EQC
EARTHQUAKE COMMISSION
Kōmihana Rūwhenua

EQC Resilience and Research Highlights 2021

WORKING FOR A RESILIENT AOTEAROA NEW ZEALAND

EQC RESILIENCE VISION THAT NATURAL HAZARDS RESILIENCE BECOMES EMBEDDED IN ALL ASPECTS OF DECISION-MAKING FOR OUR HOMES, TOWNS AND CITIES.

EQC KIA MANAWAROA TĀTOU KIA MAU TE MANAWAROA MŌ NGĀ MATEPĀ TAIAO I ROTO I NGĀ ĀHUATANGA KATOA O NGĀ TUKANGA WHAKATAU E PĀ ANA KI Ō TĀTOU WHARE, KI Ō TĀTOU TĀONE ME Ō TĀTOU TĀONE NUI.

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October 2021
Earthquake Commission

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WELCOME TO OUR 2021 RESILIENCE AND RESEARCH UPDATE

It has been another big year for the Earthquake Commission – EQC. Though the COVID-19 pandemic has continued to dominate the emergency focus throughout 2021, we have been working hard to make sure EQC is ready, should there be another major natural hazard event. After all, natural hazards remain one of Aotearoa New Zealand's always-present risks.

We have an extensive readiness plan in place, and, in June, began a ground-breaking partnership with private insurers who are now handling claims, giving customers a single point of contact for their natural hazard insurance claims.

We've also expanded and strengthened our focus on looking at what happens before an event so we can, as much as possible, reduce risk and build resilience beforehand to reduce the impact on people and property.

You can expect to see much more of the EQC team sharing the results of our research programme and becoming directly involved in conversations around where and how we build houses and infrastructure, land use planning decisions, and taking active steps in risk reduction.

I'm pleased to share this report with highlights of what we have been doing over the past year for a more resilient Aotearoa New Zealand.

Sid Miller
Chief Executive

SID MILLER, CHIEF EXECUTIVE

At EQC, we're on a mission to reduce the impact of natural hazards on people and property.

Contributing to reducing risk and building resilience is a big part of how we do this. We fund research and data to build the evidence base for decisions, translate the science so it is easy to use, and work to get the right information to decision-makers whether they are homeowners, in central or local government or in the design and construction industry.

Although we don't deal with climate change directly, we know it will intensify some of the risks that EQC covers, such and floods and landslides, and we are increasingly including this in our thinking.

This year, we asked our key partners and stakeholders where we could most effectively target our research investment. The result is our *Research Investment Priorities Statement 2021–23*, which sets our funding direction for the next two years. We were pleased to attract a record number of applications this year for our Biennial Grants, from a wide range of disciplines and perspectives.

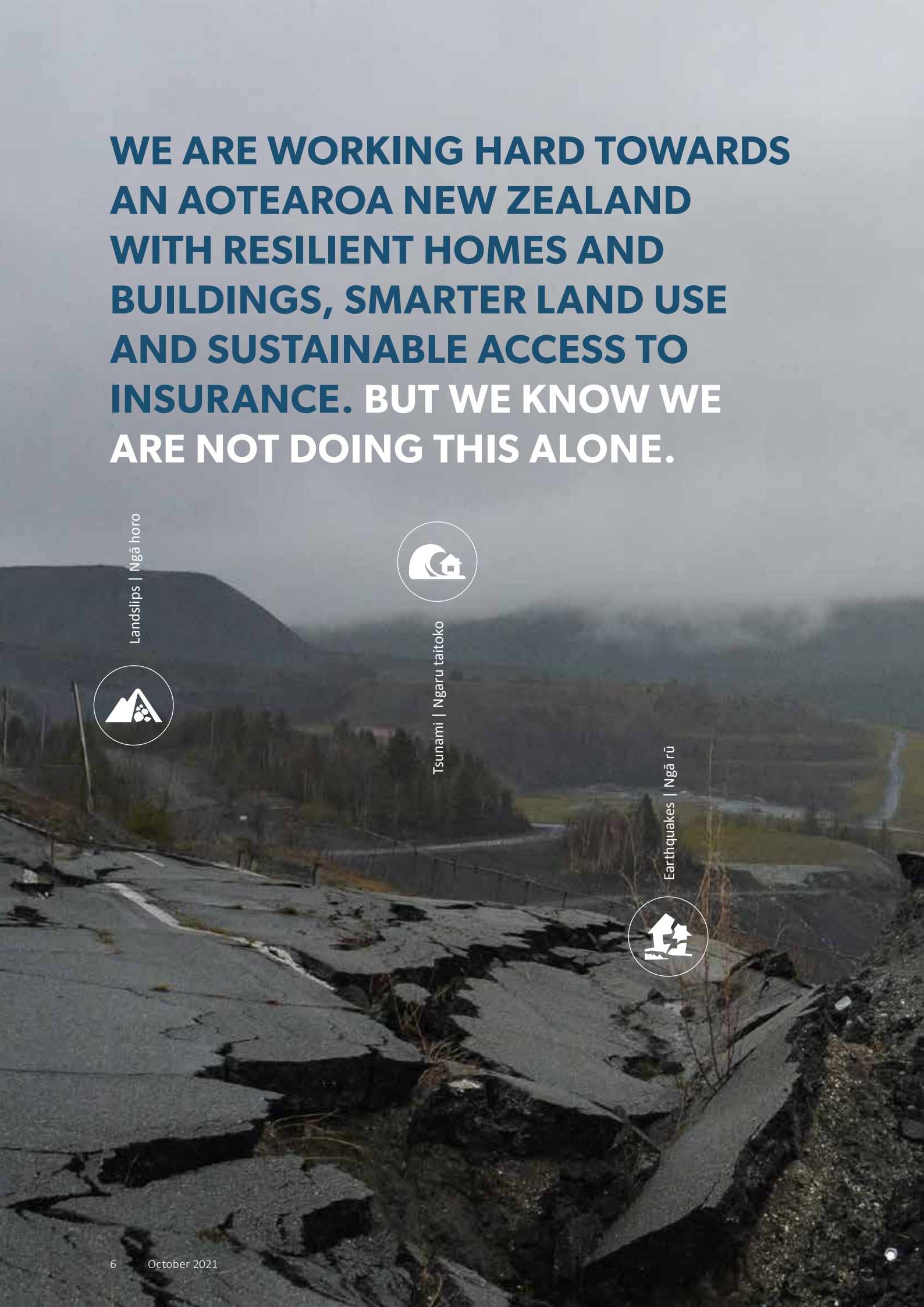
We'll be looking to use insights from our research, data and modelling to support the people making decisions so Aotearoa New Zealand's homes, towns and cities are more resilient.

This report shares highlights from our work over the past year, including celebrating the 20th birthday of that powerhouse of natural hazards data: GeoNet.

As always, if there is something you want to know more about or are keen to work on together, please don't hesitate to get in touch at jhorrocks@eqc.govt.nz

DR JO HORROCKS, CHIEF RESILIENCE AND RESEARCH OFFICER

WE ARE WORKING HARD TOWARDS AN AOTEAROA NEW ZEALAND WITH RESILIENT HOMES AND BUILDINGS, SMARTER LAND USE AND SUSTAINABLE ACCESS TO INSURANCE. BUT WE KNOW WE ARE NOT DOING THIS ALONE.



INTRODUCTION

Many people and organisations are working to the same aim of reducing risks and building resilience in the face of the many natural hazards we live with.

EQC plays a unique role in that it is an insurer of homes, and increasingly moving to be a strong partner in trying to minimise the need for New Zealanders to experience the disruption and hardship that accompanies claims for damage from disasters.

We are working hard towards an Aotearoa New Zealand with **resilient homes and buildings**, **smarter land use** and **sustainable access to insurance**. But we know we are not doing this alone.

Much of what we do is to provide evidence for change in a way that **empowers people** to make decisions and take action. This could be councils wanting to resist pressure for building on unsuitable land, engineers looking for new technologies, or homeowners wanting to make their houses more resistant to damage from natural hazards.

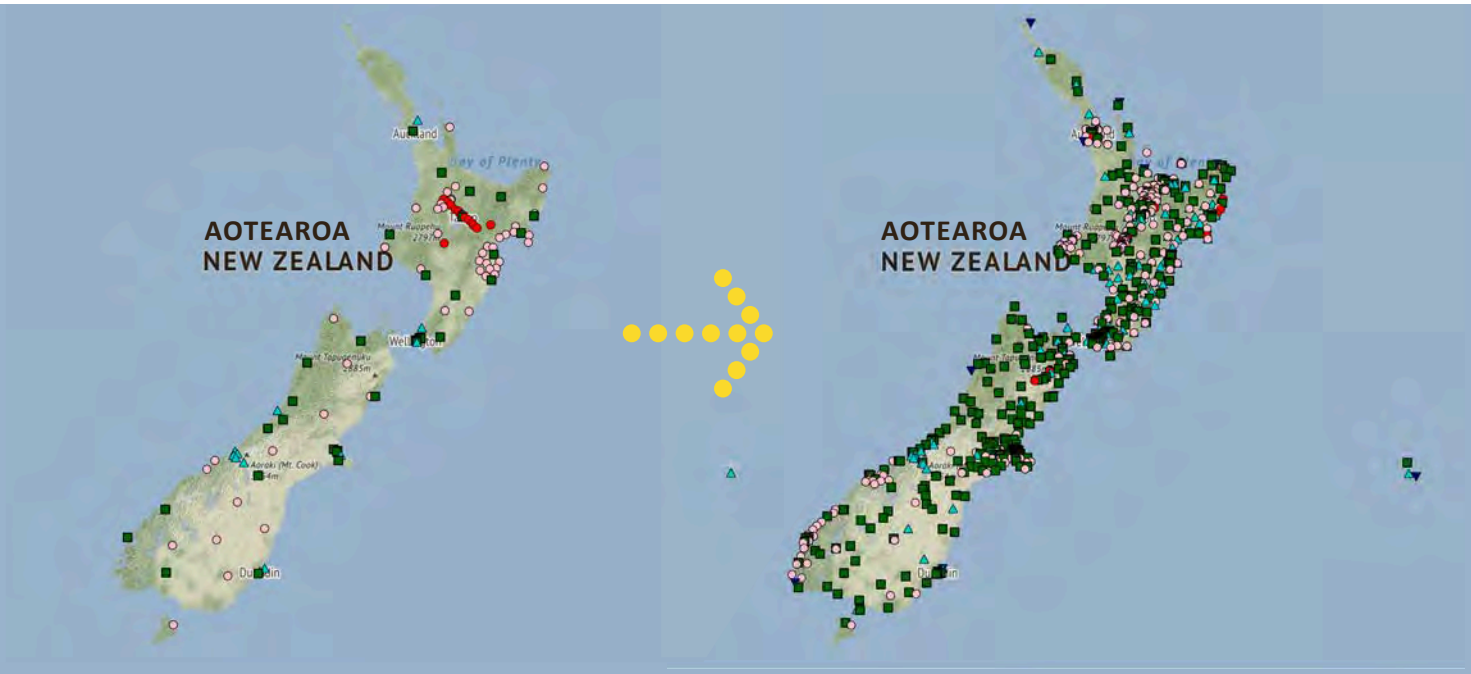
This update gives an overview of some of EQC's contribution over the past year towards a more resilient Aotearoa New Zealand.

HAPPY 20TH GEONET!

On 1 July 2001, GeoNet was launched. The rapid expansion of the sensor network generated the ever increasing stream of data about Aotearoa New Zealand's land and sea that now sits behind nearly all our natural hazard science and emergency management.

EQC was a founding partner of GeoNet and remains a major funder, contributing close to $14 million last year. Over the past 20 years, EQC has invested nearly $190 million in this critical service that monitors earthquakes, volcanic activity, large landslides and tsunami.

GeoNet is now a national network of 1000 instruments in nearly 700 locations delivering continuous streams of live data – over 11 billion samples a day – with 24/7 near-instant analysis in the National Geohazards Monitoring Centre/ Te Puna Mōrearea i te Rū.

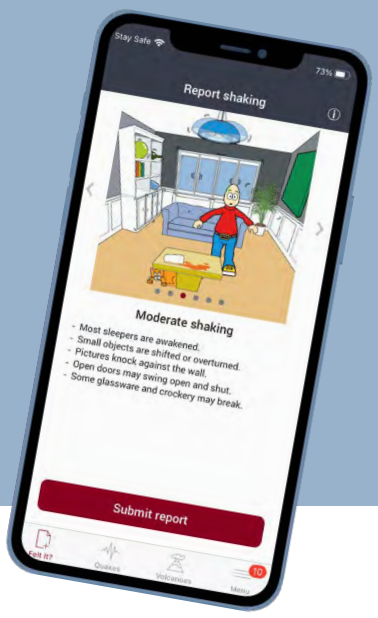


2001 PRE-GEONET NETWORK

2021 GEONET NETWORK

FOR EVERYONE

- GeoNet data is available **free to everybody**.
- GeoNet locates between 50 and 80 earthquakes each day, or between 20,000 to 30,000 a year, with most of them too small to be felt.
- More than 250,000 Kiwis have downloaded the GeoNet app.
- When there's a widely felt earthquake, the GeoNet website gets up to 16,000 hits a second.
- Everyone can be part of GeoNet by contributing "Felt it?" reports on their own experience of earthquake shaking.



LEFT + RIGHT: INSTRUMENT FIELDWORK. **PHOTO CREDIT**: GNS SCIENCE

DATA EXPLOSION

Earthquakes recorded in the 20 years before Geonet: **200,127**

Since GeoNet: **437,226**

Lowest magnitude earthquake that could be recorded before GeoNet: **0.34 ML** in 2001

Since GeoNet: **-0.07 M** in 2020*

Amount of raw data coming in 2001: **0.1 TB**

2020: **14.4 TB**

GeoNet's data archive now has **86.2 TB** of digital data, growing at the rate of **43 GB/day**, or **15 TB/year**.

TEAM EFFORT

GeoNet is hosted by GNS Science and supported by a dedicated group of contributors. EQC remains a major funder along with other partners like Toitū Te Whenua Land Information New Zealand, the Ministry of Business, Innovation and Employment (MBIE), MetService and the Department of Conservation.

WHO USES GEONET DATA?

Scientists, international researchers and monitoring agencies, the National Emergency Management Agency, the Department of Conservation, Waka Kotahi New Zealand Transport Agency, air traffic control, ports, power and water suppliers, insurers, reinsurers, designers, engineers, building owners and many others along with everyday New Zealanders through the app and website.

**A negative measure happens because of the logarithmic scale used to measure earthquakes.*

SECTION ONE

RESILIENT HOMES AND BUILDINGS – NGĀ WHARE WHAKAMĀROHIROHI

Demolition of “built to code” homes and buildings following the Christchurch and Kaikōura earthquakes has led to an increasing expectation that buildings should survive earthquakes in a way that allows people to keep living and working in them.

But the reality is that given how the current housing stock has been built in Aotearoa New Zealand, and the perceived additional costs to build stronger in new builds, there is a long way to go to meet that expectation.

EQC is supporting many research projects aiming to develop cost-effective techniques for resilient homes and buildings, old and new, and cost–benefit information for decision-making on new buildings.

Carry on for updates on some of the EQC-funded projects contributing to resilient homes and buildings for Aotearoa New Zealand.



DR ENRIQUE DEL REY CASTILLO AND VICTOR LI IN THE TEST LAB, AND CHECKING THE EXTENT OF DAMAGE UNDER LOAD.

ADDING STRENGTH TO OLD WALLS

With increasing numbers of older commercial buildings being converted to apartments, finding cost-effective ways to strengthen walls to meet modern earthquake standards is urgent.

The thinner walls of pre-1982 construction can be at higher risk of axial and brittle failure – where the wall buckles and collapses – yet no general guidance is available on how to strengthen these walls, meaning engineers must each develop their own solutions.

University of Auckland researchers Dr Enrique del Rey Castillo, Dr Rick Henry and PhD student Victor Li tested 56 different combinations of concrete, steel and carbon fibre to find which would be most effective for "wrapping" at-risk walls to make them stronger.

They are now applying the most effective wrapping method on 4 metre high walls loaded to simulate 3 to 4 storey and 8 to 12 storey buildings, and subjecting them to seismic forces in the lab.

Results so far show the wrapped walls can flex more than two times as much and still have the ability to take the load, and even at flexing four times as much, only a 30 percent loss of strength occurs. This increased strength allows these walls to survive not only the main earthquake, but aftershocks that follow.

The project's next stage is to use test data to model how the strengthening of parts of the wall has affected the whole structure of the building. This is to ensure that the weakness has not simply been transferred to another part of the building.

Following the final results, guidance will be created so engineers can choose the most suitable fix for any particular wall.

Industry partners Mapei, Holmes, Concrete New Zealand, Sika New Zealand and BBR Contech have contributed advice and materials to the project to help ensure guidance can be put into practical use quickly.

CONNECTING TO RESILIENT, LOW-CARBON DESIGN

After two years of work on design and components, world-first testing is now under way on new types of seismic connections for cross laminated timber (CLT) shear walls at the University of Canterbury.

DR MINGHAO LI (LEFT) AND BEN MOERMAN CHECK THE CLT WALL TEST SET UP.

The CLT walls are made from New Zealand Douglas fir, a sustainable material much lighter than concrete both in terms of weight and carbon footprint, but with similar strength.

CLT panels have already proved to be seismically strong. Research team Dr Minghao Li and PhD student Ben Moerman are now testing the connections between panels, and between panels and the foundation, to see how a building using CLT walls would stand up to the type of seismic forces that Aotearoa New Zealand experiences.

The team believes the new connections and optimum layouts could provide three- to five-times more strength than conventional CLT connections. One of the elements being tested is a wall-to-foundation connection using a group of 300-millimetre long self-tapping screws that will bend and yield to take the stress of shaking and then can be relatively easily replaced.

For the tests, 7 metre high walls will be loaded to simulate earthquake performance in a 6 storey building with different types and layouts of connections between walls and the foundation. Measures are recorded on the lowest storey, which takes the biggest forces in an earthquake.

Once tests are finished, the team will develop guidelines for the connections and their installation that can be used by designers and builders of CLT buildings tested for New Zealand conditions.

NEW MATERIALS MAKE THE SEISMIC GRADE

Structural insulated panels (SIPs) can offer a fast, efficient way to build new homes, but consenting processes have generally required a full engineering evaluation for each build.

SIPs – sandwich panels made of two structural face layers and an insulating inner core – have been used overseas since the 1990s for fast construction of homes and low-rise buildings but have not undergone national-level testing in Aotearoa New Zealand.

Dr David Carradine and a small research team at the Building Research Association of New Zealand (BRANZ) have now finished testing SIP wall-bracing panels for seismic performance in New Zealand conditions. They found SIPs provide comparable seismic performance to more commonly used bracing materials like plasterboard or plywood.

LEFT: DR DAVID CARRADINE (RIGHT) IN THE TEST LAB. **RIGHT**: MODULAR HOUSE WITH COMPOSITE WOODEN SIP PANEL WALLS.

Results demonstrated that the SIPs could dissipate seismic energy and remain stiff and strong under earthquake loads with minimal damage. They also worked well when connected to foundations and framing made from more traditional New Zealand home building materials.

The seismic testing is part of a wider BRANZ research project looking at the suitability of SIPs for New Zealand homes. The project includes testing of durability and a review of fire performance literature, all due to be completed at the end of this year.

The team expects results from the full testing programme will help people building homes to get faster consent for using SIPs, which can be prefabricated and assembled quickly on site to speed up construction and reduce overall building costs.

TECHNIQUE DOUBLES FOUNDATION STRENGTH OF HOMES ON SLOPES

Research led by Roger Shelton, from BRANZ, on wooden-framed houses on slopes has delivered retrofit solutions to strengthen some types of homes by more than 100 percent against earthquake shaking.

Data from the Christchurch earthquakes showed that the same level of shaking caused more damage to homes in Port Hills areas like Cashmere and Redcliffs than it did to homes on the flat, largely due to the flexibility of the foundation systems.

With support from EQC and Victoria University of Wellington, researchers built four types of timber foundations on a sloping paddock north of Wellington: two to the current NZS 3604 standard and two in the style of homes built before the 1970s. The team tested each foundation under simulated earthquake shaking.

While the modern standard houses performed well overall, the older style foundations showed a clear need for strengthening.

Two cost-effective methods of strengthening were then installed and tested: diagonal braces between the piles and sheets of plywood fixed to jack-stud walls.

Results showed the plywood was the best performing solution, delivering more than double the performance of unstrengthened foundations. Where access prevented this solution from being used, extra bracing between foundation piles still provided a significant increase in performance.

Once final analysis and reporting on the testing is finished, results will be shared with engineers and builders.

LEFT: ROGER SHELTON ON SITE FOR FOUNDATION TESTING. **RIGHT**: PLYWOOD DELIVERS EXTRA STRENGTH TO AT-RISK FOUNDATIONS.

QUANTIFYING COSTS FOR LOWER DAMAGE BUILDINGS

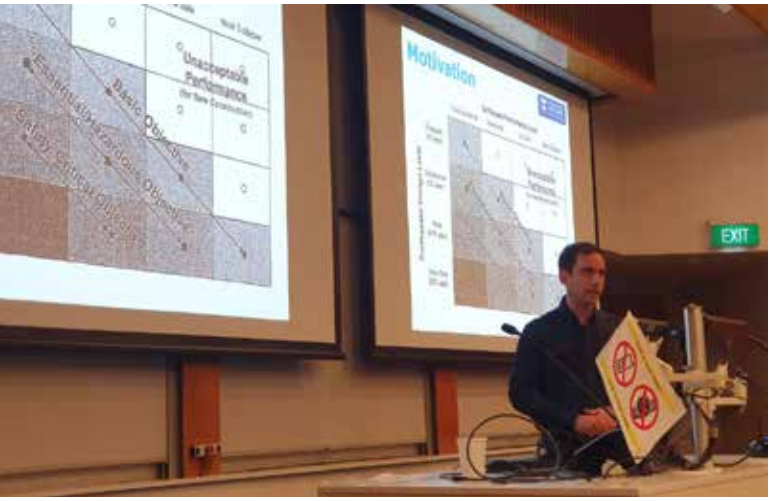
Following the Christchurch and Kaikōura earthquakes, many buildings, some even quite new, were assessed as uneconomic to repair and were demolished. This puzzled many members of the public but was expected by design professionals because the New Zealand building code has a primary objective for life safety.

Current engineering practice largely meets this standard by using building movement to dissipate energy from seismic shaking, which can, and sometimes does, result in some form of damage to the building.

Social expectations have now shifted towards buildings remaining operational immediately or shortly after an earthquake, or at least being easily and rapidly repairable at low cost. Though well-established low-damage technologies are available, such as base isolators and damping, these are not widely used in Aotearoa New Zealand.

Researchers Dr Enrique del Rey Castillo, Associate Professor Vicente Gonzalez and Associate Professor Charles Clifton at the University of Auckland say this is due largely to the perception that lower damage building design is complex and costly. Other seismically active countries, however, have building codes requiring stronger and stiffer buildings, though data on how this affects the cost of construction is not publicly available.

The research team is developing a model to quantify the additional cost of building to various



DR ENRIQUE DEL REY CASTILLO SHARES EARLY LEARNINGS.

higher levels of seismic performance for both reinforced concrete and steel multi-storey buildings. The objective is to test the hypothesis that a step change in increasing the seismic resilience of the structural design of a building does not necessarily equate to a significant step change in the overall cost of designing and constructing the building.

The first phase has been to gain an understanding of the cost estimation methods used in the construction industry. The researchers are now developing a database of typical New Zealand buildings, their seismic capacity and the associated construction costs. This provides the base for modelling the additional inputs and costs required for higher levels of seismic strength, and how much that would increase construction costs for a building in Aotearoa New Zealand.

Once the model is refined and fully tested, it will be turned into an easy-to-use tool for engineers, developers and policy makers to help with decisions about building design and building regulations.

HOW DO PEOPLE IN AOTEAROA NEW ZEALAND EXPECT THEIR BUILDINGS TO PERFORM IN AN EARTHQUAKE?

Following the Christchurch earthquake sequence and the Kaikōura earthquakes where many buildings, even near new ones, built “to code” were so damaged they had to be demolished, there has been much greater public and homeowner awareness of the damage earthquakes, large and small, can cause to homes and buildings.

EQC research, led by seismic engineers and social researchers, is under way to understand in greater detail what expectations New Zealanders have about how medium to high density multi-storey buildings should perform in an earthquake.

The team, led by Dr Hugh Cowan, Helen Ferner and Dr Charlotte Brown, aims to take a snapshot of views from across Aotearoa New Zealand.

Extensive interviews and focus groups are being undertaken with people from different communities, businesses, iwi, building owners,

PARTICIPANTS IN A RESEARCH FOCUS GROUP MARK BUILDINGS OF PARTICULAR IMPORTANCE TO THEM.

insurers and others from geographical regions that include both high- and low-seismicity areas, dense urban areas and smaller regional towns.

Questions cover issues like the environmental impacts of building damage and reconstruction, the social, cultural and economic disruption to people of building failure, and what expectations people have of building performance and whether it is different from the current "life safety" standard.

The aim of the project is to ensure a wide range of voices is involved in laying the groundwork for resilient building design for the next decades. Results will provide input for future reviews and updates of building regulations and standards.

RESEARCH GETS REAL WITH RESILIENT SLIP FRICTION TECHNOLOGY

A low-cost technology to limit damage to buildings from an earthquake has made a remarkably fast move from research to real life, with the help of an MBIE Endeavour grant, investment from the commercialisation arm of the University of Auckland and a great deal of encouragement by Dr Ashkan Hashemi.

Dr Hashemi's path to being a lead advocate for the new seismic engineering solution started when he was doing an EQC-funded PhD at the University of Auckland in 2014.

A structural engineer from Iran, Dr Hashemi became involved in a project to develop and pilot the practical implementation of the new resilient slip friction (RSF) joint. The joint is embedded in a building's columns, bracing or walls and moves to absorb and dissipate seismic energy before it reaches the foundations. Once the shaking has stopped, the joint's re-centring mechanism restores the building back to its original alignment.

DR ASHKAN HASHEMI RECEIVES THE 2021 NZSEE/EQC IVAN SKINNER AWARD FROM EQC'S DR JO HORROCKS.

From final laboratory tests in 2015, RSF joints are now being used in 12 buildings in Aotearoa New Zealand and overseas. RSF joints can be used in both new buildings and as a retrofit solution for seismic strengthening.

To overcome the natural cautiousness of engineers and designers in using new technologies, Dr Hashemi developed tools, procedures and guides, shared through workshops, to make the new technology easy to adopt.

This work gained him the 2021 New Zealand Society for Earthquake Engineering (NZSEE)/ EQC Ivan Skinner Award, with a $10,000 prize that he plans to use to continue to build knowledge about RSF joint use in the design and construction sectors.

LOOKING AHEAD

RESILIENT HOMES AND BUILDINGS

Homes and buildings in Aotearoa New Zealand are products of their environment, resulting from a complex system of stakeholders, industries, and policies that all change over time. Similarly, standards of what constitutes "good enough" have been a moving target. This has resulted in varying states of resilience across New Zealand's built environment. Risk reduction measures are crucial for addressing the longevity and suitability of New Zealand's homes and buildings for current and future hazards.

While continuing to invest in research to build the evidence base for a high performing built environment, EQC intends to be a strong advocate in conversations on issues like improving the building regulatory system, the implications of climate change for buildings, and ways of enhancing building performance.

Our contribution will be guided by our three-year *Resilient Homes and Buildings Action Plan*, which aims to increase the resilience of homes and buildings to improve safety and wellbeing for New Zealanders. The plan sets out where and how EQC can be most effective in increasing the resilience of New Zealand's built environment.

NGĀ WHARE WHAKAMĀROHIROHI

The plan is currently in development. We intend to hold workshops and engage with key stakeholders across the built environment sector. Our goals are to support and influence:

- the development of new homes and buildings so they are designed and built for resilience
- the management and assessment of existing buildings so they are safe and resilient
- New Zealand's built environment "system" so it continues to be fit for purpose.

Focus areas include:

- getting wider society involved in conversations about structural building performance
- identifying vulnerabilities and cost-efficient solutions for existing buildings
- investigating incentives for homeowners to reduce risk, such as removing chimneys and fixing houses to foundations
- promoting low-damage design for new buildings
- balancing lower embodied carbon with increased natural hazard resilience.

SECTION TWO

SMARTER LAND USE – TE WHAKAMAHINGA PAI AKE O TE WHENUA

With its role as an insurer and goals of risk reduction and greater resilience to New Zealand's natural hazards, EQC is in a unique position to understand the pressing need for smarter land use.

Much of the land damaged in the Canterbury earthquake sequence had been previously known to be at risk. The lessons from those events have been widely analysed, reported and disseminated, but we continue to see houses consented and built in questionable, high-hazard areas, or insurance claims for natural disaster damage soon after construction.

Looking ahead to the effects of climate change, we know natural hazard risks will increase in some places. This knowledge does not seem to be heeded. Examples can be seen of property developments that have recently been consented but not yet built that will likely need to consider retreat in the not-too-distant future.

EQC is supporting research and education to provide evidence for different aspects of land use planning to help decision-makers balance development with natural hazard risk.

We aim to support councils, builders, developers and homeowners to make decisions that mitigate risk, for example, by avoiding the worst land, strengthening land under houses, and development planning that takes a climate change future into account.

Carry on to see updates on EQC-funded work under way to support smarter land use.

LEFT: MATT COOK USES GROUND-PENETRATING RADAR TO INVESTIGATE A POTENTIAL LANDSLIDE IN GISBORNE.
RIGHT: DR MURRAY CAVE ON A ROCKSLIDE AT MANGAPOIKE NEAR GISBORNE.

GETTING GRANULAR WITH LANDSLIDE RISK IN GISBORNE

A project underway in Gisborne will deliver hard data on the areas of greatest landslide risk in the area.

PhD student Matt Cook, from the University of Auckland, and Dr Murry Cave, Principal Scientist at Gisborne District Council, say detailed data will help the council, homeowners and home builders to have well-informed discussions on landslide risk.

Currently, the district plan defines most areas on hillsides as landslide prone, and this is reflected in the Land Information Memorandum (LIM), affecting people whose houses may not actually be at risk.

The project is using EQC claims data, LiDAR and InSAR data, and detailed soil testing from "typical" local landslides to find a way of fine-tuning landslide risk at the level of individual properties. This will mean that LIMs will better reflect the actual level of risk.

As a first step, the researchers studied 200 historic landslides to analyse the main factors that drive landslide activity. They found that, along with the degree of slope and type of soil, longer term trends also make a significant difference. For example, a cycle of a potential landslide experiencing rainfall, then drying out, then rainfall again over a six-month period increases the risk.

Findings from the research will be presented at a community workshop later this year and used to amend the Tairawhiti Resource Management Plan to better take account of landslide risk.

NATIONAL LANDSLIDE DATABASE

EQC claims data shows that landslides are a major source of damage to homes, but getting a nation-wide picture of landslide risk is not easy.

Information is held on many separate databases and repositories of landslide information around the country by organisations such as GNS Science, local authorities, and infrastructure providers like NZTA and KiwiRail.

Development of a cross-organisation national landslide database that everyone can contribute to and use is being co-funded by EQC and Auckland Council. The database will deliver details on identified landslides, such as the type, size and likely impact, in a consistent way.

The new National Landslide Database will launch in the second half of 2021 and be an invaluable resource for any organisation wanting to understand the location of vulnerable land and how to manage risk when planning housing and infrastructure.

RAIN INDUCED LANDSLIDE, OHIWA, BAY OF PLENTY, JULY 2004 **PHOTO CREDIT**: GNS SCIENCE

RESEARCH FOR ANSWERS ON GRAVELLY SOIL LIQUEFACTION

The Kaikōura earthquake answered an important question that had been on University of Canterbury's Associate Professor Gabriele Chiaro's mind for some time: "Can New Zealand gravelly soils liquefy?".

The answer, it turned out, was "yes", with sites near Blenheim and at Wellington's port liquefying from the earthquake shaking, in some cases, leading to extensive building damage.

Associate Professor Chiaro has now finished a pilot research project looking at why gravelly soil liquefied in Blenheim, and how such soils can be more accurately tested in the field to find out if they are liquefaction prone or not.

As part of the project, and for the first time in Aotearoa New Zealand, the research team carried out dynamic cone penetration tests (DCPTs) suitable for gravelly soils with larger particles. This technique consists of pushing a large-diameter steel cone into the ground – by means of a 120 kilogram weight falling from a height of 1 metre – to measure the soil resistance.

Standard cone penetration tests (CPTs) using a much smaller size steel cone could only go to a depth of 5 metres from the ground surface, so Associate Professor Chiaro and his team came up with the idea of performing DCPTs instead. Once they could get useful data to the depth of 15 metres from the ground surface, they

LEFT: ASSOCIATE PROFESSOR GABRIELE CHIARO ON SITE WITH THE DYNAMIC PENETRATION TESTING RIG.
MIDDLE: SOIL SAMPLE AFTER BEING SEPARATED. **RIGHT**: PHD RESEARCHER ABILASH POKHREL WITH THE CUSTOM-MADE LARGE-DIAMETER TRIAXIAL APPARATUS AT THE UNIVERSITY OF CANTERBURY GEOTECHNICAL LABORATORY.

found that the test sites chosen for potential liquefaction risk had a layer of weak gravelly sandy soils that was likely to liquefy during strong earthquakes.

Samples were taken back to the laboratory in Christchurch to determine the soil composition and particle size. Following the field investigation and initial laboratory investigations, Blenheim's gravelly soils liquefaction potential is assessed by using a specially imported large-diameter triaxial apparatus capable of testing soil particles up to 5 centimetres in diameter. This provides additional unique high-quality data not available elsewhere, making it possible to gain a better understanding of the gravelly soil liquefaction phenomenon and its governing factors.

The project results have now set the stage for Aotearoa New Zealand to have the capability to test gravelly soil anywhere in the country to see if it is likely to liquefy or not.

MANAWATŪ DISTRICT COUNCIL MOVES TO DEFINE FEILDING FAULT RISK

When an initial GNS Science report reclassified the Rauoterangi Fault running through Feilding as active, Manawatū District Council moved quickly to share knowledge on the likely area of fault zone hazard through public meetings, and commissioned further investigation to find out more.

EQC is helping fund detailed research – a paleoseismic trench study – on the fault that runs through central Feilding under homes, businesses and a school, to understand more about its potential impact.

Led by earthquake geologist Dr Rob Langridge, from GNS Science, the team is now radiocarbon dating and analysing samples from the trench to find out how often the fault has ruptured and at what magnitude. Early indications are that the fault could trigger a quake every 5,000 to 10,000 years.

LEFT: TRENCHES ACROSS THE RAUOTERANGI FAULT IN FEILDING **RIGHT**: PUPILS FROM MANCHESTER STREET SCHOOL GOT AN UP-CLOSE LOOK AT THE FAULT THAT RUNS UNDER THEIR SCHOOL. **PHOTO CREDIT**: MANAWATŪ DISTRICT COUNCIL

Research results will be used in council land use planning, to ensure buildings in the fault zone are appropriate for their location, and in scenario planning for a coordinated earthquake response.

Sharing information with the public has been part of the project, with extensive public information and discussion. During the research, pupils from Manchester Street School, located along one of the fault traces, were invited into the trench to talk to the scientists about their work.

HELPING PLANNERS PUT NATURAL HAZARDS IN THE PICTURE

Support for planners to include and manage natural hazards and the impacts of climate change in their work, with practical training and guidance, is an important element of EQC's aim to drive smarter land use.

The first step was to fund GNS Science to carry out a survey on the needs of planners in both councils and private practice. Responses from 283 planners nationwide showed they wanted to know more about understanding and implementing good planning practice for flood and coastal hazards, land stability, earthquake faults and sea level rise.

SECTION OF A CHRISTCHURCH AREA NATURAL HAZARDS MAP.

Results of the survey are now being used to develop a continuous professional development programme tailored to the needs of planners, in conjunction with the New Zealand Planning Institute.

The aim is for all planners to have access to quality natural hazards and climate change professional development opportunities. EQC and the New Zealand Planning Institute are also jointly looking at opportunities to support university planning programmes to include more natural hazard planning content in their courses.

SMARTER LAND USE

Decisions around land use planning have a profound effect on the resilience of homes and the wellbeing of communities.

As both an insurer of homes and contributor to natural hazards resilience, EQC is aiming to take a more active role in influencing and advocating for better risk-based land use planning.

We will be doing this in line with our *Smarter Land Use Action Plan for Risk Reduction 2021–2026*, developed over 2020 to 2021. The plan has been tested with key stakeholders from the research, insurance, and central and local government sectors.

The plan sets out how we will support decision-makers and communities to make evidence-based decisions that will sustain their wellbeing for future generations.

TE WHAKAMAHINGA PAI AKE O TE WHENUA

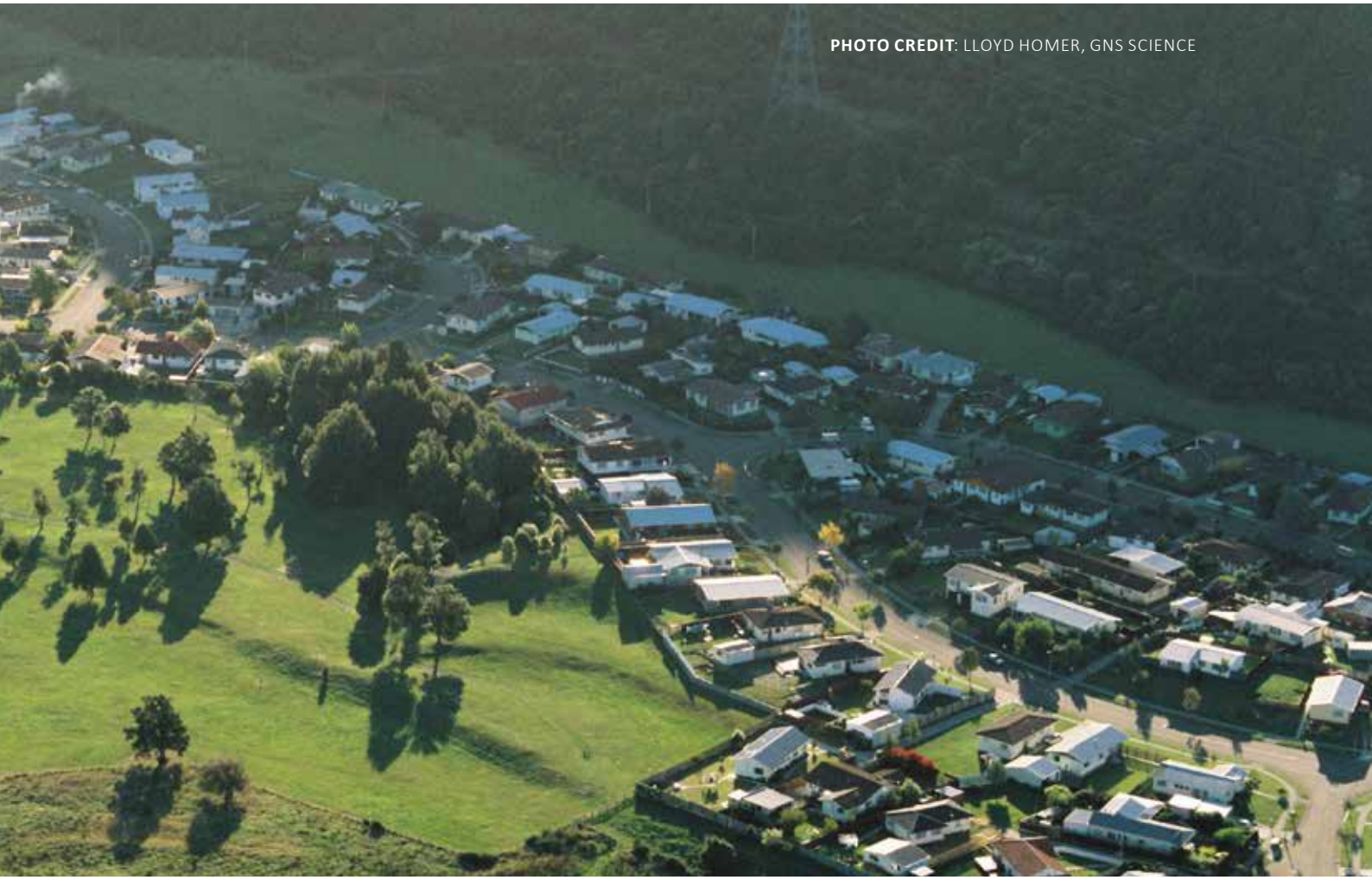


PHOTO CREDIT: LLOYD HOMER, GNS SCIENCE

Along with submissions on legislation and policy, and establishing partnerships with the planning profession, the plan includes actions such as:

- establishing a resilience fund to support Māori to fulfil their risk reduction aspirations in respect to land use
- establishing a resilience partnership fund to support councils to translate and interpret science for land use planning and engineering
- providing support for scientists to be able to present their evidence in different forums.

Our long-term aim is to see land use planning become a topic of public conversation and one that the whole community is engaged with and can contribute to.

SECTION THREE

EMPOWERING PEOPLE – TE WHAKAMANA I TE TANGATA

Aotearoa New Zealand is known as the second riskiest country in the world for natural hazards (by percentage of GDP), but we can do a great deal to reduce risk and minimise the impact. Homeowners and people working in central and local government, the design and construction industry, and many others are the decision-makers for homes, towns and cities to build a more resilient future.

EQC helps provide the best available evidence for these decision-makers, investing $21 million over the past year in research, data and education.

The Resilience and Research team works hard to get the right information to the right people in the right way. This can include advertising campaigns to homeowners, building science-based scenarios for discussion and planning, hosting expert workshops or raising awareness of hazards risk reduction through media stories.

Carry on for examples of some of the work we have done over the past year to support people taking action for resilience.

PHOTO CREDIT: LLOYD HOMER, GNS SCIENCE

ADVOCATING FOR RISK REDUCTION AND RESILIENCE

This year has seen EQC make a significant shift in how we actively engage with the natural hazard risk and resilience sector to support, influence and enable better decisions at the national and local level.

To strengthen how we deliver on the EQC Resilience Strategy for Natural Hazard Risk Reduction, we are providing thought leadership and expertise to make a positive impact across the public and private sectors. Being a trusted source of advice or support on hazard risk management and resilience is at the heart of EQC's resilience work programme. This has allowed us to provide effective advice on key policy discussions and local government submissions, for example, on the Resource Management System Reforms and Climate Change Adaptation policy development, elements of the building performance regulatory system, and regional spatial plans.

MOVING RISK AND RESILIENCE INFORMATION INTO ACTION

A key focus for EQC is how New Zealanders access, use and interpret natural hazard information.

We want risk information associated with natural hazards to be more freely available and better understood. We want to see risk data drive action. To make progress on this, we are scoping the development of a public self-service portal to house comprehensive data and information on New Zealand's natural hazard risk, with tools to encourage risk-informed decision-making.

The portal will also promote the use of hazard mapping for communicating and managing land use risks. We want individuals at the community, local, regional and national level to have a useful "go-to" source, so they can understand and consider their risk, their tolerance to that risk and, most importantly, what they can do about it.

SCENARIOS MAKE SCIENCE REAL FOR RESPONSE

Using EQC in-house expertise, strong relationships with the research community, and building on the data or research we fund or own, we have developed a National Hazard Scenario Database.

This is being used to ensure EQC is tested, prepared and ready to respond to credible natural hazard events, and to improve our ability to better understand impact and loss estimations. We have developed 10 scenarios, aligned with nationally agreed "maximum credible" and "most likely" natural hazard scenarios. These are being used by the EQC Readiness Team to exercise and work with insurance partners to advance EQC's readiness, event response and business continuity arrangements.

In future, we will make these scenarios publicly available through the Risk and Resilience Portal. An agreed set of nationally consistent, credible, hazard scenarios will provide a common understanding of risks and a consistent basis for preparedness and planning.

CALCULATING AUCKLAND VOLCANIC EVACUATION TIMES

Research by University of Auckland PhD student Alec Wild has shown that up to 320,000 Auckland residents may need to evacuate, taking up to 49 hours, once the location of a new eruption on the Auckland volcanic field is well understood.

Unlike large central North Island volcanoes, eruptions in the Auckland volcanic field are usually smaller, and in a new location each time, with 53 volcanic centres identified to date.

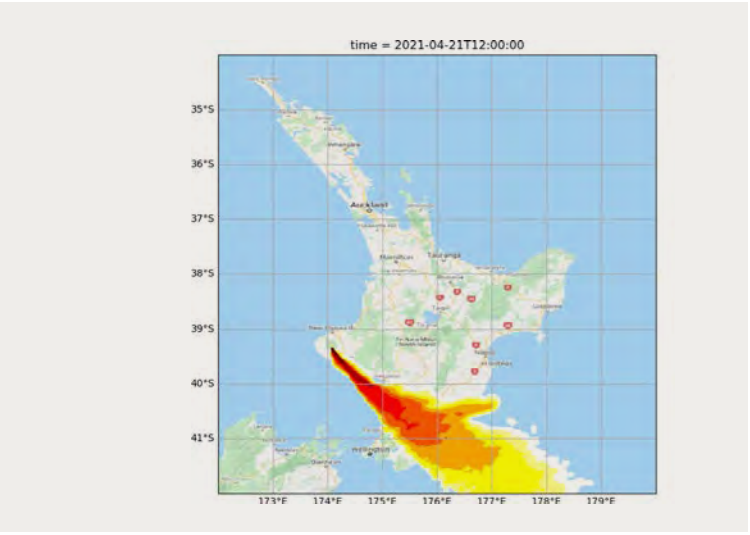
Although unlikely in our lifetimes, the next eruption could happen anywhere in the existing field, either on the land, or in the sea, so estimating how many people might be affected is difficult.

To address the unpredictability in any future eruptions, Mr Wild and his team created a geospatial model using demographic information, such as population distribution and

ALEC WILD

vehicle ownership information, to understand how many people might be at immediate risk during a volcanic eruption once the location is “fairly well” understood, and how long it would take for them to evacuate away from danger.

The project’s next step is to turn the model into an easy-to-use tool, to help Aucklanders plan and prepare, and, in the event of volcanic activity, help emergency managers to make decisions quickly.



LEFT: A HYPOTHETICAL LARGE ERUPTION OF TARANAKI MAUNGA SHOWING WHERE ASH WOULD FALL ON THE GROUND AND ITS THICKNESS. **MIDDLE**: DR YANNIK BEHR **RIGHT**: DR ROSA TRANCOSO

LIVE ASHFALL FORECASTING

Joint GNS Science and MetService research will help deliver real-time forecasting on where and how heavily volcanic ash is likely to fall, giving communities greater ability to manage the impact of future eruptions.

Ash can be carried hundreds of kilometres, creating hazards for human health, property, aviation and infrastructure like roads and water supply.

Dr Yannik Behr, from GNS Science, and Dr Rosa Trancoso, from MetService, are leading the project. They will combine existing eruption scenarios with weather forecasting into an improved model that will better predict the likelihood of an area being affected by volcanic ashfall, and remove the false-positives and false-negatives than can occur with current modelling. With central North Island volcanoes able to affect communities at great distances, better information will help homeowners, businesses and service providers to be prepared. This may involve power companies assessing the risk of flashovers due to ash, NZTA assessing the visibility of road markings, farmers preventing cows from ingesting toxins in the grass and homeowners preparing to deal with ash on their roofs.

The new model for ashfall forecasts is based on dispersion models fine-tuned for New Zealand's weather. It is constantly updated as conditions change, making it possible to give probabilities for ash falling in any particular area.

This type of model will be more accurate than those currently available, enabling better decisions to be made for communities to prepare and respond to volcanic ashfall.

IS A LOW-COST EARTHQUAKE EARLY WARNING SYSTEM FEASIBLE?

Community involvement is essential to the development of a low-cost earthquake early warning system, say researchers running a feasibility study in the Wellington region.

Dr Raj Prasanna, from the Joint Centre for Disaster Research at Massey University, is leading a team studying the feasibility of how low-cost micro electro mechanical systems embedded in ground motion sensors interconnected through the internet, could work to provide earthquake early warnings to anyone connected to the system. The research team comprises seismologists, social scientists, design specialists, software engineers, information technology and telecommunication experts.

DR RAJ PRASANNA WITH A SENSOR FOR THE EARTHQUAKE EARLY WARNING SYSTEM TRIAL.

EQC and Massey University are co-funding the project, which started with building a community of practice and conducting community workshops in different parts of the country to investigate the needs, concerns and expectations of members of the public towards an earthquake early warning system. Points discussed included what people would use the warning time for, whether they would be happy to have a sensor in their homes, and their level of tolerance for false alerts.

In parallel to these community workshops, the research team has been conducting technology experiments in a laboratory setting that include connecting multiple types of off-the-shelf sensors to work on the same network.

The team is also in the process of installing 20 to 25 low-cost sensors in community buildings and homes in the Wellington region for field trials.

Unlike most earthquake warning solutions, which depend on external infrastructure for centralised data processing, this research is trialling decentralised processing. The team is investigating using the low-cost sensors themselves to process the data and execute the detection algorithms without a central server, which may increase the warning time by crucial seconds.

Research will include assessing geographical and topological considerations, communication protocols and latency, and how well the network can adapt to disruptions (eg, parts of the network losing power during an earthquake).

Research results, will give a broad picture of both the social and technical aspects of a community-networked earthquake early warning system.

AF8 ROADSHOW 2021.

AF8 ROADSHOW SHARES ALPINE FAULT SCIENCE DIRECTLY WITH SOUTH ISLAND COMMUNITIES

The Science Beneath Our Feet 2021 AF8 roadshow, supported by EQC, saw scientists and civil defence emergency management teams talking directly to communities and schools in areas likely to be significantly affected by an Alpine Fault earthquake about the science of a quake, the likely impacts and how to be prepared.

This year's tour included 16 public science talks and 16 school visits, where scientists and local experts shared Alpine Fault research, models of how a rupture may move along the fault and preparedness information. Sessions were packed, and each visit gave communities an opportunity to ask questions and gain a better understanding of the potential impacts of a large Alpine Fault earthquake in their region.

With the likelihood of an Alpine Fault rupture recently estimated at a 75 percent chance of happening in the next 50 years, there was strong interest from local communities.

CREATING COMMUNITY NATURAL HAZARD TEAMWORK

Planning and preparing for the impact of natural hazards is important for any community. But for remote communities, such as on the West Coast of the South Island, it is critical, because they may remain isolated for some time and will need to rely on their community for response and recovery.

Working with the Franz Josef community during his PhD research, Dr Alistair Davies developed and piloted a method of connecting community members, providers of infrastructure, including

roads and electricity, scientists and government agencies to increase preparedness for natural hazards.

Using the scenario of an Alpine Fault earthquake rupture, participants assessed the likely impacts and disruption this would cause. Each group contributed knowledge from their specific area, for example, how long it would take to clear landslides, when power would be restored, or how much fuel would be left in the town. This informed discussions on risk reduction actions that can be taken now, and planning for future response and recovery strategies.

Along with identifying risk reduction actions, the method built stronger relationships between all parties likely to be involved in the event of an Alpine Fault earthquake.

As part of the AF8 public education roadshow, Dr Davies (now at EQC) was invited back to the West Coast to present his research and discuss what community members can do to get prepared so natural hazards will not lead to disastrous impacts.

DR ALISTAIR DAVIES IS INTERVIEWED BY TVNZ DURING THE AF8 ROADSHOW.

CHECKLIST FOR SEISMICALLY SAFER WORKPLACES

Research on earthquake risk in businesses has delivered an "Earthquake Preparedness" checklist to support business owners in reducing seismic risk at work.

Dr Tracy Hatton and Sophie Horsfall, from Resilient Organisations, and Dr Toni Collins, from the University of Canterbury, surveyed businesses nationally to find out whether seismic safety is a priority for New Zealand business, and what safety measures they undertook to reduce risks.

The team found that, although seismic safety is a priority, a lack of information on the who and the how was limiting action, especially for small- to medium-sized businesses.

To help fill this information gap, the research team created the free Earthquake Preparedness Checklist to help businesses prepare for earthquakes. This checklist helps businesses to understand and take steps to reduce their

SOPHIE HORSFALL (LEFT) AND DR TRACY HATTON

TV3 ON SITE AS RESEARCHERS WORK ON A TRENCH AT CAPE PALLISER.

earthquake risk before an event, and highlights areas where they can improve their business continuity in the event of an earthquake.

You can get the checklist at www.resorgs.org.nz/earthquake-preparedness-checklist

GETTING THE MESSAGE THROUGH WITH MEDIA

People living in Aotearoa New Zealand are certainly interested in stories about the country's active landscape and ways we can successfully live with it.

Over 2021, our strong relationships with both researchers and the media have resulted in a steady stream of stories about EQC's investments in research on natural hazards and ways to reduce the impact of these hazards.

Over the past year, the EQC media team invited members of the media to take a closer look at researchers at work, whether that was analysing faults in the field, investigating volcanoes, testing new engineering ideas or firing volcanic ballistics through roofs.

The result was a significantly increased level of television, press and radio coverage. This raised public awareness of natural hazards and the importance of preparing for and reducing the impact that those hazards have on households and communities.

Our media programme also gave researchers the opportunity to develop their skills in raising the visibility of the work they do and to tell their research story to a wide public audience.

PUBLIC EDUCATION

An Aotearoa New Zealand that is more aware of its natural hazards, and well prepared for when they inevitably occur, will better weather the significant challenges those hazards present.

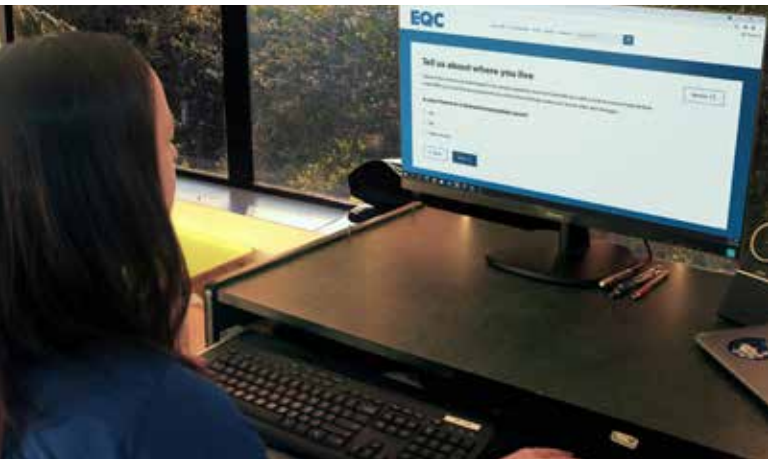
Through our public education programme we reach a wide range of New Zealanders with our preparedness messaging, with the aim of inspiring people to make their homes safer and stronger. We also support some of the country's most important and innovative hazard outreach programmes, which raise awareness of the turbulent natural forces that continue to shape our land, communities and people.

THINKING ABOUT NATURAL HAZARD PREP? THERE'S AN EQC TOOL FOR THAT

Many people in Aotearoa New Zealand know that natural hazards are a fact of life that comes with living in this sometimes restless and unpredictable land.

From floods to volcanic eruptions to earthquakes, the hazards with potential to affect New Zealanders are many. Even more numerous are the actions we can take to prepare ourselves and our homes to lessen the impact of disaster events: EQC has identified more than 25 actions to prepare for earthquakes alone.

For some it may be comforting to know there's so much we can do to exercise some control over natural hazards. For others it's likely to be daunting and they simply don't know where to start.



THE NEW EQC TOOL DUE TO BE LIVE EARLY 2022.

EQC is developing an online tool that provides the most relevant hazard and preparedness information for everyone, so people can focus on the steps to take that will make the biggest difference in the event of a disaster.

The tool forms an integral part of the new EQC website, due to be live by early next year. The tool asks users to answer eight simple questions on their home and location. They are then provided with a basic hazard profile for their location and a list of prioritised preparedness steps that link to more detailed information on the EQC website.

A campaign is also being developed to encourage use of the tool and hopefully kickstart New Zealanders on their journey towards more prepared and safer homes.

OUR CONSISTENTLY SHAKY ISLES INSPIRE NEW AD CAMPAIGN

Encouraging New Zealanders to make their homes safer and stronger for natural hazards has been a long-standing goal of EQC's public education programme.

But we know that trying to get people to take action is difficult at any particular point in time.

Now, a new EQC advertising campaign aims to use the "window of opportunity" presented by earthquakes that are moderately or strongly felt to inspire preparedness in the home.

Called the "After Quake Double Take", the campaign is based on the spur-of-the-moment commitments many of us make after experiencing a decent shake, when we promise we'll get onto making our homes safer … this time.

Starring local actor and comedian Josh Thomson, the campaign reflects those under-the-table pledges back to people after real quakes, using the things people say to themselves after a quake as a reminder to get onto it.

GeoNet "Felt it?" reports, as well as peak ground acceleration and peak ground velocity 'ground shaking' data, are used to help decide whether the campaign is appropriate to run following a quake (it won't run if there's widespread damage) as well as what geographical locations should be delivered the content.

The campaign material is intended to go live to audiences within 48 hours of an appropriate

quake and then run for one-to-two weeks across multiple channels. However, the campaign has also been delivered to areas of Aotearoa New Zealand that most strongly felt the latest decent shake, the magnitude 7.3 quake that occurred off the East Cape of the North Island on 5 March 2021. While this was months after the event itself, audience response to this timing of the campaign will be used to compare with future roll-outs that are timed closer to the events themselves.

VIRTUAL FIELD TRIP EXPLORES TARANAKI MAUNGA

Piercing from the lush green landscape that surrounds it, Taranaki Maunga is one of Aotearoa New Zealand's most recognisable natural features.

THE TEAM GETS UP CLOSE WITH THE NATURAL WONDER OF TARANAKI MAUNGA. **PHOTO CREDIT:** SHANE CRONIN

But a photogenic and peaceful exterior belies a turbulence deep below the Earth's surface: the next Taranaki eruption is not a matter of "if" but "when". And it could be sooner than many of us might imagine, with recent research estimating an 81 percent probability of an eruption by 2065.

While EQC and LEARNZ have combined to deliver annual field trips for year 1 to 8 students since 2009, this year's trip took a modified approach, with students encouraged to play more of a lead role in the learning process. Before the trip itself started, students were able to explore a variety of supporting material on volcanism and preparedness, selecting what was of greatest interest to them. They then viewed video content shot on location in Taranaki before asking questions of experts during live web conferences.

Māori were living in the area when Taranaki last erupted, and their oral record has helped us understand the possible impacts of a future eruption. Today, eight different iwi surround the maunga, each with their own cultural narratives of the mountain. Integrating mātauranga Māori was a vital aspect of the field trip, and students heard legends and stories of New Zealand's volcanoes from mana whenua, while Māori academics shared their fascinating research into wahi tapu sites, waiata and whakairo.

The complete field trip content is available for teachers and students to access, for free, on the LEARNZ website.

EQC would like to thank Professor Shane Cronin, volcanologist with the University of Auckland, for sharing his wealth of expertise with this year's virtual field trip, and all other contributors who helped make the trip possible.

EMPOWERING PEOPLE

EQC will continue to support and inform the many people making decisions for the resilience of homes, towns and cities with sound evidence about natural hazard risk and risk reduction.

We will be using the research and data we fund to guide priorities for our team and our future research programme. Members of the team will become more directly involved in giving support to people making natural hazards resilience decisions such as councils, policy makers and industry. We will also be looking for ways to link researchers more directly and quickly to decision-makers and will continue our public education and media efforts to communicate the science and data more widely.

Householders are critical decision-makers to reduce the impact of natural hazards on whānau and communities. Since 2009 we have been running a major survey four times a year through Nielsen to understand what householders know about their risks, and what action they have taken to prepare their homes. We've also done additional research ourselves, and funded others to understand more about the barriers to action. Our research tells us that though most householders say they know the steps to take

TE WHAKAMANA I TE TANGATA

to prepare their homes, many have not taken action. A key focus for us will be looking for ways to help householders overcome the barriers to action.

We will also continue to encourage the curiosity of young New Zealanders by supporting museums and education programmes that are helping raise a natural hazards aware generation. These young people will be the knowledgeable decision-makers of the future.

SECTION FOUR

FINANCING RISK – TAUTOKO Ā-PŪTEA I NGĀ TŪRARU

In 1945, the Earthquake and War Damage Commission was set up so homeowners and building owners would be able to afford to repair or rebuild after damage from an earthquake or war. Although our legislation has changed over the years, helping homeowners get their lives back on track after natural hazard damage, by having the insurance cover to repair or rebuild their home, remains EQC's core function.

Our ability to meet the costs of insurance claims is founded on our management of the Natural Disaster Fund, which is built through homeowner levies, the continuing support of international reinsurers and our Crown guarantee.

EQC's long-term investment in scientific research and data (including GeoNet), modelling of natural hazard risks and potential losses, and risk reduction activities help give reinsurers the confidence to support the New Zealand market.

EQC's success in providing the platform for natural hazards insurance has meant Aotearoa New Zealand has one of the highest rates of homeowner insurance in the world.

Carry on to see some of the work underway to support EQC's risk financing.

PARTNERSHIP WITH PRIVATE INSURERS

EQC aims to ensure that homeowners have ready access to insurance for residential property against earthquakes, tsunami, volcanic activity, landslides, hydrothermal activity and land damage arising from storms and floods.

EQC pays insurance claims up to the statutory capped level of damage under the EQC Act for homeowners with private insurance policies with fire cover. Private insurers cover additional losses up to their sum insured.

By taking the first part of the insurance risk, EQC helps private insurers enter and stay in the New Zealand residential insurance market, despite the high level of natural hazard risk. This helps ensure cost-effective cover for New Zealand homeowners.

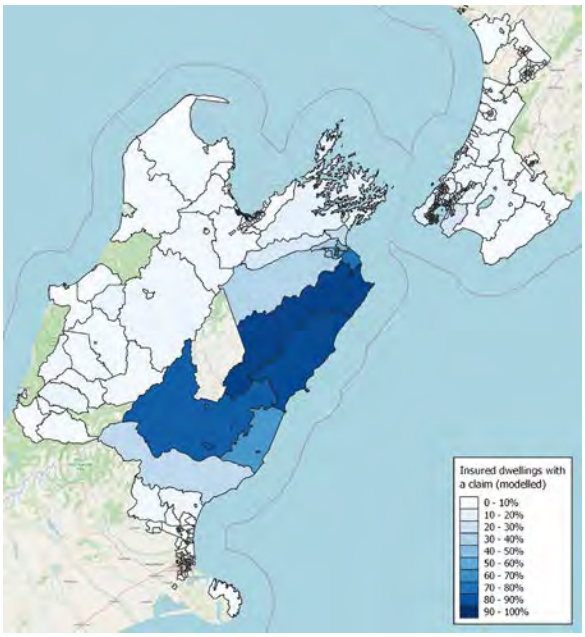
Our relationship with private insurers has strengthened this year on the claims side of insurance. From June 30 2021 the Natural Disaster Response Model – a partnership between EQC, private insurers and the Insurance Council of New Zealand (ICNZ) – sees private insurers managing EQCover claims on behalf of EQC and providing customers a single point of contact to support their insurance recovery. Private insurers now assess, manage, and settle the entire claim - including the EQCover portion of a claim – to deliver a more effective and efficient insurance response for New Zealanders. This model gives homeowners simplicity and clarity at a time they need it most.

FAST FIX ON NATURAL HAZARD LOSSES

EQC is now close to moving to its new loss modelling tool, which like its predecessor, Minerva, will quickly estimate losses after an earthquake and allow modelling of residential housing damage costs from any given future earthquake.

Though initially focused on earthquakes, the new loss model based on RiskScape software means, over time, EQC will be able to expand its loss modelling to other hazards it covers, such as volcanic activity, landslides and tsunamis, as well as more complex modelling, such as multi-hazard events like landslides after earthquakes.

The new model will also be able to more easily integrate new research as it is developed, turning science into actionable data and insights that



OUTPUT FROM A TEST OF THE NEW MODEL, BASED ON THE 2016 KAIKŌURA EARTHQUAKE.

can be used for decision-making. EQC, GNS Science and the National Institute of Water and Atmospheric Research are working together on expanding the capability of the RiskScape software.

Although other models of natural hazard risk exist, the new loss model will provide a highly credible, specifically New Zealand view of risk that reinsurers and others can use alongside their other mechanisms for assessing risk.

NATURAL DISASTER FUND

Rebuilding the Natural Disaster Fund (NDF) is an important strategic goal for EQC.

Payments for claims for the Canterbury earthquake sequence and Kaikōura earthquake depleted EQC's NDF, which was nearly $6.1 billion just before the first Canterbury earthquake.

EQC was then able to call on the Crown guarantee to continue to meet its obligations to insured homeowners and its operating costs.

The NDF is built through levies included when homeowners pay their home insurance to their own insurer. Insured homeowners pay a maximum of $345 (including GST) per year. With more than 90 percent of New Zealand homes having EQCover, EQC receives around $500 million in levies per year. Levies are set based on an assessment of the risks covered by EQC insurance, and the cost of administering the scheme.

Sophisticated modelling is used to understand the cost of the hazards EQC insures against, the appropriate level for levies, the amount of reinsurance to purchase, and to help determine the most appropriate investment strategy to grow the NDF over time. The unpredictable nature of natural hazards, however, means there are many unknowns.

We have developed a probabilistic model that can assess the financial impact of a wide range of scenarios on the rebuild of the NDF. As well as potential disasters, the model can test factors such as potential policy changes to the cover provided by EQC, varying returns on investment of NDF funds and changes in insurance coverage rates across Aotearoa New Zealand.

Outputs of this modelling will be used to support effective decision-making and prioritisation across EQC as we rebuild the NDF over the medium term.

GIVING ASSURANCE FOR REINSURANCE

Each year, EQC's Chief Executive and members of the Finance team, and our reinsurance broker Aon, meet with a significant number of international reinsurers to put together a reinsurance programme that can be called on in major events, ensuring EQC has the resources to meet homeowners' claims.

The Christchurch earthquake sequence was the most insured natural hazard event worldwide at that time. Once all of the Canterbury earthquake claims are settled, EQC expects to have paid around $12 billion.

At the time of the earthquakes, EQC had $6.1 billion in the NDF, and could call on nearly $5 billion from international reinsurers to meet claims. EQC has continued to receive strong support from international reinsurers for its reinsurance programme.

Reinsurance transfers some of the financial risk from large scale natural hazard events out of Aotearoa New Zealand and provides comfort for EQC that it will have additional resources to pay claims for major events.

Retaining the confidence of reinsurers is supported by the effort we put into understanding EQC's financial exposure and openly sharing our modelling with reinsurers over a long period. This is especially important given how geologically active Aotearoa New Zealand is, with the significant number of known earthquake faults and volcanoes across the length and breadth of the country.

Along with our modelling of impact on residential property and the likely costs, our contributions to major New Zealand risk models and tools like RiskScape and the National Seismic Hazard Model help insurers and reinsurers assess their risk and price their premiums.

Our research programme and risk reduction activities also provide assurance that we are looking to continually reduce exposure to natural hazards for people living in Aotearoa New Zealand.

Reinsurers have shown their confidence in our approach through a significantly higher placement of reinsurance for the 2021/22 year at nearly $7 billion.

PULLING THE SEISMIC SCIENCE TOGETHER – THE NATIONAL SEISMIC HAZARD MODEL

Advances in science and modelling are driving a major revision of the National Seismic Hazard Model (NSHM), reflecting the great complexity of seismic activity in Aotearoa New Zealand.

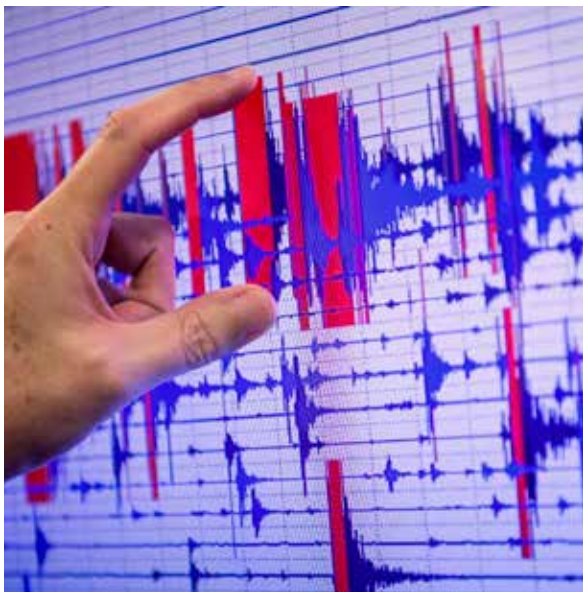


PHOTO CREDIT: SCIENCELENS

The NSHM estimates the likelihood and strength of earthquake shaking in different parts of Aotearoa New Zealand and is a critical input into decisions on how buildings are built and on insurance and reinsurance risk assessment and premium pricing.

The revised model will include science on many different aspects of earthquakes, such as multi-fault earthquakes, and how waves bounce around the sedimentary basins that most major cities are built on. It will deliver reports and forecasts on how seismic waves will likely travel through the ground, and what that means in terms of possibilities for shaking on the surface.

The revision, a joint project between EQC, GNS Science and MBIE, is expected to be completed by mid-2022.

PHOTO CREDIT: DICK BEETHAM, GNS SCIENCE

EQC DATA GIVES INSIGHTS INTO HOUSE RISK

EQC claims data has given a team of engineers headed by Eric Bird and Sjoerd Van Ballegooy, from Tonkin and Taylor, new insight into which homes could be more at risk from earthquake shaking and which are more likely to be damaged by liquefaction.

For the research, EQC provided anonymised data from claims and assessments from the Canterbury and Kaikōura earthquakes.

Results from the analysis will offer more precision for models estimating residential housing losses and solid data for developing policies, standards and construction industry practice for building houses.

Shaking damage

The first stage of analysis on shaking damage looked at risk factors in standalone houses on flat land, including the type of cladding and foundations, roof type and age and size of the house.

The researchers found that, for the same level of shaking, a larger house is much more likely to sustain damage than a smaller one. They concluded this is because a small house is likely to have a simpler design, have fewer and smaller rooms with fewer weak points making it stronger overall. Large homes have more rooms, larger overall dimensions and more complexity, all of which increase the chance of structural weak points.

In terms of repair cost, the researchers found the construction era of the house and number of storeys are the most significant factors. Older construction era houses sustain more damage, as do two-storey houses. Single-storey houses built to modern standards are the most resilient to earthquake shaking, showing that progressive changes to New Zealand's building regulations have been effective in increasing housing resilience.

Liquefaction

Analysis of liquefaction claims identified factors that were most likely to result in the need for a "rebuild". These included the size of the house, with larger houses being more at risk due to the

greater floor area, potentially exposing at least part of the building to liquefaction.

Houses with irregular footprints were also likely to behave less predictably and sustain greater damage from liquefaction, as well as being more difficult to relevel, and so require rebuilding.

The foundation type, whether concrete slabs on grade or timber floors on piles, was also a significant factor, with concrete slabs likely to be affected by ground distortion caused by liquefaction.

Surprise in significance

Some factors commonly thought to be related to the level of damage, however, were found not to be significant either for shaking or liquefaction. After accounting for other influential factors, the analysis showed that cladding and roof weight did not significantly affect a house's average level of damage from earthquake shaking, or the likelihood it would be a rebuild due to liquefaction.

The researchers are quick to note that their analysis is probabilistic and at a city-wide level, describing "average" housing behaviour that pulls together a wide range of house performance.

The team now intends to do further analysis to understand the performance of other types of houses, such as those on hills, and whether findings from Christchurch and Kaikōura can be applied to houses in other parts of the country.

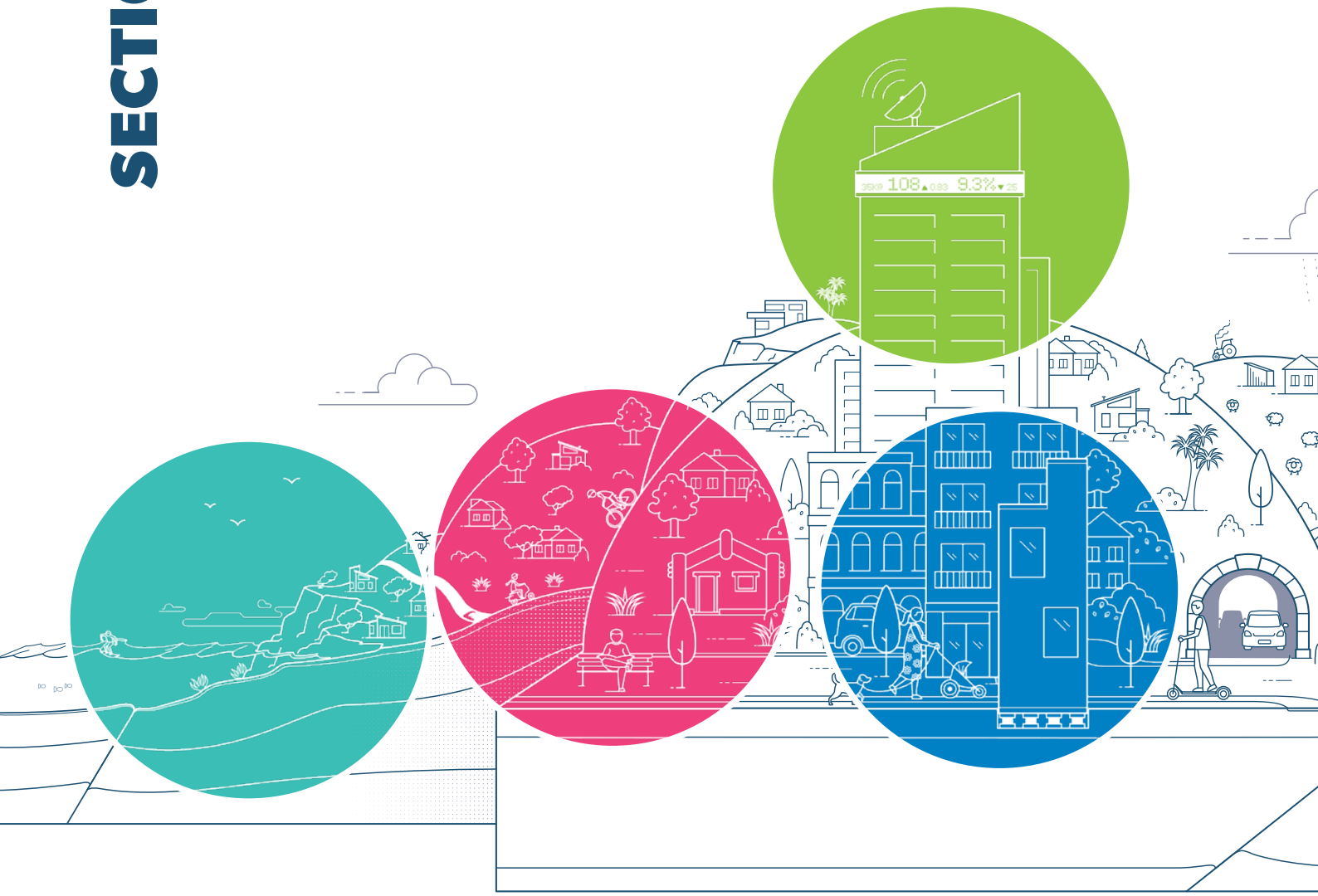
FINANCING RISK – TAUTOKO Ā-PŪTEA I NGĀ TŪRARU

Along with significant work such as the National Seismic Hazard Model and our new loss model, EQC is deeply involved in supporting Treasury in its policy advice on updating the Earthquake Commission Act 1993. Draft legislation is now being developed and it is expected a bill will be introduced into Parliament in late 2021.

EQC is also working with various organisations on solutions to build out hazard and risk data, as well as trying to ensure this work has more sustainable funding in the long term, and any major gaps in risk understanding are filled.

Having a solid evidence base for risk-informed decision-making is our enduring goal.

SECTION FIVE



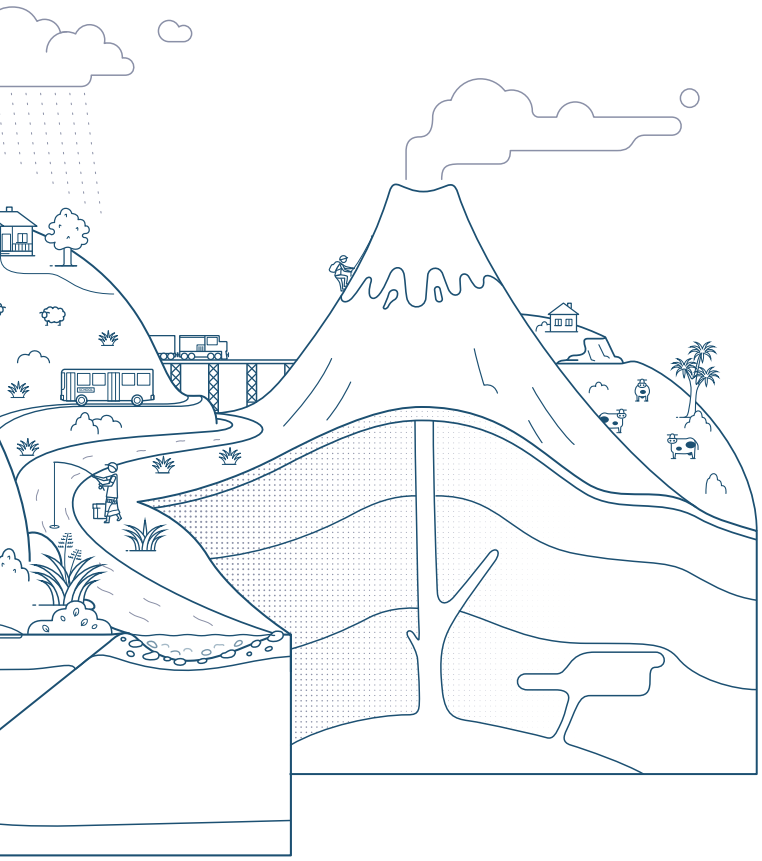
2ND AOTEAROA NEW ZEALAND SYMPOSIUM
ON DISASTER RISK REDUCTION

Managing Risk, Accelerating Resilience

HUI TAUMATA TUARUA O AOTEAROA MŌ TE WHAKAITI TŪRARU AITUĀ

Te Whakahaere Tūraru, Te Whakahoro Whakamārohitanga

HELPING PUT THE PEOPLE AND THE KNOWLEDGE TOGETHER



Everyone is a part of reducing the impact of natural hazards and building a more resilient Aotearoa New Zealand, from researchers to policy makers, to councils, homeowners and the next generation of risk aware young people.

EQC collaborates with others and shares information about natural hazards to achieve its aim of a more resilient Aotearoa New Zealand.

Over the past year, we were a major sponsor of conferences that brought researchers, policy makers and industry together to connect and share ideas and practice for greater resilience. These included the Geoscience Society of New Zealand conference, the QuakeCoRE annual meeting, Lifelines annual forum, Emerging Planners forum, Disastrous Doctorates, and the New Zealand Society for Earthquake Engineering annual conference.

Early next year, we are hosting the *2nd Aotearoa New Zealand Symposium on Disaster Risk Reduction – Managing Risk, Accelerating Resilience. Hui Taumata Tuarua o Aotearoa mō te Whakaiti Tūraru Aituā – Te Whakahaere Tūraru, Te Whakahoro Whakamārohitanga.* The symposium will look at the main mechanisms for managing risk: how we can tackle gaps and barriers and build on our strengths to create a safer, more resilient nation. We have a focus on participation and will be bringing together different sector professionals, with the aim of using the collective expertise of delegates to identify gaps and issues. We intend to set out a plan to achieve what's missing in the short, medium and long term with regard to building a more resilient Aotearoa New Zealand.

GET IN TOUCH WITH THE TEAM

Dr Jo Horrocks

Chief Resilience and Research Officer

Jo joined EQC in mid-2019, following 13 years in the Ministry of Civil Defence and Emergency Management, in the Department of the Prime Minister and Cabinet. There she led development of the National Disaster Resilience Strategy, as well as other strategic national policies and programmes. Jo is a geoscientist by background, completing a PhD in central North Island volcanic ash deposits. She is now more motivated by the social science side of life, including tackling complex social issues and progressing improved outcomes for New Zealanders. Her future focus is ensuring scientific research and data on risk gets to the right people making decisions on the policies and practices that make a difference for households and communities across Aotearoa New Zealand.

jhorrocks@eqc.govt.nz

Sarah-Jayne McCurrach

Manager Risk Reduction and Resilience

Sarah-Jayne came to EQC after successfully leading numerous national-level projects and programmes of work to improve hazard risk management decisions and outcomes in Aotearoa New Zealand and internationally. Sarah-Jayne has a passion for building strong, knowledge-aware communities regarding hazard and risk, so everyone in Aotearoa New Zealand is empowered to make their own choices regarding the risks they face. She also has Chair roles within UNESCO's Pacific Tsunami Warning System and is supporting the organisation of the seventh session of the Global Platform for Disaster Risk Reduction, 2022.

smccurrach@eqc.govt.nz

Mushiirah Alladeen

Team Coordinator

Mushiirah's administrative skills keep the Resilience and Research's team operations running smoothly. She has a Master of Laws from the University of Central Lancashire and a background in teaching. She has a deep interest in supporting Aotearoa New Zealand's people and communities become more resilient to natural hazards.

malladeen@eqc.govt.nz

Dr Wendy Saunders

Principal Advisor Risk Reduction and Resilience

Wendy is EQC's land use planning specialist. Following her PhD on risk-based land use planning, she has worked with councils to develop and implement their risk-based planning policies, and on the science side at GNS Science. At EQC, she leads the Smarter Land Use plan with a full focus on how land use planning can reduce natural hazard risk.

wsaunders@eqc.govt.nz

Dr Alistair Davies

Senior Advisor Risk Reduction and Resilience

Ali started out studying geography at the University of Cambridge. He worked in a flood risk consultancy in the United Kingdom, before coming to Aotearoa New Zealand to do his EQC-funded PhD on disaster risk and resilience at the University of Canterbury. He then moved to the National Emergency Management Agency before joining EQC. Ali is leading the development of EQC's internal climate change adaptation plan, alongside work on the National Hazard Scenario Database and submissions on government policy.

adavies@eqc.govt.nz

Caleb Dunne

Advisor Risk Reduction and Resilience

Caleb is a licensed professional engineer from California. After some years practising structural engineering, a passion for risk reduction led him to Aotearoa New Zealand, where he thought people might know a few things about disasters. He completed a Master of Disaster Risk and Resilience and postgraduate studies in earthquake engineering at the University of Canterbury. He is currently developing EQC's "Resilient Homes and Buildings Action Plan".

cdunne@eqc.govt.nz

Dr Natalie Balfour

Manager Research

Natalie has a PhD in seismology and a strong interest in generating and using research and data to understand natural hazard risk. She came to EQC from GNS Science, where she was involved in the management of GeoNet. Earlier in her career, she helped build the Australian Seismometers in Schools Network and has lectured at universities. She is currently an associate editor for Seismological Research Letters, and a Fellow of the Higher Education Academy in the United Kingdom.

nbalfour@eqc.govt.nz

Nicola Little

Senior Advisor Science Communication

Nicola works with EQC-funded researchers to help them raise the visibility of their research to the public and key stakeholders, and to get their results to the decision-makers who can put the research into action.

nlittle@eqc.govt.nz

Janette Merlo

Research Advisor

Janette has a background in risk management from the University of Colima, Mexico, and a Masters in seismic engineering from IUSS Pavia, Italy. Like everyone in the team, she is passionate about disaster risk reduction. She is a main point of contact in the Research team for researchers and works closely with Research team members to ensure EQC's investment delivers maximum value to increase resilience in Aotearoa New Zealand.

jmerlo@eqc.govt.nz

Hamish Armstrong

Public Education Manager

Hamish leads some of EQC's most visible programmes of work from advertising campaigns to work with schools and museum partners.

Hamish monitors public awareness of what to do to reduce natural hazard risk, and is always looking for new ways to motivate people to reduce their risk at home.

harmstrong@eqc.govt.nz

EQC-FUNDED RESEARCH PROJECTS

Research under way

A fuzzy approach to understanding multi-fault earthquakes, Dr. Timothy Stahl, University of Canterbury

An innovative self-centering slip-friction connection system for seismic damage avoidance design of braced timber frames, Dr. Pouyan Zarnani, Auckland University of Technology

Application of AI to advance structural performance and resiliency quantification, Dr. Max Stephens, University of Auckland

Can concepts of the seismic cycle be used to forecast future large-magnitude earthquakes in New Zealand?, Professor Andy Nicol, University of Canterbury

Catalysing the New Zealand Volcanic Hazard Risk Model (NZVHRM) framework – including probabilistic volcanic loss modelling pilot in Auckland, Dr. Graham Leonard, GNS Science and Professor Thomas Wilson, University of Canterbury

Community led low-cost micro-seismic (MS) sensor network applications for Earthquake Early Warning (EEW), Dr. Raj Prasanna, Massey University

Countdown to eruption: Timescales of magmatic processes in the crust, Dr. Michael Rowe, University of Auckland

Deformation map of New Zealand, Professor Rupert Sutherland, Victoria University of Wellington

Delineation of landslide hazard and development of mitigation tools in a vulnerable city, Associate Professor Martin Brooke, University of Auckland

Determining ability for ground improvement to improve seismic foundation performance through full scale field testing, Dr. Lucas Hogan, University of Auckland

Developing pathways for improving the uptake of innovative seismic-proofing products in New Zealand, Associate Professor Pierre Quenneville, University of Auckland

Development of a population exposure model for New Zealand, Finn Scheele, GNS Science/University of Canterbury

DEVORA, Programme leads: Professor Jan Lindsay, University of Auckland and Dr Graham Leonard, GNS Science

Earthquake risk mitigation for the 21st Century, Resilient Buildings, Helen Ferner, New Zealand Society for Earthquake Engineering

Economic impact of a more stringent design philosophy in New Zealand, Dr. Enrique del Rey Castillo, University of Auckland

Engaging South Asian and Chinese migrants in disaster risk reduction in New Zealand, Dr. Nadia Charania, Auckland University of Technology

Explicit incorporation of uncertainties in ground motion simulations and their use in NZ probabilistic seismic hazard analysis, Professor Brendon Bradley, University of Canterbury

Frictional strength and stability of greywacke fault zones, Dr. Carolyn Boulton, Victoria University of Wellington

Geodetic and hydrological controls on seismic velocity changes after large earthquakes, Professor Martha Savage, Victoria University of Wellington

Geometries and slip of historical surface-rupturing earthquakes in New Zealand and their application to seismic hazard analysis, Professor Andy Nicol, University of Canterbury

GeoNet, Programme lead: Catherine Ross, GNS Science

Geophysical signatures of hydrothermal alteration for evaluating volcanic flank instability, Professor Jan Lindsay, University of Auckland

Research under way – continued

Hidden hazards: Revealing new insight into ashfall volcanic hazards in the Waikato region by detecting and analysing glass shards (cryptotephras) in sediments, Professor David J Lowe, University of Waikato

High resolution basement mapping beneath Wellington City based on gravity anomaly and borehole data, Professor Tim Stern, Victoria University of Wellington

Improved constraint on past Hikurangi subduction earthquake rupture dimensions using a locally derived marine reservoir correction, Dr. Kate Clark, GNS Science

Integrated intelligent structural control and health monitoring using innovative methodologies, Dr. Sherif Beskhyroun, Auckland University of Technology

It's Our Fault, Programme lead: Dr. Nicola Litchfield, GNS Science

Multi-criteria spatial optimisation for guiding long-term land use planning for resilience and sustainability, Dr. Tom Logan, University of Canterbury

National Seismic Hazard Model – the revision programme, Project Lead: Dr Matt Gerstenberger, GNS Science, Project Manager: Rachel Kirkman, GNS Science

New Zealand Geotechnical Database, Director: John Leeves, Tonkin + Taylor

Paleoseismology of the newly discovered Te Puninga Fault, Hauraki Plains, Dr. Pilar Villamor, GNS Science

Performance objectives for seismic design, Professor Kenneth Elwood, University of Auckland

Physics-based ground motion modelling for the urban Wellington region: Basin-edge effects and implications for seismic design, Professor Brendon Bradley, University of Canterbury

Progressive failure of house foundations on slopes in earthquakes, Roger Shelton, BRANZ

Quantitative hazard and risk modelling approaches for volcanic crisis management, Professor Jan Lindsay, University of Auckland

Rauoterangi Fault trenching project, Manawatū District Council

Seismic design of low-rise and mid-rise hybrid residential buildings, Angela Liu, BRANZ

Seismic performance of multi-storey cross-laminated timber shear wall structures with high-capacity anchoring systems, Associate Professor Minghao Li, University of Canterbury

Seismic strengthening of reinforced concrete walls in existing buildings with fiber-reinforced polymer materials, Dr. Enrique del Rey Castillo, University of Auckland

Site characterisation and liquefaction potential of Blenheim gravelly sandy deposits, Associate Professor Gabiele Chiaro, University of Canterbury

Structural resilience and lifecycle cost implications of designing to various international standards, Dr. Max Stephens and Professor Ken Elwood, University of Auckland

Towards real-time probabilistic ash deposition forecasting for Aotearoa New Zealand, Dr. Yannik Behr, GNS Science

Tsunami impact and loss modelling in Hawkes Bay, Dr. William Power and Dr. Bill Fry, GNS Science

University Research Programme – Assessment and mitigation of liquefaction hazards, Professor Misko Cubrinovski, University of Canterbury

University Research Programme – Building resilience through earthquake and landslide multi-hazard research in New Zealand, Dr. Timothy Stahl, University of Canterbury

University Research Programme – Te Toi Whakaruruhau o Aotearoa, Mātauranga Māori Disaster Risk Reduction Research Centre, Professor Christine Kenney, Joint Centre for Disaster Research, Massey University

University Research Programme – Engineering for stronger homes and better land in Aotearoa New Zealand, Associate Professor Liam Wotherspoon, University of Auckland

Recently completed research

University Research Programme – EQC Programme in Earthquake Seismology and Tectonic Geodesy, Professor John Townend, Victoria University of Wellington

University Research Programme - Next-generation seismic hazard analysis for NZ, Professor Brendon Bradley, University of Canterbury

University Research Programme – Seismic hazard of the southern South Island: the neglected provinces, Professor Mark Stirling, University of Otago

University Research Programme – The economics of financial natural hazard risks and changing insurance markets, Professor Ilan Noy, Victoria University of Wellington

Upgrading New Zealand's historic tsunami database, Dr. Kate Clark, GNS Science

Development of a cyber-based automated structural health monitoring (SHM) system for steel bridges, Dr. Sherif Beskhyroun, Auckland University of Technology

Earthquake hazard in Dunedin: paleoseismology of the Titri Fault, Dr. David Barrell, GNS Science

Encoding earthquake ruptures into the stratigraphic record: Changes in near-surface structure of the Kekerengu Fault zone before vs. after the 2016 Kaikoura earthquake, Adjunct Professor Timothy Little, Victoria University of Wellington

Investigation of development history of 40/42 Beechwood Road, Browns Bay, Auckland site affected by a recent cliff failure, Murray Triggs, WSP

Phase 1 – New Zealand Landslides Database, Ross Roberts, Auckland Council and BECA

Post-seismic deformation following the 2009 Mw7.8 Dusky Sound earthquake, Dr. Sigrun Hreindottir, GNS Science

Seismotectonic source characterisation in low seismicity regions of New Zealand: Otago case study, Professor Mark Stirling, University of Otago

Stop disasters 2.0: Exploring disaster awareness through video games, Professor JC Gaillard, University of Auckland

The evolution of past and present magmatic systems in the north Taupō area: Implications for modern hazards, Professor Colin Wilson, Victoria University of Wellington

Towards the calibration of tsunami models in the Auckland region using paleotsunami deposits, Dr. Kate Clark, GNS Science

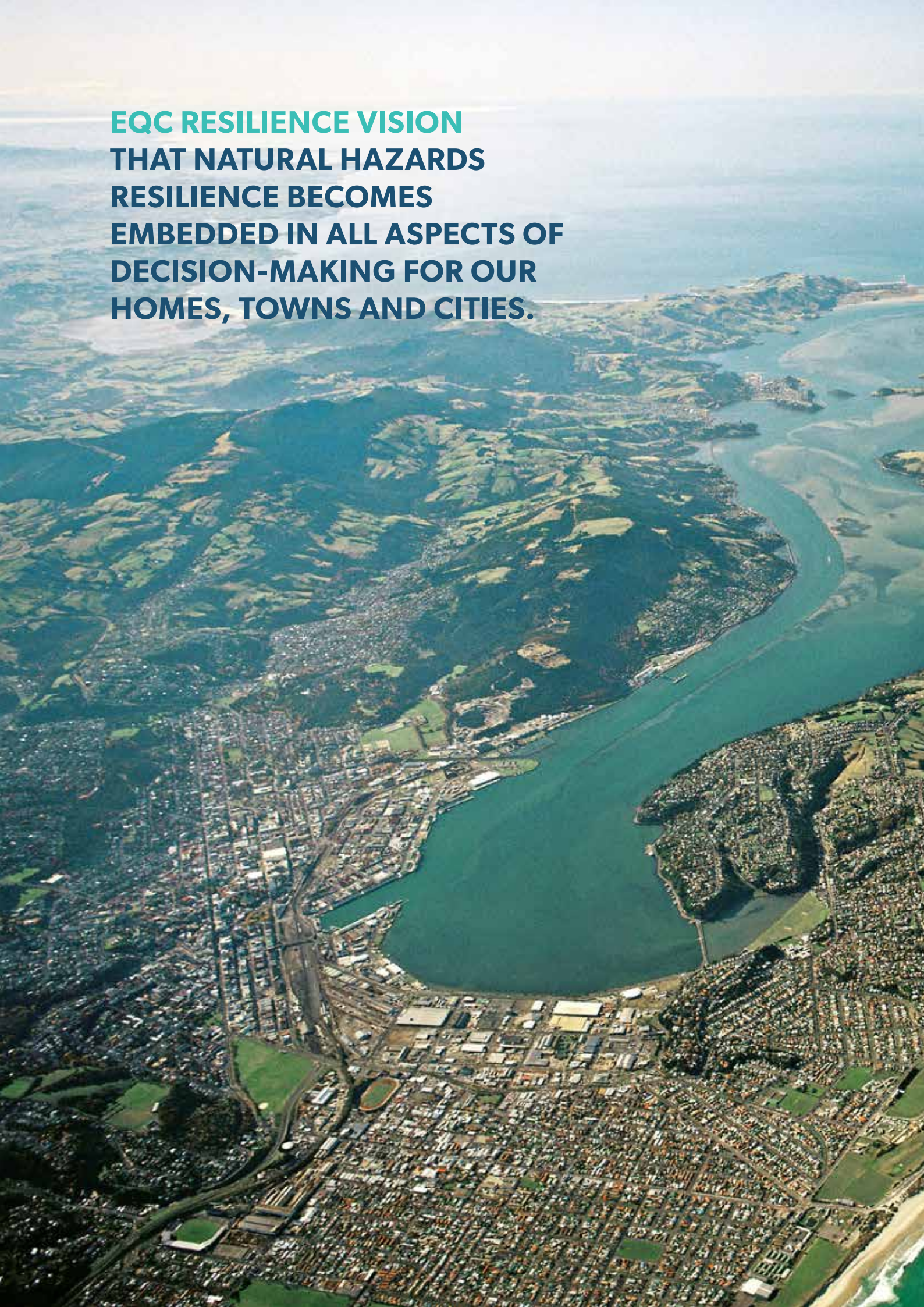
Understanding organisations' perceptions of obligations under the Health and Safety at Work Act 2015 in relation to seismic hazards, Dr. Tracy Hatton, Resilient Organisations Ltd

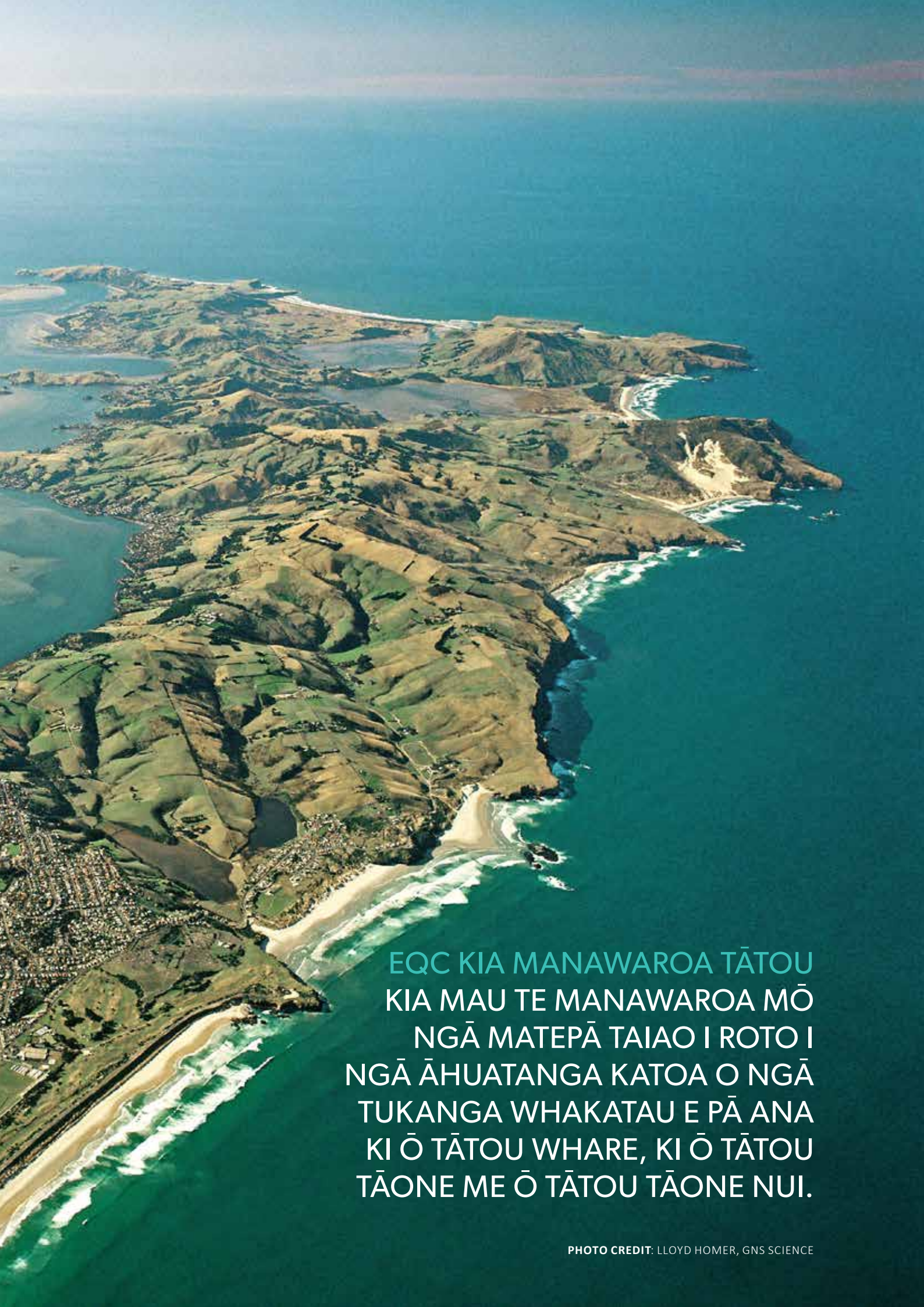
Understanding the seismic performance of structural insulated panels for use in New Zealand, Dr. David Carradine, BRANZ

Volcanic loss modelling and impact forecasting in Auckland, Dr. Graham Leonard, GNS Science

EQC RESILIENCE VISION

THAT NATURAL HAZARDS RESILIENCE BECOMES EMBEDDED IN ALL ASPECTS OF DECISION-MAKING FOR OUR HOMES, TOWNS AND CITIES.





EQC KIA MANAWAROA TĀTOU

KIA MAU TE MANAWAROA MŌ NGĀ MATEPĀ TAIAO I ROTO I NGĀ ĀHUATANGA KATOA O NGĀ TUKANGA WHAKATAU E PĀ ANA KI Ō TĀTOU WHARE, KI Ō TĀTOU TĀONE ME Ō TĀTOU TĀONE NUI.

PHOTO CREDIT: LLOYD HOMER, GNS SCIENCE

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