# NATURAL HAZARDS 2015

Latest on the Alpine Fault

RiskScape at Home & Abroad

Platform's New Research Projects

NATURAL HAZARDS RESEARCH PLATFORM

## Cover credits

**Front:** Pilar Villamor (right, GNS Science) and PhD student Monica Giona Bucci (left, Lincoln University) examine liquefaction at Pines Beach, Christchurch following the earthquake on 14 February 2016.

**Back:** Julian Thomson (GNS Science) controls the drone overhead at Pines Beach. Drone images allow scientists to quickly survey vast areas of land for signs of damage.

## Citation

Pinal, C and Brackley, H. (Eds.) 2016. Natural Hazards 2015. Lower Hutt, NZ: GNS Science. GNS Science Miscellaneous Series 88, 44 p.

Our thanks to Eileen McSaveney (GNS Science) and Colin Barkus (NIWA) for their editorial assistance.

GNS Science Miscellaneous Series 88

ISSN 1177-2441 (Print)

ISSN 1172-2886 (Online)

# CONTENTS

# FOREWORD

## There's never really a quiet time in New Zealand when it comes to natural hazards and 2015 has been no exception.

With several earthquakes – the M6.0 Wilberforce earthquake in January and the M8.3 Chile earthquake/tsunami-threat in September which resulted in tsunami warnings being issued for New Zealand coastlines; weather-related events – Tropical Cyclone Pam in March; significant flood events over May-June in Wellington, Dunedin, the West Coast, Taranaki, Manawatu and Whanganui, and dry conditions leading to drought in the parts of the South Island – this has been illustrated all too clearly.

The response to and recovery from these events again demonstrates the importance of working together in times of emergency by the people involved in the science community, emergency services, local and central government, lifeline utilities, private and not-for-profit sectors. It also emphasises the on-going need to assess our natural hazards and the risks from those hazards both pre- and post-event.

A key priority for the next two years is the development of a National Disaster Resilience Strategy. The current Strategy has guided effective Civil Defence Emergency Management (CDEM) for almost 14 years, resulting in solid emergency response arrangements, increased recognition of CDEM as a profession and improved integration of activities across stakeholders. However strong our response efforts are, New Zealand is still faced with an increased awareness of its hazards and the effects that these can have on our communities.

There are significant opportunities to strengthen New Zealand's ability to minimise the consequences of disasters on our communities. The shocks, crises, and emergencies that New Zealand will inevitably face do not need to become 'disasters' that compromise our prosperity and living standards. International best practise suggests that for New Zealand to achieve its vision of resilience, a collective effort should shift the focus to 'managing risk' rather than 'managing disasters'.

In March 2015 New Zealand made a commitment to the international Sendai Framework for Disaster Risk Reduction. Within 15 years the Framework seeks to achieve:

"The substantial reduction of disaster risk and losses in lives, livelihoods and health and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries."

The intent for New Zealand is that we examine our current work and consider where efforts could be better targeted to yield the greatest benefit across four priority areas:

1. Understanding disaster risk;
2. Strengthening governance to manage disaster risk;
3. Investing in disaster risk reduction for resilience;
4. Enhancing disaster preparedness for effective response, recovery, rehabilitation and reconstruction.

This is a unique opportunity for us to deepen relationships between the science community, local and central government, the private and not-for-profit sectors and, most importantly, with our communities to think ambitiously about how we can all contribute to building a resilient New Zealand.

I hope you enjoy this edition of Natural Hazards 2015. The coming year promises to be no less busy for everyone involved in natural hazards research and disaster risk reduction, and I look forward to working with many of you throughout the year, including through the development of the National Disaster Resilience Strategy.

Sarah Stuart-Black
Director
Ministry of Civil Defence & Emergency Management

# PLATFORM MANAGER'S PERSPECTIVE

Members of the Platform Management Group (l-r): Peter Benfell, Opus Research; Sam Dean, NIWA; Gill Jolly, GNS Science; Hannah Brackley, Platform Manager; Peter Kemp, Massey University. Absent: Pierre Quenneville, University of Auckland; Rajesh Dhakal, University of Canterbury

Welcome to another edition of Natural Hazards. You may have noticed our new Platform branding for this issue, as well as on our website and other material. We've given ourselves a bit of a refresh and hope you like the new look!

During 2015 we contracted six new partner-led research programmes that will run through to 2019 (see page 15). Further details of these can be found on our website, and we look forward to highlighting some of them in the next issue of Natural Hazards.

Research is well underway for the thirteen contestable projects that were also awarded in 2015 (see page 16) and one of these projects is featured in this issue (see page 32). Our next contestable funding round will be in early 2017 - keep an eye out for announcements.

This year saw two new members join the Platform Management Group: Dr Sam Dean, Chief Scientist from NIWA and Professor Rajesh Dhakal from University of Canterbury. We formally welcome them both.

In September 2015, the Platform signed a Memorandum of Understanding with the Australian Bushfire and Natural Hazards Cooperative Research Centre (BNHCRC), cementing a relationship that had developed over the previous year. Discussions are under way to share the research findings between Australia and New Zealand; this MoU will make that easier.

Like the Platform, the BNHCRC is a National Committee for the Integrated Research on Disaster Risk (IRDR). Both of us support and supplement IRDR's research initiatives, and help to further develop links between national disaster risk reduction programmes within an international framework.

This year the Platform has continued its strong engagement with both central and local government agencies, supporting them in order to help New Zealand make progress towards the priorities of the Sendai Framework for Disaster Risk Reduction. The recent convergence of the Sendai Framework, Sustainable Development Goals and the Paris Climate Agreement has also produced an unprecedented opportunity to maximise the contribution of science-based disaster risk management to sustainable development.

The end of 2015 saw Kelvin Berryman step down from his role as Platform Director. His effective leadership and commitment to the Platform since its inception have been instrumental to the success of the Platform, and he left large shoes to fill. Although Kelvin is now in a new role at GNS Science, he remains strongly committed to natural hazard research working to best effect for New Zealand, the best team approach and the Platform model.

Lastly, it is really encouraging to reflect on the contributions the Platform and other funding bodies have made towards developing future talent. Several of the articles in this issue feature research contributions by graduate students: from Lincoln University, Monica Giona Bucci (paleoliquefaction), and from University of Canterbury, James Williams (Chile tsunami), Daniel Blake (volcanic hazards), Rebecca Fitzgerald (volcanic hazards) and George Williams (volcanic hazards). Well done to all, and we look forward to seeing more from them in the future.

Hannah Brackley
Manager
Natural Hazards Research Platform

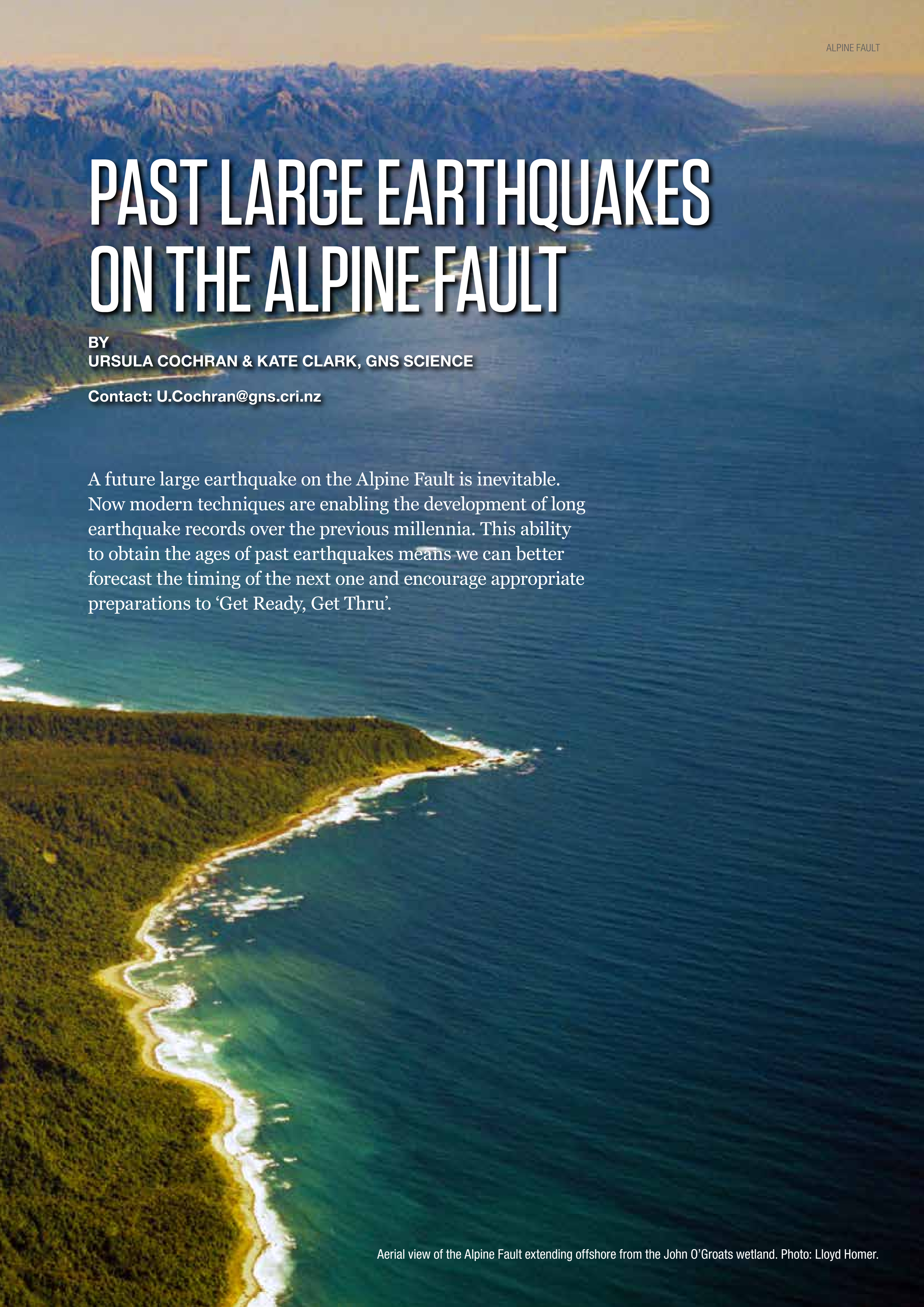

Alpine Fault
John O'Groats wetland

# PAST LARGE EARTHQUAKES ON THE ALPINE FAULT

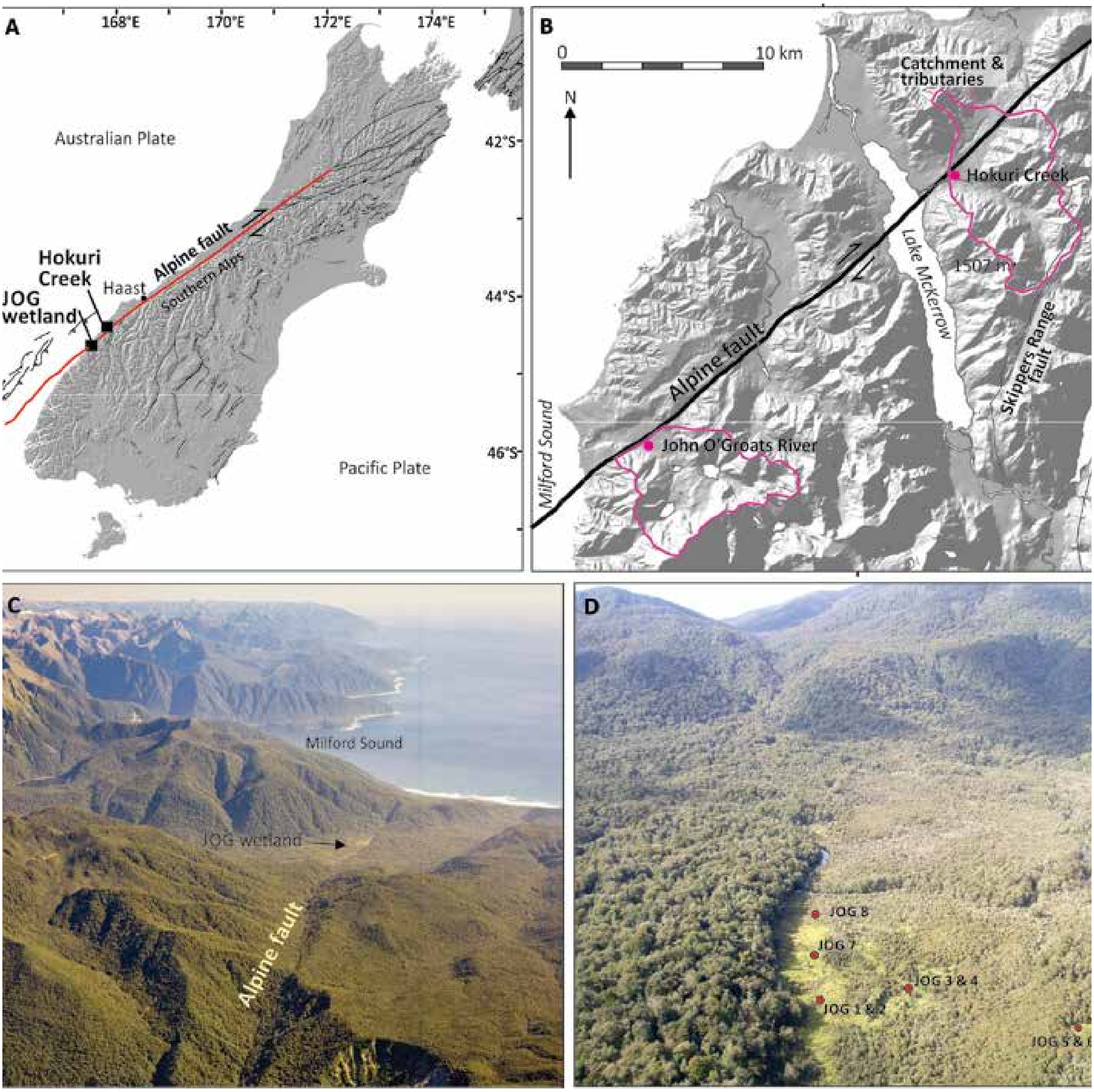
BY
URSULA COCHRAN & KATE CLARK, GNS SCIENCE

Contact: U.Cochran@gns.cri.nz

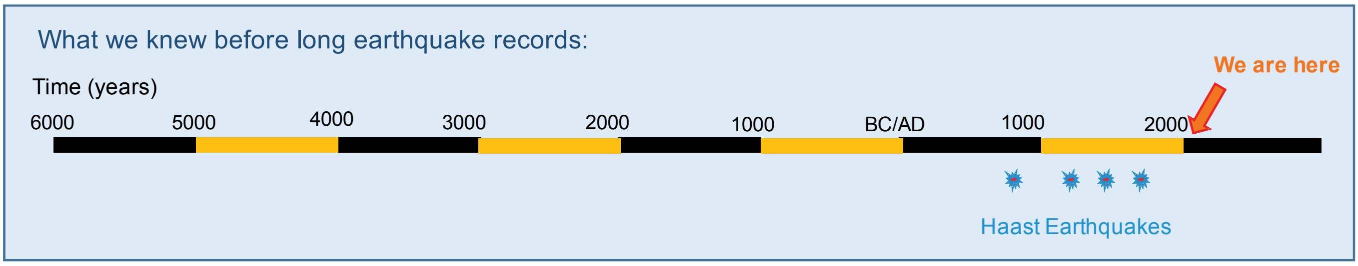
A future large earthquake on the Alpine Fault is inevitable. Now modern techniques are enabling the development of long earthquake records over the previous millennia. This ability to obtain the ages of past earthquakes means we can better forecast the timing of the next one and encourage appropriate preparations to 'Get Ready, Get Thru'.



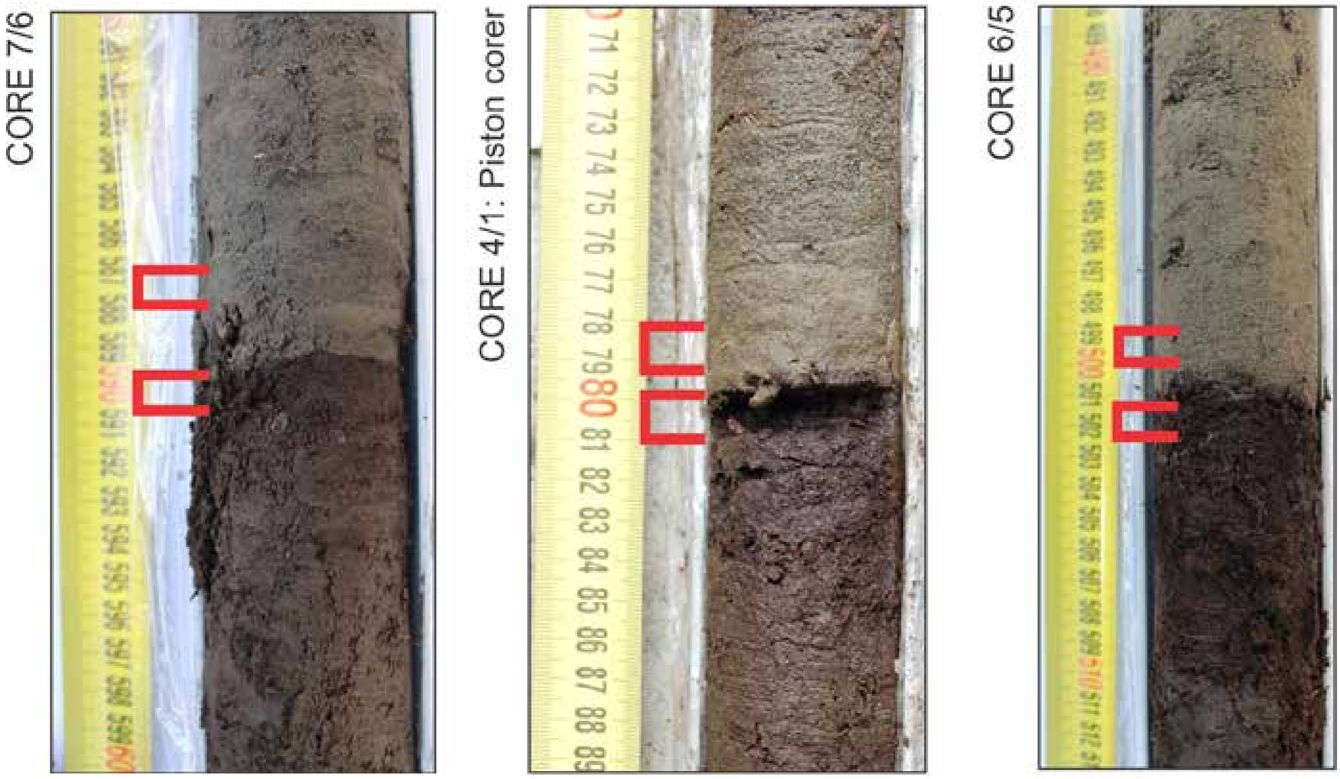
Aerial view of the Alpine Fault extending offshore from the John O'Groats wetland. Photo: Lloyd Homer.




A depiction of the Alpine Fault as it traverses the South Island. The area indicated by squares (top left) is shown in close-up (top right). An image of the John O'Groats River Valley (bottom, right) looking northeast along the Alpine Fault. Circles mark the core sites used in this research. Photo: GNS Science.




Timelines showing ages of earthquakes (red dots) from studies at Haast (above) and Hokuri Creek and John O'Groats Wetland (next page).




Examples of the peat-silt couplets that represent earthquakes in cores at this site. Data: GNS Science.

## The Significance of Long Earthquake Records

New Zealand's longest earthquake record consists of 24 earthquakes occurring over 8,000 years on the South-Westland section of the Alpine Fault at Hokuri Creek. This record provides a reasonable number of earthquakes on which to base hazard calculations and reveals that this part of the fault ruptures relatively regularly, with an average time between earthquakes of about 330 years.

However, the last thousand years of sediment is missing from Hokuri Creek, so the long record relies on comparisons with past findings from Haast, 100 km away. This possible weakness led us in search of more clues from the nearby John O'Groats River site (image, left).

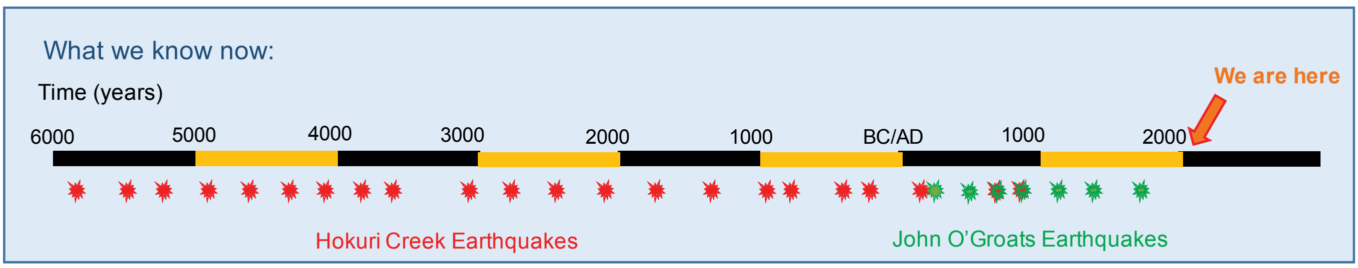
## Coring a Wetland

We went to John O'Groats River to look for data that could provide a more complete record of activity over the last thousand years and improve our estimates of earthquake frequency for the South-Westland section of the Alpine Fault. We collected eight core samples to a depth of seven metres from the wetland immediately adjacent to the fault. By examining these cores, we found evidence of past earthquakes in the form of peat-silt couplets. Peat layers represent the wetland under stable conditions and silt layers represent deposition triggered by earthquakes. Radiocarbon dating of these layers provided ages for seven earthquakes occurring within the last 2000 years.

## Improved Long Earthquake Record

We compared the John O'Groats wetland record with that from Hokuri Creek, and found that the John O'Groats site preserved evidence of earthquakes that were missing from the Hokuri Creek record.

Our new findings, based on the combined Hokuri Creek – John O'Groats records, suggest there have been 27 previous earthquakes, with a recurrence interval of about 300 years (slightly shorter than the previous estimate of 330 years). We have greater confidence in this revised record because we have added to the Hokuri Creek data with a site in closer proximity. The new data will be fed into updated seismic hazard estimates that take account of the wide variability in earthquake recurrence in this record.




The long earthquake record in the panel above clearly illustrates that another earthquake is inevitable and provides a much stronger dataset from which to estimate the time of next occurrence.

Ursula Cochran (left) and Kate Clark (right) examine a geological core for evidence of past earthquakes. Photo: Margaret Low, GNS Science

## Size and Extent of Quakes

We know these past earthquakes were large (magnitude 8 or greater) because they ruptured the ground surface, and we have found examples of large movements across the fault from a single event; 7.5 metres horizontally and 1 metre vertically.

However, it is important to note that these results are just from the South-Westland section of the Alpine Fault. While many of the earthquakes recorded at these two sites are likely to have ruptured the central and possibly North-Westland sections of the fault as well, we don't know the length of rupture from this research. Long earthquake records from lakes along the length of the Alpine Fault are proving very useful for determining which sections of the fault ruptured in which earthquakes.

## Improve Our Understanding of the Hazards

The last major earthquake on the Alpine Fault occurred in 1717. With an average of about 300 years between earthquakes, our findings suggest that we are due for another Alpine Fault earthquake in the near future. Simple actions, such as storing food and water, and securing large and heavy items, go a long way to prepare for such events, but also consider your neighbours, businesses, and wider community in your action plan.  To learn more about what you can do to prepare for an earthquake, please visit 'Get Ready, Get Thru.'

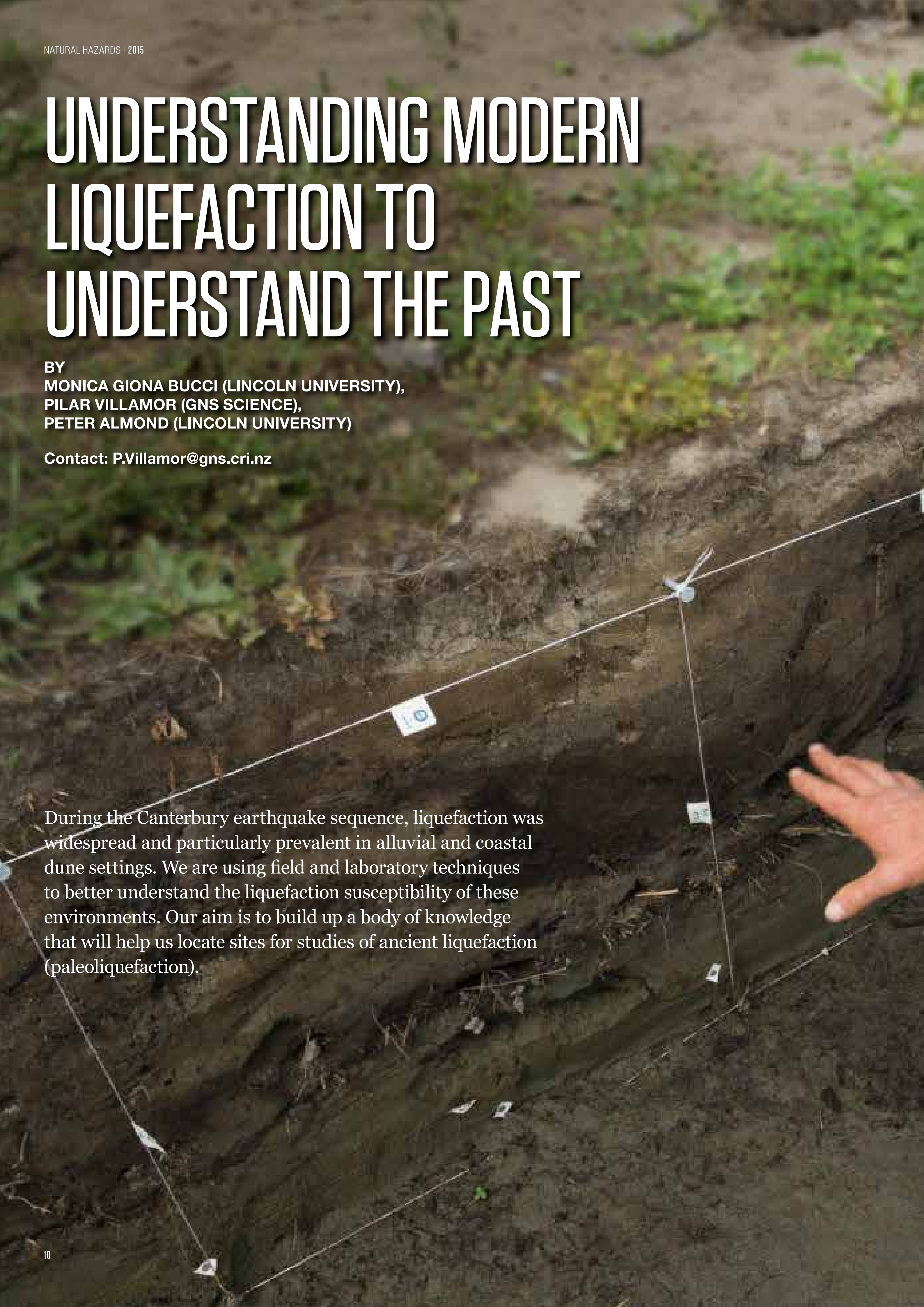
http://getthru.govt.nz/

*With an average of about 300 years between earthquakes, our findings suggest that we are due for another Alpine Fault earthquake in the near future.*

Earthquake geologists collecting cores in the John O'Groats wetland. Photo: GNS Science.

## ECONOMICS *of* RESILIENT INFRASTRUCTURE

*Researchers from the 'Economics of Resilient Infrastructure' research programme are working with roading and other infrastructure providers to better understand possible outcomes stemming from an Alpine Fault rupture and aftershock sequence. The 'Economics of Resilient Infrastructure' is funded by the Ministry of Business, Innovation and Employment.*



# UNDERSTANDING MODERN LIQUEFACTION TO UNDERSTAND THE PAST

**BY**
**MONICA GIONA BUCCI (LINCOLN UNIVERSITY),**
**PILAR VILLAMOR (GNS SCIENCE),**
**PETER ALMOND (LINCOLN UNIVERSITY)**

**Contact: P.Villamor@gns.cri.nz**

During the Canterbury earthquake sequence, liquefaction was widespread and particularly prevalent in alluvial and coastal dune settings. We are using field and laboratory techniques to better understand the liquefaction susceptibility of these environments. Our aim is to build up a body of knowledge that will help us locate sites for studies of ancient liquefaction (paleoliquefaction).

Right: Paleoseismic trench with evidence of blisters and sand volcanoes following the 14 February 2016 earthquake. Note the ground uplift on the left and the complementary depression on the right. Previous: Peter Almond examining features in the trench.

Evidence of paleoliquefaction can inform us about the history and distribution of liquefaction and associated earthquakes over a long time-frame, and is useful when attempting to study hidden faults that have failed to rupture at the surface or are covered by thick sediment. This is well understood from studies overseas, but gained traction in New Zealand following the 2010/11 Canterbury earthquakes.

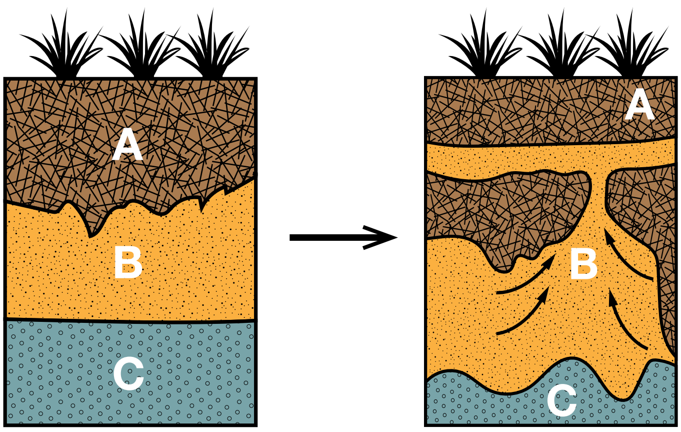
## Building a Liquefaction Profile

Our research set out to describe the sediments and sedimentary layering in alluvial and coastal dune settings. Their susceptibility to liquefaction was not surprising, as these are geologically young sites (less than 4000 years old), made up of sandy/silty-sand sediments that are water-saturated and have not undergone the aging process that increases their cohesion.

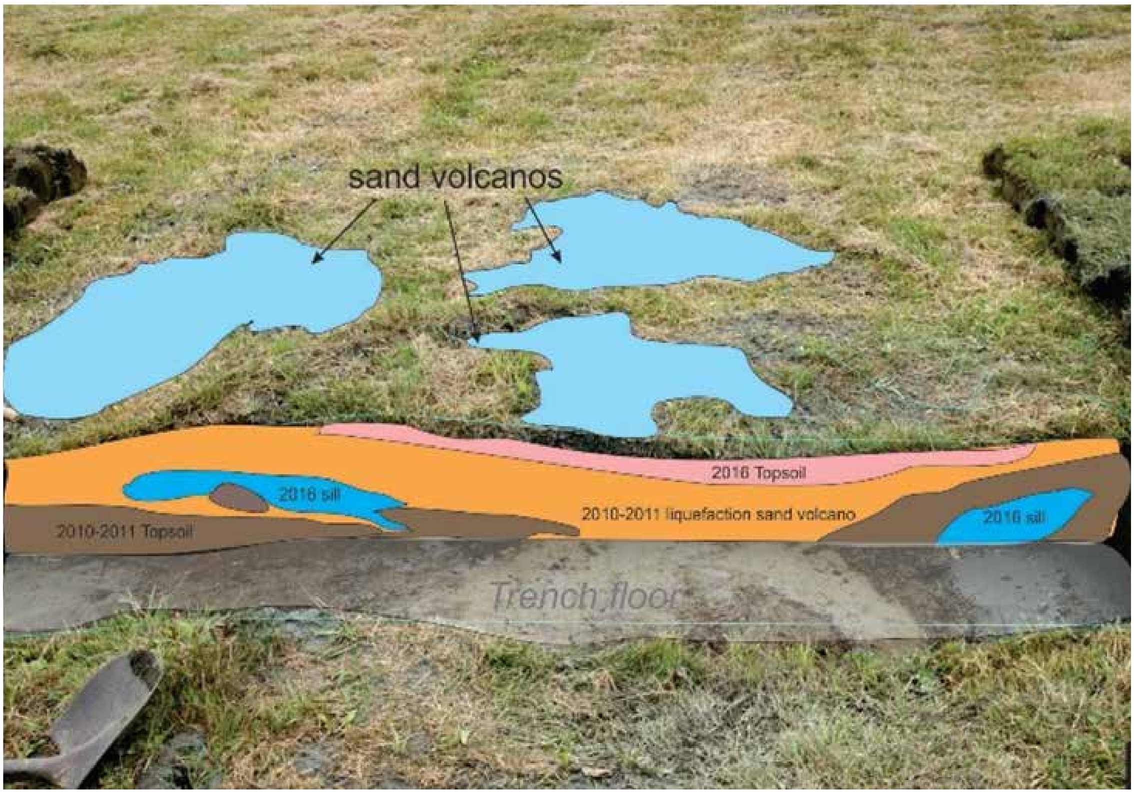
Our field studies involve paleoseismic trenching. A trench is the best exploratory method as it provides a visual cross-section of the sedimentary features in context, boundaries are clearly exposed, and 'weathering' features distinguish new liquefaction from old.

Importantly, the trench reveals distinct soil layers. As vegetation develops on the surface, chemical processes between the organic matter and the soil create three distinct layers. As shown, the top layer (A; topsoil) typically contains plant and organic material; the middle layer (B) is 'weathered' and characterised by reduction-oxidation processes, and below that is a non-weathered mineral layer (C). Understanding these patterns is critical to interpreting the data from the trench.

Our first study site was on the floodplain of the Halswell River in Greenpark, near Christchurch. We dug trenches, obtained soil samples for microscopic analysis, and investigated the shallow subsurface. We uncovered old buried river channels that had been in-filled with sediment, sandy river bars on the inside of river bends, buried soils, forests and swamps. We also identified sand volcanoes left behind by the 2010/11 Canterbury earthquakes that allowed us to trace their source and determine precisely which layers liquefied. Our observations suggest that while some alluvial settings are highly susceptible to liquefaction – we could identify liquefaction events dating back 1000 years – the distinct soil layers mostly remain intact.




An example of how liquefaction may disrupt the soil profile.




Same photo with overlay: pink depicts the 2016 topsoil; orange identifies a 2010/11 sand volcano; brown identifies the pre-2010/11 topsoil; blue identifies the 14 February 2016 liquefaction features; light blue at the surface identifies sand volcanoes from the 14 February 2016 earthquake.

## The 2016 Valentine's Day Earthquake

Our investigations next moved to the coastal dune environment with data collected from paleoseismic trenches in Wainoni and Queen Elizabeth II (QEII) Parks, and more recently at Pines Beach. In the weeks prior to 14 February 2016, open trenches were being analysed at Pines Beach. After the earthquake, we were able to quickly return to observe the immediate effects of liquefaction at the surface and within the trenches. Unlike the alluvial environment, the coastal dune data were more challenging to interpret.

## Soil Science Held the Clues!

In the coastal dune setting we observed that the soil layers could be highly disrupted by liquefaction, as shown in the graphic. We carefully mapped and analysed the layers to piece together what was happening. We observed that Pines Beach is prone to forming complex structures that consist of collapse features, blisters and sand volcanoes. Sub-horizontal injection of sand into the organic layer is common, which not only caused blisters on the ground but also split and deformed the uppermost soil layers.

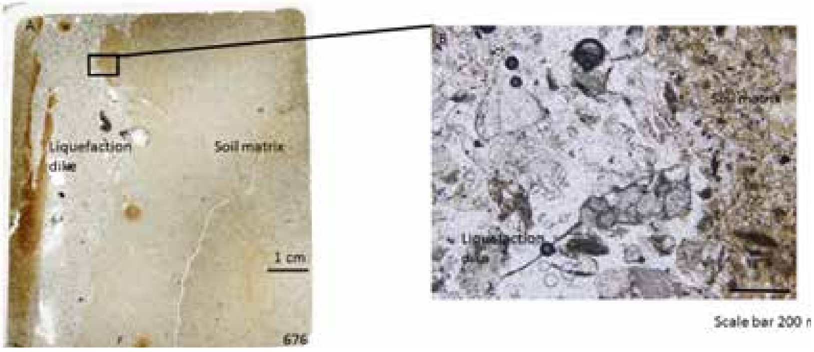
## Geotechnical Assessments Key to Land-Use Planning

Our data show that both alluvial and coastal dune environments are vulnerable to liquefaction, with coastal dunes being more susceptible. We now know more about how liquefaction manifests in these environments and what to look out for. Our findings reinforce the need for detailed geomorphological and sedimentological assessments to inform national land-use planning and will contribute to international understanding of different sediment settings prone to liquefaction.

*Evidence of paleoliquefaction can inform us about the history and distribution of liquefaction and associated earthquakes over a long time-frame*

# STUDENT PROFILE: MONICA GIONA BUCCI

Monica's thesis includes pioneering methods to analyse the spatial patterns of surface liquefaction in coastal and alluvial environments. One aspect focuses on the detailed architecture of sediments susceptible to liquefaction at the macro- and micro-scale, the latter which allows her to distinguish liquefaction injections of different ages.




A Thin section sample from alluvial setting; B Sample detail showing the important difference between liquefaction and the soil matrix fabric.

# INTRODUCING THE PLATFORM'S NEW PROJECTS: PARTNER-LED

## Quantifying Exposure To Specific And Multiple Volcanic Hazards

*Jonathan Procter (Massey University), in collaboration with University of Auckland, University of Canterbury, Victoria University of Wellington and GNS Science.*

» Volcanic eruptions are rarely single event hazards. Instead, a majority of eruptions worldwide manifest as complex evolving sequences with unforeseen impacts. This 4 year project will develop the first multi-stage, multi-hazard eruption impact model for New Zealand's volcanoes. The research will develop a quantitative data set for multi-stage, multi-hazard volcanic eruptions; develop a novel stochastic model for analysis and prediction; and translate the estimated hazard impacts into forecasts of damages & loss of capacity.

## Tools & Knowledge to Improve New Zealand's Long Term Resilience to Wind Storms

*Peter Cenek (Opus Research), in collaboration with University of Auckland, GNS Science and NIWA.*

» The typical wind storm can generate $10-40 million NZD worth of insured damages. Their accumulated impact to both built environment and commercial interests rivals that of earthquakes because of their frequency and pervasiveness. With climate change, the frequency of severe wind storms is predicted to increase. This 4 year project will inform and improve (i) mitigation measures such as retrofit, land-use planning and building code enforcement; (ii) current procedures for determining design wind speeds; and (iiI) our understanding of how climate change will affect the nation's wind vulnerability.

## Quantifying & Predicting the Role of the Built Environment in Social & Economic Recovery

*Vivienne Ivory (Opus Research), in collaboration with University of Auckland.*

» This research will provide decision-makers with improved understanding of the mechanisms that influence the ability to thrive during recovery by identifying when and how changes in the built environment contribute to social and economic recovery. This 4 year project will (i) describe built, social and economic recovery in Christchurch; (ii) examine the impacts over long-term recovery by analysing the relationships between different rates of recovery, outcomes and other factors such as infrastructure; and develop a predictive tool for identifying places and sectors at risk of poor recovery outcomes.

## Building Quake & People: A Serious Game Platform for Informing Life-Saving Strategies

*Vicente Gonzalez (University of Auckland), in collaboration with Opus Research and University of Canterbury.*

» There are a number of shortcomings in evacuation planning and research. This project will develop a computer-based modelling framework able to assess occupant behaviour in buildings in the event of an earthquake.  A prototype game will be developed and tested in two case study building types heavily used by the public – councils and hospitals. The findings will contribute to improved strategies for building evacuation leading to improved citizen safety.

## Climate Change Impacts on Weather-Related Hazards

*Giovanni Coco (University of Auckland), in collaboration with University of Waikato, NIWA, Scripps Institute of Oceanography (USA), Universidad de Cantabria (Spain), University of Florida (USA), University of New South Wales (Australia).*

» This 4 year project will develop a finer-scale resolution (<10 km) set of projections of near shore wave and surge conditions for the next 100 years applied to the whole of the NZ coastline. The data will feed into hazard projection models for coastal erosion and coastal inundation. The research will produce (i) wave climate and storm surge projections; (ii) new methodology to assess coastal change (shoreline position); (iii) an improved understanding of physical processes related to coastal inundation; and (iv) the development of a risk vulnerability framework to support councils and communities in making informed choices.

## Research-Informed Advancements in Guidelines & Standards of Engineering Practice for Natural Hazards

*Misko Cubrinovski (University of Canterbury), in collaboration with University of Auckland and GNS Science.*

» This 4 year project will address key issues in NZ standards and guidelines that require research-based resolution and advancement. Focus areas include (i) seismic loading and performance objectives; (ii) geotechnical hazards & impacts on infrastructure; (iii) seismic assessment & improvement of existing buildings; (iv) understanding whole building system effects for concrete, steel & timber buildings (v) improved transportation infrastructure (bridges);  (vi) and development of guidance for tsunami loading on NZ port infrastructure and bridges.

# INTRODUCING THE PLATFORM'S NEW PROJECTS: CONTEST 2015

## Faster Flood Forecasting

*Graeme Smart*

- Adapt & combine existing rainfall, hydrological, and hydrodynamic models to create faster, more accurate flood inundation predictions.
- End users: NZ Hydrological Society, IPENZ Rivers Group, Regional Council River Managers group

## High Water Red Alert Calendar

*Rob Bell*

- Enhance tool to provide 1-3 months warning of dates for high background sea levels when coastal inundation could easily occur.
- CDEM/Regional council support from Auckland, Christchurch, Tasman, Otago

## Disaster Risk Full Cost Accounting

*Brown & Smith*

- Prototype framework to support disaster risk management decision-making for broad view of policy & investment decisions.
- Considers multi-capital costs & benefits, distributional effects, risk preferences and uncertainty.
- End users: Ministry of Civil Defence and Emergency Management, Christchurch, Wellington, Auckland

## National Volcano Hazard Model

*Mark Bebbington*

- By 2018 aim to have an initial National Volcanic Hazard Model
- For incorporation into risk & economic growth models, policy, planning
- End-users: Taranaki Seismic & Volcanic Advisory Group, Central Plateau Volcanic Advisory Group, Auckland council

## Alpine Fault Paleoseismicity

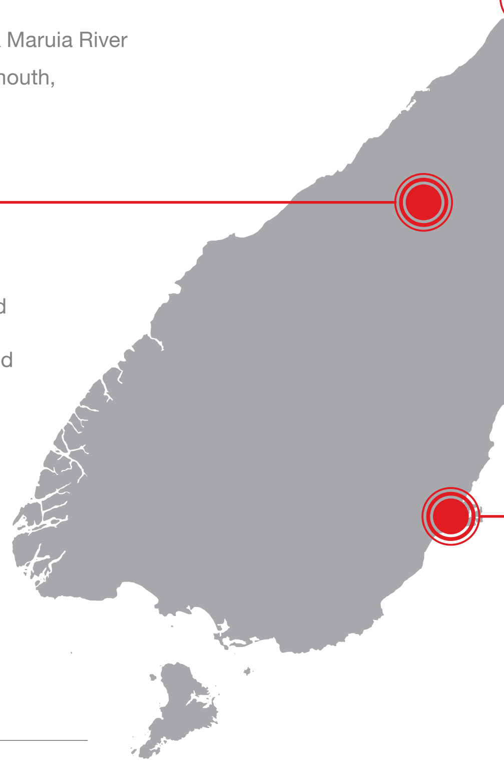
*Rob Langridge*

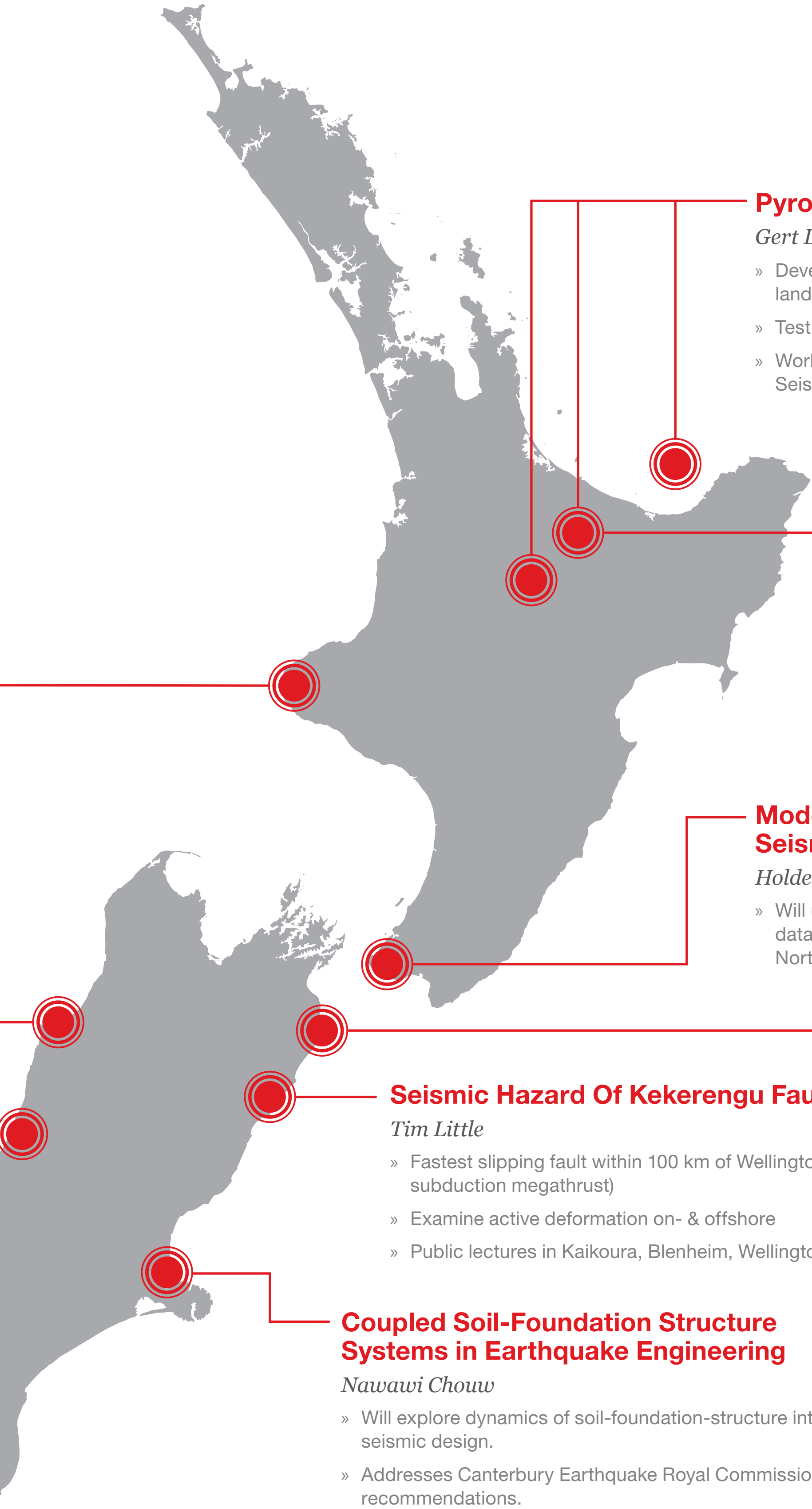
- Focus on central to northern section of Alpine Fault to better understand: When? Where? How big?
- LiDAR between the Hokitika & Maruia River
- Public outreach talks in Greymouth, Westport, Christchurch

## Southern Lakes Tsunami Hazard

*Joshu Mountjoy*

- Tourist destination surrounded by mountainous terrain – high sediment input, faults & ground shaking
- Lake Tekapo case study
- Assess tsunami hazard from landslide sources
- End users: Environment Canterbury, Otago Regional Council, Genesis Energy, Meridian Energy





## Pyroclastic Density Currents

*Gert Lube*

- Develop model of PDC destruction potential over variable landscapes
- Test model against White Island, Tongariro & Rotomahana
- Work with Central Plateau Volcanic Advisory Group, Taranaki Seismic & Volcanic Advisory Group

## Okataina Caldera

*Ian Hamling*

- Using InSAR, GPS and other data, will measure & model surface deformation over the Okataina Volcanic complex
- Creation of NZ volcanic supersite in 2015 has enabled access to free data from multiple satellite providers.

## Modeling Earthquake Engineering Seismic Parameters

*Holden & Kaneko*

- Will use broadband ground motions, to produce datasets and rupture scenarios for the lower North Island

## Marlborough Fault

*Phil Barnes*

- Area of high displacement rate faults that link the Alpine Fault with the Hikurangi subduction zone.
- Utilises previously mapped offshore region
- End users – Greater Wellington Regional Council, Marlborough District Council, Environment Canterbury

## Seismic Hazard Of Kekerengu Fault

*Tim Little*

- Fastest slipping fault within 100 km of Wellington (other than subduction megathrust)
- Examine active deformation on- & offshore
- Public lectures in Kaikoura, Blenheim, Wellington

## Coupled Soil-Foundation Structure Systems in Earthquake Engineering

*Nawawi Chouw*

- Will explore dynamics of soil-foundation-structure interactions for seismic design.
- Addresses Canterbury Earthquake Royal Commission recommendations.
- Apply these characterisations in Christchurch, Wellington, Auckland

## Unknown Faults Under Cities

*Pilar Villamor*

- Using Dunedin as pilot, will aim to identify potential active faults under or near cities, where surface evidence is lacking
- Large, multi-organisational, mutli-disciplinary,  multi-funded team
- End-user: Otago Regional Council

# UPDATES FROM THE CANTERBURY EARTHQUAKE RESEARCH PROGRAMME

The research outcomes from this programme continue. Here are two brief updates from SR Uma and Matt Gerstenberger on their Canterbury programmes.

## SQuADS: SUBJECTIVE-QUANTITATIVE ASSESSMENT DECISION SUPPORT

A free online interactive decision support tool for clients and engineers to choose a 'best-fit' building system.

Performance-based earthquake engineering provides a framework for designing buildings to meet the expectations of the client in terms of minimising damage, repair costs and down time, while preventing loss of life.

A dialogue between the engineer and the client is critical in designing effective engineering solutions. Such conversations are facilitated by our new online interactive tool – 'SQuADS (Subjective Quantitative Assessment Decision Support Tool)' – developed as an outcome of our Canterbury earthquake project on implementing low-damage design.

SQuADS allows the user to trial a variety of engineering solutions to identify what works best for their needs in terms of performance and cost. It adopts a weighted scoring method to compare different building system options against multiple criteria that would be of interest to the engineer and the client. The current version of the tool includes a list of criteria considered to be low damage performance objectives. A future version may allow user-defined criteria.

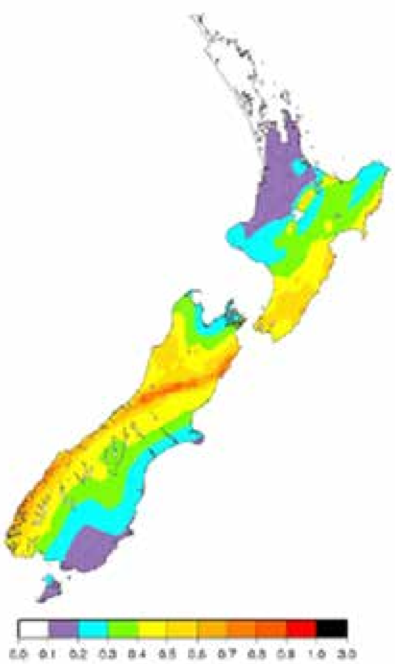
We are grateful for the early comments from university colleagues and industry professionals that allowed us to develop SQuADs.

**Contact:**

SR Uma
GNS Science
S.Uma@gns.cri.nz
http://data.gns.cri.nz/squads/



# RETHINKING PROBABILISTIC SEISMIC HAZARD ASSESSMENT




New Zealand's National Seismic Hazard Model (NSHM) consolidates our current understanding of earthquakes – from across geology, seismology, geodesy and engineering seismology – into estimates of how much earthquake shaking New Zealand can expect in the next 50 years.

The NSHM consists of two primary components: one estimates the magnitude, rate and location of earthquakes around the country; another estimates how much the ground will shake from each of these earthquakes.

The Canterbury earthquakes have provided valuable input to the NSHM, including how we understand and model uncertainty. This uncertainty is important because it is included in hazard estimates that we provide to end-users.

We are developing additional models which are based on alternative datasets, such as geodetic strain, or alternative ideas of how earthquakes interact, such as the earthquake clustering models which we applied in Canterbury. We statistically compare forecasts from each one of these alternative models to past observations to understand how much forecasting skill they have. Based on results, we then develop optimised 'hybrid' models that combine the different models together and represent a range of possible estimates, and uncertainty, of future earthquake occurrence.

In another important change, we have recently made the earthquake source models for both the NSHM and the Canterbury Seismic Hazard Model available for anyone to download from the GNS Science website. In addition, changes to the model are being developed using Open Source libraries and we aim to make those computer codes openly available to the community.

**Contact:**

Matt Gerstenberger
GNS Science
M.Gerstenberger@gns.cri.nz
www.gns.cri.nz/NSHM

# NEW ZEALAND'S RISKSCAPE

The RiskScape project began in 2004 with the aim of providing an easy-to-use decision support tool that converts natural hazards exposure data into likely consequences for a region.

RiskScape has since been applied across New Zealand and overseas to learn from natural hazards and explore mitigation options.

RiskScape began with pilot studies in Westport, Hawkes Bay and Christchurch, which enabled the software to go from proof of concept to operability.

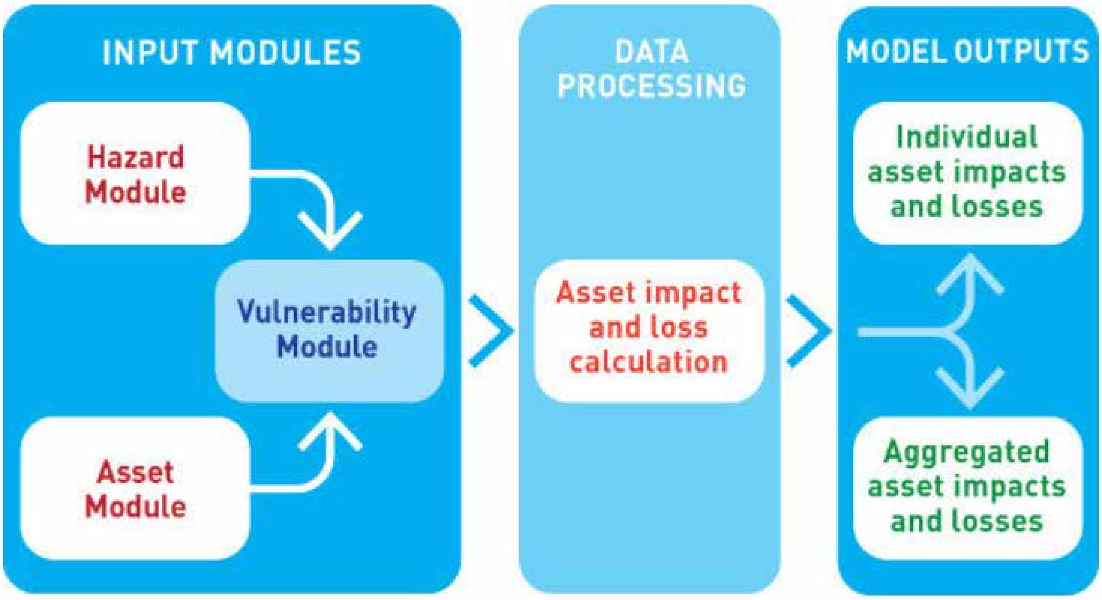
Initial modelling based on earthquakes, river floods, tsunami, windstorms, and volcanic ashfall has been expanded to include secondary perils such as the liquefaction that may follow earthquakes.

While the global risk insurance industry has a selection of models to choose from, only RiskScape provides a New Zealand–centric focus.

In this issue, we highlight how RiskScape is being utilised to understand hazard and risk from events in Chile, Japan, and New Zealand, and shed light on our increasing vulnerability to sea level rise.

RiskScape is co-led by GNS Science and NIWA in collaboration with NZ universities and the Earthquake Commission (EQC).

https://riskscape.niwa.co.nz/

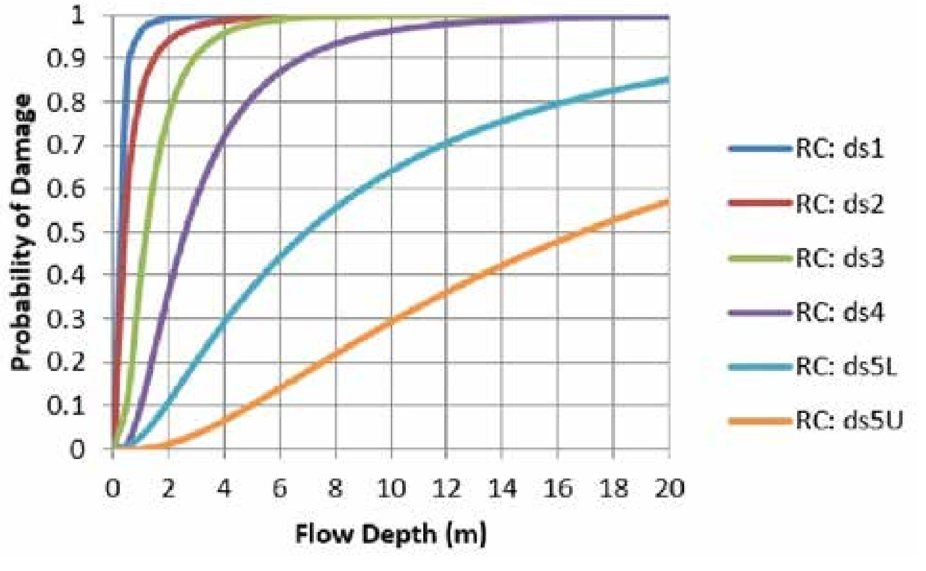



The RiskScape impact modeling system.

Yuriage Ward, Natori City, Miyagi Prefecture 11 weeks after the 2011 Tohoku earthquake/tsunami. Photo: Stuart Fraser and IStructE Earthquake Engineering Field Investigation Team.

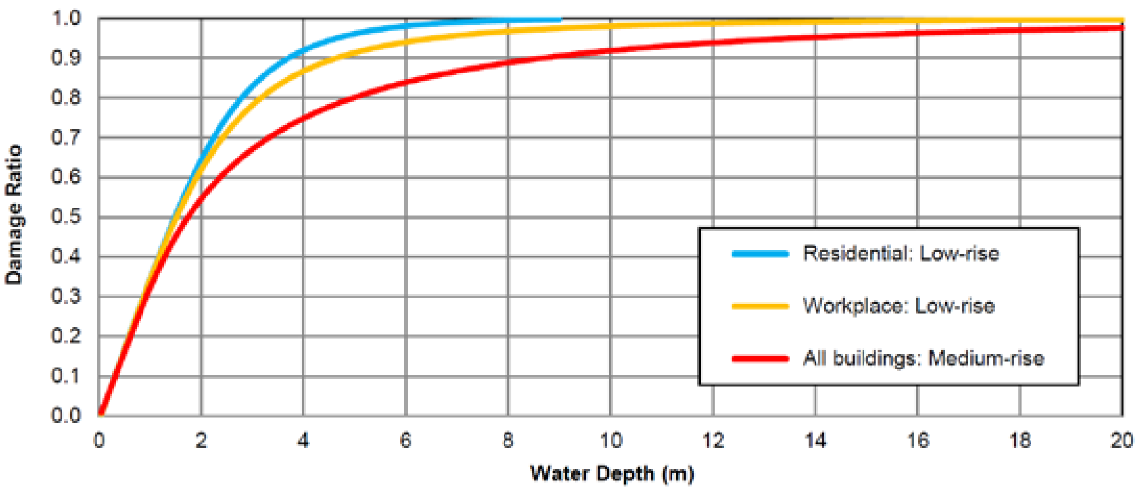
# FRAGILITY FUNCTIONS: KEY TO TSUNAMI RISK ASSESSMENTS

We are developing fragility functions to understand how tsunami may impact New Zealand's building stock. The development of fragility functions is an important component of tsunami risk assessment.




Example of fragility curves for Reinforced Concrete using Japanese data (ds = damage state), Source: Suppasri et al (2013) Natural Hazards 66(2): 319-341.

Kesennuma City, Miyagi Prefecture following the 2011 Tohoku earthquake/tsunami. Photo: Stuart Fraser and IStructE.




Example of basic application of fragility functions for buildings in NZ derived from Japanese data. Source: Nick Horspool.

Risk scientists examine the relationship between a natural hazard and an asset in many ways. To understand how tsunami may impact New Zealand's buildings, we are developing fragility functions. These functions express the probability that a particular structural damage state – either low, moderate or high – will be reached or exceeded for a given measure of tsunami intensity, such as flow depth. This in turn enables decision-makers to develop impact and loss estimates.

Fragility functions are developed using data obtained from previous events. In New Zealand, the lack of recent damaging tsunami means that we do not have impact data related to our own building stock.

To get around this, we are working alongside countries that have experienced tsunami and have similar building types to ours. Our long-standing collaboration with Japan is a good example. A New Zealand research team participated in post-tsunami damage surveys following the 2011 Tohoku earthquake-tsunami sequence. The opportunity to participate in the data collection was valuable and allows us to apply the lessons in New Zealand.

Progress is being made by scientists from NIWA and GNS Science towards the application of these data in RiskScape to enhance New Zealand's tsunami risk management. A technical report detailing this approach is due for release in mid-2016.


**Contact:**

Shaun Williams
NIWA
Shaun.Williams@niwa.co.nz

Rail line damaged by the Chile earthquake-tsunami sequence. Photo: Richard Woods.

# RISKSCAPE IN CHILE

On the evening of 16 September 2015, a Mw 8.3 earthquake struck off the coast of Illapel, Chile. Within minutes, the earthquake was followed by a tsunami.

A RiskScape survey team comprising Nick Horspool (GNS Science), Ryan Paulik (NIWA), Richard Mowll (Wellington Lifelines Group), Richard Woods (Auckland Council and Auckland Lifelines Group) and James Williams (University of Canterbury) traveled to Coquimbo, Chile to assist CIGIDEN* and the UNESCO Tsunami Information Centre by surveying damage to essential infrastructure services ('lifelines') and buildings.

The visit was a key opportunity to work alongside Chilean colleagues, share data, and improve New Zealand's own tsunami preparations. A recent review by GNS Science of tsunami impacts to lifelines, undertaken for the Wellington and Auckland Lifelines Group, revealed gaps in our knowledge and a lack of quantitative data on damage probabilities.

We focused our efforts in Coquimbo, which sustained significant damage to infrastructure. We observed the after-effects from what was a moderate-sized tsunami with maximum on-land flow depth of 5 metres. This is a 'threshold' damage event which, according to the New Zealand Tsunami Hazard Model, could occur on some parts of New Zealand's east coast with about a 1-in-100 year probability (meaning a 1 percent chance in any given year).

We undertook a census-style data collection method using the Real-Time Asset Capture Tool (RiACT), developed through the RiskScape programme. We collected information on lifelines within the inundation zone, which covered an area of around 3 square kilometres. The survey focused on the energy, transport and water lifeline sectors, of which a large number of assets were affected. In addition, we met with representatives from local lifelines companies to discuss the operability of lifeline networks during the event.

The data collected will be analysed over the next year to develop tsunami fragility functions for lifelines, which can be used for tsunami impact modelling in RiskScape.

The survey was co-funded by RiskScape (GNS Science and NIWA), NZSEE, EQC, Auckland Council and University of Canterbury.

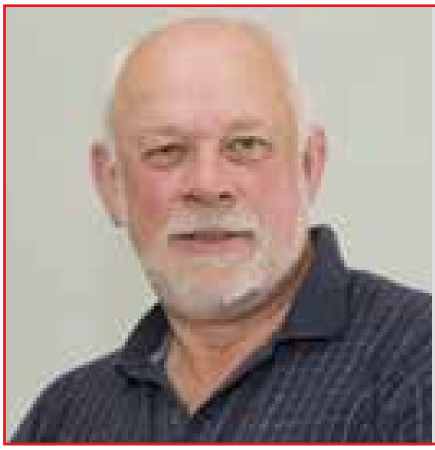
*CIGIDEN, Centro Nacional de Investigación para la Gestión Integrada de Desastres Naturales (National Research Center for Integrated Natural Disaster Management). Chile's CIGIDEN is similar to the Natural Hazards Research Platform in its scope: http://www.cigiden.cl/

**Contact:**

Nick Horspool
GNS Science
N.Horspool@gns.cri.nz

Local fisherman recovering material from his damaged fishing boat. Photo: Richard Woods.

Nick Horspool (GNS) surveying damage to the Coquimbo port where the tsunami washed large fishing vessels on to the wharves. Photo: James Williams.



## Andrew King's contribution to RiskScape

*The RiskScape project was established in 2004 with Andrew King as GNS Science project coordinator. RiskScape began with pilot studies in Westport, Hawkes Bay and Christchurch, and since then, various partners have contributed to its development, notably EQC with assistance in accessing building datasets, colleagues at the universities who have contributed peril-specific vulnerability functions and enthusiastic student effort, and many government departments.*

*The RiskScape model has now reached a point where asset exposure data is available for about 75% of New Zealand, all with its associated vulnerability functions to enable consequence and impact evaluation. As Andrew hands over the reins to Nick Horspool at GNS Science, he thanks the team for their huge contributions over the past decade.*


Whanganui flood damage. Most flooded homes lost over 65% of contents. Photo: NIWA.

# POST-EVENT FLOOD SURVEY: WHANGANUI

The development of vulnerability models is an essential component of the natural hazard impact and risk assessment process. These models enable RiskScape to quantify impacts or risk for buildings, infrastructure and people exposed to natural hazards.

Understanding how different asset types are impacted by flood water is vital for developing vulnerability models to support flood risk management. Flood vulnerability models are often a single or series of functions (commonly known as 'damage curves') that describe a relationship between the degree of asset damage sustained at a given flood hazard intensity, such as water depth. Depending on the function, its output can be used to derive information about direct or indirect impacts sustained by assets exposed to flood waters.


NIWA team measuring high water marks. Photo: NIWA.


The map provides an estimation on whether an adult can safely wade through the depth of flood waters at a particular point. These calculations are based on the Australian Rainfall and Runoff Guidelines, www.arr.org.au. Data: NIWA.

When developing functions, vulnerability assumptions are initially an estimate until they can be validated with actual observations. The June 2015 Whanganui floods provided an opportunity to collect such data.

A NIWA RiskScape team visited flood-affected Waitotara, Whanganui and Whangaehu. The team visited flood-damaged buildings at each location and measured water depths above ground and flood level, recorded building attributes and estimated the degree of structural and non-structural damage.

In Waitotara and Whanganui, the team measured flood depths of up to 1.5 metres within residential buildings. Structural and non-structural damage in most buildings was estimated to range between 20 to 40 percent of replacement cost. In most homes, more than 65 percent of the contents were damaged. Residents had little or no time to save belongings, and in some cases only 15 minutes to evacuate.

The data collected enabled the NIWA team to update its flood vulnerability functions for residential buildings and contents. These functions are available in the RiskScape tool and support future flood risk management decisions, such as the cost-benefit of raising stopbank heights to reduce building damage or identification of buildings where human safety may be threatened in a flood event.

*Residents had little or no time to save belongings, and in some cases only 15 minutes to evacuate.*

**Contact:**

Kate Crowley
NIWA
Kate.Crowley@niwa.co.nz


Vulnerability testing of building material (weatherboard) to ballistic impacts using the UC pneumatic cannon. Photo: University of Canterbury.

# DEVELOPING RISKSCAPE FOR VOLCANIC HAZARDS

**BY DANIEL BLAKE (UC), REBECCA FITZGERALD(UC), GEORGE WILLIAMS (UC), NATALIA DELIGNE (GNS SCIENCE), TOM WILSON (UC), GRAHAM LEONARD (GNS SCIENCE) AND BEN KENNEDY (UC)**

RiskScape vulnerability modules define the way that "assets" – buildings, roads, electrical cables – respond to a given hazard. Compared to many other natural hazards, there has been limited data on volcanic hazards to inform RiskScape development. Over the past few years, we have been enhancing RiskScape's capabilities for volcanic risk analysis.

Here we report on two particular volcanic hazards – ballistic impacts and volcanic ash. These studies have only been possible through our ongoing local and international collaborations.

## Understanding Ballistic Impacts: Lessons from Japan

A volcanic eruption can result in the ejection of ballistic projectiles – fragments of lava or rock of varying sizes that explode from the volcano at high velocity. Volcanic ballistics are a major hazard to both life and infrastructure, and are among the most frequent causes of fatalities on volcanoes. Many New Zealand volcanoes, including Ruapehu, Tongariro and the Auckland Volcanic Field, produce ballistics. A high number of people may be in proximity on any given day.

The University of Canterbury (UC) is leading the study of ballistic impacts using data gathered in New Zealand and Japan. In mid-2015, researchers from UC and GNS Science travelled to Mt Usu, Japan, which erupted in 2000 ejecting ballistics that caused severe damage to many buildings. Due to successful warnings and evacuation of the immediate area, there were no fatalities. Ten impacted buildings – constructed of varied materials similar to those used in Auckland's building stock – were assessed by our team to understand the range of damage that can occur from ballistic impacts.

Back at home, UC developed a pneumatic cannon to systematically test the vulnerability of weatherboards, corrugated iron and reinforced concrete to ballistic impact – all building materials used throughout New Zealand. The aim was to define the probability of different damage intensities (for example, superficial damage, roof puncture) occurring for a given intensity of ballistic impact. The findings will be included in RiskScape so that impact and loss can be estimated, providing hazard and risk managers with data to make informed decisions.


Volcanic ash and the laboratory set-up in the VAT Lab used to investigate visibility through airborne ash. Photo: University of Canterbury.

## Ash Impacts on Roads: Lessons from Kagoshima, Japan

In 2015, PhD student Daniel Blake visited Kagoshima to learn how local authorities deal with frequent volcanic ashfall from nearby Sakurajima Volcano. Kagoshima's regular ashfalls and similar infrastructure to New Zealand make it an ideal study site. This visit allowed Daniel to compare results from UC's Volcanic Ash Testing Laboratory (VAT Lab) with real-life situations, including understanding skid resistance on ash-covered roads and airfield surfaces, visibility of road markings covered by ash and visibility through airborne volcanic ash.

The Kagoshima authorities reported that a common impact on drivers is reduced visibility – sometimes to just 20 metres – from ash particles suspended in the air.

Vehicles driving in low visibility and covered road markings caused by volcanic ash in Kagoshima City. Photos courtesy of Kagoshima City Office.

They also reported that just 1 millimetre of volcanic ash accumulation is enough to make road surfaces slippery. In lab findings we found that just 0.1 millimetre of fine-grained ash accumulation is enough to obscure markings on the road, reducing safety. In addition, ash of more recent eruptions (from the Showa crater of Sakurajima) appears to be less slippery than that of older eruptions (from the Minami-daki crater), probably due to the smaller particle size associated with the recent eruptions.

These findings from the field align well with recent lab results and emphasise the importance of different ash characteristics (not just ash depth) when considering the exposure of assets to volcanic ash.

**Contact:**

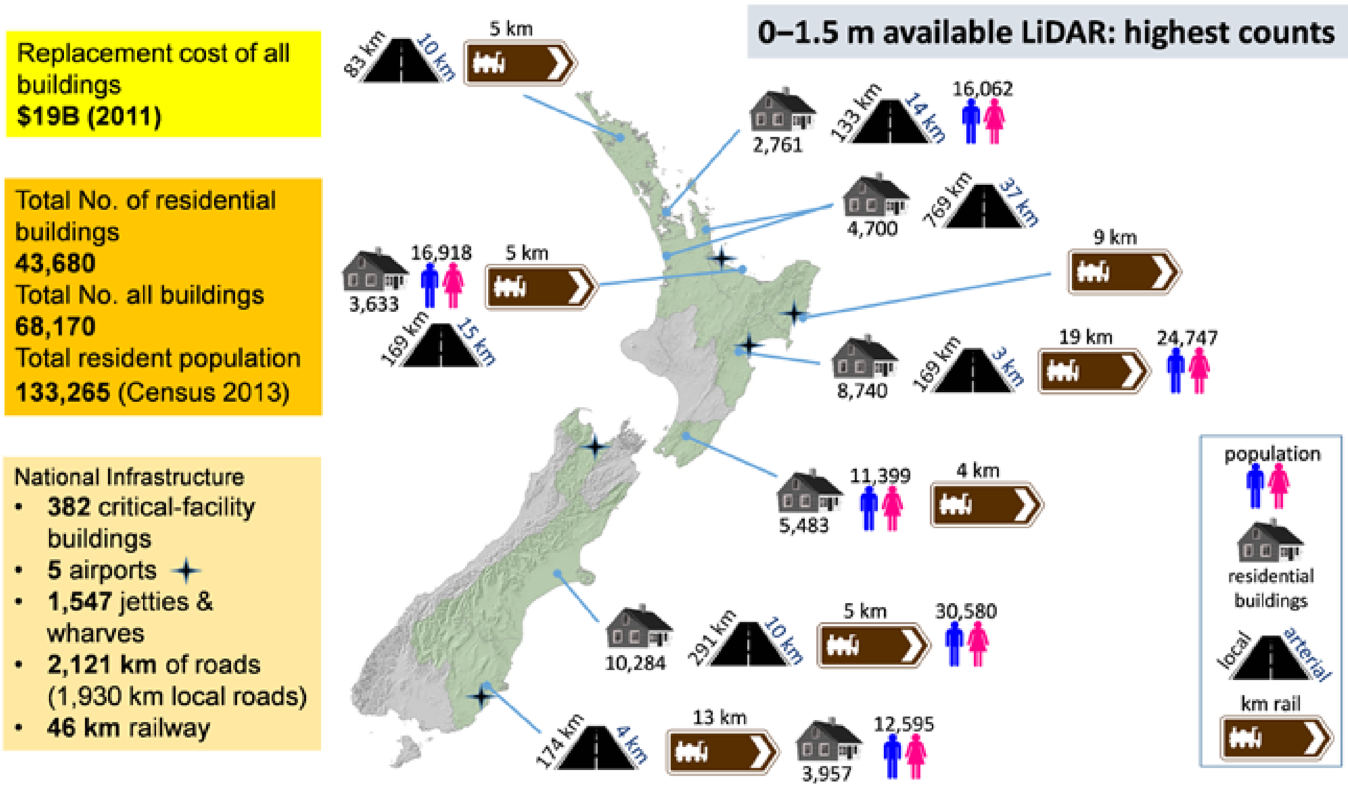
Thomas Wilson
University of Canterbury
Thomas.Wilson@canterbury.ac.nz

# QUANTIFYING NEW ZEALAND'S COASTAL RISK EXPOSURE

**BY ROB BELL, RYAN PAULIK, AND SANJAY WADHWA, NIWA**

In November 2015, the Parliamentary Commissioner for the Environment (PCE) released her report 'Preparing New Zealand for Rising Seas'. NIWA contributed to the report by providing a 'risk census' on the regional and national risk exposure in low-lying coastal areas.

Mātihetihe marae on the coast north of Hokianga harbour. The hapū of Te Tao Mauī from Mitimiti are working with NIWA to understand how sea level rise might affect their marae. Photo: Anne Te Wake




This census is the first attempt to consistently quantify the risk of exposure to rising seas in coastal areas across New Zealand. It was made possible because of the availability of both high-resolution LiDAR datasets and the national repository of buildings, roads and railways within RiskScape. These two critical geospatial datasets represent the two sides of the risk coin: hazard exposure (which, for inundation by sea level rise, is governed by land elevation), and who or what ('assets') is likely to be exposed.

A national stocktake was completed looking at increments of narrow coastal elevations up to 3 metres above the mean high water spring (MHWS). Risk exposure was expressed simply as counts of normally-resident population, areas of land parcels, and numbers or lengths of built assets or infrastructure within these incremental elevation bands. The stocktake also provided a comparison of risk exposure between regions, territorial authorities and urban areas.

Resolving areas of coastal plains with such narrow increments in land elevation was mostly undertaken with LiDAR, but there are stretches of the New Zealand coast not represented by LiDAR.

For these areas, we used the lower-accuracy national digital elevation model (DEM), with counts undertaken for a single 0–3 metre elevation zone. Comparisons between the two revealed that DEM underestimates the risk exposure by about half. Our recommendation is that coastal risk studies should only be done using LiDAR data. A summary of the risk-exposure across regions is shown.

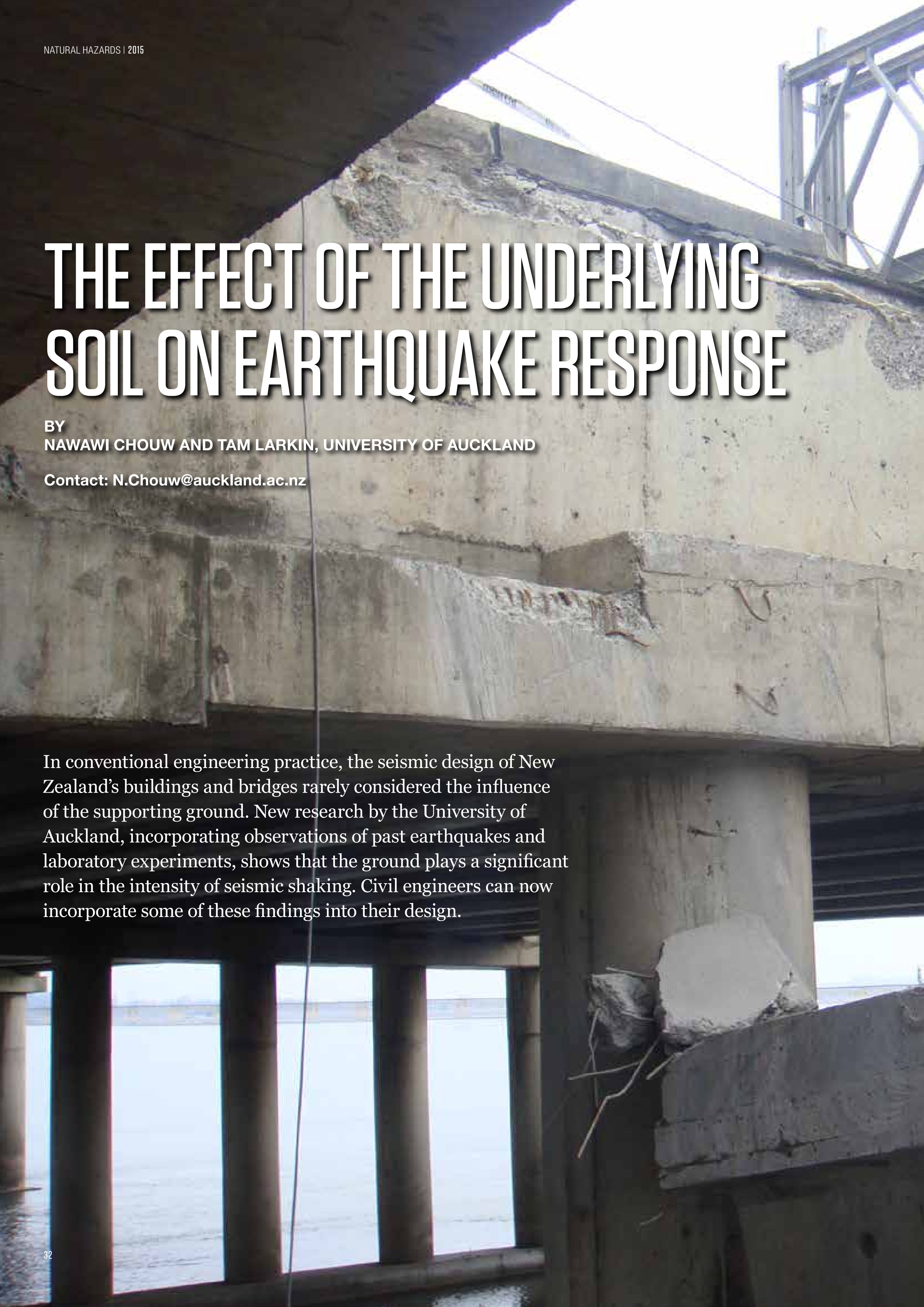
At 0-1.5 metres elevation above MHWS, regions with the highest risk exposure include Canterbury, Hawke's Bay, Waikato (roads especially), Wellington and Otago.

Some key findings in relation to residents and buildings:

- Of the regions with LiDAR data available, two-thirds of people living in 0–1.5 metres coastal elevation zones are in Canterbury (23%), Hawke's Bay (19%), Bay of Plenty (13%) or Auckland (12%), based on the 2013 Census.
- Canterbury and Hawke's Bay, followed by Waikato (mainly Hauraki-Coromandel), have the most buildings of all types in the 0–1.5 metres elevation zone.
- Canterbury, Auckland, Wellington and Hawke's Bay dominate the building replacement cost national totals. Across all areas with LiDAR available, the total replacement cost for all buildings comes to NZ$19 billion (2011) for land below 1.5 metres, rising to $52 billion for coastal land below 3 metres.
- Dunedin (2683), Napier (1321) and Christchurch (901; excluding the Red Zone) have the most dwellings in the vulnerable lowest elevation band less than 0.5 metres above spring tide mark.

These findings do not necessarily mean that people and assets will be directly affected but it does mean they are potentially exposed to coastal hazards and sea-level rise over differing timeframes – with residents and buildings in lower elevation bands more likely to be impacted in the shorter term.

**Contact:**
Rob Bell
NIWA
Rob.Bell@niwa.co.nz

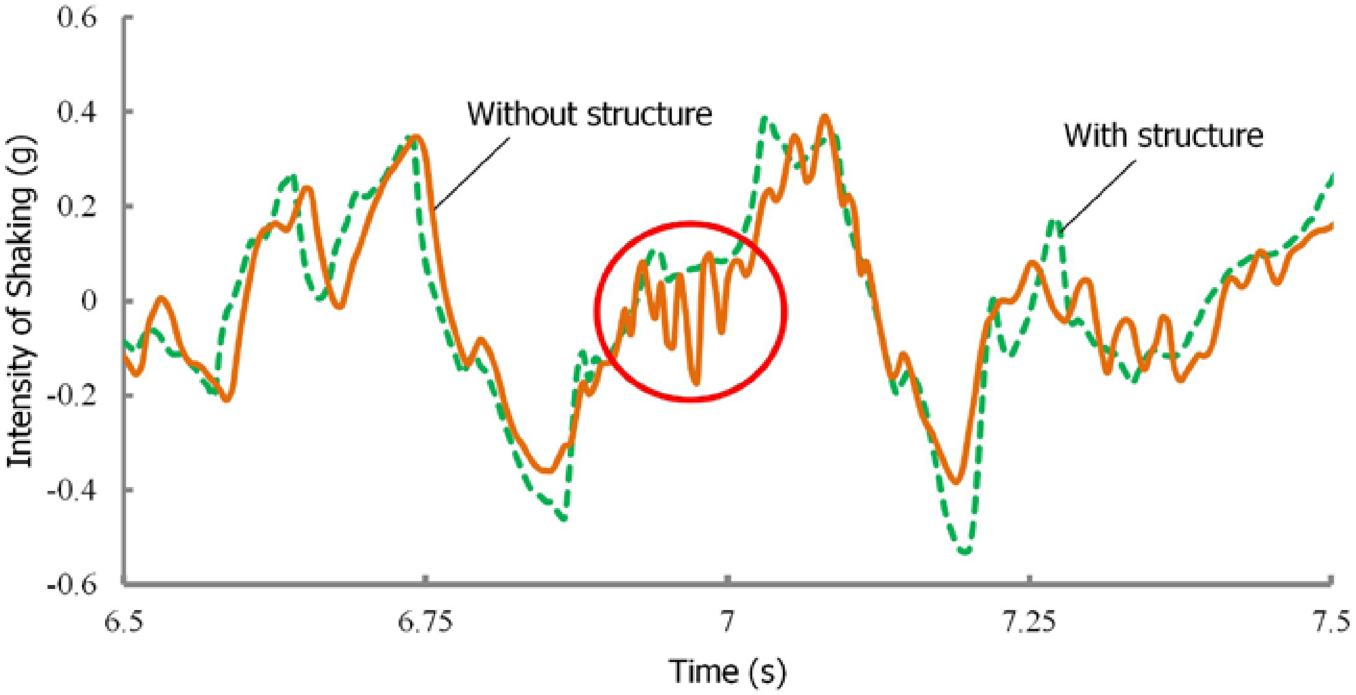


# THE EFFECT OF THE UNDERLYING SOIL ON EARTHQUAKE RESPONSE

**BY**
**NAWAWI CHOUW AND TAM LARKIN, UNIVERSITY OF AUCKLAND**

**Contact: N.Chouw@auckland.ac.nz**

In conventional engineering practice, the seismic design of New Zealand's buildings and bridges rarely considered the influence of the supporting ground. New research by the University of Auckland, incorporating observations of past earthquakes and laboratory experiments, shows that the ground plays a significant role in the intensity of seismic shaking. Civil engineers can now incorporate some of these findings into their design.




Influence of a structure on earthquake ground shaking. Data: N. Chouw, University of Auckland.

While seismic shaking travels up from the depths of the earth, the rock and soil along the way alter the characteristics of the spreading shaking patterns. This influence is particularly strong when the seismic waves approach the surface, with the geology of the site further affecting ground movement, sometimes to a significant extent.

In current design practice, the movements predicted at the ground surface at a building or bridge site are usually used as the motion causing possible damage. In reality, the building or bridge will affect the earthquake ground movements through its own weight and movement. In some cases, the magnitude of the building movements will significantly change the shaking pattern initiated by the earthquake alone.

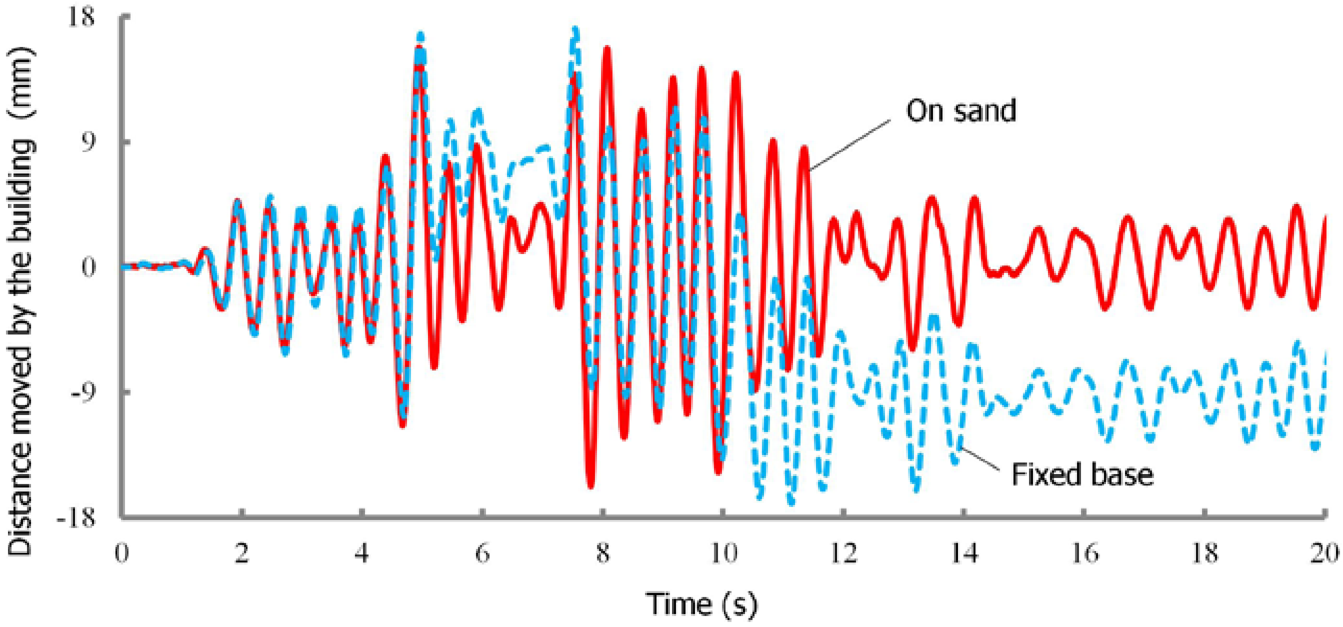
The weight of any construction applies load to the underlying soil and will modify how the soil responds to earthquake movements as the structure compresses the soil, increasing its toughness or capacity to sustain strong earthquake shaking.

The graph above shows an example of how a structure modifies ground movement. Without a structure (solid line) the soil movement can fluctuate faster, as illustrated within the red circle. With a structure present (dashed line) the movement is smoother and quite dissimilar in places (e.g., within the red circle). A structure designed for the conditions of the solid line will lead to different outcomes to that of the dashed line.

When buildings and bridges respond to earthquake ground movements, their foundations (where the concrete and steel is connected to the ground) cause the soil to deform and thus create further movement in the supporting soil. These additional movements in turn may affect the surrounding infrastructure and modify the earthquake-generated movements in the structure, as well as the soil in the vicinity.

If designers ignore the soil effects described above, then the building or bridge may fall short in terms of structural safety.

The practice of excluding the soil effects is known as a 'fixed base assumption.' While using a 'fixed base assumption' is simpler, it is not in the best interests of New Zealand engineering practice. Civil engineers now have the ability to incorporate the effects of the supporting soil into their designs through the knowledge gained by research, for example that carried out in the new laboratories of the University of Auckland Centre for Earthquake Engineering Research (UACEER).




Influence of soil-footing-structure interaction on structural responses. The footing is the structural component that distributes the weight of the structure to the soil. Data: N. Chouw, University of Auckland.

The graph above shows an example of results from an experiment carried out at UACEER. The graph shows the distance moved by a model building during earthquake shaking where in one case the model is 'fixed base' and in the other resting on sand. The significant difference in the distance moved by the building is shown. These results can be reproduced using theoretical calculations, thus advancing the practice of earthquake-resistant design in New Zealand.

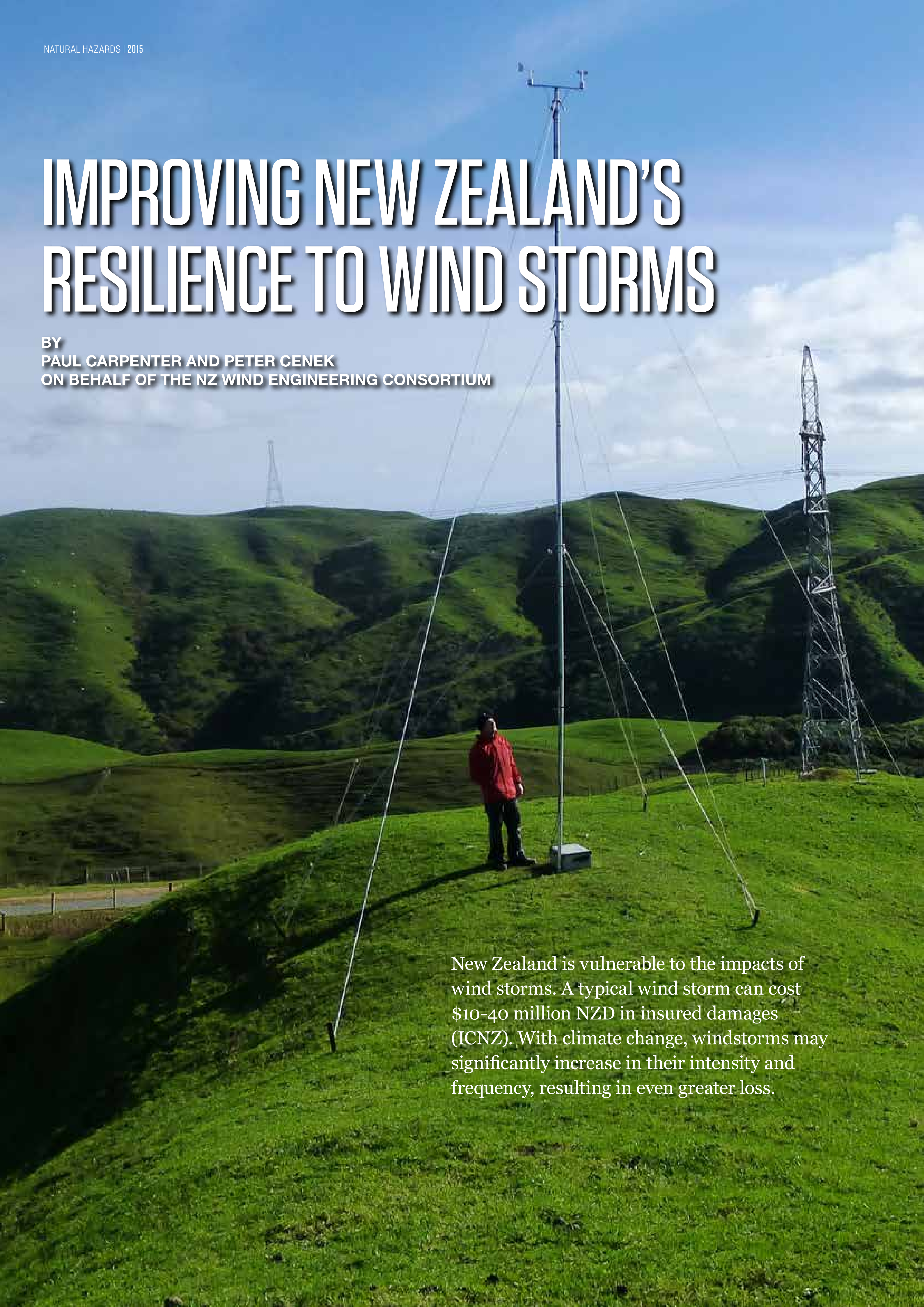
To pursue our mandate of developing safe and economic civil infrastructure, UACEER has been carrying out research with the support of the Natural Hazards Research Platform.

This photo (right) shows preparation for a large-scale investigation of a bridge founded on sand, using a platform that can shake the bridge in all directions. These studies will contribute to safer future design practices and hence improvements to existing structures needing rehabilitation, enabling infrastructure equal to the best in the world.


Preparation of a large-scale model of a bridge on sand. Photo: University of Auckland.

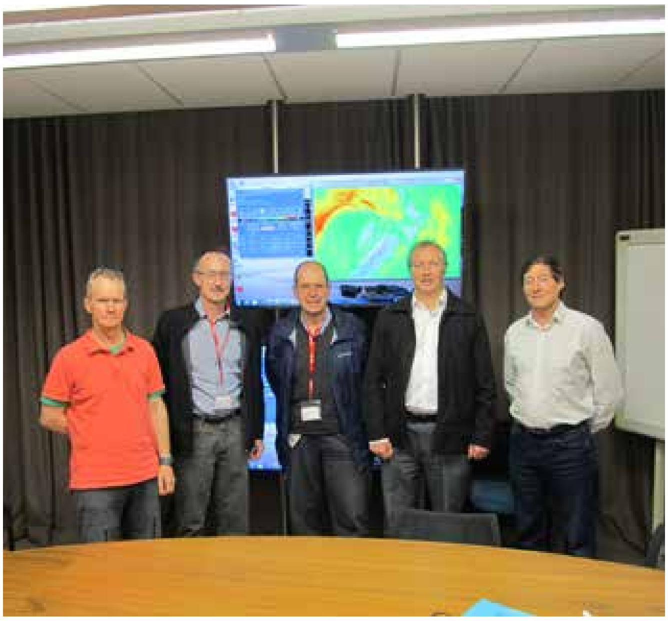
# IMPROVING NEW ZEALAND'S RESILIENCE TO WIND STORMS

BY
PAUL CARPENTER AND PETER CENEK
ON BEHALF OF THE NZ WIND ENGINEERING CONSORTIUM



New Zealand is vulnerable to the impacts of wind storms. A typical wind storm can cost $10-40 million NZD in insured damages (ICNZ). With climate change, windstorms may significantly increase in their intensity and frequency, resulting in even greater loss.

Tony Bromley (NIWA) stands under a 10 metre anemometer and wind vane that measures wind speed and direction in the Belmont Hills, Lower Hutt. Photo: Paul Carpenter (Opus).



**From left to right:** Dr Mike Revell, Neil Jamieson, Peter Cenek, Dr Richard Turner and Dr Brent Mullan. In the background is output from New Zealand Convective-Scale Model (NCSM). Photo: NIWA.

Paul Carpenter (left) and Professor Richard Flay (right) standing beside University of Auckland's new boundary layer wind tunnel. In the foreground is a model of a stadium roofing system. Photo: University of Auckland

Research is underway that aims to improve the resilience of New Zealand's infrastructure against the effects of severe winds. Our goal is to improve practitioner understanding of the wind effects that structures are designed to withstand, and the types of damage that may result.

The research team includes members of the New Zealand Wind Engineering Consortium, made up of researchers from the University of Auckland, NIWA, GNS Science and Opus Research. They are incorporating sophisticated weather forecasting models and anemometer records from windstorms to review wind damage, developing and promoting a standardised method for assessing and reporting wind damage, and investigating the potential changes caused by a range of climate change scenarios.

All buildings and structures in New Zealand are designed to withstand the effects of wind actions specified in the wind loading standard AS/NZS 1170.2, either directly or via other standards and codes. While much of the content of the wind loading standard has been prepared in Australia, the design wind speeds for New Zealand are the responsibility of New Zealand researchers and practitioners.

A new technique to be applied to the research will be to use weather forecast models in combination with historical wind speed records. NIWA have been operating a new high-resolution New Zealand Convective Scale Model (NZCSM). Weather monitoring sites, which include the anemometers measuring wind speeds at New Zealand airports, are sparsely distributed at widely separated sites around the country. We anticipate that, by combining the outputs from NZCSM with the anemometer records and wind damage records, a deeper insight into the risks from such storms will be obtained.

The research team have also been able to gain valuable data and insights from case studies overseas. Members of the research team were invited by the Fijian Ministry of Rural and Maritime Development and National Disaster Management Office to undertake surveys in the wake of Cyclone Winston.

Fiji provides an excellent case study as there are many similarities to New Zealand – the influence of slopes in accelerating wind speeds is quite common for New Zealand; and in Fiji there are many structures built of reinforced concrete masonry with corrugated iron roofs and solar panels – all quite common in New Zealand.

Wind damage from Cyclone Winston, Fiji. **Photo:** Sheng Lin Lin, GNS Science.

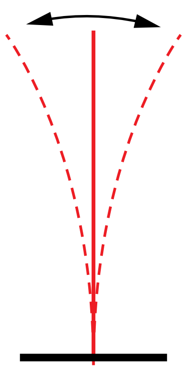
**Contact:**

Peter Cenek
Opus Research
Peter.Cenek@opus.co.nz

# DESIGNING A BUILDING FOR WIND AND EARTHQUAKES

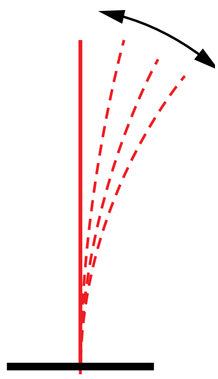
**BY**
**PAUL CARPENTER AND PETER CENEK, OPUS RESEARCH**

**EARTHQUAKE**



Differences between earthquake and wind loading. Earthquakes start affecting the building from its base whereas wind forces act all over the exposed faces of the building. As a result, during earthquakes a building oscillates about its centre of mass whereas during strong winds it oscillates about its deflected position.

**WIND**



Buildings are designed to resist both wind and earthquake loading. This requires a structural engineer to calculate design loads for both situations and to carry out a structural analysis to ensure the building and all its parts are capable of coping with these loads.

For New Zealand's multi-storey buildings, the earthquake load usually dominates the basic structure while wind load dominates the façade and cladding members ('envelope'). In other parts of the world with lower seismic risk, the wind load may dominate both the structure and envelope.

The diagram above shows the differences between earthquake and wind dynamic loading. Earthquake actions are generated by shaking at the base of the building and are amplified by the dynamics of the structure up its height about its centreline. In contrast, oncoming wind flow causes large pressure fluctuations over all exposed areas of the building. These pressure fluctuations are a function of the building shape and the turbulent nature of wind, in which both the mean wind speed and the turbulence vary with height.

For rectangular-shaped buildings, wind-induced pressures give rise to aerodynamic forces which push on the front face and pull on the side and rear faces and roof. The drag force created by the pressure difference between the front and rear faces causes a to-and-fro motion in the direction of the wind, the motion dictated by how heavy and stiff the building is.

Designing for wind and earthquake loading can lead to conflicting building requirements. From an earthquake perspective, it is desirable to make the building as light as possible, as this reduces the earthquake loads. However, from a wind perspective, it is desirable to make the building as heavy as possible to limit the motions caused by wind.

Considerable effort has been put into reducing the earthquake risk for existing buildings in New Zealand. Often this involves additional components that increase the strength and stiffness of the structure. Fortunately, this is also beneficial for resisting dynamic wind loads.

# NATURAL HAZARDS IN 2015

## A BRIEF SNAPSHOT OF THE MAIN EVENTS

### Earthquake

New Zealand had a relatively quiet 2015 for earthquakes. The January 2015 M6.0 Wilberforce earthquake had minimal impact due its location beneath the Southern Alps, while the April M6.2 earthquake beneath St Arnaud had minimal impact due to its depth at 51 km. A M5.8 earthquake occurred in April near Matukituri, near Wanaka, also with only minor impact. In 2015 there were 43 earthquakes in New Zealand with magnitude greater than 5, of which 31 were north of East Cape, beneath the Kermadec Islands.

### Landslide

Two earthquakes in mountainous terrain produced landslides and rockfall: the M6.0 Wilberforce earthquake on 6 January and the M5.8 Matukituki on 4 May. Both of these earthquakes were some distance from populated centres. More significant landslide impacts were associated with the winter storms in the Kapiti Coast-Hutt Valley (14 May), and in the Taranaki-Whanganui-Manawatu region (19-20 June).

### Volcanic Hazards

There were no volcanic eruptions onshore in 2015, however some submarine activity was observed at Monowai in the Kermadecs. In March, increased seismic activity around Ngauruhoe resulted in a raising of the Volcanic Alert Level (VAL) to Level 1. By April, the seismic activity subsided and the VAL was lowered to Level 0. Mt Ruapehu's Crater Lake went through a cooling phase beginning in April and in August experienced a moderately large snow avalanche into the lake. Also during August, the VAL for Mt Tongariro was lowered to Level O, which was its lowest alert level since the 2012 Te Maari eruption. By the close of the year, White Island was showing signs of minor volcanic unrest and the VAL remained at Level 1. Visit GeoNet for more information about volcanic alert levels: http://info.geonet.org.nz/display/volc/Volcanic+Alert+Levels

### Heavy Rain and Flood

In 2015 there were three significant flood events in Whanganui (18-21 June, $41.5 M), Dunedin (2-4 June, $28.2 M) and the Lower North Island (13-15 May, $21.9 M). A state of emergency was declared in Whanganui where there were widespread slips, road closures and homes evacuated. The Whanganui River breached its banks around midnight 20 June, spilling floodwaters into the CBD. Across the country ICNZ estimated that flood-related costs amounted to just over $100M NZD for the year 2015.

### Coastal Hazards

Ex Tropical Cyclone Pam (15-18 March) impacted the North Island east coast from the Coromandel Peninsula to Gisborne, causing debris and flooding on coastal roads along with rising seas (waves up to 9 m), resulting in closure of some routes (Bay of Plenty, East Cape), evacuations (Gisborne) and emergency beach scraping to shore up dune defences (Whitianga). On 15 April, large swells caused road flooding and damage in Lyall Bay (Wellington), while on 1 September, Tamaki Drive (Auckland) was flooded, leading to traffic disruption.

### Low Rain and Drought

The year 2015 started off very dry with below normal soil moisture levels observed for the majority of the country through January and February. It was particularly dry in Central and North Otago, Canterbury and Marlborough, and as a result a drought was officially declared in those areas on 12 February. As of June 2016, these areas are still classified as being in drought conditions by the Ministry for Primary Industries.

### Tsunami

A national tsunami warning was issued in New Zealand following the M8.3 Chile earthquake in September. In this instance, there was no significant impact to New Zealand. We are grateful to the NZ public for heeding the warnings issued by MCDEM.

### Winds and Tornadoes

The number of damaging high wind and tornado events was about half of what was experienced in the previous 5 years. There were significant events in the East Coast, Canterbury, and Tauranga (where a weak tornado damaged 30 houses). Ex-Tropical Cyclone Pam hit East Cape on 16 March with wind gusts of 144 km/h, roofs were lifted off houses and widespread power cuts occurred. On 4 October winds downed trees, caused power cuts, and damage totaling $680,000 NZD to irrigators in Canterbury.

### Snow, Hail and Electric Storms

There were four significant snow events affecting both North and South Island and resulting in major disruption of services (road, airport and school closure) and 1 causality (10 August). The largest snow event occurred during 18-23 June, when heavy snow in the South Island was followed by severe frosts resulting in ~4500 households in inland Canterbury losing power. Two significant hail events were recorded during 2015 in Hawkes Bay and the Motueka district, resulting in considerable damage to cars and the horticulture sector.

**For more info, visit –**

GeoNet: www.geonet.org.nz

NIWA's National Climate Summaries: www.niwa.co.nz/climate/summaries

## Resilience to Nature's Challenge

http://resiliencechallenge.nz/

The Resilience Challenge aims to enhance New Zealand's resilience to natural hazards. The Challenge is a partnership of researchers from all NZ universities, four CRIs and several other agencies working together with councils, communities, businesses, iwi, and central government units. The focus is on developing resilience solutions to our differing environments, including specialist case studies in urban, rural, Māori and coastal settings.

The Resilience Challenge is a National Science Challenge funded by the Ministry of Business, Innovation and Employment.

---

## Quake Core

http://www.quakecore.nz/

QuakeCoRE will transform New Zealand's earthquake resilience through innovative world-class research, education of the next-generation, and deep national and international collaborations. QuakeCore's multi-disciplinary research and stakeholder engagement will lead to policy and practice developments to improve how communities recover and thrive after major earthquakes.

QuakeCoRE is funded by the Tertiary Education Commission.


NATURAL
HAZARDS
RESEARCH PLATFORM