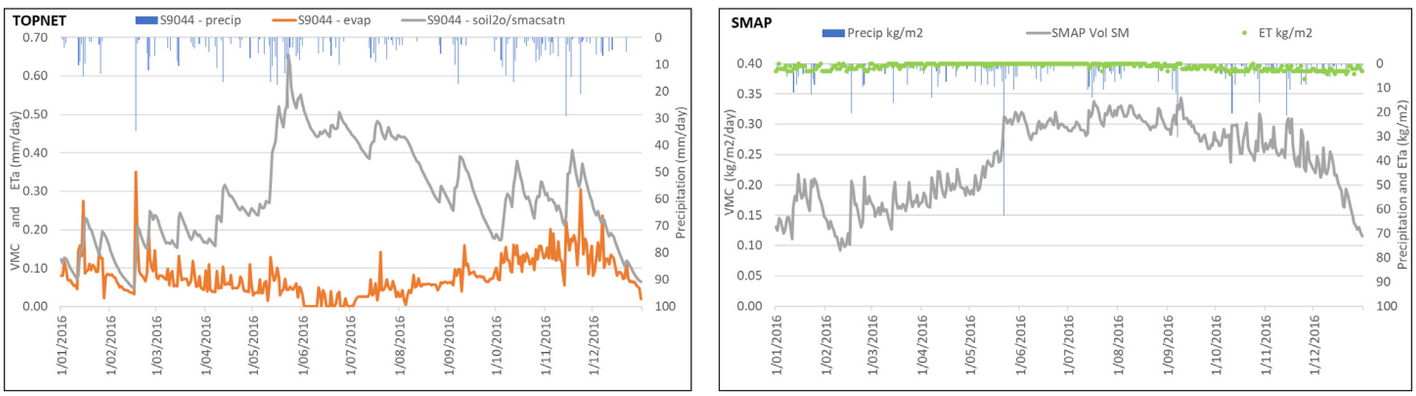


Figure 2. Precipitation, ET and soil moisture from TopNet (left) and SMAP (right); for Gore in the Mataura.

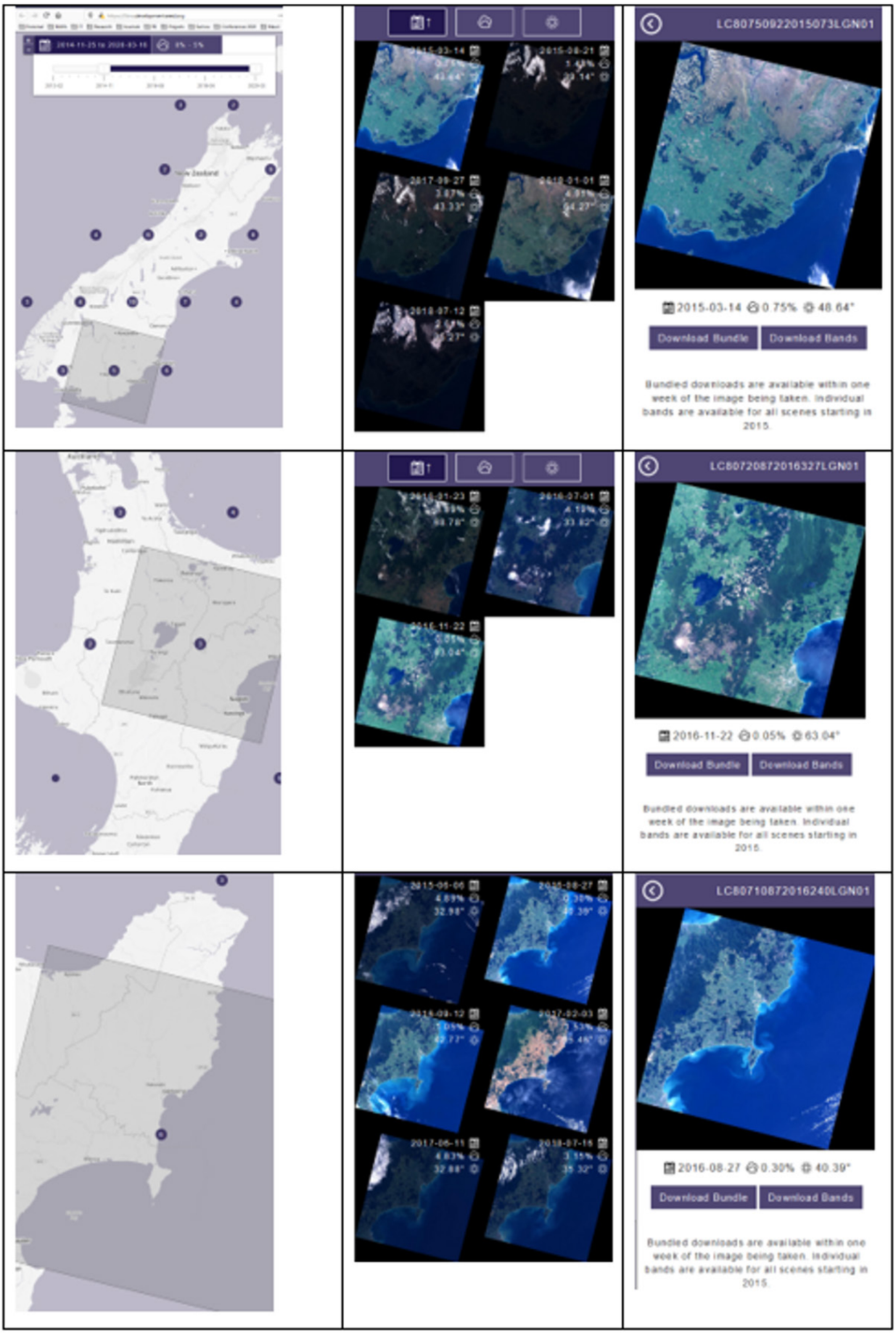


Figure 3. Landsat-coverage for NZWaM test catchments in Southland (Mataura), Horizons (Rangitikei) and Gisborne (Taruheru).

COUPLING OF THE TOPNET RECHARGE AND STREAMFLOW UNCERTAINTY INTO MODFLOW

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Aims

Groundwater model simulated outputs relating to stream-depletion, contaminant concentration in streams and water balances between management zones commonly support water and land resource management decision making. These simulated outputs can all be sensitive to model inputs of recharge and streamflow---two quantities that carry significant uncertainty. Effective use of models for decision support relating to these types of issues, therefore, relies on appropriate estimation of these inputs and definition of their uncertainties, both spatially and temporally. With appropriate definition of recharge and streamflow input uncertainty in groundwater simulations we can also generate a probabilistic description of the spatial and temporal distribution of surface water-to-groundwater (sw-gw) exchange. This can provide valuable feedback for surface water models especially for systems where groundwater contributions to surface water flow can be considerable, as is often the case for hydrological systems in New Zealand.

Method

The contribution of uncertainty in recharge and stream flow to groundwater model surface water-to-groundwater exchange simulated output uncertainty was explored using stochastic TOPNET realisations within a probabilistic groundwater model framework using a transient MODFLOW groundwater flow model for an example real-world catchment (Mid-Mataura, Southland, NZ). Twenty-five realisations of TOPNET simulated recharge and streamflow for the region were used in conjunction with 100 realisations that encapsulated the high-dimensional uncertainty in other MODFLOW model parameters (e.g. grid-scale hydraulic conductivity) to produce probabilistic outputs of sw-gw exchange. These are compared to simulated output distributions for alternative definitions of recharge and streamflow input (plus uncertainty); for example, the use of a single TOPNET realisation with empirically derived uncertainty bounds.

Results

By comparing the simulated output probability distributions for different recharge and streamflow paramterisation schemes the results provide insight into the value of defining and propagating the TOPNET-derived groundwater model input uncertainty to predictions of spatial and temporal stream flow (e.g. Figure 1) and sw-gw exchange. Additionally, topological aggregation of probabilistic sw-gw exchange derived through these methods can be used as a feedback to surface water models, providing a valuable expression of baseflow and its uncertainty.

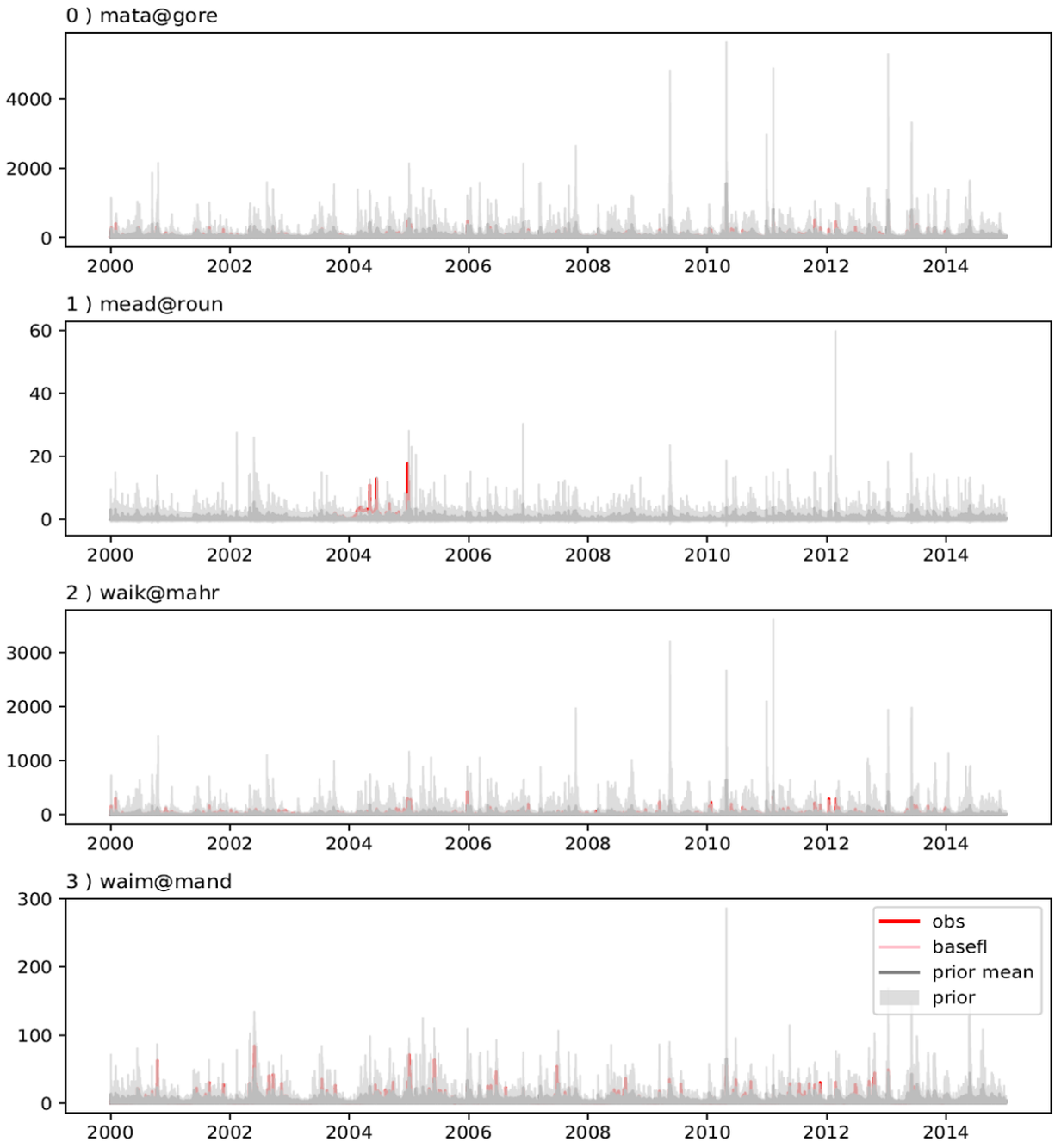

Figure 1. Example stochastic groundwater model streamflow simulated outputs at four locations within the Mid-Mataura model region.

EFFECTIVENESS OF ON-SITE SKETCHING AND ARCGIS MAPPING IN PRODUCING RIPARIAN AND WETLAND RESTORATION PLANS

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[1] Southern Institute of Technology
[2] Environment Southland

This research explores how to produce effective riparian and wetland restoration plans. It considers design and visual communication in seeking to produce plans that are environmentally effective and easy to understand. Through an in depth understanding of the literature and current best practice, a potential design strategy was unveiled. This led to the discovery of how design initiatives should move beyond uniform riparian buffer zones to also consider critical source areas, concentrated flow paths and convergence zones. These ideas were explored through the production of riparian and wetland restoration plans for farmers at three different sites in Southland. Two distinct methodologies were used to produce riparian and wetland restoration plans. The first methodology involved the use of on-site sketching in collaboration with farmers to produce plans on Adobe Illustrator. The second method involved the use of ESRI's ArcGIS employing a range of geographic factors that can help target key areas for riparian and wetland restoration. Strengths and weaknesses of each approach were established during the production of these plans. These were further verified in the form of ground truthing and interviews with the farmers. Each method had positives and negatives, from software cost and data resolution to the level of detail in each plan. It is recommended that a more integrated approach using the strengths of each method to inform each other is the optimum way forward to producing more effective riparian and wetland restoration plans.

DESIGNING MUSSEL RAFTS FOR FRESHWATER BIOREMEDIATION

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[1] National Institute of Water and Atmospheric Research
[2] Missouri State University
[3] Manaaki Whenua - Landcare
[4] AM2 & Associates
[5] Matahuru Marae
[6] Waikato Regional Council
[7] Department of Conservation

A large number of our shallow lakes are in a degraded state with turbid water, dominated by algal blooms and aquatic plants no longer have sufficient light to grow and stabilise the lake bed. There are several mechanisms that allow this ecological state to be resilient to rehabilitation efforts, for example, without plants wave action can resuspend sediments and release nutrients from the sediment pore water into the photic zone fueling phytoplanktonic production. Multiple restoration actions, including the removal of bottom-feeding pest fish, and reduction of nutrient inputs are required alongside the development of remediation tools to restore these degraded aquatic habitats. In high densities, freshwater mussels (*Echyridella menziesii*—also known as kāeo, kākahi or torewai) can markedly influence water quality, nutrient cycling, and biodiversity. Their natural filter-feeding capacity has the potential to clear large volumes of water, that could be harnessed to aid the bioremediation of freshwaters. This project investigates the use of kāeo on rafts in a degraded lake (Ohinewai) to support restoration of freshwaters alongside research in other key tasks (e.g., environmental tolerances, nutrient dynamics, modelling and eco-sourcing).

To date, proto-type rafts have been designed to support kāeo within the water column, enabling them to be lifted from the lake bed, where suitable habitat is limited The rafts were successfully installed in Lake Ohinewai in January 2020 and kāeo response has been monitored. This paper reports on the use of bioremediation rafts as a 'proof of concept' to support restoration of freshwaters.

SUSPENDED SEDIMENT IN GRANULAR DETAIL

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[1] University of Otago
[2] Landpro Limited

The shape and composition of suspended sediment strongly affects the side scattering of light in nephelometric turbidimeters. Side scattering of light in standard nephelometric turbidimeter techniques assumes coherency in particle shape and compositions, usually that particles are spheroid and optically consistent with quartz minerals. The inorganic composition of suspended particulate material is a function of catchment lithology and different minerals, like phyllosilicates, that have a different refractive light surface and preferentially weather to rods or elliptical disc shapes. These non-spheroid shapes and materials therefore scatter light differently and are a potential source of bias and noise in turbidity–suspended sediment ratings. We are interested in examining the mineralogy, particle size distribution, and particle shape of suspended sediment and what role this may play in noisy turbidity–suspended sediment ratings. Suspended sediment samples were collected from the Haast/Awarua River in spate and analysed for their nephelometric turbidity, suspended sediment concentration, particle size distribution, mineral composition (XRD, pXRF), and subsampled and examined under a scanning electron microscope with an EDS detector. Preliminary microscopy images revealed suspended sediment grains were highly angular and fractured and of a variety of different particle shapes, that potentially affects its optical properties when using nephelometric turbidity, and laser particle size determination. In particular, the phyllosilicates were irregularly shaped rods and occurred as smaller fragments compared to feldspathic minerals and quartz grains.

STIMULATION OF NITRATE REMOVAL IN GROUNDWATER

Houghton, K.[1]
[1] GNS Science

More than a third of New Zealand groundwater sites have high nitrate concentrations, and high nitrate can be toxic for humans, fish, and other animals. Bacteria remove nitrate from soil and water but different species convert it into either nitrogen, ammonia, or nitrous oxide. While nitrogen is harmless, high levels of ammonia can also be toxic, and nitrous oxide currently comprises 11% of our greenhouse gas emissions. We need to know how nitrate removal can be enhanced without triggering the growth of bacteria which produce harmful by-products.

Previous research has shown that adding stimulants can increase nitrate removal, for example, with ferrous iron treatment of wastewater, but only when certain species of bacteria are present. In this preliminary study, samples were taken from groundwater bores with a range of nitrate (0.2-19 mg/l) and oxygen (4 – 68 %) concentrations. The groundwater samples were cultured in the presence and absence of methane or molybdate to determine how microbial communities would respond. The relative abundance of bacterial genes necessary for the removal of nitrate (*narG*), as well as the production of nitrogen (complete denitrification) (*nosZ*), were monitored over time.

The results show that each groundwater microbial community responded differently to additives, and that increased removal of nitrate was not always followed by conversion to nitrogen. More work needs to be done to accurately establish cheap and practical additives to reduce nitrate in specific groundwater sites, without increasing the production of ammonia or nitrous oxide.

NGĀ TAONGA WAIMĀTAITAI KI MURIHIKU: CO-DEVELOPING APPROPRIATE MANA WHENUA APPROACHES TO IMPROVE ESTUARINE MAHINGA KAI MANAGEMENT

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[1] Ngāpuhi, Ngāti Kahu ki Whangaroa
[2] Te Kūwaha, NIWA
[3] Ngāi Tahu, Ngāti Mamoe, Waitaha
[4] Kitson Consulting Ltd
[5] Ngāti Whakaue, Ngāti Pikiao, Te Whanau a Apanui
[6] Ngāi Tahu ki Murihiku, Te Rūnaka o Ōraka-Aparima

Globally, estuaries are one of the most anthropogenically impacted aquatic systems with increasing observations of degradation throughout Aotearoa-NZ, including Murihiku (Southland). Estuaries have special significance to Ngāi Tahu as their identity is inextricably linked to these locations. However, the current state of Murihiku estuaries are unable to support Ngāi Tahu cultural values, uses and associations with these environs. For example, Aparima (Jacobs River) and Koreti (New River) Estuaries, once renown for mahinga kai are now deemed "unsuitable for swimming", potentially posing health risks and undermining the values and practices of Murihiku whānau .

There is a need for estuarine-specific research and the development of culturally appropriate methodologies to monitor the state and pressures on cultural values and uses associated with estuaries, e.g., mahinga kai.This project represents a proactive approach to co-develop best practices and inform estuarine decision-making, such as the current freshwater limit setting process. Murihiku is unique in that estuaries are part of the Freshwater Management Units (FMU), rather than being designated within the coastal zone, as done in many parts of Aotearoa-NZ (DOC 2010, MfE 2017).

We draw from mātauranga Māori and science to identify indicators to measure the current state of estuarine mahinga kai to strengthen the input of Murihiku whānau and rūnaka into decision-making processes. The field work included additional collaboration with Environment Southland to set-up new monitoring sites to better understand the impacts of sedimentation on mahinga kai gathering sites.

References

(Environment Southland 2016)

(Te Rūnanga o Ngāi Tahu 2017)

Referring to the species that have traditionally been used as food, tools, medicine, or other resources, including the act of harvesting/ practice/use of those resources and the places they are gathered.

https://www.lawa.org.nz/

PUMPED STORAGE POTENTIAL OF THE UPPER NGARURORO RIVER

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[1] University of Waikato

On July 26, Energy & Resources Minister Megan Woods announced a $30 million business case review of pumped storage in New Zealand, with particular reference to the Onslow Scheme. (Bardsley, 2005). The business case review is also likely to overview Ngarururoro pumped storage, which appears to be the largest achievable energy-based pumped storage in the North Island (2.7 TWh). The energy storage is achieved by an upper reservoir behind a new high dam (120 metres) in the upper Ngarururoro River, just downstream from the confluence of the Panoko Stream. To achieve maximum storage capacity, the lake would allow dry year drawdown from a maximum water level of 1040 metres, to a minimum level of 1000 metres. Some low embankment dams would be required at some saddle points on the eastern side of the new lake. The lake surface area would range between 32 and 18 km^2, depending on level.

The scheme would operate by a 30 km tunnel linked to Lake Taupo (twice as long as Onslow). The turbine operating head would be similar to Onslow but energy stored per unit volume of upper reservoir is greater than Onslow, because the gravitational potential energy is linked to the base of the Karapiro dam – the final hydro dam on the Waikato River.

There is likelihood of greater environmental impact than Onslow, with some of the new lake extending into the Kaimanawa and Kaweka forest parks. There would also be loss of some iconic landform and ecological features, as described in Singers (2015). However, the scheme has the advantage of being located in the North Island, nearer major power use. The new lake might also have the possibility of a Hawke's Bay water supply role. This could include increasing summer low flows in the Ngarururoro River, or even constructing an extended domestic water supply pipeline to Napier and Hastings by gravity flow.

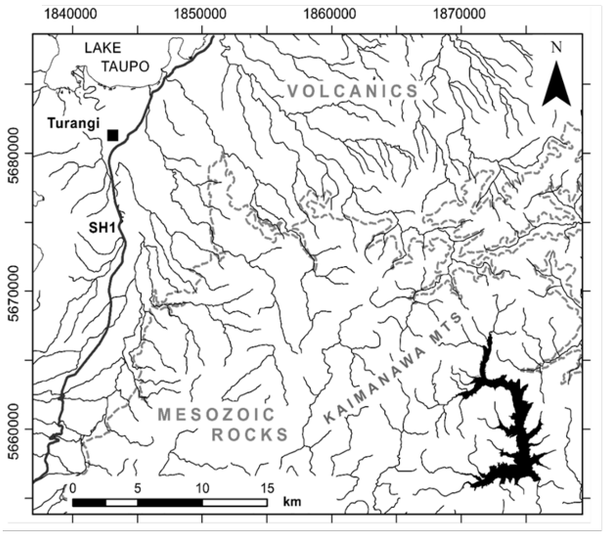

Figure 1. Location of upper reservoir (lower right).

Figure 2. Lake water level in part of the upper Ngarururoro River.

The dashed line in Figure 1 is the southern boundary of the Taupo volcanic units, with the Mesozoic greywackes. The tunnel to Taupo would be mostly through greywacke. The dashed line in Figure 2 shows the approximate position of the minimum lake level (1000 metres), looking down the Panoko Stream valley (Gold Creek).

Reference

Singers, N. 2015. *Ecological Survey and Assessment Natural Values of Owhaoko A1B and A East Blocks, Kaimanawa Ranges.* NSES Ltd report number 40: 2014/15.

INVESTIGATING TECHNOLOGIC ADVANCES IN WATER SAMPLING

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[1] Southern Institute of Technology
[2] Environment Southland

Water quality monitoring on a regular basis is an important part of managing New Zealand's waterways and gauging changes in the aquatic environment. Traditional methods of taking samples from boats or canoes can be expensive, labour intensive and have health and safety risks. Advancements in drone technology have made it possible to sample bodies of water via a drone platform in areas where boats or personnel are unable to access. Large expensive boats with a licenced skipper where people lean over the side to take samples will no longer be needed and labour costs with a drone can be reduced to as little as one or two operators who stand on the shore. Before drones can be used as water sampling devices it is critical to assess their effectiveness in collecting samples without affecting the quality of data collected. This research investigated the production and modification of a novel, low cost, open source Niskin bottle (device that can be attached to a drone), to assess its effectiveness in collecting water samples compared to traditional methods of a Van Dorn. The water samples were taken from several locations using the created device and traditional method, with samples tested in the lab and graphed to compare for significant differences and similarities. The findings of this research show that the quality of water samples collected using the novel drone device was not significantly different from that of samples collected using traditional sampling techniques. The study also demonstrates that low-cost water sampling devices can be constructed using off the shelf parts and electronics.

STRATEGIES FOR SUSTAINABLE WATER MANAGEMENT IN CANTERBURY: AN APPLICATION OF THE FOOD-ENERGY-WATER NEXUS FOR THE RANGITATA RIVER BASIN

Mangoro, D.,[1] Pahlow, M.,[2] Singh, S.K.,[3] Ratna, N.[1]
[1] Lincoln University
[2] University of Canterbury
[3] NIWA

The unique values of the Rangitata River led to its legislative protection under the Water Conservation Order of 2006, which sets the flow management regime. At present the water is fully or nearly fully allocated in the minimum-to-flood flow band. Meanwhile irrigators face supply reliability challenges particularly in the low flow seasons, avid kayakers and rafters perceive a decline in respective recreational values, fishermen report increasingly less favourable flows and riparian dwellers notice a change in sediment distribution. The principal abstractor of water is the irrigation sector with the Rangitata Diversion Race Management Limited (RDRML) delivering water to three irrigation schemes, two hydropower stations and stockwater races reducing mean monthly flows. Both irrigated area expansion and production intensification have and continue to increase demand for water over the years.

This investigation aims to inform sustainable management of the Rangitata River by adopting a collaborative and community-led approach for decision-making. We address two research questions: One, whether the RDRML can sustainably divert less water from the Rangitata River, while satisfying user demand particularly during high demand and low flow periods; and two, to quantify the extent to which the RDR shareholders need to adapt their water demand and minimize trade-offs under climate change. To answer this question a Water Evaluation and Planning (WEAP) model is developed to simulate the Rangitata River flow regime and associated water demands. Potential future scenarios will be developed via the participatory Risk and Options Assessment for Decision-making (ROAD) framework. Scenario simulations will be carried out to develop risk-based mitigation strategies to enhance resilience of irrigators in mid-Canterbury, to improve reliability of supply by RDRML without abstracting more water, and to inform policy coordination in the food-energy-water nexus in the Rangitata River basin.

FRESHWATER PESTS - A HIDDEN THREAT OF EXTREME EVENTS

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[1] Department of Conservation, Christchurch

Extreme events are predominantly managed for humans and sometimes threatened species, but rarely for pest species. Floods, in particular, can provide opportunities for pest fish and pest plants to further disperse. As part of the 2018 budget funding the Department of Conservation is growing its capacity in freshwater biosecurity and is looking at ways to improve surveillance and control of freshwater pests.

How can knowledge of flood events and flow-paths help us manage the threat that freshwater pests pose to our native biodiversity? To manage the threat of pests we need to know where the pests are and where they might be, and part of this is knowing where floodwaters have been and where floods may travel to. Historic, including anecdotal, information of flood pathways, old river courses and wetlands, could be used to predict floodwater movements and help target surveillance efforts after a flood event. This could also be used to help prioritise control efforts, eg. sites with pests and low biodiversity values could be prioritised for pest removal if they are at high risk of flooding and releasing pests to other sites. Also, this information could help inform the design of floodways during developments and the use of protective measures in waterbodies/waterways with high biodiversity values, eg. structures such as screens, cordons or diversions, could be installed at sites so that if floodwaters reach such areas the pests are prevented or contained.

USING SIMPLIFIED RIVER CATCHMENT MAPS TO DIRECT FUTURE RESTORATION EFFORTS

Meijer, C.G.,[1] Devlin, H.S.,[1] Harding, J.S.[1]
[1] University of Canterbury

Restoration projects in freshwaters are becoming increasingly important as these ecosystems are faced with increasing threats and greater future uncertainty. However, many restorative projects have had limited success, with failures due to ineffective or inappropriate tools and little or no response from aquatic biota. The Canterbury Waterway Rehabilitation Experiment (CAREX) has focused on collecting pre-restoration information and trailing a toolbox of targeted restoration approaches in agricultural streams. As part of our recent work in the Ararira/L II River catchment near Christchurch, New Zealand, we developed simplified maps of water quality, instream habitat, sources of contaminants, and fish communities across the catchment. These maps provide an easy visual example of stressors and issues that are a powerful tool to inform landowners and general practitioners. A review of these maps indicated that the westernmost sub-catchment has multiple water quality and instream habitat issues, but also high ecological values driven by a relatively diverse fish community. Consequently, we suggest that restorative efforts in these waterways should be prioritised over other areas in this catchment due to the greater potential for realised improvement. Moreover, we posit that this approach of collecting pre-restoration information on the affected freshwaters would likely see improvements made in our capacity to restore these aquatic ecosystems.

N-WISE IRRIGATION – FIELD TESTING

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[1] Aqualinc Research
[2] Grounded

N-loss to water from the majority of NZ's irrigated area must be reduced to meet water quality criteria. The reductions required are being given legal standing through the RMA Regional Planning process that Regional Councils implement and, in some regions, land-use consents.

There are multiple ways in which a farm's N-loss to water can be reduced, one of which is improving irrigation practices to reduce the risk of drainage.

A recent desk-top pilot study provided 'proof of concept' that radically changing irrigation management strategies on case-study dairy farms in Canterbury would, on average, achieve a 27% reduction in N-loss to water. The irrigation management strategy developed in this study balances the risk of pasture production loss against the risk of N-loss to water. This we refer to as "N-Wise" irrigation.

The performance of N-Wise irrigation strategies, as N-loss mitigation options, has not been field-tested. To-date it has only been assessed using computer simulation studies.

This paper will describe the design of the field experiment being conducted to test the hypothesis ***that N-Wise Irrigation strategies significantly reduce the risk of N-loss to water without significantly raising production loss risks, even when water supplies are unreliable,*** the monitoring system, and present some initial data.

ECOLOGICAL HEALTH OF RIVERS AND STREAM IN THE WELLINGTON REGION

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Over the last four years (2016-2019) GWRC has been trialling a new monitoring programme which differs from its existing programmes in that it: involves more ecologically focussed indicators; uses a new monitoring network design based on randomly selected sites with a known probability of occurrence (ie, a "probabilistic network design"); and will enable extent estimates of ecological health for mapped rivers and streams on developed land.

The purpose of this study was to compare data against the numerical and narrative aquatic ecosystem health objectives in GWRC's Proposed Natural Resources Plan (PNRP). This new monitoring approach involves undertaking assessments of periphyton and macrophyte cover, macroinvertebrate and fish communities, and aspects of aquatic habitat quality, at 48 sites that were randomly selected and located on permanently flowing streams and rivers on developed land (ie, <100% indigenous forest cover in the upstream catchment).

The potential impacts/issues associated with periphyton and macrophyte cover on river and stream health in the Wellington Region are estimated to be relatively minor; with most river and stream reaches on developed land estimated to be compliant with objectives in GWRC's PNRP (78.1 and 70.8% of river length compliant, respectively). In contrast, the majority of river and stream length on developed land is estimated to be non-compliant with the objectives stated in the PNRP for healthy macroinvertebrate and fish communities (75.3 and 64.8% of river length non-compliant, respectively).

The application of a probabilistic network design and the analyses mean that unbiased estimates of the state of aquatic ecological health in rivers and streams in the Wellington Region can be presented for the first time.

PRIORITISING AREAS FOR RIPARIAN MANAGEMENT WITHIN THE TE AWARUA-O-PORIRUA HARBOUR AREA.

Mulling, B.T.M.,[1] Clarke, N.,[2] Wright, Jo.,[1] Prujean, A.,[1] van Meeuwen-Dijkgraaf, A.[1]
[1] Cardno NZ Ltd.
[2] Porirua City Council

Porirua City Council (PCC) governs the catchments surrounding the Te Awarua-o-Porirua Harbour which provide a multitude of social, economic, cultural and ecosystem services. Since the 1950s the Te Awarua-o-Porirua Harbour and associated waterways have experienced significant anthropological pressures including land reclamation, urban development, intensification of land use and increased influx of contaminates like nutrients and fine sediments. This has resulted in significant and ongoing environmental and ecological degradation of Te Awarua-o-Porirua Harbour. To slow or reverse further deterioration and restore the mana of the Te Awarua-o-Porirua Harbour, it is imperative that the influx of fine sediment and nitrogen originating from the surrounding catchments is reduced by improved riparian management.

Te Awarua-o-Porirua Harbour catchment is approximately 192 km^2 and is the receiving waterbody for over 500km of streams within six main stream/creek catchments. The extensive size of the area demanded an innovative, holistic and systematic approach to determine where management should occur, which areas should be prioritised and how much funding is required for implementation.

An extensive geospatial analysis was undertaken to establish area risk scores related to erosion and nitrogen leaching using publicly available data sources including information on terrain slope, land use, land cover and potential vegetation cover. Appropriate management strategies were based on reach specific characteristics. Costing associated with different management strategies were estimated and combined with the risk score to undertake a cost/benefit analysis which allowed for prioritisation of riparian management areas to achieve optimal long-term results.

The process resulted in prioritisation maps that can be used for public consultation, and costing specific enough to be used in district long term planning. The developed approach is not specific to the Porirua district and can be applied elsewhere to support development of catchment, district or region wide riparian management plans.

1D VERTICAL SCALING OF S-MAP-HYDRO USING RICHARDS EQUATION FOR LAYERED SOILS

Pollacco, J.A.P.,[1] Fernández-Gálvez, J.,[2] Christian, Z.,[3] Rajanayaka, C.[3]
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[3] National Institute of Water and Atmospheric Research, Christchurch, New Zealand

Aims

For areas covered by S-map, the Kosugi (1994; 1996) hydraulic parameters describe the soil *water release characteristic θ(h)* (which is the relationship between *soil moisture θ* [L^3 L^{-3}] and *pressure h* [L]), and *unsaturated hydraulic conductivity K(θ)* (the relationship between *θ* and unsaturated hydraulic conductivity *K*). These functions are available at a spatial resolution of 150 m x 150 m and are discretised at the following 14 depths: 2.5, 5, 10, 15, 20, 25, 30, 40, 50, 60, 70, 80, 90, 100 cm. This high-resolution soil property database is known as **S-map-Hydro.**

Different hydrological models are currently used in New Zealand that require soil hydrological characterisation at a coarser vertical resolution than that provided by **S-map-Hydro** (e.g. 1, 2, 3 layers). This usually requires upscaling the hydraulic parameters so that they can be used within those models. Upscaling is defined by Vereecken et al. (2007) as the process that replaces a heterogeneous domain with a homogeneous domain in such a manner that both domains produce a similar hydrological response (*groundwater recharge, evapotranspiration, surface and root zone soil water contents, etc.*) under certain upscaled boundary conditions. Implementing scaling methods in New Zealand is particularly challenging because its soils have high variability of hydraulic parameters over short distances.

The objective of the study is the development of scaling techniques such that the 14 layers in **S-map-Hydro** are down-scaled into fewer layers. Another useful outcome of this study is that the developed algorithm can optimise the hydraulic parameters by matching times series of *θ* from probes installed at various depths in the soil profile.

Method

In this case study we assume that the *θ* time series profiles obtained from the soil moisture probes at different depths are similar to **Smap-Hydro.** The use of Kosugi hydraulic characteristics (Pollacco *et al.,* 2013) requires the estimation of 5 soil parameters for each layer of soil. Previous attempt to optimize the soil parameters layer per layer in highly heterogenous soils has been unsuccessful in representing the overall water movement through the soil profile (Pollacco 2005). Therefore, we are presenting a new optimization algorithm overcoming this issue.

When optimising the profile soil hydraulic parameters, initially the soil profile will be considered as homogeneous. Then a step-wise grouping of local layers (zones defined by the end user) allows addressing heterogeneous patterns. The optimisation of the different layers in a specified order and pattern is presented in Table 1, where 0 or 1 indicate which soil layer is calibrated at each specific step. In this example, the soil profile is divided into five layers and grouping is indicated by the index value of 1. For example, cells containing the number 1 in Table 1 show the grouping of different layers (zones) in which the soil hydraulic parameters have the same optimal value (homogeneous layer).

In the first step (*Opt_1*), all layers have the same optimal parameters. The derived effective optimal hydraulic parameters will be used for hydrological models requiring only one homogeneous layer such as TopNet. In the second step (*Opt_2*), (*optimal hydraulic parameters for models requiring two layers*), only the upper half of the profile is optimised, maintaining the bottom half (below the root zone) with the value of optimised parameters derived from the previous step, and then the third step (*Opt_3*) (*optimal hydraulic parameters for models requiring three layers etc…*) operates on the deeper zone, keeping the upper half of the profile with the previously optimised parameters. It was found that optimising from top to bottom produces better results than bottom to top, as water percolates downwards, and so a change of the hydraulic parameters of the top layer would affect the lower layer. Each zone of the profile is successively split into two zones from top to bottom, and the optimisation is repeated by copying the values of the optimal parameters from the previous optimisation step.

The improvement of the fit between observed and simulated *θ* with increasing splitting (layers) would depend on the heterogeneity of the soil layers. We illustrate the methodology by using some sites in Waikato, where we have time series data of *θ* measured at different depths.

Table 1: The vertical multi-step optimisation method is described, whereby the order in which the optimisation is performed for the different groups of layers is presented for five measurement depths. The root zone is set at 600 mm. The parameters that correspond to 0 are the cells that keep the values they had in the previous step.

	Layers	Opt_1	Opt_2	Opt_3	Opt_4	Opt_5	Opt_6	0pt_7	Opt_8	Opt_9
0-175	**1**	1	1	0	1	0	0	0	0	0
175-450	**2**	1	1	0	0	1	1	0	0	0
450-600	**3**	1	1	0	0	1	0	1	0	0
600-850	**4**	1	0	1	0	0	0	0	1	0
800-1200	**5**	1	0	1	0	0	0	0	0	1

Results

The multi-step optimisation is described in Table 1 above. For the four different sites in the Waikato region we will present the improvement made in using models with more than one layer. We will also show that the maximal number of splits (layers) to achieve the desired accuracy in the profile depends on the severity of the heterogeneity in the soil profile.

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SPATIAL AND TEMPORAL ANALYSIS OF THE BASEFLOW INDEX AT NATIONAL SCALE IN NEW ZEALAND

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[1] University of Cant erbury
[2] NIWA

Streamflow is typically divided into two components for hydrograph separation, quickflow and baseflow. Baseflow is the portion of streamflow that contains groundwater flow and flow from other delayed sources and is of key importance for river basin ecology and water resources planning and management. The baseflow Index (BFI) is defined as the ratio of long-term mean baseflow to total streamflow. The BFI indicates dominant flow pathways in a given catchment. Improved understanding of the spatial and temporal trends of BFI can inform planning of water allocation decision making.
The aim of this study is to provide a comprehensive assessment of the spatial and temporal trends of the baseflow contribution to rivers across New Zealand. In previous work the BFI was determined for 482 gauged sites across New Zealand. BFI was found to vary between 0.20 to 0.96, with an average of 0.53, which indicates that 53% of long-term streamflow in New Zealand is likely to originate from groundwater discharge and other delayed sources. The focus of the current study is to identify how physical characteristic of river datasets can be used to quantify spatial and temporal variations in the BFI. The Mann-Kendall statistical test was used to identify trends. First results indicate that 10% of rivers show a decreasing trend, 27% show an increasing trend and 63% show no significant trend. In this talk we will explore the likely drivers for trends in BFI such as changes in climate, landcover and abstraction practices. Results of an in-depth analysis of the spatial correlation of catchment characteristics and BFI will be presented. Knowledge regarding the spatially differentiated baseflow contribution and its trend over time can support water resources allocation decision making within a given region and can furthermore be considered in future water resources scheme appraisals.

EUTROPHICATION EFFECTS ON STREAM MACROPHYTES

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Interactions between nutrient status and -plant performance in streams have been of interests for researchers for several decades, however, much remains to be investigated. Previous studies have shown that increases in nutrient availability (i.e. eutrophication) can give competitive advantages to plants that favour light gathering traits and to epiphytic biomass. Furthermore, this can lead to dominance of invasive species as they are often good competitors. Prevailing research gaps pertain especially to thresholds of when effects of eutrophication start to occur as well as the interaction of eutrophication and light effects.

In my PhD project I aim to investigate the effect of changing nutrient concentrations on the macrophytes inhabiting lotic ecosystems. By a field survey of open lowland streams in New Zealand, I aim to quantify the effect of water column and sediment nutrients on abundance and composition of aquatic macrophytes on a reach scale. In addition, using a novel experimental setup in stream mesocosms, I will perform two growth experiments, One experiment will investigate the responses (growth rate, morphology, performance) of two native New Zealand macrophytes (*Potamogeton ochreatus, Myriophyllum propinquum*) and two exotic (*P. crispus, M. variifolium*) under different nutrient levels in combination with various levels of shading. The other experiment aims to determine the competitive outcome of *Potamogeton crispus* and *P. ochreatus* grown at different nutrient and shade levels. In my poster I will show preliminary results of the field survey and the first experiment.

FRESHWATER FISH MONITORING IN THE WAIKATO – DRY SEASONS AND WET SEASONS

Smith, J.P.,[1] David, B.O.[1]
[1] Waikato Regional Council

For the past 12 years the Waikato Regional Council has conducted State of the Environment (SOE) monitoring of freshwater fish within its region. This consists of 180 random sites sampled over three years and 12 reference sites sampled annually. One of the main objectives of the sampling is that the methods are a robust and repeatable means for sampling fish communities in wade-able New Zealand streams. Year to year these sites can differ depending on environmental conditions prevalent at the time of sampling. Dry and wet sampling seasons pose issues in terms of consistent and comparable data and with on-going climate change we look at how we manage these effects now and into the future.

TOOLS FOR OPERATIONAL AND STRATEGIC MANAGEMENT OF IRRIGATION IN DAIRY FARMS

Srinivasan, M.S.,[1] Elley, G.,[1] Measures, R.,[1] Muller, C.,[2] Neal, M.,[3] Rajanayaka, C.,[1] Shankar, U.,[1] Kinsman, M.,[1] Srinivasan, R.,[1] Fear, A.,[1] Carey-Smith, T.[1]
1 National Institute of Water and Atmospheric Research
2 Perrin Ag Consultants
3 DairyNZ

As a part of Irrigation Insight MBIE Endeavour programme, we have developed operational and strategic irrigation management tools for dairy farms. The aim of the programme and the tools that were developed is to achieve a 'sweet-spot' between *efficiency* ("maximising the retention of irrigation in the rootzone and minimising drainage and runoff losses"), *economics* ("maintaining optimal soil moisture conditions within the rootzone for maximum pasture growth") and *effectiveness* ("timing the irrigation by considering current demand, and current and forecast supplies"). The operational tool, IrriMate, combines on-farm measurements of soil moisture, irrigation and rainfall with current (e.g. river flows) and forecast irrigation supplies (6-day rainfall forecast) to forecast soil moisture conditions. The insight soil moisture plot, a component of IrriMate, helps farmers to visually understand the movement of water, and thus, potentially nutrients, within and below rootzone. The irrigation strategy tool, HydroEcon, allows farmers to assess their current irrigation capabilities and capacities to practice more efficient, economical and effective irrigation scheduling methods. The strategy tool is designed to be farm specific. It accounts for long-term climate data for the farm location, soil-water holding capacity, on-farm irrigation infrastructure (irrigator type and capacity), use of weather forecast to schedule irrigation and irrigation supply reliability, and compares demand and supply-based irrigation practices for their efficiency, economics and effectiveness. The presentation will include examples based on the IrriMate and HydroEcon tools.

RECENT DEVELOPMENTS IN EXCESS NITROGEN ANALYSIS

van der Raaij, R., [1] Morgenstern U., [1] Rogers, K., [1] Cantwell, R. [1]
[1] GNS Science

Denitrification is a natural process that is mediated by the metabolism of microorganisms where dissolved nitrate is eventually reduced to environmentally inert nitrogen gas (Chapelle 1993). Denitrifying bacteria are mostly anaerobes, that generally respire oxygen but can switch to anaerobic respiration after oxygen depletion.

$NO3 \rightarrow NO2 \rightarrow NO(g) \rightarrow N2O(g) \rightarrow N2(g)$ Equation 1

Nitrate attenuation factors which quantify denitrification and other nitrate removal processes are thus an important consideration in water resource management within New Zealand, namely setting nitrogen load limits for hydrological catchments. To understand the quantitative effect of denitrification on catchment-scale N budgets, information on the redox status of groundwater systems needs to be reconciled with denitrification data to confirm actual denitrification. Measurement of 'excess N2', the product of the denitrification reaction (N2(g) in Equation 1), is a promising method for assessing the amount of nitrate that has undergone denitrification in an aquifer under natural conditions.

To differentiate between atmospheric N2 and (denitrified) excess N2, many studies have related the measured N2 concentration to that of the noble gas argon (Ar). However, this method has high uncertainty due to the need to estimate one of the critical groundwater recharge parameters, recharge temperature or excess air. Reliable separation of atmospheric N2 and excess N2 from microbial denitrification requires measurement of at least two noble gases, usually argon and neon, to constrain both of these recharge parameters.

In recent years we have developed an analytical method for the simultaneous measurement of Ne, Ar and N2. Although the current method has only analysed a small number of samples, the results have shown that the excess N2 method via Ar/Ne/N2 can detect denitrification and quantify the amount of nitrate that has undergone denitrification, even at sites with mixed redox states.

We are currently developing a higher throughput / better sensitivity analytical capability to measure noble gases and excess N2 in groundwater, including research into improved sampling techniques. This presentation will provide an update on the current developments.

THE NEW ZEALAND WATER MODEL ISOTOPIC DATA LAYERS

van der Raaij, R., [1] Dudley, B., [2] Westerhoff, R., [1]
[1] GNS Science
[2] NIWA

The New Zealand Water Model Hydrology Project (NZWaM-Hydro) aims to develop hydrological understanding across the New Zealand landscape with a combination of data on surface water, soil, subsurface (geology), and groundwater. As part of this project GNS and NIWA are collecting tritium and stable isotope data from three test catchments in the Southland, Horizons, and Gisborne regions. The work aims to refine isotopic data layers to make them applicable for studies that estimate groundwater – surface water interaction at the catchment-scale.

Sampling objectives are to capture seasonal and geographical variations in 1) stable isotope compositions (rainfall and river sites) to inform catchment transit times to surface waters; 2) tritium input to groundwater (river and groundwater tritium samples) to acquire data for use as a calibration target for the water age modelling. Collection of both stable isotope and tritium data will enable the model to link relatively young and old water components

Data collection is ongoing. For two of the three catchments, we have collected over two years of data (Figure 1). This data will be made available via an open access online spreadsheet. This poster will describe the sampling programme in the three case studies, with an overview of acquired samples so far.

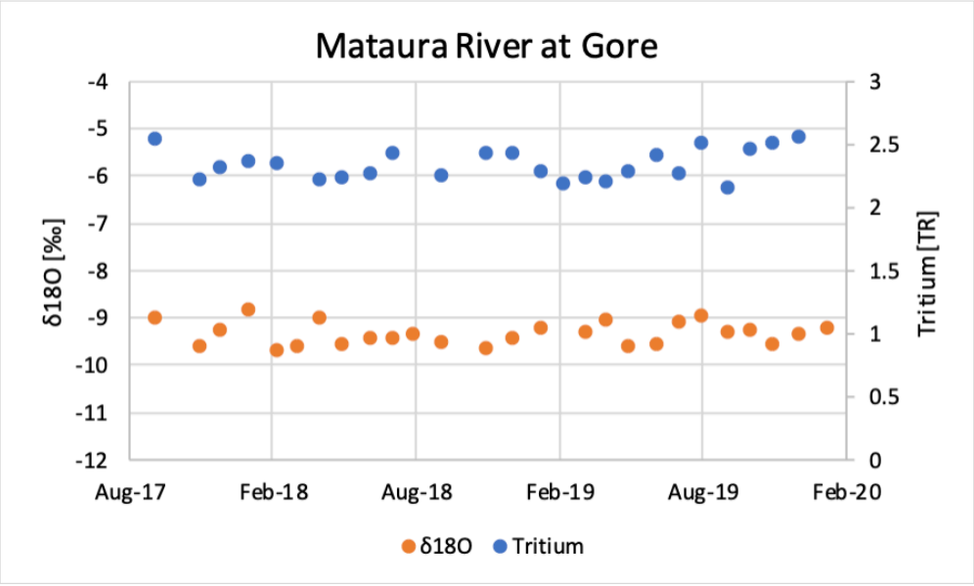

Figure 1 Stable isotope and tritium data from the Mataura River

A GEOSPATIAL MULTIPLE REGRESSION HYDROLOGICAL MODEL FOR WATER LICENSING DECISIONS IN BRITISH COLUMBIA, CANADA.

Sentlinger, G.,[1]
[1]Fathom Scientific

Working with the BC Provincial government, First Nations, and the Oil & Gas Commission, we have developed hydrological statistics (hydro-stats) and water allocation estimates that capture the most sensitive times and conditions for making water related resource decisions. In this study, we generate the necessary geospatial variables for all 4618 FreshWater Atlas (FWA) assessment polygons in the study area (220,132 km²), and generate 27 hydro-stats for all 4618 sites. Beyond the Mean Annual Discharge (MAD) and Mean Monthly Discharge (MMD), we also developed models for the Summer (Jun-Sep) 7 day average Q with a 10 year return period as a fraction of MAD (S-7Q10/MAD), the Annual 7-Q10/MAD (A-7Q10/MAD) and the A-30Q10, along with Monthly Q10/MAD (MmmQ10/MAD) for each month. We then combine water availability and allocation data and make observations such as:

- The low-flow period occurs in winter in 84% of the catchments, summer in 3%, and could occur in winter or summer in 13%.
- From a drought management perspective, an important finding is that 18.8% of the 1074 catchments (with a water license) have more than 100% of their A- 30Q10 allocated without EFN protection.

We understand that Allocation and Water Management decisions are multi-layered, sophisticated, and ever-changing requiring water managers to balance stakeholder interests, human resources, and environmental stewardship. There is always more that we can do, and deciding the most effective way to manage our shared resources is the purpose of this study.

AN INTER-COMPARISON OF FOUR GROUNDWATER MODELS AND MODULES IN THE MATAURA CATCHMENT, NEW ZEALAND.

Westerhoff, R.,[1] Taves, M.,[1] Hemmings, B.,[1] Zammit, C.,[2] Griffiths, J.,[2] Yang, J.[2]
[1] GNS Science, New Zealand
[2] NIWA, New Zealand

Aims

Most of New Zealand's surface water originates from groundwater (e.g. Singh et al. 2019). Therefore, characterisation of groundwater aquifers and the coupling of groundwater to surface water, should be the highest priority for any quantitative surface water research. The New Zealand Water Model Project (NZWaM) aims to develop hydrological understanding across the New Zealand landscape with a combination of data on surface water, soil, subsurface (geology), and groundwater.

Given the NZWaM is developed across different institutes, there is a significant risk that differences in underlying model algorithms cause an unknown inconsistency in the estimation of groundwater properties, such as water table or identification and quantification of gaining streams (groundwater discharge to surface). Differences are mostly caused by different modelling tools and methods and input components in different organisations.

The aims of this research are to compare the outputs of the different model algorithms in an inter-model comparison between water table (hydraulic head), losing and gaining stream identification, and input components of four models/ modules with groundwater output.

Method

An inter-comparison study was developed in the Mid-Mataura catchment, New Zealand. The components used in the comparison were: water table, identification of losing and gaining streams; numbers of layers and depth of layers used in the models; hydraulic conductivity/ transmissivity; and the input of recharge used in the models. Four groundwater models/modules were used: [1] MODFLOW; [2] an Equilibrium Water Table (EWT) application for New Zealand (Westerhoff et al., 2019); [3] TopNet-GW and [4] a losing and gaining stream statistical identifier by Yang et al (2019).

Beyond output datasets, the comparison also involved relative merits and possible drawbacks of each method (e.g. simulation time).

Results

The water tables (hydraulic head) of the EWT and MODFLOW models correlate well (Fig. 1). Differences are local and are most likely caused by the differences in model parametrisation of individual models, e.g., a one-layer approach in EWT with conductivity as a function of slope and depth vs. a multi-layer discrete vertical layer model in MODFLOW.

Simulations for EWT are quicker than for MODFLOW, i.e. for the research area on a desktop PC approximately 5 and 30 minutes, respectively. Also, set up times for EWT are quicker than for MODFLOW, i.e., 1 hour and several weeks, respectively. However, EWT results are limited by their simplicity, because they only provide water table and groundwater discharge to surface and there is no good capability for incorporating complex vertical geology and calibration: features that MODFLOW facilitates better.

Significant differences between the estimates and locations of losing and gaining reaches are found, which point out that more research is still needed to better develop joint and consistent groundwater and surface water datasets at the nationwide scale, e.g. in TopNet (Fig. 2) This was already pointed by earlier studies (Westerhoff et al., 2019), who further addressed the ongoing need for additional observations in local studies where the effects of complex hydrogeology can be better explored.

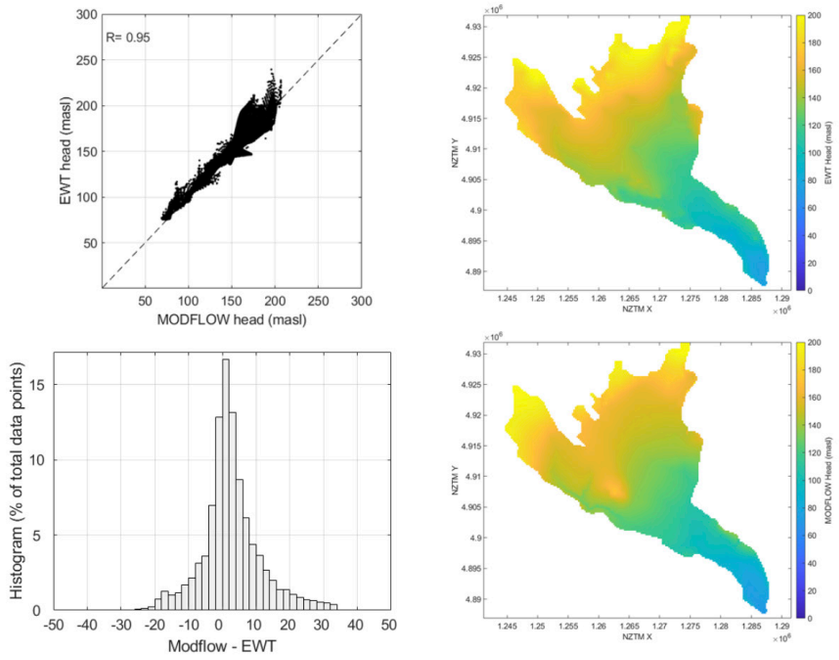

Figure 1: Hydraulic head comparison in the Mid-Mataura between the EWT model and MODFLOW models

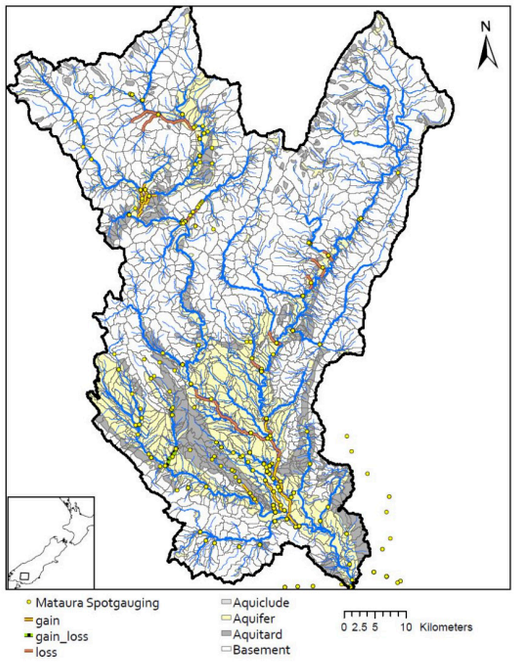

Figure 2: Example TopNet representation of surface water and groundwater attributes in the Mataura

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CHANGING LIGHTSCAPES: NIGHT SKY VISIBILITY UNDER DIFFERENT STREETLIGHTING SCENARIOS

Whitehead, AL.,[1] Bennie, J,[2] Greenwood, MJ.,[1] Hogsden, KL.[1]
[1] NIWA
[2] University of Exeter

Artificial light at night is thought to negatively affect terrestrial and aquatic ecosystems and reduce night sky visibility globally. Across New Zealand, 370,000 streetlights are currently being replaced by energy-efficient, blue-white light-emitting diodes (LEDs). While the economic benefits of conversion are significant (~$10 million/year operational costs), the potential cultural and environmental impacts of the increased blue light emitted by LEDs are unclear. The night sky is integral to Māori culture, demonstrated by the revival in Matariki celebrations. Yet >50% of New Zealanders cannot see the Milky Way from home, a percentage likely to increase with LED conversions. Urban skies are ideal systems in which to investigate the potential cultural and ecological impacts of such LED conversions and develop recommendations to minimise the impacts of large-scale streetlight conversions.

Using a 3D model of the Christchurch lightscape and findings from night sky monitoring, we will discuss how different configurations of streetlight types can affect the city lightscape, particularly along urban waterways. Understanding these results, in combination with the ecological impacts, will help planners to prioritise critical areas for alternative lighting solutions and aid in the design of culturally and ecologically sensitive streetlighting.

SIMULATING RAINFALL-RUNOFF RESPONSE FOR AUCKLAND'S WATER SUPPLY CATCHMENTS

Whitelock-Bell, L.S.1, Leong, D.C.K.1
1 Tonkin & Taylor Ltd

Aims

Tonkin & Taylor Ltd (T+T) have modelled Auckland's water supply catchments since 2000 as part of our development and delivery of the Integrated Source Management Model (ISMM) used by Watercare Services Ltd (Watercare). ISMM simulates the operation of Watercare's headworks, so as to compute optimal abstraction solutions – i.e. solutions addressing the conflicting objectives of yield maximisation and cost-effective allocation of water supply. As part of the decision support software, a bespoke rainfall runoff (RFRO) model is utilised to simulate inflows into the ten reservoirs that, together, supply 80% of Auckland's water on average.

Some twenty years have elapsed since this RFRO model was developed and calibrated. Thus, a review of the latest technologies and an update to the model's implementation is appropriate, particularly for modelling warmer future climates. This paper aims to present the findings of a literature review of the available options as well as recommendations for the specific RFRO model to be (re-)implemented. The results of said implementation are then discussed.

Method

The application of any model as part of ISMM is limited by the following considerations:

- Availability – the model must be freely available and easily reproduced within the ISMM programme. This restricts the selection to models with accessible source code and excludes of any 'black box' and/or proprietary models.
- Reputability – it must be based on sound hydrological theory and withstand review.

These considerations have guided the selection of models for review as well as the final recommendation. A selection of the models reviewed are compared in Figure 1 overleaf.

New Zealand alone does not have the industry nor geographic scale to require reviews of existing rainfall-runoff models specific to our climate and needs. Instead, it is common practice to turn to Australia for guidance and direction. Rainfall-runoff modelling began in Australia about four decades ago. It is now a mature practice with several models in use for design of water supply systems, flood estimation, management of water resources for allocation and use, management of stormwater and wastewater in urban areas, and management of aquatic ecosystems (Boughton, 2005).

Beven (2012) and Boughton (2005) suggest that a successful outcome from a RFRO model is less reliant on the specific model employed than one might think – as modern water balance models are all stemming from the same original concept (as pioneered by the Stanford Watershed Model) and are thus all bound by the same principle of mass conservation. The success of a RFRO model is more reliant on the availability and quality of input data with which one can calibrate to. Therefore, it could be said that the proof of success is simply in achieving an acceptable calibration result under a plausible range of catchment conditions.

We too have found this to be true in our experience using RFRO models. We have found that, generally, the limiting factor in the accuracy of simulated discharge response is the representativeness of the input rainfall data, particularly with respect to spatial coverage, and not deficiencies in the model formulation itself.

Results

With the review findings in mind, we recommend a re-implementation of the bespoke RRO model currently used in ISMM for the reservoir catchments. This option provides the best chance of ensuring a successful calibration (considering it has been achieved satisfactorily in the past).

The bespoke RFRO model is similar to many of the models in wide use today in that it is a catchment-specific development of the explicit soil moisture accounting framework. It may be considered a simplified variant of the original Stanford Watershed Model. In developing and calibrating this model emphasis was put on volumetric accuracy (rather than on peak inflow or timing) and in the recession into low flows as these aspects govern storage behaviour when Watercare's supply system is under stress.

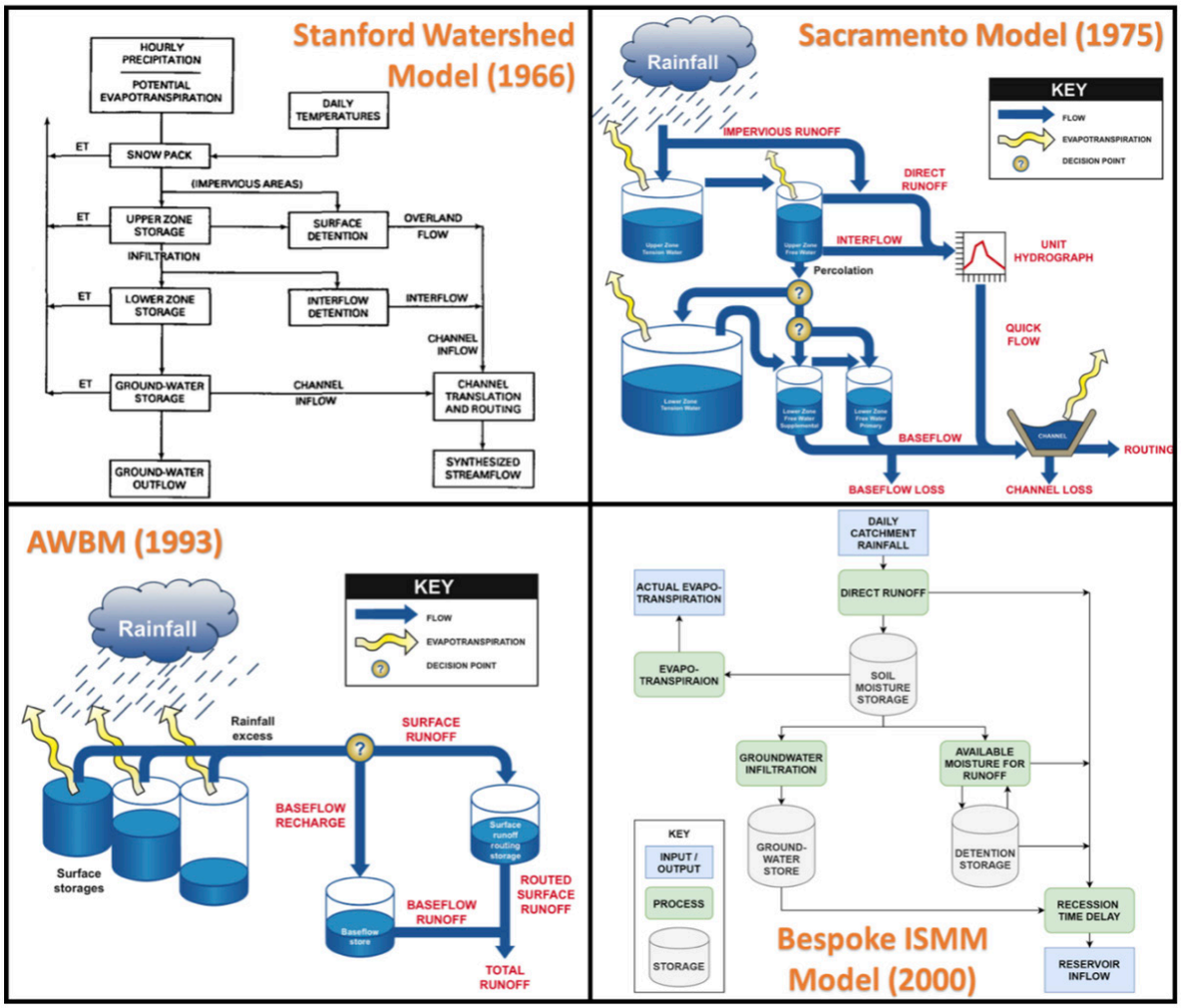

Figure 1 Selected rainfall runoff model schematics. Sources clockwise from top left: Crawford & Linsley (1966), eWater (2017), eWater (2017), Leong (2000).

We describe the model structure and outline the updates explored in the review. For example, the model currently employs an empirical function to model evapotranspiration. The key deficiency in such a scheme for application in climate change assessment is its inability to explicitly represent the increased potential evapotranspiration (PET) anticipated under warmer future climates. Therefore, a change to the current model input structure and a recalibration of the model parameters is required.

Finally, we present some results of model calibration and discuss the wider outcomes of implementation.

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E. COLI OCCURRENCE IN CANTERBURY GROUNDWATER AFTER STORM EVENTS

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Heavy rainfall during storm events can act as the impetus for E. coli detections in groundwater as water provides a transport mechanism. The rate of transport and the concentration of E. coli detected depend on a number of factors, such as; soil saturation, groundwater depth, distance from contaminant source and the presence of preferential pathways. The relationship between E. coli concentrations in groundwater and rainfall events are therefore non-linear, non-stationery and show hysteresis effects (changing concentration relationships during the rise and fall of water levels). Subsequently, there is often no strong correlation between the occurrence of rainfall and E. coli detections. However, other studies have found that the main control for the detection of E. coli in groundwater is rainfall intensity rather than the volume, and that the highest concentrations of E. coli are found as the water table rises in shallow systems. Understanding the relationship between rainfall events and E. coli concentrations in groundwater is important for providing advice to well owners and water suppliers.

E. coli detections in Canterbury groundwater and their relationship to rainfall events were analysed using a variety of methods. Case studies were analysed where high temporal resolution data was available for rainfall (from NIWA's CliFlo) and E. coli concentrations in monitored wells. At a broader scale, the relationship between E. coli detections of Canterbury regions and annual rainfall was analysed. Results exhibit a non-linear relationship to rainfall volume. A Land Surface Recharge (LSR) model was used to determine the impact that periods of sustained rainfall resulting in higher water tables have on the detection of groundwater E. coli in the Waimakariri region.

A-PRIORI PARAMETERISING GROUNDWATER PARAMETERS OF TOPNET-GW IN NEW ZEALAND

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Aims

Integrated surface-groundwater models are widely used for water resource research and management purposes as they can simulate hydrological processes occurring in both surface and subsurface zones and their interactions, The integrated models can be used to assess diverse aspects of water resources such as the impacts of human activity (e.g. water abstraction) and climate change on the water resources. In New Zealand, such models can support the implementation of the National Policy Statement for Freshwater Management (NPS-FM; Ministry for the Environment, 2020) for regional authorities to carry out their responsibilities for managing freshwater, and implementation of *Te Mana o te Wai* (*integrated and holistic well-being of a freshwater body*) to reflect the Maori's philosophy and cultural values in managing both surface and groundwater bodies holistically. NIWA has been developing a national surface-groundwater model (Topnet-GW; Yang et al., 2017), as part of the New Zealand Water Model (NZWaM-Hydro) framework. Here we present a methodology to a-priori parameterise groundwater processes and application of those in four hydro-geological different catchments. This contributes to the national parameterisation of TopNet-GW in New Zealand.

Method

Over the past two years, we have developed a a-priori parameterisation method for groundwater processes of TopNet-GW model through a collaboration between NIWA and University of Bristol, UK. This method uses multiple national datasets that combine expert knowledge (e.g., surface water and groundwater flow processes) of scientists from Crown Research Institutes and regional authorities and national datasets. These datasets include: 1) national QMAP of GNS (Rattenbury and Isaac, 2012); 2) national losing and gaining streams (Yang et al., 2019); 3) national aquifer layers (White et al, 2019); 4) national steady-state groundwater level from GNS Science EWT model simulation.

Assessment of the performance of a-priori parametrization of TopNet-GW is applied to four grondwater affected catchments: Parawa in upper Mataura, Southland; Pareora in Canterbury; Rangitikei in Horizons; and Taruheru in Gisborne.

In each application, a-priori driven model simulations will be compared to those from literature, without any model calibration attempt.

Results

Results of the performance of uncalibrated TopNet-GW for the case study in the Parawa catchment, Southland are shown here. Figure 1 depicts the TopNet-GW setup for Parawa catchment, including location of losing and gaining streams, and aquifer boundary.

Figure 2 shows the simulated losing and gaining flow rates of uncalibrated TopNet-GW, as a comparison with spot-gauged flows (Hughes et al., 2011). The results show that the losing and gaining fluxes simulated by the uncalibrated TopNet-GW are comparable to the observed values.

Similar results are found in the other three catchments, implying that suitability for employing the general application of the method is valid for different geological and aquifer conditions.

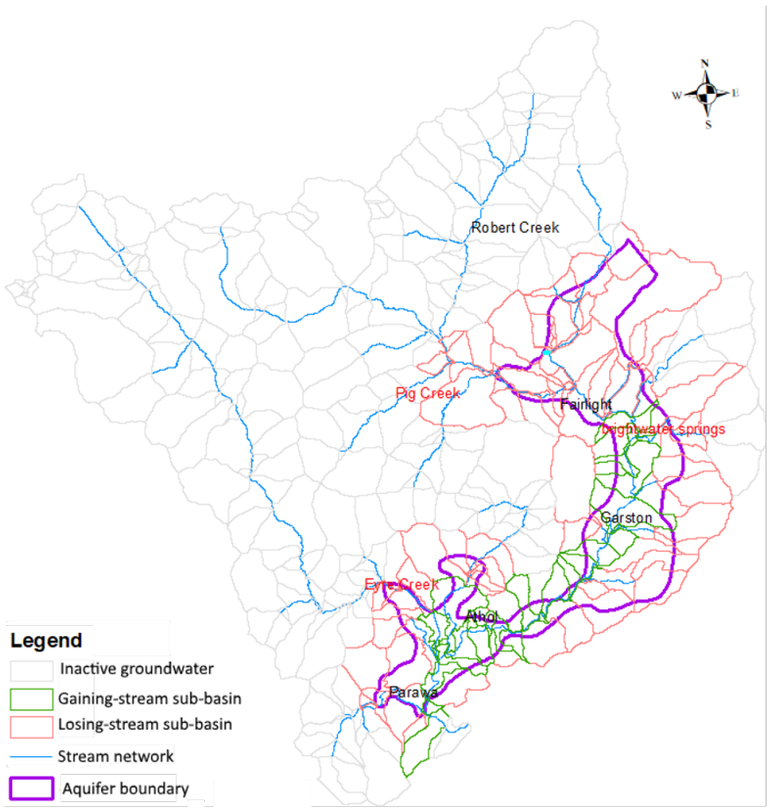

Figure 1 TopNet-GW model setup in the Parawa catchment

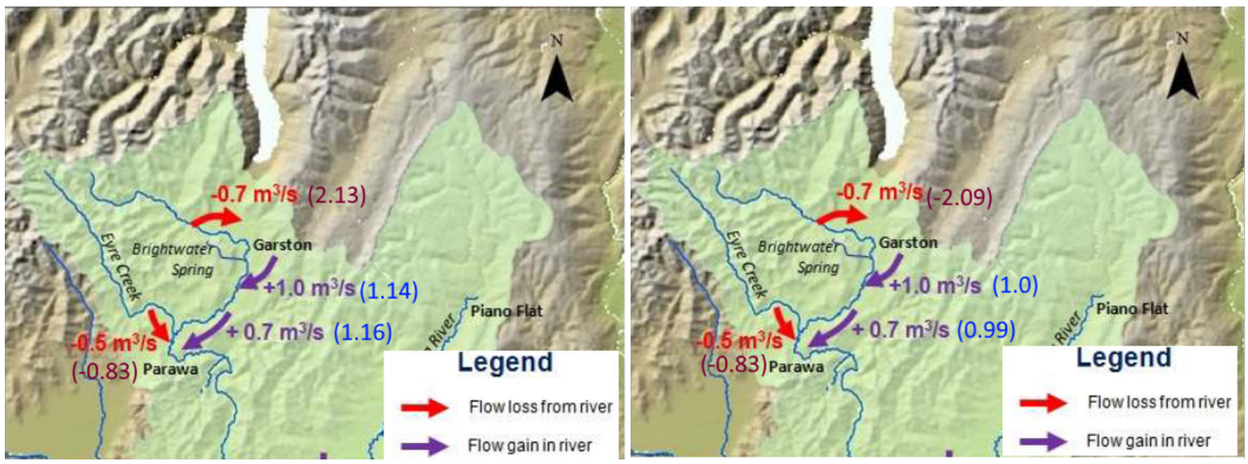

Figure 2 Comparison of simulated losing and gaining streams with uncalibrated TopNet-GW (bracketed numbers) and observed (unbracket numbers) from Hughes et al (2011). Left: rates are based on the entire simulation period (2000-2013); Right – rates are based on the dry period whenever there is a spot gauging taken.

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HYDROCHEMISTRY OF SHALLOW GROUNDWATER IN DUNEDIN, NEW ZEALAND

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Groundwater is a dynamic aspect of the hydrological cycle and has many different impacts, both positive and negative. It can be a valuable water resource but conversely can be a source of hazards to people and the environment. The aim of this study is to characterise the hydrochemistry of shallow groundwater in low-lying areas of Dunedin, New Zealand. Through the analysis of in situ measurements and water samples extracted from 23 bore across the study area, a hydrochemical signature was used to infer water sources and inform the dynamics of subsurface water transport. Understanding the sources of water in the groundwater system is needed to develop an informed strategy to combat the issue of surface flooding in South Dunedin, which is linked to the storativity of the underlying groundwater system. Additionally, analysis has been undertaken of the coastal and Harbourside margins to determine the vulnerability of groundwater in these areas to the effects of coastal intrusion and saturation from permeating surface water.

Preliminary results from this study indicate that seawater and rainfall are contributing sources of recharge for this groundwater system, with saline intrusion occurring in some areas at the coast and rainfall recharge dominating the inland portion of the study area. The extent to which these factors control the hydrochemistry of the groundwater is dependent on the location of each bore. For example, the Kennedy Street site approximately 200 m from St Clair Beach has sustained, high specific electrical conductance concentrations of 42703 µS/cm, on average, and elevated concentrations of boron, bromine, chloride, and strontium. Collectively, these solute data, along with a δ18O ratio of -0.5 are consistent with a marine origin of the groundwater at this location. Other locations, however, have more complex hydrochemistry that indicate mixtures of both salts from a marine origin, but isotopic ratios similar to rainfall. These results indicate the groundwater characteristics across South Dunedin and the Harbourside illustrate different recharge compositions. Therefore, the areas that are vulnerable to groundwater related hazards, such as surface flooding, and the extent to which they are impacted will vary across the study area. By understanding predominant water sources across the study area, the areas most vulnerable to surface flooding under different conditions can be determined, allowing targeted mitigation measures to be successfully implemented.

HOW A SMALL PASTORAL CATCHMENT RESPONSE TO VARIATION OF STORM EVENTS

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Precipitation is often recognised as a driving force to mobilisation and delivery of contaminants from catchment. High flow conditions relate to storm events dominate the annual loads of dissolved nutrient to water bodies. Hence this study aimed to characterise the temporal variation in water quality as a catchment response to storm events. This study utilises high-frequency measurements to observe the changes in streamflow chemistry at the study site in a dominated pastoral catchment flowing to one of polluted lake in Bay of Plenty, North Island. Additionally, isotope-based hydrograph separation is used to estimate contributions of event and pre-event of streamflow. Preliminary results suggest that solute-flow behaviour changed with the advent of the storms, but depended on rainfall amount, intensity, and antecedent wetness conditions. Nitrate-N concentrations during storm events are significantly higher relative to baseflow conditions. Event-based sampling exhibited substantial changes in turbidity, electrical conductivity, and dissolved oxygen during more intense rainfall. The water isotope signatures in rainwater are highly variable across events, and the stream-water isotope compositions show different responses to the individual event. Moreover, the relative contribution of pre-event water to streamflow revealed a large variation storm-to-storm; indicating how varies the catchment response to precipitation. The study using water isotope tracer includes high data resolution that can improve understanding of the control points for contaminant losses and will aid management strategies in the pastoral farming system.

THE NEW ZEALAND WATER MODEL-SURFACE WATER ABSTRACTION MODULE: SIMULATING ACTUAL WATER USE

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[1] NIWA, Christchurch

Introduction

Our river flows are highly modified owing primarily to increasing demand for water for farming, domestic and industrial uses. It is widely recognised that water use should be managed within the constraints of maintaining healthy river systems. This is a challenge for central and regional governments because, while using water for irrigation and industrial purposes can generate important economic benefits, abstractions also alter both the magnitude and timing of river flows thereby causing potentially adverse environmental consequences. Managing use of water sustainably is a key objective of the Resource Management Act, and achieving that objective is a responsibility of administrative regional authorities. The National Policy Statement for Freshwater Management (NPS-FM) also directs regional authorities to set limits on the use of water resources for all waterbodies.

Methods

To assist with the administrative freshwater management responsibilities, we have developed a module for the New Zealand Water Model (NZWaM) to simulate water abstraction and its use. By default, this new capability merges the 2017 Ministry for the Environment Irrigated Area national coverage (Dark et al., 2017) with a simple water take module and ecological flow characteristics. NZWaM-surface water take module can be used to simulate flow modifications of a river following a surface water abstraction(s) for irrigation, application of irrigation water on land and its effects (e.g. change in evapotranspiration, soil-moisture and drainage). The water abstractions can be modelled in two different ways: either based on actual water meter data or the module's inbuilt simple water balance modelling approach to estimate irrigation wate demand. The module provides a simple but reasonably accurate mechanism to simulate water abstractions and consequent change in hydrological regimes to aid limit setting processes and managing water within limit.

To support the implementation of the NPS-FM, the surface water take module has been built as a scenario explorer enabling user to assess impact of minimum flow requirement at a specific reach or distributed across the river network owing to surface water takes.

Results

Results will be presented from the implementation and application of the surface water take module to one of the NZWaM case study catchments (Oreti and Mid Mataura in Southland, Rangitikei in Horizons and Taruheru in Gisborne) as well as for a number of catchments (located in different climate and hydrological regions) where groundwater takes are considered to be minimal (Booker and Henderson, 2019). Implications for the future development of the surface water module will also be discussed.

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