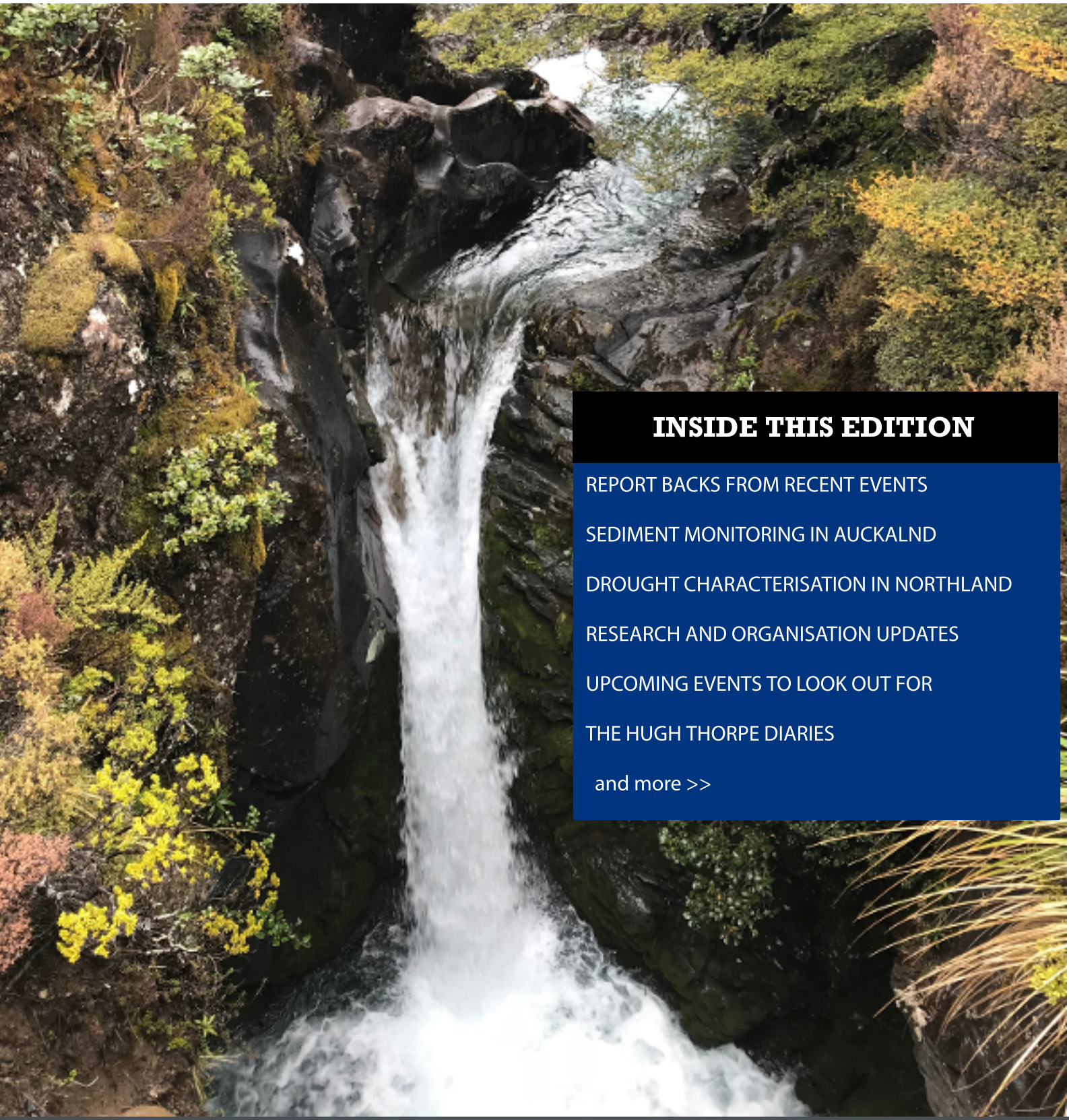
NEW ZEALAND HYDROLOGICAL SOCIETY

Current Newsletter



INSIDE THIS EDITION

Newsletter No.52 / November 2017

MESSAGE FROM THE EXECUTIVE

Clare Houlbrooke

I am taking my turn to introduce this edition of Current as after 6 years, I am stepping down from the NZ Hydrological Society Executive at the AGM in Napier. I always enjoy the range of articles and news items in our newsletter - Current. Thank you to all the contributors and to Mike Thompson for doing another excellent job in pulling it all together. Current provides an excellent platform for us to communicate with members of our whole society. I encourage individuals and organisations to continue to participate and provide interesting content.

Many of you will be looking forward to the upcoming conference in Napier (Tuesday 28 November to Friday 01 December). It has been many years since we held the NZHS Conference in the NZ Art Deco Centre. Recently, the Hawkes Bay region has been central to national conversations around water storage options and water quality. As hydrologists and hydrogeologists supporting these national discussions we can expect interesting presentations and debate at the Napier Conference as we consider future management of our surface water and groundwater resources.From my previous experiences in Napier it is a vibrant, thriving coastal city and I look forward to the excellent food and beverage at local cafes, vineyards and restaurants. Thank you to Steven Swabey and the rest of the conference committee for pulling the conference together.

As part of my role on the Executive I have been involved in helping with judging student talks over several years now. It is always pleasing to see so many of our hydrology students attending the annual conference and continuing to attend while they develop their careers. The standard of student presentations is excellent, and the conference is a great platform for students to consider various hydrological career paths and meet potential future employers. Supporting hydrology students falls under the NZHS objective "to further the science of hydrology and its application to the understanding and management of New Zealand's water resources". This support also involves grants and scholarships such as; the project grant, travel grants and Kees Toebes scholarships which the society supports.

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

Advertising space is available; contact Helen Kinaston at the above address to find out more.

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

Photo on the front cover: a stream near Taranaki Falls in Tongariro National Park. Taken by Clare Houlbrooke in early November 2017

Project grants are usually given to postgraduate students seeking support for travel, field consumables and lab costs for their Master and Doctorate research. In addition, travel grants can be given for students travelling to conferences including throughout NZ and overseas. Many of you would have seen short articles from these students as part of the conditions of the grants. NZHS supported two students in late 2016 to attend the hydrology summer course in Sydney, Australia. The "Kees Toebes" Scholarship has been supported by the kind donation of Mr. Justin Toebes in remembrance of his father, who started the society over 55 years ago. He is keen to further support young hydrologists to train towards their prospective careers. We encourage all students to watch Current newsletter and the NZHS website for more information and please let any NZ hydrology students you may know to make the most of the support provided by the society.

Another opportunity supported by the society as mentioned in Current last year by Helen Rutter is the support of workshops with "seed" money to get the workshop off the ground. Helen is always keen to hear your ideas so please contact her if you have a workshop you want to run. I hope to see many of you in Napier or future conferences, and I wish the Executive all the best to continue the excellent support of our society.

Over and out.

Clare Houlbrooke

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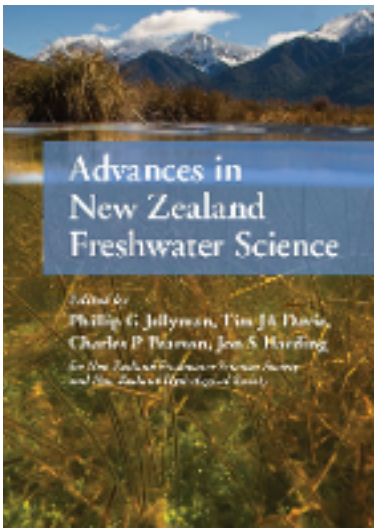
Freshwater book - get a copy in Napier



It is not too late!. There are still copies of *Advances in New Zealand Freshwater Science* for sale.

The book costs $90 + $10 for postage and handling. Or you can save the postage fee and pick up yourself from the Napier conference (so long as you pre-order).

You can download an order form here and submit to **Helen Kinaston** at this email address. Please note on the form whether you intend to pick up at the Napier conference. Books will also be available for sale at the conference, for payment by credit card only (but supplies will be limited unless pre-ordered).

2018 Annual Technical Hydrology Workshop - save the date

The 2018 Technical Hydrology Workshop will be held in **Palmerston North** from Monday **05 March to Friday 09 March**. The theme for this workshop is Sediment Monitoring & Reporting.

This workshop provides a unique opportunity for field hydrologists and industry suppliers to network, learn from each other and promote their products to representatives from all over New Zealand. More specifically, we encourage and anticipate participation from leading local government, crown research agencies, water utility providers, hydro power generators, private industry groups and individuals. All practitioners with an interest in the profession of field hydrology are welcome. It is an opportunity for field hydrologists to gather and learn more about their profession as well as share knowledge and experiences from their working environment or projects they may be involved with other field hydrologists and other interested professionals.

The venue will be confirmed in due course, as will the detailed programme. However, at this stage the following is planned:

Monday – ENVCO Training

Tuesday – HydSoc workshop

Wednesday HydSoc Workshop & dinner

Thursday – Field day sediment sampling and gauging regatta

Friday – Advanced techniques and processing sediment data

NOTICES

Farewell Peter Thomson (1931-2017)

The Society notes the recent death of **Peter Alexander Thomson**, the longest standing member of the New Zealand Hydrological Society. Peter commenced work as Assistant Engineer with the newly formed Marlborough Catchment Board in 1957, and joined NZHS in 1962, shortly after its formation in late 1961. During his 31 years with the Board he was heavily involved in river protection works; major projects included the construction of the Taylor Flood Detention Dam, and the Wairau Diversion. He was appointed Chief Engineer of the Board in 1964, and held that position until he took early retirement in 1987, at the time of the formation of the Regional Council.

In the early days much of the Boards effort concentrated on river control works to reduce the effects of flooding from the Marlborough rivers, most notably the Wairau, which is one of the largest alluvial rivers in the country with a comprehensive river control scheme. In those days river control was part science, part art, and part trial and error. eter sometimes described himself as a Potomologist, as one who studied the effects of engineering works on river channels.

Although not an active member of the Society in later years, Peter in his role at the Catchment Board actively encouraged those more directly involved in Hydrology to participate in symposiums , workshops and general activities of the society.

Peter is survived by his wife Sue, children Craig and Wendy, three grandchildren, and two great grandchildren.

Val Wadsworth

Don't forget.....we have a Facebook page

You may or may not be aware that the Society has an active Facebook page. This is a great place to reach a diverse and growing audience with information, articles and videos, links, invites to events and much much more. Take a look here if you haven't already.

Raelene Mercer is the caretaker of the page.

Keep in mind.....submitting a paper to the Journal

Papers for the Society Journal (NZ Journal of Hydrology) are always encouraged. Think about turning your conference papers in to journal articles. If not a full paper, perhaps a Technical Note. And papers need not be constrained to pure hydrology; water planning and management papers are of equal interest.

Richard Hawke is the JoH Editor

Late spring snowfall in the Glendhu catchment, November 2017. Photo: Sarah Mager

Suspended sediment: Part 1

Assessing the ability of current analytical fluvial sediment monitoring methods in the delineation of volatile organic content

AUTHOR: **Ebrahim Hussain** and **Nicholas Holwerda**, Auckland Council

River fluvial sediment is one of the major water quality issues in low land rivers and estuarine environments. Therefore understanding the issues associated with specific analyses techniques is critical to adaptive catchment management. Laboratory test methods vary and can influence the intended outcome. If the incorrect test method is chosen for a specific assessment the overall result could be misleading or non-reflective of actual trends.

Following on from the New Zealand Hydrological Society technical workshop in April 2017, this article further discusses the issues associated with monitoring suspended sediment. Are we using the correct test methods when we conduct analysis for "sediment"? This short paper will cover some of the misconceptions surrounding common lab analysis techniques and the potential effect of volatile sediment concentrations on sediment load predictions.

Background

The use of suspended sediment samples as a means to quantify sediment loading and instream sediment transportation in rivers and receiving environments has been done since 1965 (Hicks D.M, Fenwick J.K 1994; Hicks D.M 2011). Historically, suspended sediment samples have been collected in the field and analysed by laboratories using a technique involving the vacuum filtration of the sample through a glass fibre filter then drying the filter and weighing the precipitate (Hicks D.M, Fenwick J.K 1994; Hicks D.M 2011). However method choices vary and often involve using different amounts of sample and drying regimes. This variance in method selection can have a significant influence on the resulting measurements.

A brief description of the commonly used laboratory methods in New Zealand for sediment analysis is outlined below:

1: TSS (total suspended solids) suspended Solids by gravimetry - In house based on APHA (online edition) 2540 D, E.

This test method is used throughout New Zealand as a standard test on water quality samples. Historically it was the most common test method for sediment analysis. This is because the entire sample is not used for TSS analysis which means the remainder of the sample could be used for additional tests. This method involves taking a measured

sub aliquot from the main bottle and vacuum filtering it through a Whatman GF/C or equivalent 1.2µm pore size filter, the filter is then dried at 103-105 degrees C and weighed. The dried residue weight is then divided by the filtered sample volume to determine the suspended solid concentration(Hicks D.M, Fenwick J.K 1994; Hicks D.M 2011).

2: SSC (suspended solids concentration) suspended solids (remaining aliquot) by gravimetry ASTM D3977-97 (modified) APHA (online edition) 2540 D, E.

This method has been adopted in recent years by regional councils for event based sampling and annual yield calculations. The key difference between this method and the above mentioned TSS method is that the entire sample is vacuum filtered rather than just a measured aliquot. The processing of the sample post vacuum filtration is identical to that of the TSS method (Hicks D.M, Fenwick J.K 1994; Hicks D.M 2011). This method limits the loss of particulates due to failed resuspension and provides a more accurate measurement of the suspended solids in a sample.

3: VSS (volatile suspended solids) is traditionally calculated by adding an additional step post TSS analysis. The same method as TSS is used but the additional step involves ashing the filter at 550 degrees C to burn off any volatile organic matter. The use of the entire sample can also be requested which would eliminate some of the inherent issues surrounding the use of measured aliquots. TSS is calculated by dividing the initial dried residue weight by the filtered sample volume, whereas VSS is calculated by dividing the difference between the initial dried residue weight and the ashed residue weight by the sample volume.

The primary difference that distinguishes the VSS method from TSS and SSC methods is the assessment of organic content within the sample. Both TSS and SSC are a measure of all the solids in suspension with no differentiation between organics and mineral based materials.

Catchment mangers are primarily reporting the results as sediment when in fact it is solids (organic content included). The results can potentially be misleading as the organic fraction of sediment loads are less persistent and tend to break down relatively quickly in comparison to non-volatile mineral based solids. One of the issues is that organic material is not usually associated with large scale developments, man-made land cover changes and natural erosion, rather they tend to stem from detritus, faeces and instream macrophytes. This means that in order to accurately quantify the extent of anthropogenic sediment loading you would need to factor in the proportion of natural ambient organic matter. The hypothesis tested by Auckland Council aimed to investigate the potential concentration of volatile organic matter in automatically collected sediment samples and assess whether or not this fraction is adequately accounted for using standard test methods.

Method

For this preliminary study the Auckland Council conducted investigations over a range of events at a single site (Wairoa River @ Clevedon). This site is located in a catchment with an area of 114km^2. The land use is 23% indigenous, 63% Pasture, 6% exotic forestry and 8% other (Curran-Cournane F, Holwerda N, Mitchell F 2013). Events over three different flow ranges were sampled with 12 samples taken at each flow point. Six samples were used for SSC analysis and the remaining six samples were used for VSS analysis and the associated TSS results were also recorded. All samples were taken using ISCO automatic samplers and manually forced at the same point in time. Samples were also taken over a one month period in early 2017 so seasonal variation was kept at a minimum.

Results

SSC, TSS & VSS concentrations for all samples collected at each flow event

Event type	Discharge (m3/s)	Sample numbers	SSC (mg/L)	TSS (mg/L)	VSS (mg/L)
Low	0.548	1	3.086		
		2	3.614		
		3	4.375		
		4		3.372	1.163
		5		3.294	1.176
		6		6.705	2.727
		7	3.200		
		8	3.000		
		9	4.189		
		10		5.310	1.77
		11		4.301	0.538
		12		5.093	0.926
Medium	12.306	1	162.024		
		2	154.066		
		3	153.114		
		4		163.60	35.600
		5		168.40	33.200
		6		198.8	40.000
		7	174.884		
		8	171.636		
		9	180.710		
		10		185	33
		11		178	28
		12		177	25
High	181.115	1	824.785		
		2	841.702		
		3	811.333		
		4		860	123
		5		855	116
		6		854	113
		7	986.258		
		8	821.882		
		9	838.571		
		10		889.5	112
		11		862.5	110
		12		882	113.5

Average SSC, TSS & VSS concentrations for all events

Event type	Discharge (m^3/s)	Average SSC (mg/L)	Average TSS (mg/L)	Average VSS (mg/L)
Low	0.548	3.577	4.679	1.383
Medium	12.306	166.072	178.467	32.467
High	181.115	854.089	867.167	114.583

Average VSS & non-volatile sediment concentrations

Event Type	Average VSS (mg/L)	Average non-volatile sediment (mg/L)
Low	1.383	3.296
Medium	32.467	146.000
High	114.583	752.583

Average % of volatile organic material per event

Event type	Average percentage of volatile organic material (%)
Low	29.56
Medium	18.19
High	13.21

Discussion

The preliminary results from this study indicate that the concentration of volatile organic matter in the test samples range from 13% to nearly 30%. The biggest influence appears to be at low flow stages. During periods of high flow the ambient in stream organic material would be rapidly washed down stream during the first flush stage of the event and the concentration of in stream non-volatile solids will increase as a result of sediment laden runoff entering the stream. This could account for the reduced non-volatile content percentage at the high stage events. The low flow conditions promote the persistence of light weight in stream organic material and with limited sediment influx from runoff the composition of the suspended solids is largely organic. The medium flow samples follow this trend by exhibiting intermediate organic concentration.When comparing the SSC and TSS results to the total non-volatile sediment concentrations (calculated by subtracting the VSS concentration from the TSS concentration), it is evident that both standard test methods (SSC & TSS) do not accurately reflect the true non-volatile sediment load in the stream. SSC values were shown to be 8% to 12% higher than the true non-volatile sediment concentration and the TSS values were 13% to 30% higher than the true non-volatile sediment concentration.

Conclusions

Laboratory test method types need to be considered and linked back to the original question being investigated. The volatile organic content can contribute a significant portion of the overall result and as such should be considered. This is of particular concern for monthly water quality sampling as these samples are typically being taken at base flows and it is likely that they contain a significant concentration of volatile organic matter, this is evident in lake water quality samples were bulk of the TSS result could be attributed to algal colonies and phytoplankton blooms in suspension. The adoption of VSS for lake water quality analysis is being recommended in the recent NEMS lake water quality document. Accounting for the volatile organic fraction of sediment samples is imperative when assessing sediment loading as a result of land use change and anthropogenic modifications. Ignoring this fraction can lead to a false increasing trend in sediment yields. The increase in sediment concentration could be a result of increased organic loading (natural or anthropogenic) and not necessarily due to land use changes or anthropogenic induced erosion.

The information from this preliminary study has been provided to the working group for National Environmental Monitoring Standards for sediment monitoring. The working group is proceeding to advance this study through a literature review to understand the test methods that should be applied nationally and the limitations of each of them.

Auckland Council has yet to change test methods to VSS pending national and international guidance. We would like to extend the study to further validate the use of this method by encompassing various land usage types as well as explore seasonal and regional variance.

References

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Suspended sediment: Part 2

Fluvial suspended sediment yields from differing land cover types: a multiple catchment case study on Auckland's north east coast

AUTHOR: **Nicholas Holwerda,** Auckland Council

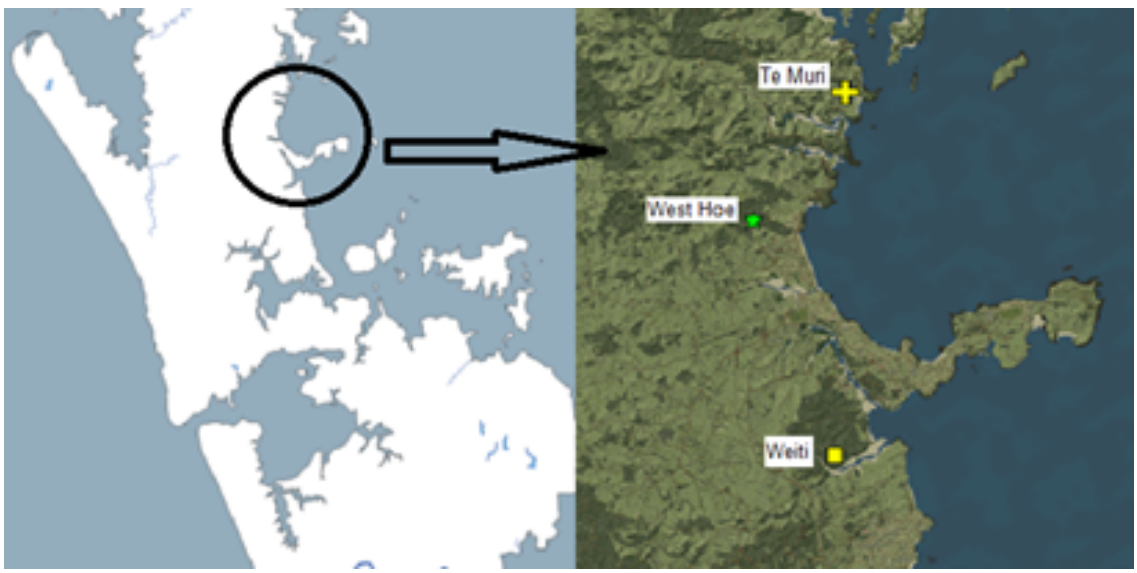
Auckland council has been fortunate to collect a unique data set from three catchments with one primary difference - land cover types. The data is part of the long term sediment monitoring program. The sediment program was developed to spatially represent Auckland's geology, climate and land cover (Hickset al. 2009a). Two of the catchments in this paper are part of the 2009 study with one further catchment added to the network.

Methods

The data collected to generate the catchment yields has been completed as per Auckland's sediment monitoring methods (Hicks , D.M. 2011). The majority of samples have been collected using automated ISCO samplers with flow sampling regimes. All samples analysed at the laboratory used either TSS or SSC methods. Yields have been calculated from every event above a certain threshold. Non sampled events have been filled using peak discharge to event yield rating equations.

The three catchments are located in the north east of the Auckland region. They are unique in that they are dominated by different land covers - Site 1; West Hoe is 97% native land cover, Site 2; Weiti is 84% exotic forest and Site 3; Te Muri is 93% pasture. All three sites have almost identical characteristics such as, soil order, slope, aspect, and annual rainfall.

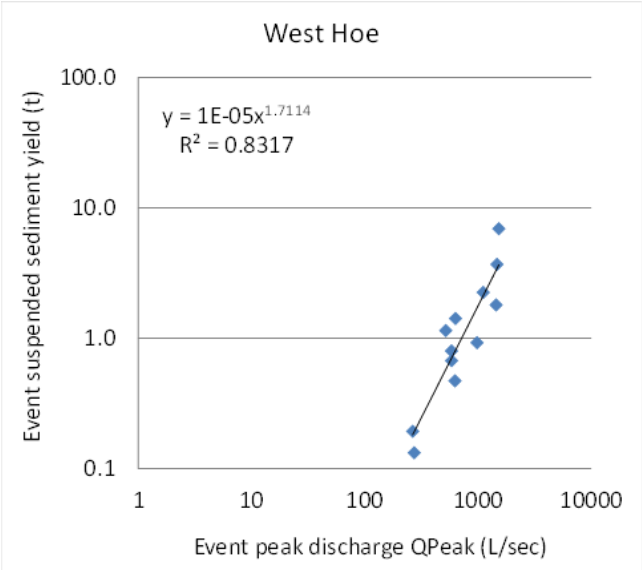
Location of the three sediment monitoring sites, north east of Auckland city

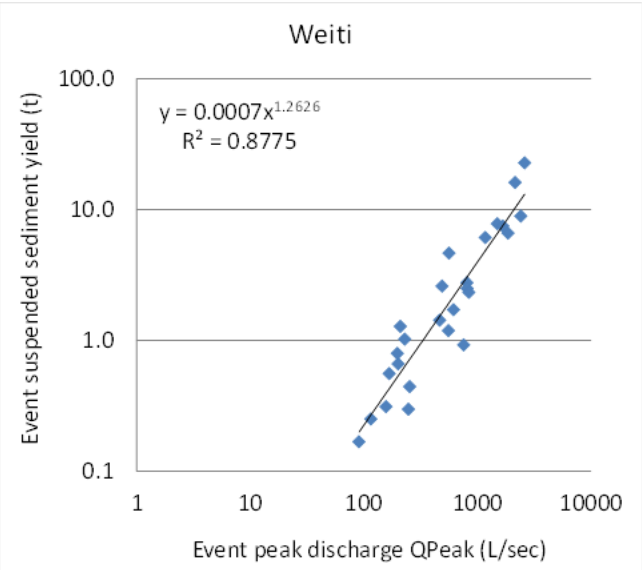


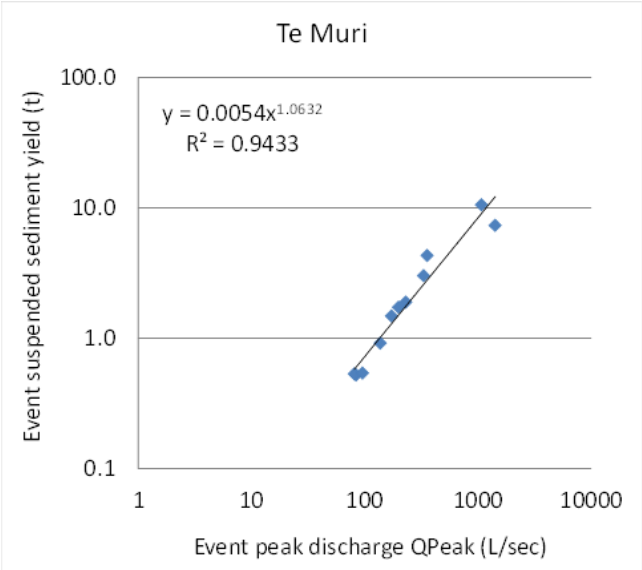
Summary catchment information

Site	Stream Order	Catchment km²	Land Cover	Soil order	Slope	Aspect	Annual rainfall mm	Mean annual flood m³/s
West Hoe	2	0.5	**97% Native** 3% Pasture	Ultic (100%)	Moderately steep	South East	1225	1.400
Weiti	2	1.7	2% native, 14% pasture **84% Exotic**	Ultic (100%)	Rolling	South East	1272	2.540
Te Muri	2	0.3	7% native **93% pasture**	Ultic (100%)	Moderately steep	North East	1150	1.200

We have developed event suspended sediment rating curves for each site. These use peak discharge to event yield to determine the yield for non-sampled events.







Results

Site	Data length years	Number of events reported on	% Data measured	% Data from sediment rating curve	Yield t/km^2/year	Primary land cover
Weiti	5.5	78	70	30	**17.4**	Exotic forest
West Hoe	8.7	194	72	28	**21.2**	Native forest
Te Muri	3.5	120	29	71	**163.0**	Pasture

Conclusions

We can conclude that land cover is one of the major drivers for differences in suspended sediment yields from catchments. Pasture land cover produces the highest suspended sediment yield compared to native and exotic forest land covers. The higher yields are also being derived from low order streams as compared with other literature. Our results are only specific to our catchment characteristics and for our spatially represented area. However they provide a good indication for other catchments when results are being modelled.

Discussion

We have not analysed the erosion type (gully, rill, sheet, landslide or stream bank) causing the yields seen in the catchments. This would further help define the sediment sources. Continued data is being collected at two of the sites to help refine the catchment yields and ratings over time.

Using correct farm plan implementation methods suspended sediment loads in targeted water management zones will decrease by about 40% (J.R. Dymond et al 2016). The Te Muri site is located on a Council owned regional park. The actual study catchment is part of a wider body of work where best farm practise are being applied. The data being collected at Te Muri could be used to help validate the farming methods over time, inform model assumptions and catchment management decisions in reducing sediment to receiving environments.

References (see previous article for additional references

Hickset al. (2009a). TR2009/125

Hicks, D.M Fenwick, J.K. (1994). Suspended sediment manual. NIWA Science and Technology Series No.6, NIWA, Christchurch,

J.R. Dymond et al. / Geomorphology 257 (2016)

Northland drought assessment using Standard Precipitation Index

AUTHORS: **Hoa X. Pham** and **Jason Donaghy,** Northland Regional Council

The Standard Precipitation Index (SPI) is a powerful, flexible index which is commonly used to assess meteorological drought caused by rainfall deficit. New Zealand SPI maps provide a good indication of droughts at national level. However, this information is relatively coarse for Northland where drought severity can be strongly localised. The following article presents some insights from the application of the SPI method to historical drought events in Northland.

Introduction

Drought has a significant impact on Northland farming. It tends to starts slowly, often without warning, and can last for significant periods of time and cover large spatial areas. Drought in Northland has become more frequent and impacts more severe during summer months as a result of increasing temperature and decreasing rain totals.

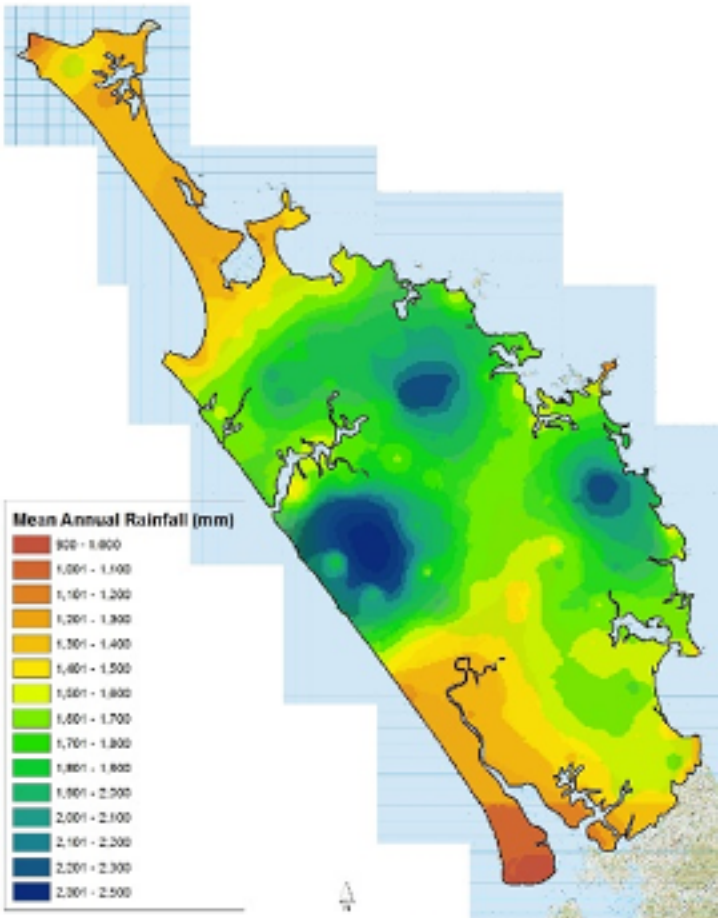
At least eight severe droughts were recorded in Northland since 1900 (Keyte, 1993 and NIWA, 2010 & 2013). The Northland Avocate (Feb, 2017) reported five droughts have occurred in the past eight years and been of a highly localised nature. The frequency and severity of drought in Northland is projected to continue to increase in the future under a changing climate (NIWA, 2013 & 2016). The research presented in this article represents the first steps of an attempt to develop a regional drought warning system. It involves identifying climatic zones, applying SPI and mapping SPI for severe 1914-15, 1945-46, 1982-83 and 2009-10 drought events.

Takou Bay area at the height of drought (left) and a few months later (right) .*Photo: Matt Johnson, NRC*

Input Data

This study used rainfall data from 140 stations owned by NIWA, MetService and NRC for grouping climate zones. Data at a maximum of 40 stations was used for historical drought assessment at regional scale. Daily rainfall data was synthesised in some cases in order to extend the time series beyond gauge operating periods.

Methods and Results



Rainfall in Northland is highly variable leading to the development of localised drought in the region. Hence, the first step was to sub-divide the region into four climate zones based on long-term annual rainfall variability (see map to right). This was done with the aid of ArcGIS Geostatistics. A ratio of 70:70 stations was used for calibration and verification of spatial interpolation process. Rainfall stations could then be selected for further analysis in this study based on achieving representation across the four climate zones.

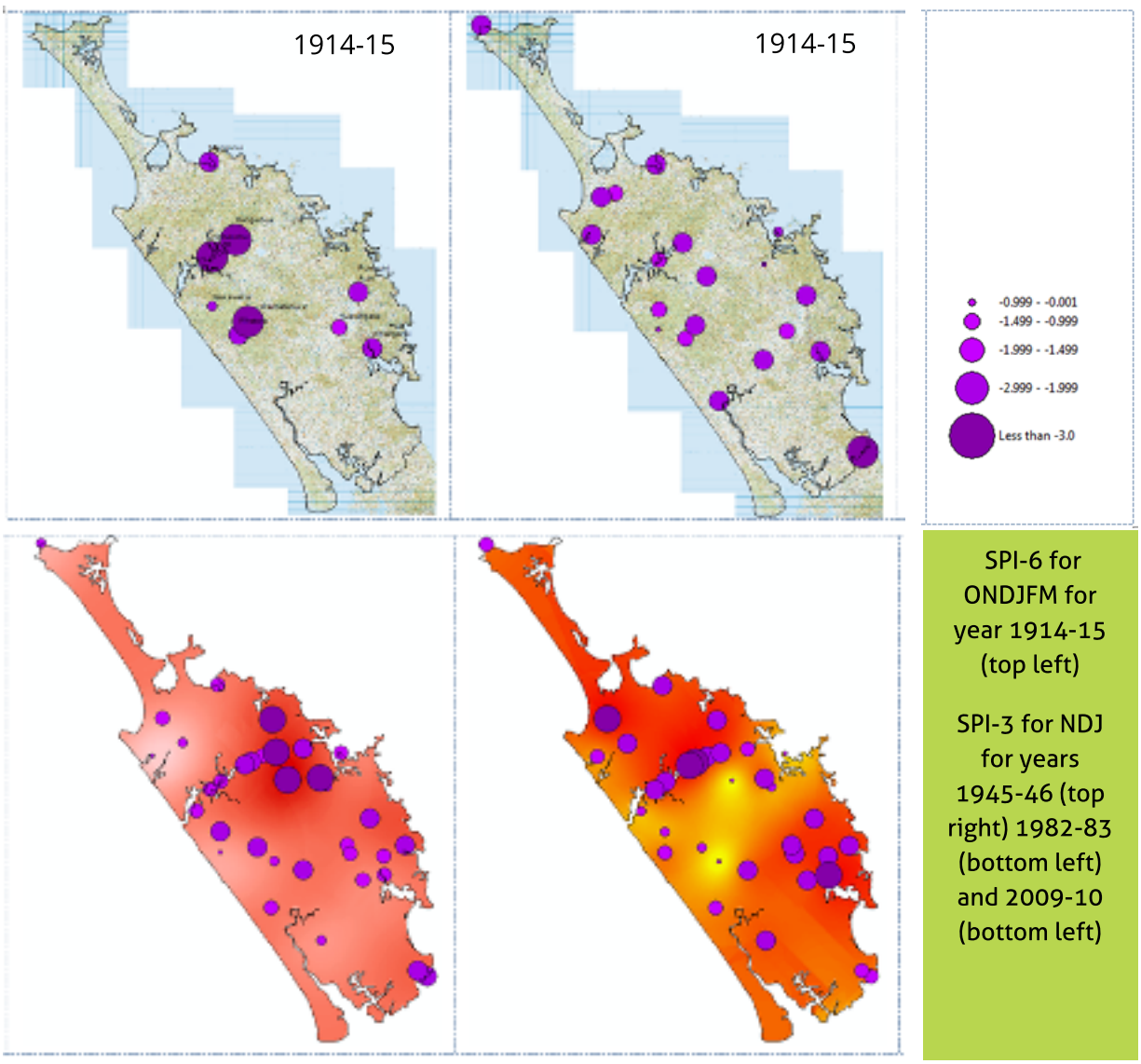
The SPI was introduced by McKee et al. (1993) as a method of measuring drought severity for a particular rain station. The SPI is based on the probability of precipitation for any time scale. The probability of observed precipitation is then transformed into an index. The table below shows how SPI values correspond to categories of drought severity.

The main advantage of the SPI is that it allows for areas with different rainfall regimes to

[±] 2.00 and above/below	Exceptionally [wet, dry]
[±] 1.60 ÷ 1.99	Extremely [wet, dry]
[±] 1.30 to 1.59	Severely [wet, dry]
[±] 0.80 to 1.29	Moderately [wet, dry]
[±] 0.51 to 0.79	Abnormally [wet, dry]
[±] 0.50	Near normal

be compared. In addition, the SPI provides a method for comparing an area against its own history and giving a normalized value to describe the current rainfall conditions. Through this normalization, rainfall values at different locations can be compared (WMO, 2009). The latest SPI program (SPI_SL_6.exe) developed by the Colorado State University, USA was used in this study. This program provides monthly-based SPI values.

Northland usually experiences 2-3 month droughts with the exception of a six-month drought in 1914-1915. Drought has occurred in spring and summer during El Niño and La Niña. In order to best describe the 1914-15 and 2009-10 drought events, SPI 3 and 6 were computed, respectively. SPI-6 was computed for six consecutive months (from October to February) while SPI-3 was computed for three consecutive months (November - January). Results of these computations were used to develop SPI maps for selected historical drought events shown in the maps below. These station-based SPI maps allow drought intensity at both temporal and spatial scales to be visualised.



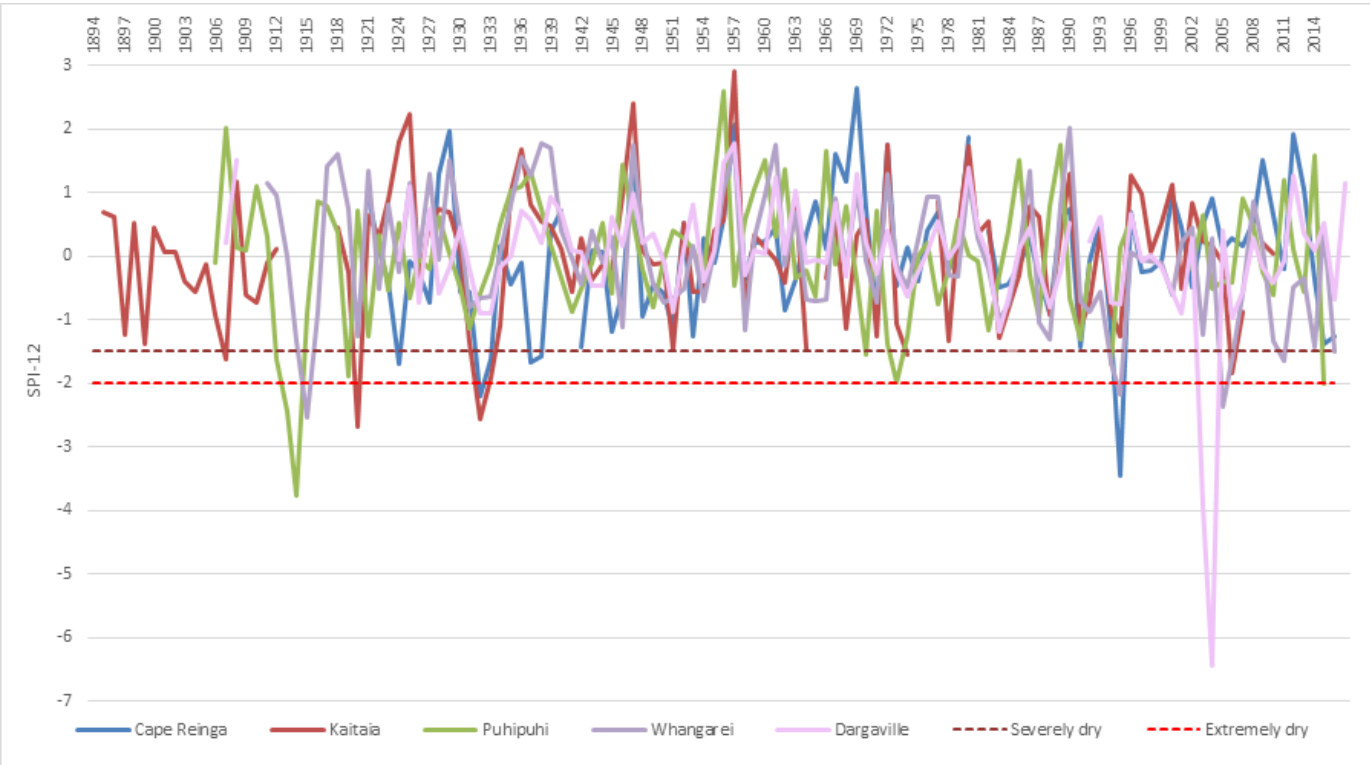
SPI-6 for ONDJFM for year 1914-15 (top left)

SPI-3 for NDJ for years 1945-46 (top right) 1982-83 (bottom left) and 2009-10 (bottom left)

The images on the previous page display some of the general trends of dryness in the region and help to identify the most vulnerable areas to drought. There are a number of obvious features present across the landscape, but the visualization also revealed some apparent errors in the data.

- The most obvious feature in the spatial variability of dryness is a big shift from the west to east coast from early last century (1914-15) to present (2009-10). Also, more areas in the the east are identified as being extremely dry for year 2009-10 (Fig. 3).
- Another noticeable feature is that drought severity relies upon both the magnitude of rainfall deficits and its duration. For example, the 1914-15 drought was caused by both high magnitude rainfall deficits and long duration while the 1982-83 drought was induced by low magnitude rainfall deficits but long duration.

The graph below shows that majority of extreme drought events were prior to 1931 and post-1994 when SPI varies between -1.5 to -3.5 (except for Dargaville in 2004 with the SPI value of -6.44 as an error). At least five droughts have been declared by the Government since 1994, suggesting an increase in drought frequency over the past two decades.



SPI-12 computed for selected rainfall stations

At this time the research has not progressed to the point of ranking the droughts as well as prediction of drought return period. It is also expected that agricultural and hydrological droughts will be integrated in the system when automated network data are available.

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LOOK OUT FOR

FLOODS, SLIPS & COASTAL EROSION MANAGEMENT

12-13 Feb 2018

PRESENTATIONS ON:

- Flood modelling and forecasting masterclass
- Examining the national economic impacts of disruption in NZ from natural hazards
- Managing coastal erosion by working with nature and adaptive management

EXPERT INSIGHTS FROM:

Opus • NIWA • GNS Science • Kaikoura District Council • Professor Ilan Noy KiwiRail • DHI Water & Environment

national freshwater CONFERENCE

14-15 FEB 2018

PRESENTATIONS ON:

- The effects of intensive farming and urbanisation on freshwater
- The Hinds/Hekeao managed aquifer recharge pilot project
- The Havelock North water contamination inquiry

EXPERT INSIGHTS FROM:

NIWA • Wallbridge Gilbert Aztec PLUS Various Regional Councils

Dr Delwyn Moller
Systems Engineer,
Remote Sensing Solutions, California, USA

INTERNATIONAL KEYNOTE SPEAKER AT BOTH EVENTS

- Discussing remote sensing and its role in the flood 'life-cycle'
- Discussing the importance of monitoring surface water inventory

CONFERENZ.CO.NZ/FLOODSLIPS

CONFERENZ.CO.NZ/FRESHWATER

CONFERENZ

WGA NZ

AUTHOR: **Clare Houlbrooke**

Wallbridge Gilbert Aztec (WGA) is pleased to announce the opening of our New Zealand branch, WGANZ Pty Ltd, with offices in Auckland, Christchurch and Hamilton. WGA New Zealand has a team of hydrologists and hydrogeologists specializing in integrated catchment management including groundwater replenishment using the tools of Managed Aquifer Recharge (MAR). WGA is a multi-disciplinary consultancy, with an award-winning team of over 200 engineering and water management specialists.

Our groundwater replenishment experience includes numerous MAR and Aquifer Storage and Recovery (ASR) projects in Australia, New Zealand, the USA, and Southeast Asia. Our staff include co-authors of national and state MAR guidelines for Australia and India. Our New Zealand team, **Bob Bower**, **Brett Sinclair** and **Clare Houlbrooke** complement internationally respected MAR specialists from our Adelaide head office, including **Russell Martin**, **Peter Dillon** and **Nathan Silby**.

New WGA NZ staff; from left: Bob Bower, Clare Houlbrooke and Brett Sinclair

WGA is currently involved in several MAR projects across New Zealand, Australia and China that include feasibility investigations, community outreach for sustainable water resources management, planning and operations through to policy and economic evaluation. A key WGA project currently underway in Western Australia is the Nambeelup Integrated catchment water management project. The proposed Nambeelup Industrial Area (WA) is a modern industrial estate of approximately 1,000 ha. A key issue for the project is the management of the water resources in the underlying shallow aquifer and

the predicted stormwater runoff from the hard stand areas. At present the integrated catchment water management plan calls for managing the shallow groundwater to an agreed level below ground using drainage and then recharging the captured water to the deeper confined aquifer system some 320 m below ground level. Additionally, as the industrial area expands water will be captured from the hardstand areas and roof runoff. Following treatment and storage in the aquifer the harvested water will be used to support the expansion of irrigated horticulture throughout the region.

Integrated catchment water management site in Nambeelup, Western Australia

News from NIWA

COMPILED BY: **James Griffiths**

WSAI 165 HIRDS Tool upgrade

Under HIRDS upgrade project, a task regarding areal reduction factor was completed, and a paper describing the work has been submitted to Journal of Hydrology. Methods presented in the paper will help practising and design engineers to calculate design rainfall for catchments across NZ. This is the first time this work has been carried out for New Zealand.

Edgecumbe Flooding

NIWA undertook a survey of the flood levels created by breaching of a concrete flood wall alongside the town of Edgecumbe during ex-Tropical Cyclone Debbie on the 6th of April. This was a significant flooding event and severe damage occurred to houses near the breach. The data will be used for forensic investigation of the disaster and for calibration of depth-vs-damage relations used in RiskScape enabling better estimation of losses from flood events in the future.

Calibration Data

A paper titled "Influence of calibration data on hydrological model prediction" has been accepted for publication in the International journal of Hydrology Science and Technology. This paper describes the importance of selection of calibration data to model prediction. This paper will be used help to improve calibration strategies for NIWA hydrological models.

Waimakariri Water Use Efficiency (WUE)

In May, **MS Srinivasan** gathered stakeholders for the Waimakariri Water Use Efficiency case-study annual end-of-the-irrigation-season workshop in Rangiora. A total of 21 people attended the workshop, including pilot study farmers, members of Waimakariri Zone Committee, regional council representatives, and scientists from NIWA, AgResearch and ESR. Key lessons from the project were identified and will be included in final reporting.

Process representation

Under the Waterscape project, a paper titled "Inter-comparison of experimental catchment data and hydrological modelling" has been accepted for publication in the Journal of Hydrology. This paper compares process representation of TopNet hydrological

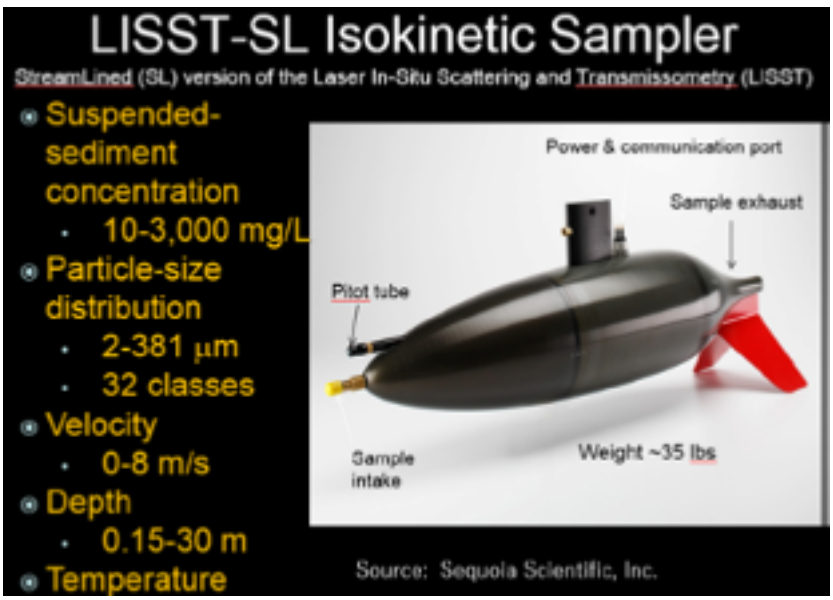
model with data collected in the Waipara experimental catchment. This paper highlights some strengths and weakness of the TopNet model. This paper will be used as a reference point for improving the TopNet hydrological model.

Using new technology to measure bank erosion

NIWA's Managing Mud research programme is focused exploring the sources, characteristics, dynamics, and fate of fine sediment in New Zealand's rivers and estuaries. NIWA's new mobile mapping system 'Snoopy', is a miniaturised LiDAR (laser) scanner capable of capturing thousands of measurements per second and is ideally suited for rapidly surveying dry areas of river channels. NIWA has recently surveyed a 5 km reach of the Oreti River in Southland, capturing accurate, high resolution measurements of both banks in under 30 minutes. The same reach will be resurveyed after the next large flood event and data will be used to calculate the volume of change.

USGS Data Conference

Andrew Willsman and **Evan Baddock** attended the United States Geological Survey data conference in Washington State at the end of August. Many of the presentations were beneficial to the innovation projects that NIWA currently has underway including continuous nitrate sensors such as the Hach (Solitax) and Suna (V2 nitrate) hyperspectral instruments; and sediment surrogate work using standard turbidity sensors, turbidity backscatter at close range (Sequoia LISST ABS sensors), and side-looking acoustic velocity meters which is now common practice. It is planned that a Sequoia sediment sampler (see below) will be used on the Oreti and Mataura rivers later this year (**Murray Hicks**).



The Sequoia Scientific sediment sampler seen at the conference which can estimate particle size distribution while in the water

Andrew presented an overview of gauging regattas in New Zealand focusing on the uncertainty calculations and quality coding aspects from the last regatta as evidence for setting the threshold between "Good" and "Fair" quality codes. Evan spent further time working with the USGS field office near the conference site, and across the border with

the Water Survey Canada in Calgary, where common practices, standards, equipment and use of Aquarius were discussed. It was reported that the USGS has completed its database migration to Aquarius and it was helpful to see their procedures and data structures, which have been well thought through and implemented. Indeed, the USGS staff were very welcoming and freely shared their research in sensing technologies, methods and procedures.

New hydrological staff

Kelsey Montgomery has joined the Hydrological Processes group at NIWA (Christchurch) as a Hydrological Modelling Technician. Kelsey is originally from the USA and has a background in physical oceanography and meteorology. She is a Masters graduate of the University of Rhode Island and has previously worked as an oceanographer in Boston and for a short time with NIWA (Hamilton).

Staff Retirement

Ian Maze retired from NIWA's Dunedin office at the end of June 2017. Ian had completed just on 48 years of service for NIWA and its predecessor organisations. He began with the Ministry of Works and Development in 1969 in the Dunedin hydrological field team office, and soon after transferred to Invercargill office to run the field team there, through to 1974 when he took up an opportunity to work for Enex (Engineering Experts), a New Zealand company in Malaysia, where he was based in Kotu Bahru. In 1978 he returned to work with the Gisborne hydrological field team, and he then moved back to the Dunedin field team in 1993, where he was field team leader for over 15 years.

ESR

COMPILED BY: **Liping Pang**

The following reports on the major activities occurring in ESR's Groundwater Group between November 2016 and September 2017.

Enhanced Mitigation of Nitrate in Groundwater

This project (led by **Murray Close**) is collaborative with Lincoln Agritech, Aqualinc Research, Southern Geophysics and University of Canterbury. Our over-arching research question is "Can we sustainably reduce N fluxes in fast-flowing alluvial aquifers, in which natural N attenuation is insignificant, by inducing conditions conducive to denitrification?" Alluvial aquifers' fast and heterogeneous groundwater flow patterns present significant challenges for the development, design and implementation of mitigation options.

Key research issues are how the heterogeneity of the aquifer structure and flows interact with the mitigation technologies at field scale and how the up-scaling from laboratory experiments influences the interaction between the movement of chemical reactants, reaction kinetics and the response and functioning of the groundwater microbial community. We will use the optimised geophysical techniques and interpretations to identify preferential flow channels at the field sites where high fluxes of nitrate flows are occurring and to optimise the design of the mitigation techniques. The selected mitigation techniques are:

(a) Denitrifying Permeable Reactive Barriers (PRB's) are engineered, passive nitrate remediation technologies that enhance nitrate attenuation in shallow groundwater systems. Woodchips, as the carbon source, are added in a trench into the aquifer, so that nitrate-contaminated groundwater is pass through the trench where the carbon stimulates denitrification by bacteria to converts nitrate predominantly to inert N2.

(b) Biogas induced groundwater denitrification (BID) aims to reduce groundwater nitrate by promoting denitrification in the aquifer through provision of locally produced biogas as a carbon source for the microbial community. This technique would be a world-first groundwater field application.

(c) Bioreactor using woodchips have been designed to provide enhanced removal of nitrate from high-nitrate shallow groundwater systems as they emerge in artificial drainage systems. We are evaluating the effectiveness of the nitrate removal as this

option could provide a very cost-effective method for removal of nitrate before it impacts receiving waters.

A key aspect of the PRB project is how the permeable barrier will interact with the permeable channels within the alluvial gravel aquifer and what modifications to the PRB design are feasible and effective to promote the denitrification reactions. A site has been selected for the PRB field trial in Canterbury on Waimakariri District Council (WDC) reserve land near Kaiapoi. It has the advantages of a shallow groundwater table, moderately high levels of nitrate in the shallow groundwater, the required alluvial gravel hydrogeologic setting, close proximity to Christchurch, and keen support from the land owner (WDC). We have made presentations to the Zone Committee and the Runanga Representatives Group and are working through the resource consenting over the next few months. A field trial for the drainage bioreactor has been selected in the Waikato region and the bioreactor was designed and installed in June 2017. Data collection has started to evaluate the performance of the bioreactor.

Modelling Transport of Nutrients and Pathogens in Heterogeneous Aquifers

This project (led by **Murray Close**) is developing and extending our expertise in modelling the transport of pathogens and nutrients in heterogeneous aquifers. This expertise was used in the recent outbreak of Campylobacter in Havelock North via groundwater and ongoing work is being carried out on the survival of the outbreak strain in both oxic and anoxic groundwater. Preliminary results indicate that the outbreak strain may survive longer than other Campy strains.

We are looking at how the water flow and contaminant transport are impacted by the presence of significant heterogeneity in aquifers and how this affects the way we can model and make predictions about their transport and fate. One approach is to use the T-Progs and ALLUVSIM software to better understand the up-scaling of transport processes in heterogeneous aquifers. The knowledge gained will be used to determine the appropriate approach and level of complexity with respect to heterogeneity that is needed for the prediction of pathogen transport in heterogeneous aquifers.

One key resource that we have for examining transport in heterogeneous aquifers is a novel and comprehensive heat tracer dataset that was collected to study the connection between fast and slow zones in a heterogeneous groundwater system and implications for contaminant transport. **Theo Sarrishas** been analysing this dataset using Modflow/MT3D and has recently submitted a manuscript to J of Hydrology.

Marsden Fund project on Legionellamimics

From June 2017, we have started a new Marsden Fund project (led byLiping Pang) on "A new approach to studyingLegionellamobility and persistence in engineered water systems". We aim to develop novel surrogates that have similar biophysicochemical features to Legionella pneumophilausing food-grade DNA-encapsulated biopolymer microparticles. The surrogates' mimicry will be validated alongside with L. pneumophilain

simulated plumbing systems under the influence of disinfectants. We have recruited a Biotechnology PhD and a Microbiology PhD who have enrolled with the University of Canterbury. We also collaborate with the University of Alberta and the University of Calgary. Read more here.

HRC project on assessing pathogen removal in water filtration systems using micro mimics

This project (led by **Liping Pang**) tests our newly developed surrogate technology for assessing the efficacies of protozoan and virus removal in drinking-water filtration systems typically used in New Zealand. It is funded by Health Research Council of New Zealand and commenced in Oct 2016. In collaboration with the Invercargill Water Treatment Plant, 15 pilot trials have been conducted so far with a purpose-built pilot plant and we have obtained some significant findings. More trials will be conducted to test a number of filter media under typical operational conditions. An experimental system has been established at ESR for testing virus removal in point-of-use domestic filters. The test systems is pressurised and simulates the operational conditions of real world. This project collaborates with Invercargill City Council, University of Otago, Community & Public Health and NIWA. Research outcomes will benefit people that use networked supplies involving rapid sand filtration and rural populations that use domestic point-of-use filtration systems. Read more here.

MBIE Smart Ideas project on synthetic DNA tracers

Starting from 1 October 2016, this project (led by **Liping Pang**) develops synthetic DNA tracers (both free and biopolymer-encapsulated) for concurrently tracking multiple sources and pathways of water contamination. The research project collaborates with the University of Calgary, the University of Canterbury, ECan, the CAREX group and Waikato Regional Council. Preliminary experiments have been conducted using 20 different DNA tracers with a soil lysimeter and a groundwater field site, and promising results have been obtained. Read more here.

Groundwater Health Index

This project (led by **Louise Weaver**) is an ESR SSIF project aligned to the NSC Biological Heritage programme. The project extends from the initial ESR core funded project and aims to develop a toolbox for identifying the health status of groundwater from the microbial and macro-invertebrate communities present. These communities are vital for the health of the groundwater as it is these organisms that process contaminants or nutrients entering the groundwater. We have been sampling sites with varying water chemistries and are building a picture of the abundance and diversity of micro and macro-fauna present related to the water chemistry. This is the first step for identifying key species to build into the toolbox.

Other projects

We are working closely with NIWA (**Graham Fenwick**) and Waikato University (**Ian Hogg**) on an aligned project which was funded by NSC Biological Heritage for two years. The project, led by NIWA, is focused on advancing our knowledge of the diversity of micro and macro-fauna present in groundwater across New Zealand. We are currently underway with sampling at sites on the North and South Islands.

Hazel Clemens (Waterways Masters student) is busy working on her project aimed at improving knowledge on the transport of viral pathogens from on-site wastewater treatment systems into groundwater. Hazel will focus on the transport of rotovirus in laboratory experiments using intact cores from the Canterbury region. Hazel will also use rotavirus surrogates to validate their further use in field trial assessments at a later date.

We are involved in an MBIE Smart Ideas project led by **Kim Handley** (UoA), investigating nitrate contaminant pathways in groundwater, which has just started (October 2017). The project will use next generation sequencing (genomics and transcriptomics) to identify microbial processes occurring down a contaminant gradient. The project team are **Dr Kim Handley, DrLouise Weaver**, **Murray Close** and **Dr Chris Daughney** (GNS).

We are continuing to investigate the potential for wastewater enzymes for virus inactivation and **Amanda Inglis** has recently been awarded an Emerging Innovator award by KiwiNet. We are planning to extend the identification of enzymes for inactivation of other contaminants, including emerging contaminants. This work will involve the Centre for Integrated Biowaste Research (CIBR) team members, **Louis Trembley** (Cawthron) and **Grant Northcott.**

Staff Changes

Bronwyn Humphries is back from maternity leave this year, and **Laura Banasiakhas** joined the team. Postgraduate students that we currently have at ESR:

Amanda Inglis: Investigating waste stabilisation ponds and the potential of enzymes present to inactivate human viruses. PhD Candidate, ESR Supervisor: Louise Weaver.

Annabelle Tham: Assessing protozoan & virus removal in drinking-water filtration systems using new surrogate technology. PhD Candidate, ESR Supervisor: Liping Pang.

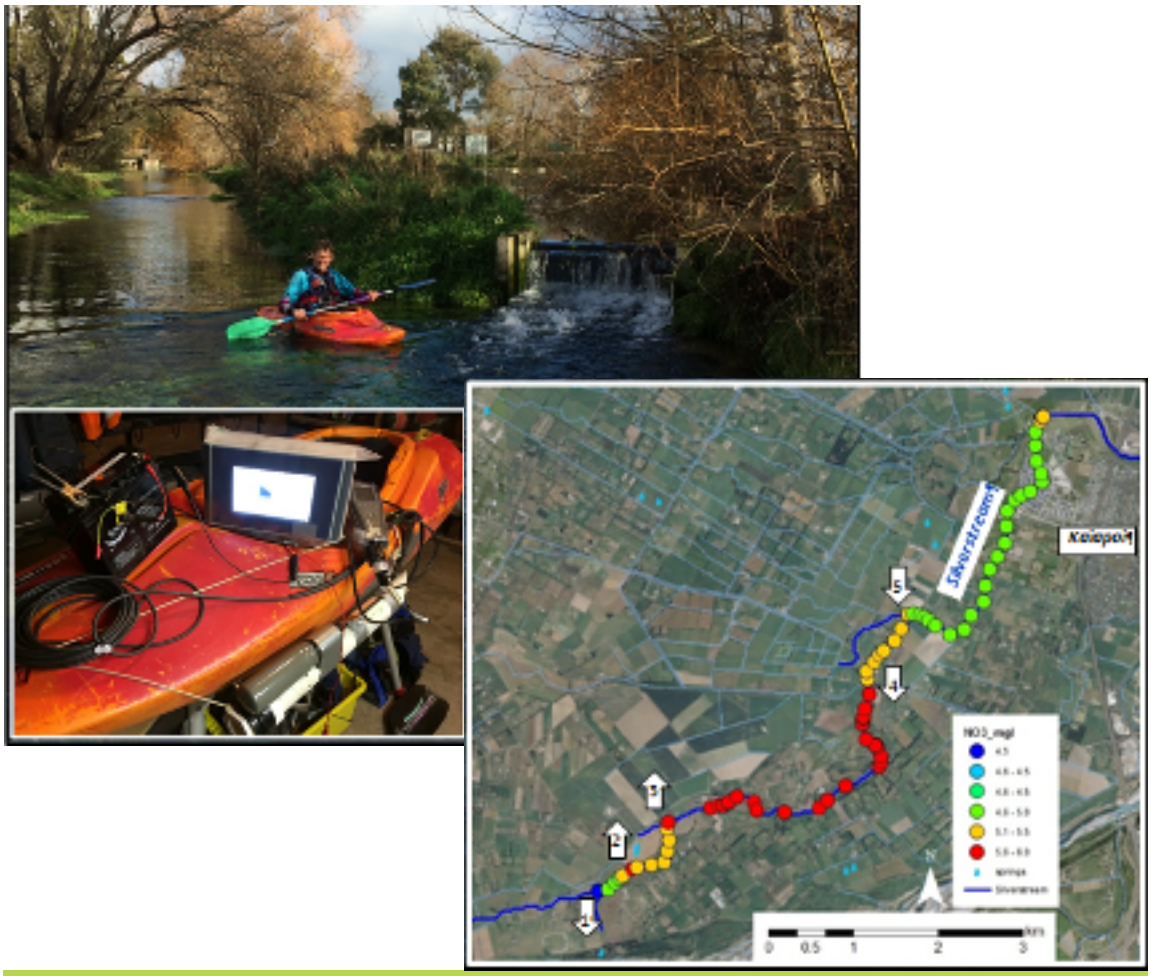
Dinesh Bhandari: Legionella mobility and persistence in engineered water systems using micro mimics. PhD Candidate, ESR Supervisor: Liping Pang.

Kyrin Hanning: Tracking sources and pathways of water contamination using synthetic DNA tracers. PhD Candidate, ESR Supervisor: Liping Pang.

Sujani Ariyadasa: Developing micro mimics for investigating Legionella mobility and persistence in plumbing systems. PhD Candidate, ESR Supervisor: Liping Pang.

Bronwyn Humphries: Investigating the microbial removal properties of coral beach sand. Masters Candidate, ESR Supervisor: Louise Weaver.

Hazel Clemens: Investigating virus transport from on-site wastewater systems to improve set-back distance guidelines. Masters Candidate, ESR Supervisor: Louise Weaver.



Phil Abraham enjoying a day out the office during ESR 's real-time survey of Silverstream, Kaiapoi. A TRIOS Opus optical nitrate sensor, YSI Proplus sensor and GPS tracking produced a high resolution dataset.Nitrate concentrations range from < 4.5 mg/L (blue dots) to > 6 mg/L (red dots).Decreased concentrations at points 1, 4 and 5 and increases at points 2 and 3 correspond inputs from alpine river sourced springs and tile drain-fed creeks.

Peer-reviewed publications published since November 2016

Burbery L, Moore CR, Jones MA, Abraham PM, Humphries B, Close ME. 2017. Study of connectivity of open framework gravel facies in the Canterbury Plains Aquifer using smoke as a tracer. Ventra D & Clarke LE (eds). Geology and Geomorphology of Alluvial and Fluvial Fans: From Terrestrial to Planetary Perspectives. Geological Society of London, Special Publications, 440, https://doi.org/10.1144/SP440.10

Close M, Humphries B. 2016. 2014 national survey of pesticides in groundwater in New Zealand. Journal of Hydrology (NZ) 55: 73-88.

Pang L, Robson B, Farkas K, McGill E, Varsani A, Gillot L, Li J, Abraham P. 2017. Tracking effluent discharges in undisturbed stony soil and alluvial gravel aquifer using synthetic DNA tracers.Sci. Total. Environ.592:144-52.

Schijven J, Pang L, and Ying GG. 2017. Evaluation of subsurface microbial transport using microbial indicators, surrogates and tracers. In: J.B. Rose and B. Jiménez-Cisneros (eds)Global Water Pathogens Project. http://www.waterpathogens.org. Michigan State University, E. Lansing, MI, UNESCO.

White PA, Close ME. 2016. Groundwater systems. In "Advances in New Zealand Freshwater Science" Eds Jellyman P, Davie T, Pearson C, Harding J. New Zealand Hydrological Society and New Zealand Limnological Society. p 325 - 343.

Aqualinc

COMPILED BY: **Tim Kerr**

Darcy Lecture

Through **Helen Rutter**, Aqualinc co-hosted the 2017 Darcy Lecture in Christchurch at the end of August. The Henry Darcy Distinguished Lecture Series in Groundwater Science has been running since 1987 and is funded through the U.S. National Ground Water Association. This year, **Dr Kamina Singha**, a professor in the Department of Geology and Geological Engineering and the associate director of the Hydrologic Science and Engineering Program at the Colorado School of Mines, travelled the world to share her knowledge of the intricacies of contaminant transport in groundwater. Over a hundred people attended, being a mix of hydrologists, academics and interested public. It was a very informative lecture, and great to have a world leader in her field presenting in Christchurch.

Staff changes

Aqualinc wishes all the best to **Channa Rajanyaka**, who, after more than ten years, has left our Hamilton office to start work for NIWA in their Christchurch office.

Meanwhile, we have welcomed **Aroon Parshotamas** (right), our newest scientist to our Hamilton office. To complete the circle, Aroon used to work for NIWA a few years back as a catchment modelling scientist. His experience is broad with recent experience as Science Leader of the University of Waikato Lake Ecosystem Restoration New Zealand (LERNZ) programme, and as a Chemometrician in the milk industry.

Continued demand for the services of the HydroServices division of Aqualinc has led to the recent new appointments of **Hamish Maxwell** (left) as an Irrigation Management technician and **Olivia Cranney** (right) as a Research Scientist. With the onset of the irrigation season, seven students have been taken on for the summer fieldwork. This important work includes carrying out neutron-probe soil moisture measurements throughout the country.

Land use consenting

Aqualinc is increasing its capability to meet the demand for Land Use Consents. **Sarah Hayman** has recently joined **Nicole Matheson** in gaining the advanced accreditation for Sustainable Nutrient Management in New Zealand Agriculture, while new recruit **Olivia Cranney** has gained her intermediate accreditation. This enables them all to prepare Overseer nutrient budgets for farms, a necessary part of land use consents. In addition, **Nicole Matheson** has become qualified as an ECan certified Farm Environment Plan auditor.

Next generation telemetry

Thanks to **Scott McQueen**, our telemetry expert, HydroServices now have very long range low data rate (LoRa) telemetry system capability. This new approach to telemetry utilises low cost, radio frequency internet communication via a regional internet gateway. No longer does every sensor require an expensive mobile phone modem, drastically cutting the ongoing charges of running a telemetry system.

Ground Source Heat Pump Systems

Mark Flintoft and **Helen Rutter** have been helping with the Christchurch rebuild through their involvement in testing and consulting for ground source heat pump installations at the Christchurch Arts Centre, Bus Interchange and Central Library. Ground source heat pumps are 40-60 % more energy efficient than traditional air conditioning systems which greatly reduces on-going costs. The rebuild, combined with the introduction of a permitted activity rule in Christchurch, has resulted in a huge uptake of this technology, and Aqualinc, through its aquifer testing and consents teams provide data, analysis and information to support these schemes. **Helen Rutter**,together with other members of the Geothermal Heating Association of NZ (GHANZ), organised a one day seminar looking at these systems in Christchurch.

Saved by the weather

Recent record low aquifer levels in Canterbury have caused concern in the region. Analysis and modelling efforts by **Julian Weir** indicate that irrigation pumping had exacerbated the low aquifer levels, as would be expected. This winter's weather has washed away the groundwater level concern with recovery of groundwater aquifers throughout the eastern parts of the country. Director **Tony Davoren** has noted that the continuation of the wet winter into spring has reduced irrigation demand for October to very low levels.

Contaminant pathways research **Greg Barkle** has been working with a team from Lincoln Agritech on an MBIE funded project to understand the pathways that contaminants take from the farm paddock on their way to the receiving water body. They're measuring the contaminant loads from artificial drains at two research sites. After their second year of monitoring they have found that the nitrogen load discharged is biased towards the

timing of when drainage starts. The earlier it starts in the year, the higher the nitrogen concentrations.

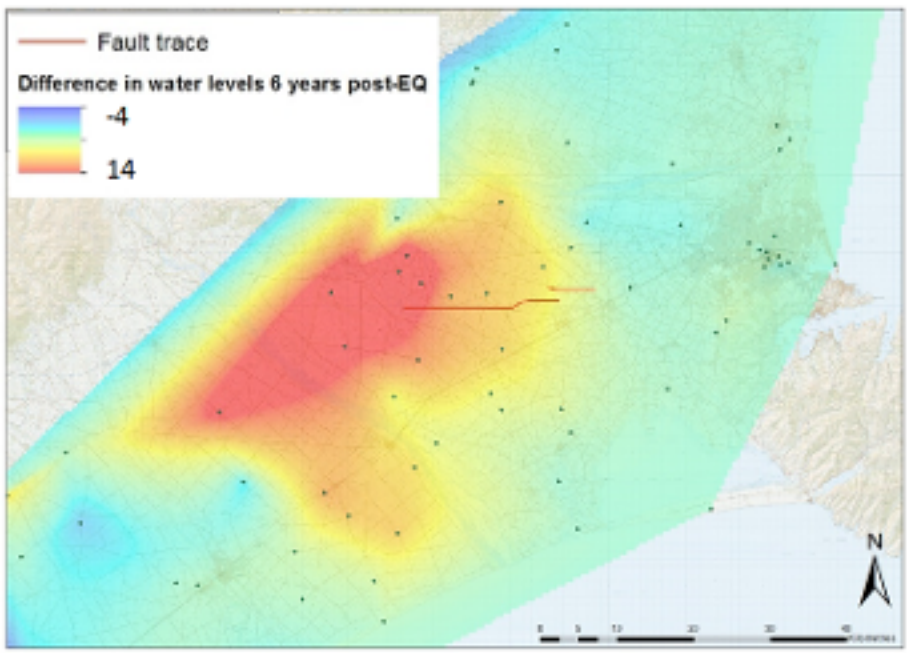
Aquifer testing

Dan Farrow, Ross Hector and **Mark Flintoft** have been busy over the last six months undertaking aquifer tests. Each winter they can be seen with their trailer of monitoring equipment checking the impacts of new or upgraded abstraction wells on aquifer levels. Their analyses are crucial for groundwater use consent applications.

Aqualinc pump test trailer ready to test a new bore

Earthquake changes in aquifer here to stay

Re-analysis of groundwater levels six years after the Darfield Earthquake has recently been completed by **Helen Rutter** and **Julian Weir** for ECan.They found that, while areas to the east of the Greendale Fault have largely recovered, the deeper aquifers across mid Canterbury, at the western end of the fault zone still show up to a 12 m increase in median groundwater level. This indicates the groundwater level changes that occurred post-EQ are a function of the aquifer material itself rather than a short-term hydrological response. This new evidence supports earlier published work that suggested the increase in groundwater levels at the western end of the fault was a result of a reduction in permeability of the aquifer system (Rutter et al 2016)



Observed persistent changes in median groundwater levels following the magnitude 7.1 Darfield earthquake

Opus International Consultants Ltd

COMPILED BY: **Lizzie Fox**

Staffing

The Water Resources team, based in the Wellington office of Opus, has grown over the last couple of years. **Matt Balkham** leads the team as Work Group Manager, providing expert engineering advice alongside **Dr Jack McConchie**, the Technical Principal of Hydrology and Geomorphology. **Franciscus (Kos) Maas, Louise Algeo, Daniel McMullan** and **Ana Serrano** are our Hydraulic Engineers and Modellers, with specialties in fluvial and coastal modelling and design. **Sheryl Paine, Samwell Warren, Lizzie Fox** and **Kirsty Duff** are Water Resource Scientists and Hydrologists, carrying out hydrological assessments and database management. We have recently welcomed **Ella Boam** on board as our Groundwater Scientist. This brings up the Water Resources team to 11 individuals, who are part of the wider Environmental Team within Wellington and across the country.

Projects

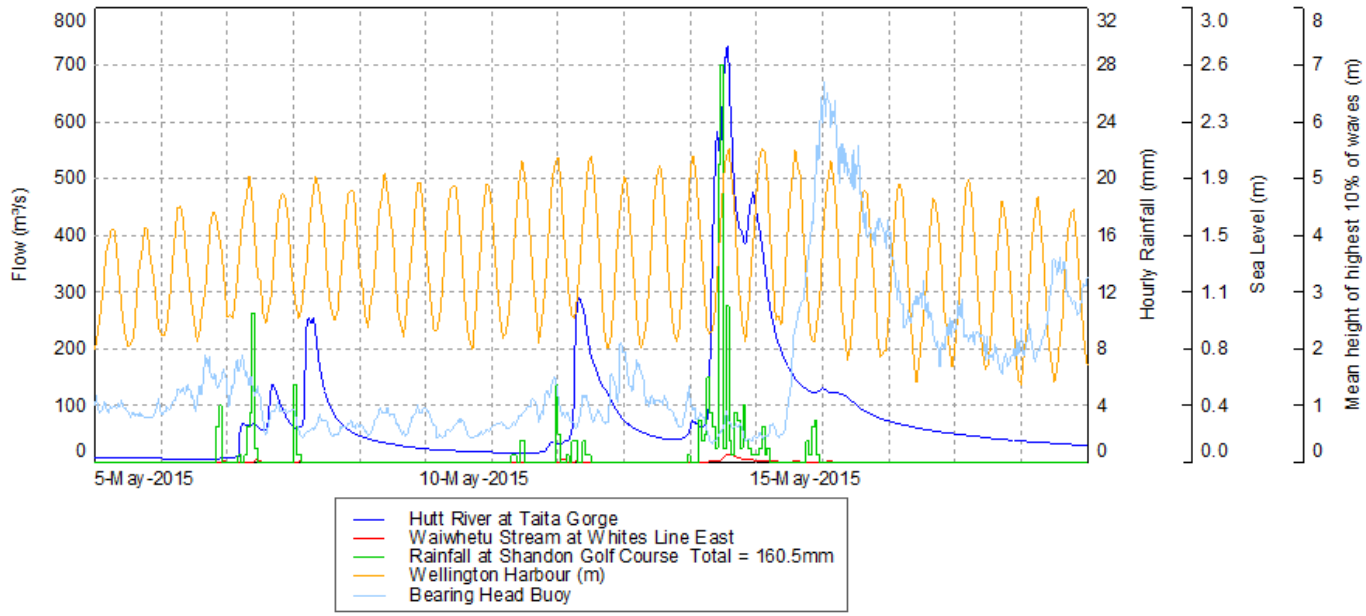
Some of the key projects that the team has worked on over the last year that highlight their expertise are described below.

Hydrological risk and hazard assessments

A growing area of work for the Water Resources Team is conducting hydrological risk and resilience assessments of site assets and operations for our clients.This involves collection of environmental data from various agencies, quality assessment of the collated data, analysis of the data, and in some cases modelling of extreme events. Outputs from this work help our clients to assess the risk of their sites to hydrological events, providing them invaluable information on how best to manage their site operations to reduce the hazards to both assets and people.

An example of such work was carried out for a private company located adjacent to the Wellington Harbour. The site has flooded historically, but in recent years the frequency has increased, disrupting operations. A hydrological assessment was therefore undertaken by Opus to investigate the dominant flooding mechanisms, and to provide recommendations for the management of the flood risk to the site. The analysis also explored any correlation between the various sources of flooding (water level and wave

action in the harbour, river flows in the local rivers and rainfall leading to flows in the stormwater drains) that have the potential to affect operations and infrastructure. The assessment showed that recent flooding at this site was the result of a combination of factors, specifically the coincidence of a high tide, increased wave height (southerly swells or storm surge) and intense rainfall, rather than a single cause (see graph below). This combination of factors is not a rare occurrence at this site and therefore a more extreme event of any of the factors has the potential to cause greater inundation. This led to hydraulic modelling of the site, further identifying the key areas and assets that are at risk of inundation, and from what source i.e. coastal, fluvial or pluvial flooding. Final recommendations were proposed to the client on how to best manage or reduce the risk where possible.



Example of a flooding event at the site location, comparing the sea level, wave height, flows and rainfall that contributed to the event.

Coastal Flooding & Erosion

Along with 'traditional' rainfall and flow analysis, we also carry out coastal inundation and erosion analysis.1D, 2D and 3D numerical models are used to simulate offshore and nearshore hydrodynamics. This helps in the design of seawalls, breakwaters and erosion protection structures; depending on the required level of service. These models can also include future scenarios including climate change, as well as modelling extreme coastal events.

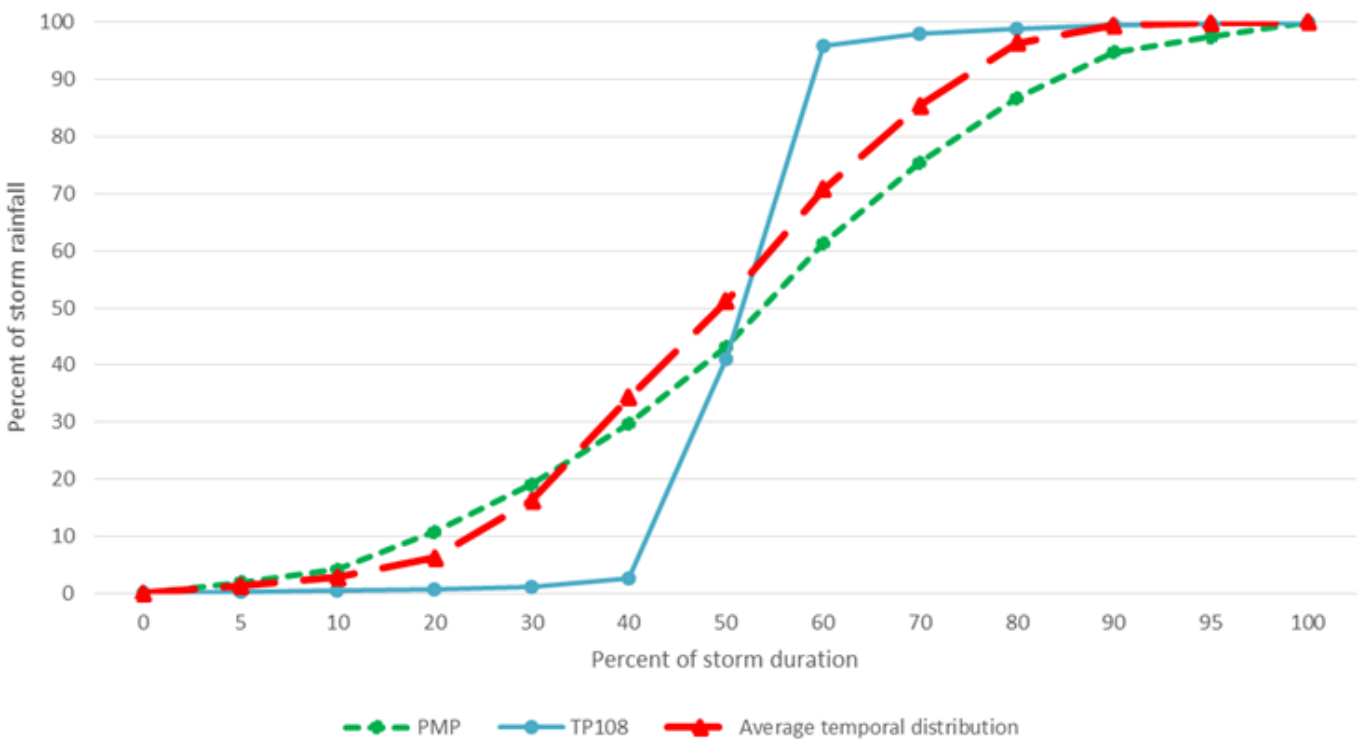
One such project that incorporated coastal modelling and expertise was developing a concept design to manage erosion along the Granity coastline, on the West Coast of the South Island. Extensive UAV (Unmanned Aerial Vehicle) aerial surveying was conducted along the coastline to determine the topography, which was coupled with available

bathymetry to create a high resolution DTM of the area of interest.Various magnitude and frequency events were modelled to determine the inundation of the coast using different concept design structures. This assessed the current predicted extent of coastal flooding and potential erosion, and what design would minimise this effectively.

Design Rainfall

Determining the spatial and temporal resolution of precipitation, along with the duration and frequency of rainfall events of a given area, is a key component to any hydraulic or hydrologic model.The Water Resources team at Opus have extensive experience in such analysis, and frequently carry out such requests and projects for our clients.

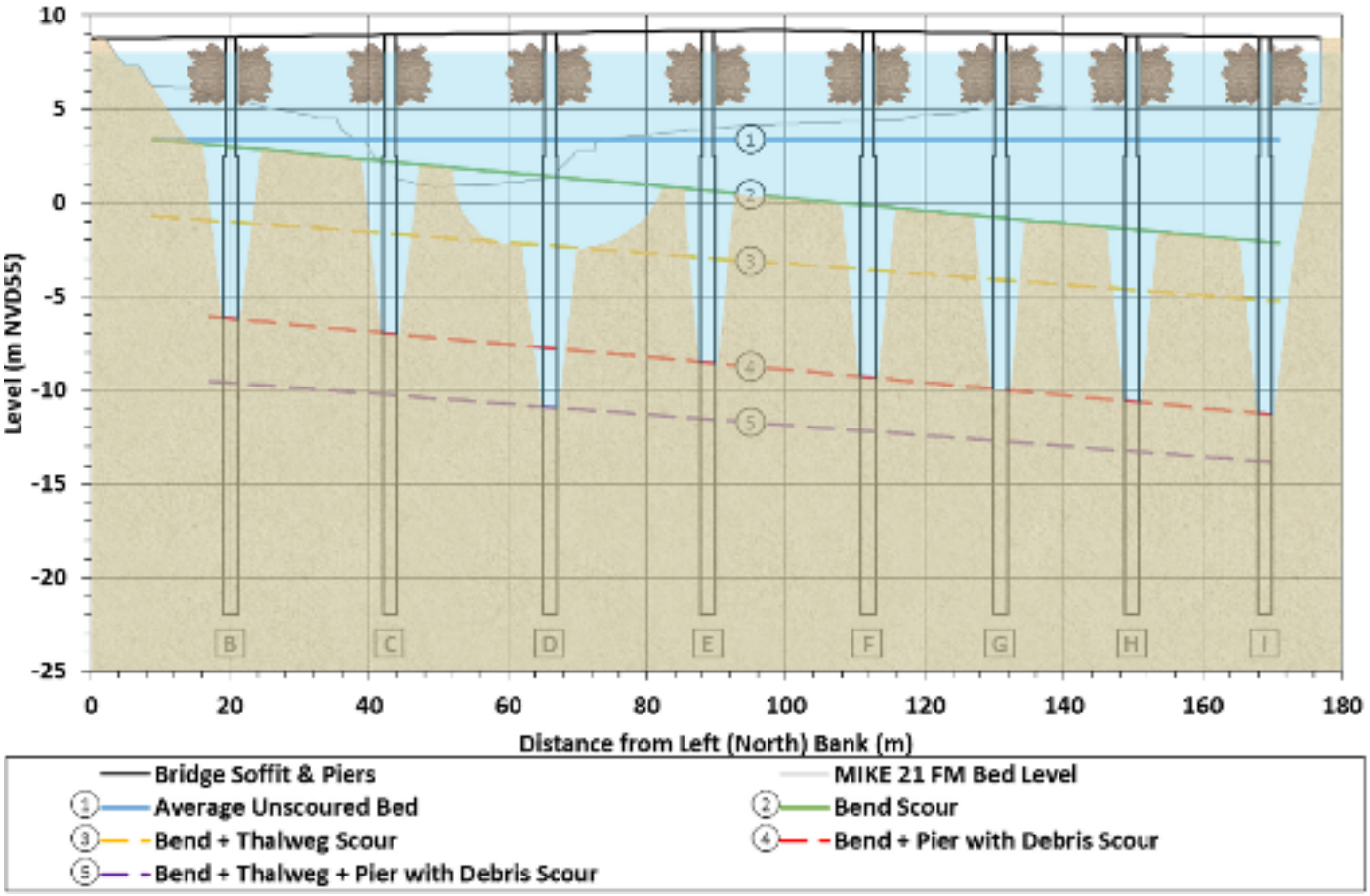
A recent project involved determining the precipitation pattern of part of the Waikato region.This was to be used as part of a hydraulic model to inform an overland flow path assessment. This involved extensive data collection of the available rainfall data, quality assurance and 'fit for purpose' determination of the data, frequency distribution analysis of the records, and assessment of the spatial and temporal variability of rainfall events across the region. Of particular interest was determining the temporal pattern of rainfall events.A common practise is the use of PMP or TP108 to characterise the distribution of rainfall over a given rainfall duration. It was demonstrated that for the rainfall gauges analysed, the temporal distribution closely matched that of the PMP distribution, rather than the TP108 (see graph below). Analysing the actual rainfall events captured by a gauge can allow a more accurate temporal pattern to be used in the model, thus estimating the overland flow paths to a higher degree of certainty.



Comparison of the average temporal distribution of rainfall within the Waikato project area and the PMP and TP108 temporal distributions for a 24-hour rainfall event.

Design of structures in rivers

Another service we provide is hydrological assessments for river channel structure design. Not only are these assessments important for the structural design process (ensuring resilient infrastructure), they also provide information to help understand how the structure may impact on the geomorphology of the channel, potentially causing scour or aggradation of the river bed, as shown by the figure below. The design of appropriate scour protection may therefore be required. Analysis of the flow regime significantly aids the design of these structures, reducing negative impacts and resulting in stable, long lasting infrastructure. Recent examples over the last year that Opus has been a part of include the design of new cycle way and road bridges for a number of local authorities, and the analysis and design of existing and new bridges for the NZTA's State Highway network. In some cases, the results of these analyses have resulted in a redesign of the foundations of a number of new bridges or the provision of significant amounts of scour protection.



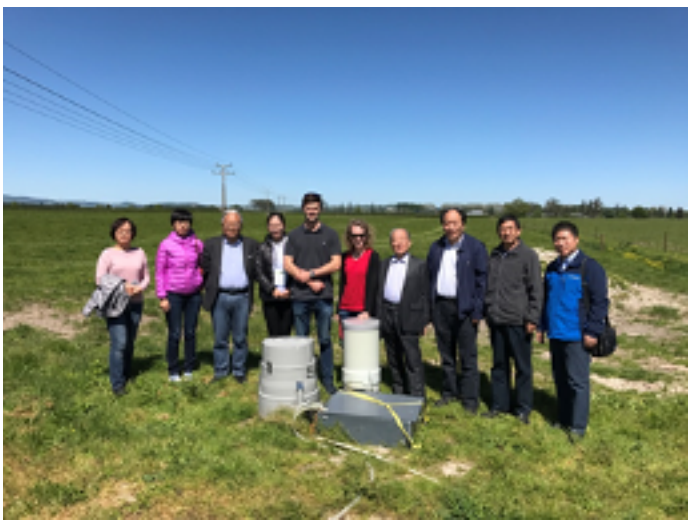
Results of a scour analysis during a design event of a proposed bridge.

News from Lincoln Agritech Ltd

COMPILED BY: Juliet Clague

Our esteemed colleague **Dr Ian Woodhead** was honoured by the Royal Society last month by being awarded the Scott Engineering Medal. This award is based on recognition by his peers across the scientific community for his career and outstanding advancement to the engineering sciences. Dr Woodhead has a particular interest in developing agricultural and environmental sensors such as an electronic soil moisture sensor called Aquaflex, which paved the way for more efficient irrigation systems, allowing farmers to use water more sustainably. He also invented a new technique to measure water distribution within materials, such as moisture profile in soil and water distribution in timber.He also leads the Agricultural and Environment Technologies portfolio of the National Science Challenge: Science for Technological Innovation.

After the International Tri-Conference for Precision Agriculture (PA17) in Hamilton last month, the Hamilton office of Lincoln Agritech hosted some visiting scientists from China Agricultural University in Beijing. A demonstration of our well installation technique was given (photo at left) and then the group were taken to see our nearby field sites, including the denitrifying bioreactor for the treatment of tile drain discharges near Morrinsville (photo at right).



Left photo: Demonstration of well installation at the LAL Hamilton office.

Right photo: Visiting scientists from China Agricultural University and LAL staff members **Tasman McKelvey** and **Juliet Clague** inspect the denitrifying bioreactor near Morrinsville.

The excessively wet autumn, winter and spring we've had in the Waikato has kept the Hamilton team busy servicing our Hauraki field sites, with double the rainfall and drainage in the 2017 season compared to last year resulting in a lot of samples to process from the subsurface drainage sites. But we did manage to get some groundwater sampling done in between the periods of rain.

Juliet Clague carrys out low flow groundwater sampling at Tatuanui, near Morrinsville

Funded project updates

The Society is currently supporting several students through funding grants to assist with their studies. The following are updates and progress reports from some of the students.

Hydrological limits setting: the missing tool for river management

Andrew Neverman, PhD candidate, Massey University

The NZHS supported my PhD project with a 2016 Project Grant. The grant was used to install differential piezometers to study the relationship between bedload transport initiation and seepage direction in gravel bed rivers. This project has been successful, with six bedload events captured, and some interesting relationships with seepage direction identified, which we think are a world first. Pilot results were recently presented at EGU 2017 in Vienna. I am currently writing the full results up for a chapter in my thesis, and will be presenting my findings at the Society conference in Napier, followed by a report for Current. I sincerely thank the NZHS for supporting my project and enabling me to find such interesting results for my PhD.

Impact of allocation on water through the Pool Burn

Henrietta Jackson, MSc candidate, University of Otago

I am now approaching the two year mark of my Master's of Science research at the University of Otago, where I am looking to complete my thesis on assessing the water flux of the Poolburn catchment and the associated effects on stream health. I hope to understand the longitudinal and temporal variations in key hydrological parameters and water quality variables, and whether a minimum flow can be established from this approach. Essentially, I want to understand whether a minimum flow value will suffice in protecting water resources and ecosystem function for this reach and where potential improvements to the stream are needed. Water level equipment was installed down the catchment in October 2016, and monthly sampling trips were completed over the course of the year till October 2017, carrying out discharge gaugings and water quality sampling at seven established monitoring sites. I envisage that I will have a full data set by the end of October 2017 and plan to finish my thesis in the next five months.

Pathways for nutrient contamination of Barkers Creek catchment, south Canterbury

Hamish Graham, MSc candidate, University of Canterbury

My Barkers Creek project has recently finished its data collection phase. This involved one year of water quality sampling (both surface water and groundwater, five SW sites fortnightly and 19 SW and five GW sites bi-monthly) combined with automated surface water flow (two sites) and groundwater level monitoring (four sites). There was also surface water quality samples collected over the course of three flood events using an autosampler. Samples were analysed for N, P and TSS with the first round of sampling having chemistry done also. I am now moving into the data analysis and writing phase with an expected completion date of February 2019.

Thanks again for the support from NZHS.

Measuring seasonal snow in the Pisa Range with a remotely piloted aircraft system

Todd Redpath, PhD candidate, University of Otago

This past winter has seen a successful field campaign continue in the Pisa Range, enabled by a NZHS Project Grant. Over the course of the winter, four remotely piloted aircraft system (RPAS) missions were undertaken. During each of these missions, the study basin (a tributary of the Leopold Burn in the Pisa Range) was flown by the RPAS, enabling the entire 0.4 km^2basin to be photogrammetrically mapped, and snow depth derived, at four epochs:

-23/07/2017: a mid-winter snow pack;

-22/08/2017: snow pack close to peak accumulation;

-22/09/2017: mid-ablation;

-12/10/2017: late-ablation.

The completed missions provide a good temporal coverage throughout the snow season enabling the characterisation of the snowpack at key points in time. Data from these flights (0.015m resolution, spatially continuous, maps of snow depth and water equivalent), will be analysed over coming months and are expected to provide new insights into seasonal snow processes and variability in support of coarser scale remote sensing observations and snow modelling efforts. Preliminary results from this research will be presented at the NZHS conference in Napier in November.

Student travel and project grants for 2018

At the 2017 NZHS executive committee meeting, the members considered student travel and project grant requests and awarded the following:

Andrew Neverman received a grant-in-aid to attend and present his science work at the 2017 NZHS Annual Symposium at Napier. Andrew is currently pursuing his doctoral degree at Massey University, Palmerston North.

Christina Bright received a travel support ($1500) to attend the Integrated Hydrosystem Modelling Conference at the University of Tubingen, Stuttgart Germany, and the European Geosciences Union General Assembly (EGU) in Vienna, Austria. Both conferences take place in April 2018. Christina is pursuing her doctoral degree at Otago University in Dunedin.

Nicole Calder-Steele has been awarded a project grant ($3200). Her research aspires to combine biophysical and social sciences in examining the application of integrated catchment management systems as a body of knowledge and its benefits and limitations to managing irrigation schemes. Nicole is working towards her master's degree at the Waterways Centre for Freshwater Management, University of Canterbury, Christchurch.

37th IAHR World Congress in Malaysia

AUTHOR: Tingting Hao, University of Auckland

Between 14 August and 18 August, the 37th International Association for Hydro-Environment Engineering and Research (IAHR) World Congress was held at the Putra World Trade Centre (PWTC), Kuala Lumpur, Malaysia. The congress was attended by over 1100 experts and delegates in the water industry from 61 countries.

The Opening Ceremony was on the first day. Every day, there were two plenary talks in the morning, thereafter, parallel technical sessions followed in various rooms. The congress was organized around seven themes: River and sediment management; flood management; environmental hydraulics and industrial flows; coastal, estuaries and lakes management; urban water management; water resources management and hydroinformatics / computational methods and experimental methods.

It was an amazing opportunity for me to deliver an oral presentation on the second day. My research aims to determine if common agriculture-based evapotranspiration (ET) equations can be successfully applied in raingardens. Based on the previous literature, there are many equations for estimating ET; many have been developed for agriculture, and are possibly only reliable in the regions and over the periods for which they were developed. It is difficult to say whether these equations are appropriate for rain gardens, because they were developed with specific assumptions, such as idealized climate, a well-watered condition, and a mono-culture vegetation of uniform height. Raingardens do not always meet these requirements because they often have a complex structure, a variety of vegetation types, and uncertain water availability. The Hooton Reserve Raingarden (North Shore, Auckland) was selected as the experimental site. Six different methods were used to calculate ET: Hamon Method, Makkink Method, Hargreaves Method, Jensen-Haise Method, Turc Method and FAO-56 Penman-Monteith Method. All the estimation methods were evaluated against the AET determined using the Bowen Ratio method. ET was calculated at a daily resolution, over a four-week period (04/08/2016-31/08/2016). A comparison of different agriculture-based ET methods showed that there are great differences in their performance; overall, the Jensen-Haise Method has the closest relationship with Bowen Ratio method, and it is concluded that it is the most accurate approach for estimating ET from the Hooton Reserve Raingarden (for August 2016). Future work will involve more agriculture-based ET equations and data collected for a longer period of time. A similar evaluation for other low impact development applications (vegetated rooftops, vegetated traffic island, etc.) would also produce practical benefits.

And, I was fortunate enough to get some feedback from international researchers from the same field, which enhanced my knowledge of hydrometeorology and stormwater management. This feedback may inform the possible methods and recommendations for my future research.

The IAHR World Congress is an important international event related to water issues and is organized every two years. It was an excellent opportunity to present the results of NZ based research to a wide, international audience. My sincere thanks to the NZHS for the travel grant, as it gave me this wonderful journey.

James Cook Memorial, Waihou River

The Society provided a small project grant in 2015 to assist with the development of a memorial site to James Cook's landing in the Firth of Thames 250 years ago.

The following is an article by **Gary Blake** who has been heavily involved in the project, and especially in producing a 'hydrological history' for the memorial site information boards.

1769 - Captain Cook's approach up the Waihou River

In November 1769 Captain James Cook and HMB Endeavour spent 13 days on maintenance duties in Whitianga harbour before departing around Cape Colville to anchor in the Firth of Thames, at Waiomu, 19 November. On 20 November and a flood tide, an exploratory party plus marines, in two row boats, traveled south to the Waihou river, about 20km. The scene reminded Cook of the London river Thames and Joseph Banks was amazed at the amount of mud present.

The landing

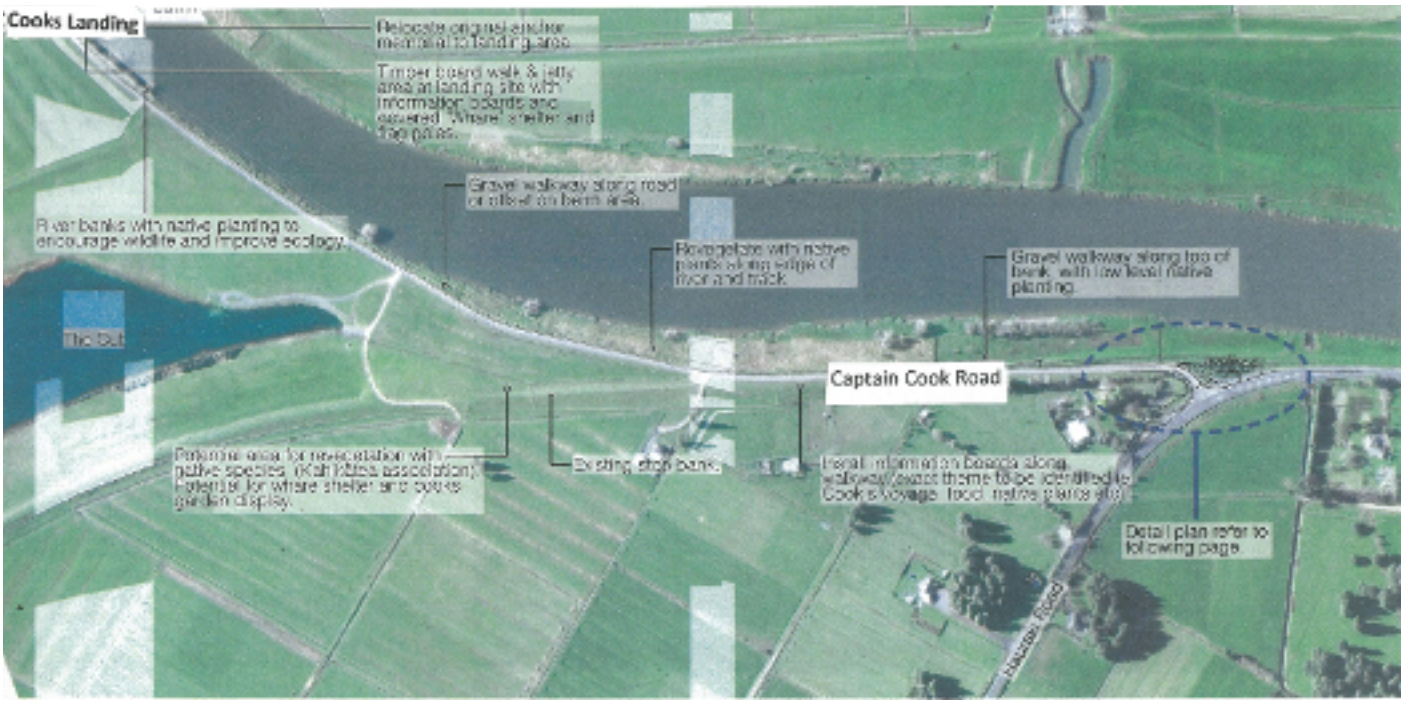
They had little contact with Maori as they traveled 22km upstream to their landing site on the left bank and now marked by the 200th Anniversary Cairn of Cook's visit. They reached the site about noon and they were there until 3pm. Cook also commented on the mud and the project plans a jetty for the landing site. They were impressed with the quality of the forest and they measured a large kahikatea tree which we believe grew 20 metres inland from the cairn. Joseph Banks was a Royal Society stalwart and an ecologist with a wealthy agricultural background. He believed the plains could be drained to grow vegetables and other produce for mother England.

Camping overnight

At 3pm, on the ebb tide, the boats departed for HMB Endeavour only to be stopped at the river mouth by a choppy sea, a combination of wind and tide. They camped in the boats and made it to Endeavour the next day. Cook seldom made it this far inland and his excellent mapping of Aotearoa/New Zealand meant that all the data collected had a coastal bias.

The 250th Memorial Site

The layout of the Memorial Site is shown below.



The Royal New Zealand Navy anchor is located at the junction of Hauraki and Captain Cook roads. (See photo below). The site was pinpointed from local historical records and the reliable knowledge of local farmers who were also able to comment on the location of the tree Cook measured. We carefully moved the Cook 200th Anniversary Cairn from 2km upstream to the present site. The plaque is still appropriately worded "Near this spot Captain Cook landed on the banks of the river November 1769".

The anchor site (with new information board) is proving popular with the picnicking public and the views across the river to the Coromandel mountains and across the Hauraki plain, dotted with Kahikatea stands and dairy farms, are striking.

Waihou catchment hydrology - 'then' and now

The Waihou catchment has a fascinating geological history. Thornton (1985) in her excellent text NZ Geology revealed the Waikato river, laden with volcanic material, built a dam near Taupiri starting 65,000 years BP. By 25 000 years BP, the blockage was sufficient to divert the Waikato river into the Hauraki Gulf. Five thousand years later it returned to its old course leaving the Waihou and Piako tributaries behind.

The headwaters of the Waihou river is the Mamaku plateau which supplies much of NZ's bottled water near Taupiri. This contrasts with the highly turbid water downstream. As part of the Memorial site, it seemed a useful thing to do to assess the hydrology of the Waihou river since European intervention. An effort has been made to produce estimates for 1769 when the catchment's land use was in a natural state. 1900 was the peak of gold mining at Paeroa and Waihi and mostly in the Ohinemuri tributary. For the present dairy landscape we have jumped a little ahead to 2019 when the 250th Anniversary of Cook's visit will be celebrated. The Celebration is attracting a lot of attention and a full scale replica of HMB Endeavour will be in NZ waters, on loan from Australia, for the event.

The historical hydrology estimates below are the opinions of this author and are based on predictions of land use impacts on hydrology and sediment supply as well as the Society's prolific publications, Hydrology Annuals (Ministry of Works and Development) and historical records. The catchment area at Cook's landing is 1504 km^2.

The pattern seems to be one of a decline in annual rainfall, a small increase in surface runoff and small reduction in low flows due to changes in infiltration and interception

	1769	**1900**	**2019**
Rainfall (mm/year)	1950	1237	1250
Annual flood (m^3/sec)	1203	1237	1250
Minimum flow (m^3/sec)	26	23	21
Suspended sediment (tonnes/year)	121,700	371,700	18,828
Water quality (N, kg/ha/year)	4	10	35
Water quality (P, kg/ha/year)	0.6	0.8	1.16

loss. Nitrogen and phosphorous concentrations reflect the land use change from primeval forest to pasture.

Sediment

The suspended sediment levels exploded during the gold mining period thanks to the Government of the day allowing the annual discharge of 250,000 tonnes of tailings into the Ohinemuri tributary which under flood conditons was spread over the Hauraki plain making early farming difficult. Post 1900 stop banking of the Waihou and Piako rivers and the construction of large drainage canals has confined the rivers and drained the plain. Joseph Bank's sediment observations at the mouth of the Waihou river 1769 are significant and implying a large sediment source that predates 1900 gold mining contributions and which was probably discharged during the Waikato River period. I believe the effect is still being felt today. The river below the Landing site is always turbid. The tidal bore effect stirs the sediment daily from about the landing site to the mouth where contact with the Firth of Thames encourages deposition. We may have a closed sediment system which has been operating for thousands of years. Waikato Regional Council channel cross sections show a reduction in catchment erosion since 1900. The Waihou river is similar to Malacca Strait rivers; It is navigable, turbid, lined with mangroves and has clear water in the upper catchments but no elephants.

The ancient kahikatea forest

The Kahikatea forest covered the Plain at the time of Cook's visit and has been around for a very long time, predating the present mountains. Pollen grains have been dated at 180 million years BP rivalling the tuatara, giant weta and snails (Park, 1996). The Coromandel volcanic mountains date between 17 and 3 million years BP. The sedimentary deposits at the north end of the Peninsula predate the volcanism and possibly produced the environment for the evolution of the Kahikatea association; a truly iconic feature of our landscape. In 2007 with DoC funding we (Waikato Farm Forestry and Waikato Regional Council) surveyed lowland stands throughout the Waikato on 165 farms.

Hugh Thorpe - Dam break analysis for the Whanganui River

COMPILED BY: **MS Srinivisan**

I decided to record some of Hugh's professional work after hearing him recount stories about pioneering hydrology work in NZ. In 2015, I spent couple of hours with Hugh talking about his various hydrological adventures and activities over decades. As one can expect, they were diverse, filled with anecdotes, and importantly, very forward-thinking for those times. Here is Part 4 of 6 where Hugh talks about a dam break analysis on the Whanganui River. [Note: Parts 5 and 6 on Hugh's recollections about the first irrigation well in Canterbury and his involvement in canal surge analysis will be available to read on the NZHS website shortly, as will an audio recording of an interview with Dr Richard Ibbit].

"One of the jobs that I did at the Ministry of Works Central Labs was a dam break analysis. At that point they were considering putting up a hydro dam on the Whanganui, and had spent a significant amount of money drilling tunnels in hills at a place called Atene, and it's not all that far up from Whanganui - probably no more than 30-40 kms. Then they abandoned the idea for various reasons. One of which would have been the concern about the issue of dam failure, and if the dam failed what would happen to Whanganui? "

"We built a physical model of the Whanganui catchment and did a dam break analysis.We were modelling the flow resistance. The Whanganui catchment is gigantic, and although we had a huge laboratory there, it was an old warehouse, it was still not big enough to fit the part of the Whanganui catchment that we needed to fit in. It's such a long, long catchment, and such a gentle gradient by New Zealand standards that there was just a vast volume of water there."

"At the very top end we put in a tank. I had a look at all the contours back up there, made an estimate of the land elevation and the water which would have been stored, and attempted to reproduce that in this tank.We were attempting to study what would have been a hyper, mega flood if the dam broke.And there was not a lot of actual flood data collected."

"We had a look at the best flood data we had, looked at the flood way, and we roughened our model at the lower parts of the channel so that we could reproduce that particular flood event.We made a gross assumption that the sort of roughness that we were putting in the lower part of the valley walls, we could extend it up the side of the valley walls to the height of the dam. Those are the days before you had sophistic computer modelling of

flood routing.So we built our model with all these assumptions and caveats built into it.And the actual dam itself was made out of a mixture of sand and heavy grease so we could hand mould it to the correct height.Then we filled the reservoir in behind it and then we broke the dam."

"First of all we decided to break it catastrophically and rip the thing out, And then what happened was that Whanganui just vanished under metres of water.So then we went ahead and broke it gently.We just sort of scoop it out, scoop it out, scoop it out.Didn't matter, there was so much water back in the reservoir that Whanganui just got drowned.And so that I think would have been a major factor as to why they never ever went ahead with that dam on the Whanganui."

"In the 1940s, I really think the dam designs were probably very crude in terms of thinking about the hydrological effects in dam break and so on.But the Whanganui job had an unusual minor spin off. About 1968 there was a big earthquake over on the West Coast, the Inangahua Earthquake, which resulted in a large landslide that blocked the Buller River.And I remember it quite well because we felt that earthquake in Wellington, and it was early morning.And that night I was at home and the phone rang and it was Bill Duncan, the chief power engineer. He knew that I'd done this dam break analysis in Whanganui, and said," Look Hugh, we're a bit worried about the Buller River, it's blocked, and Westport's down at the mouth. We want to know what's the risk to Westport because we might have to evacuate the town." So I jumped into my car and I went down to the lab, Got the topographic maps out, and sat down and did a bit of hard thinking and some very, very rough calculations. Then rang Bill Duncan and said, "I think it will be all right Bill, even if it goes in a hurry I don't think there's going to be enough water stored behind that landslide to worry Westport.At worst it would be a serious flood"."

"It turned out, and not surprisingly, that that landslide did not fail catastrophically.It came down as a mixture of huge rocks and little rocks and sand and mud, just all mixed up.The fine stuff washed away first, then the sand, and then the small rocks, and still today I think there are some big rocks there in the bottom of the Buller River.But the dam failure was slow and so the release of water was slow, and so I don't think Westport even noticed what had happened."