GNS SCIENCE **2017** ANNUAL REPORT

WHAT IS


HIDDEN

ZEALANDIA

EARTH'S CONTINENT


HIDDEN

EARTH'S EIGHTH CONTINENT

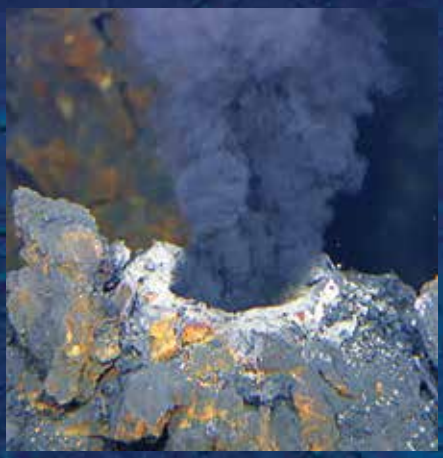
Geologists and geophysicists at GNS Science have added an eighth continent called Zealandia to the world map. At 4.9 million square kilometres it is roughly the same size as India and half the size of Europe. It is the world's smallest continent, after Europe, Asia, Africa, North America, South America, Antarctica, and Australia.

One of Zealandia's distinguishing features is that it is 94% underwater. Apart from the New Zealand landmass, it includes the subantarctic islands, New Caledonia and the Chatham Islands, but not Fiji or Tonga.

In a paper in the February 2017 edition of the Geological Society of America's publication *GSA Today*, we make a strong case that Zealandia is a single intact piece of continental crust that is geologically separate from Australia. It is a thin continent with crustal thickness of between 10km and 30km, increasing to 40km under parts of the South Island.

Our *GSA Today* paper, the culmination of about 15 years of research, became the Society's most viewed paper ever with more than 95,000 online reads. It also sparked an unprecedented flurry of international media interest. A readership estimated at more than 900 million people heard of Zealandia through 16,000 news articles in print and online media. Such extraordinary global interest is rare in New Zealand science.

Zealandia is a key strategic cornerstone for GNS Science. Our intention is to explore this vast area of the Earth's surface in a systematic way using a range of technologies. It will include surface ships, satellite gravity, remote sensing, scientific drilling, and submarine ROVs and AUVs. There are numerous potential benefits to New Zealand, including a better understanding of



offshore geohazards, mineral resources, climate history, and life in the benthic environment.

Right now, GNS Science and our national and international partners are engaged in a six- voyage programme sailing under the banner of the International Ocean Discovery Program. The voyages will probe beneath the seafloor of Zealandia to answer a multitude of earth science questions. In part, this is to address an information deficit. We know a lot about the New Zealand landmass after studying it for 150 years. However, our knowledge of the other 94% of Zealandia is scant at best.

It will not be a surprise to many New Zealanders to know that they live atop a submerged continent. GNS Science staff have been making the case for Zealandia for more than a decade, in public talks, popular articles and books. The latest paper is the most data-rich summary of this case yet published. It is expected to be the main reference paper on Zealandia for many years to come.

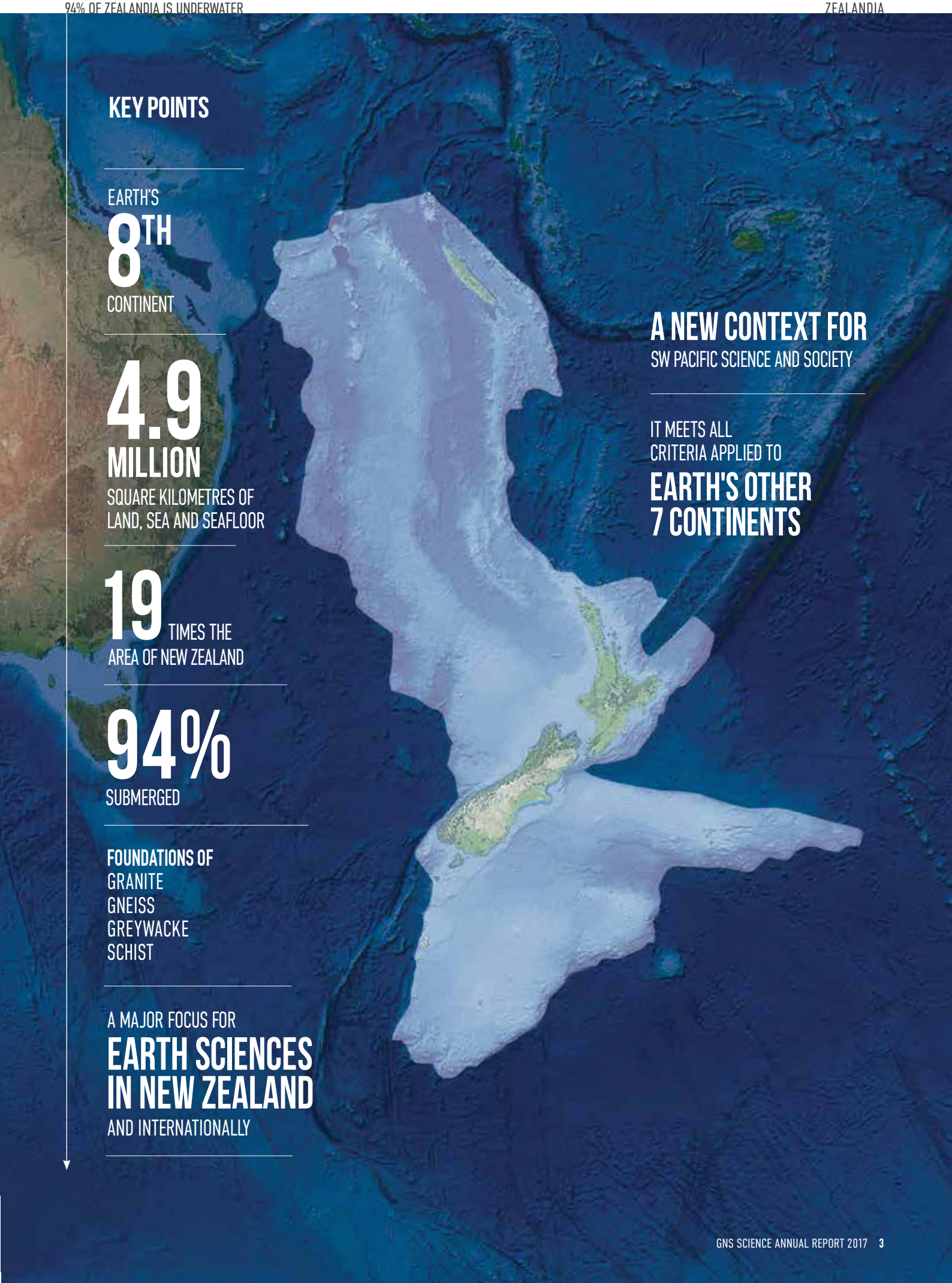
Most continents have a big landmass and a narrow continental shelf, whereas Zealandia is the opposite. There is no international body in charge of designating official continents. However, currently used geological conventions and definitions of continental crust, continents, and microcontinents require no modifications to accommodate Zealandia.

Unlike the nearby oceanic crust, which is made up of basaltic rocks from the fairly recent geological past, the crust surrounding New Zealand is composed of a variety of different rock types, including granite, schist, gneiss, limestone and sandstone, some of which are very ancient.

Zealandia began to peel away from the super continent Gondwana about 85 million years ago. The rift gave Zealandia its independence, but also stretched and thinned the crust causing much of it to sink. It has been profoundly beaten up since then with episodes of stretching, shoving and twisting sometimes happening all at once. And now there is a massive active plate boundary running through it.

Zealandia is globally important to science in that its location on the 'Pacific Ring of Fire' means it can provide vital new information about tectonics, earthquakes and volcanism. And being in the transition zone between polar and tropical ocean currents, it holds information about past climates and how the planet looked during past episodes of ocean and atmospheric warming.

One thing that Zealandia underlines is the fact that New Zealand has continental-scale resources, opportunities, and responsibilities. Like many things in science, the penny doesn't always drop immediately. It can take years to build a compelling body of evidence. Unlocking the secrets of Zealandia is the challenge for the next 150 years.



KEY POINTS

EARTH'S
8TH
CONTINENT

4.9
MILLION
SQUARE KILOMETRES OF
LAND, SEA AND SEAFLOOR

19 TIMES THE
AREA OF NEW ZEALAND

94%
SUBMERGED

FOUNDATIONS OF
GRANITE
GNEISS
GREYWACKE
SCHIST

A MAJOR FOCUS FOR
EARTH SCIENCES IN NEW ZEALAND
AND INTERNATIONALLY

A NEW CONTEXT FOR
SW PACIFIC SCIENCE AND SOCIETY

IT MEETS ALL
CRITERIA APPLIED TO
EARTH'S OTHER 7 CONTINENTS

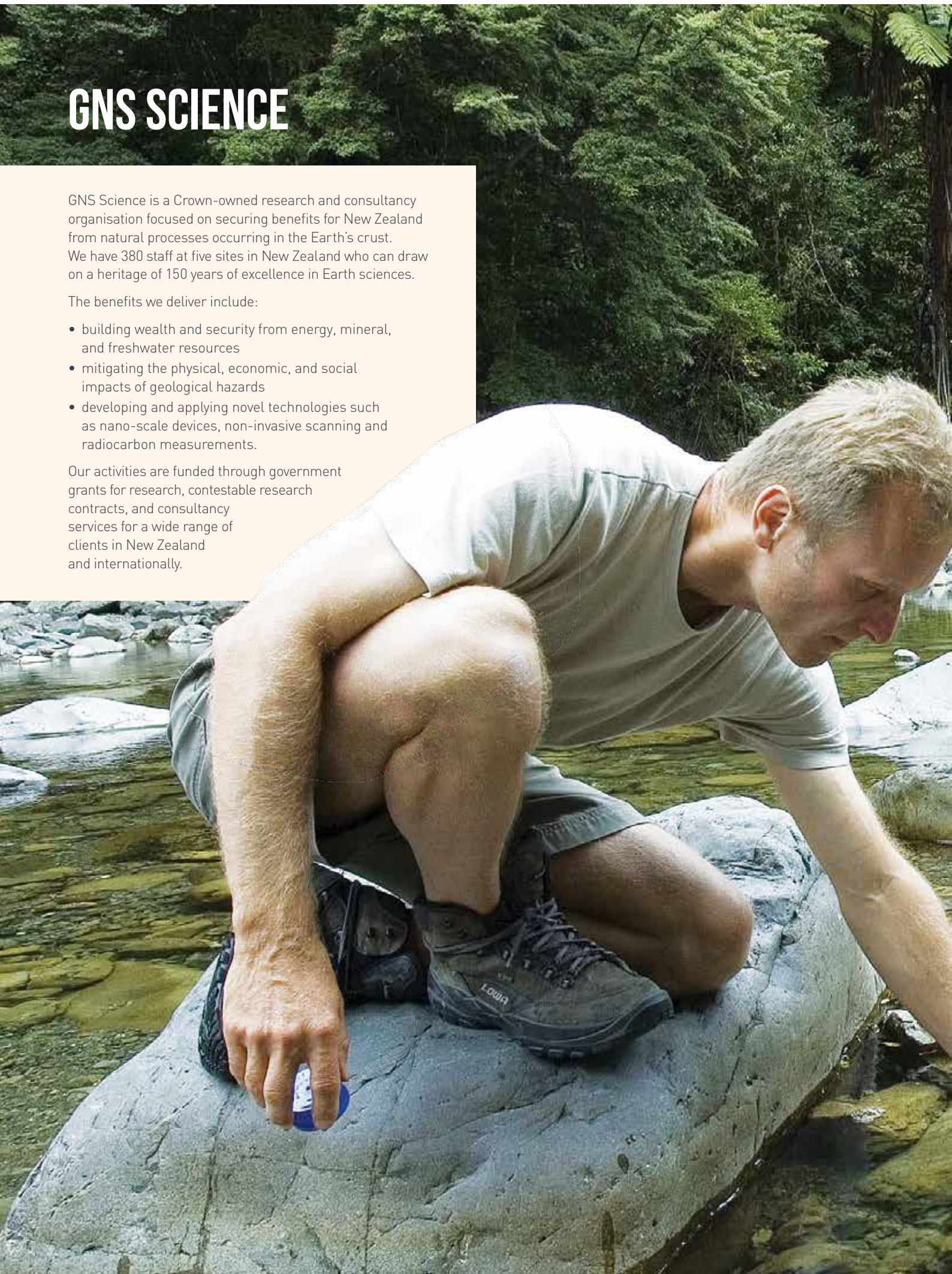
GNS SCIENCE

GNS Science is a Crown-owned research and consultancy organisation focused on securing benefits for New Zealand from natural processes occurring in the Earth's crust. We have 380 staff at five sites in New Zealand who can draw on a heritage of 150 years of excellence in Earth sciences.

The benefits we deliver include:

- building wealth and security from energy, mineral, and freshwater resources
- mitigating the physical, economic, and social impacts of geological hazards
- developing and applying novel technologies such as nano-scale devices, non-invasive scanning and radiocarbon measurements.

Our activities are funded through government grants for research, contestable research contracts, and consultancy services for a wide range of clients in New Zealand and internationally.



OUR ACHIEVEMENTS

6 Our Year in Numbers
8 From the Chairman and Chief Executive
12 Stakeholder Commentaries
16 Vision Mātauranga
17 Recognition for Outreach Initiative
18 Driving Innovation and Economic Growth
19 Science Achievements

OUR SCIENCE

26 Where Our Research Funding is Invested
27 **Core Science Area 1:** Science for a Cleaner New Zealand
30 **Core Science Area 2:** Science for a Safer New Zealand
35 **Core Science Area 3:** Science for a More Prosperous New Zealand
40 **Core Science Area 4:** Underpinning Geoscience Knowledge

OUR PEOPLE

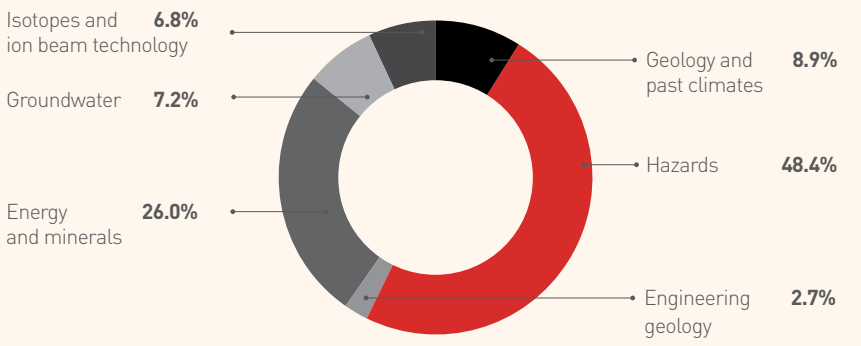
44 GNS Science at a Glance
45 Honours, Awards and Distinctions
46 2017 Excellence Award Winners
48 Being a Good Employer
50 Workplace Profile
51 Organisational Structure
52 Board of Directors
54 Executive Team

OUR NUMBERS

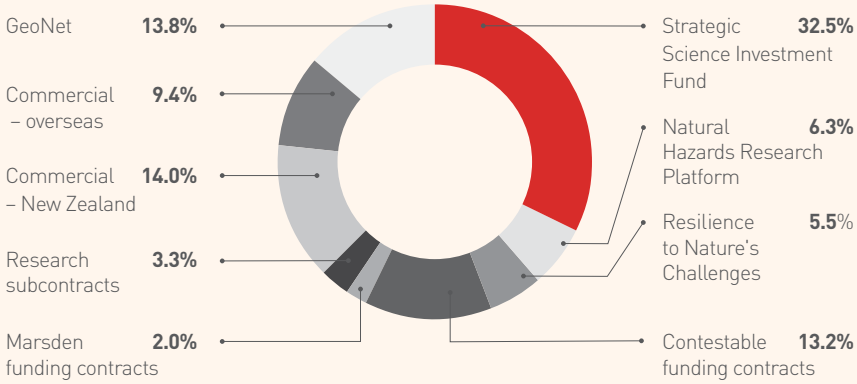
58 Performance Indicators
60 Corporate Governance
62 Report of the Directors
63 Statement of Comprehensive Income
64 Statement of Changes in Equity
65 Balance Sheet
66 Statement of Cash Flows
67 Notes to the Consolidated Financial Statements
78 Statement of Responsibility
79 Independent Auditor's Report
82 Directory

OUR YEAR IN NUMBERS

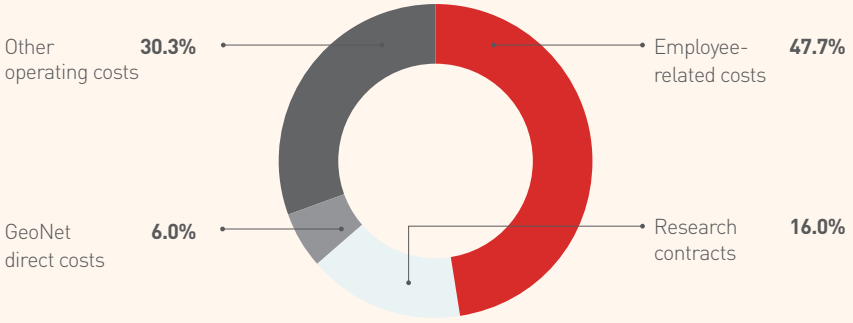
REVENUE BY SECTOR OUTCOME AREAS



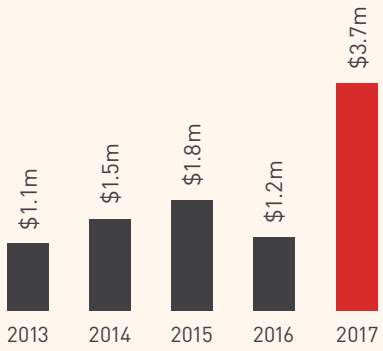
REVENUE SOURCES



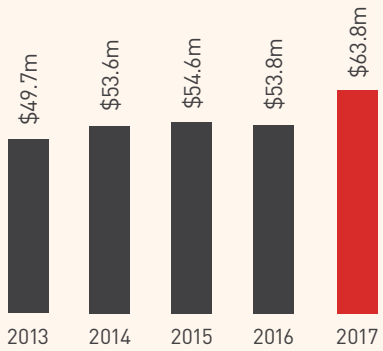
HOW WE SPENT OUR MONEY



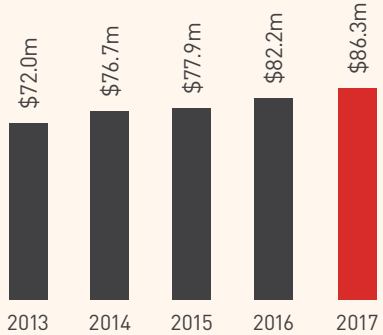
AFTER-TAX PROFIT

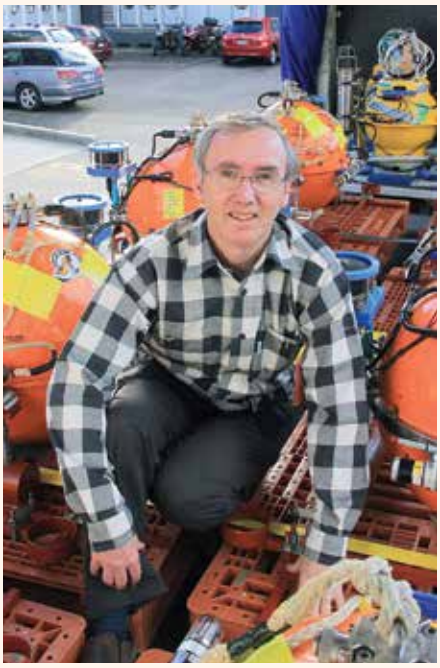


TOTAL ASSETS



REVENUE





FROM THE CHAIRMAN AND CHIEF EXECUTIVE

DELIVERING ON OUR VISION

Our stakeholders and end-users are central to everything we do. Our vision is to see them value the quality and impact of our science. In the past 12 months we have been fortunate to have many examples of this. On pages 12 to 15 a dozen of our key stakeholders talk about their relationship with GNS Science and the value we bring to their sectors. These four pages underline the diverse range of our activities and our end-user benefits, some of which keep giving value for many years. Much of this success is based on hard work and bold thinking by our science leaders. Our science outputs drive innovation and economic growth in New Zealand's geologically based industries, help manage our groundwater resources, and increase our resilience to geological hazards. Another group within our organisation uses isotope technology to develop environmental and industrial applications.

STRONG FINANCIAL RESULT

GNS Science posted a tax-paid profit of $3.7 million for the year in review, which was 68% ahead of budget. The strong result arises largely from activity associated with our science response to the Kaikoura earthquake and work flowing on from this. It represents a return on equity of 11.3% compared to the budgeted figure of 6.8%.

Revenue was $86.3 million, which was 3.7% ahead of budget. This mostly relates to healthy research funding. It includes higher revenue from the Government's Strategic Science Investment Fund for database development and funding for development of a business case for improvements to the monitoring capability of GeoNet. We were also successful with a number of research proposals to the Endeavour Fund – the Government's main vehicle for funding excellent scientific research in New Zealand. Commercial revenue was close to budget.

Expenses were $81.6 million, which was 1% above budget. This was due to variances in research and service contracts and GeoNet expenses being higher due to activity associated with the Kaikoura earthquake.

KAIKOURA EARTHQUAKE

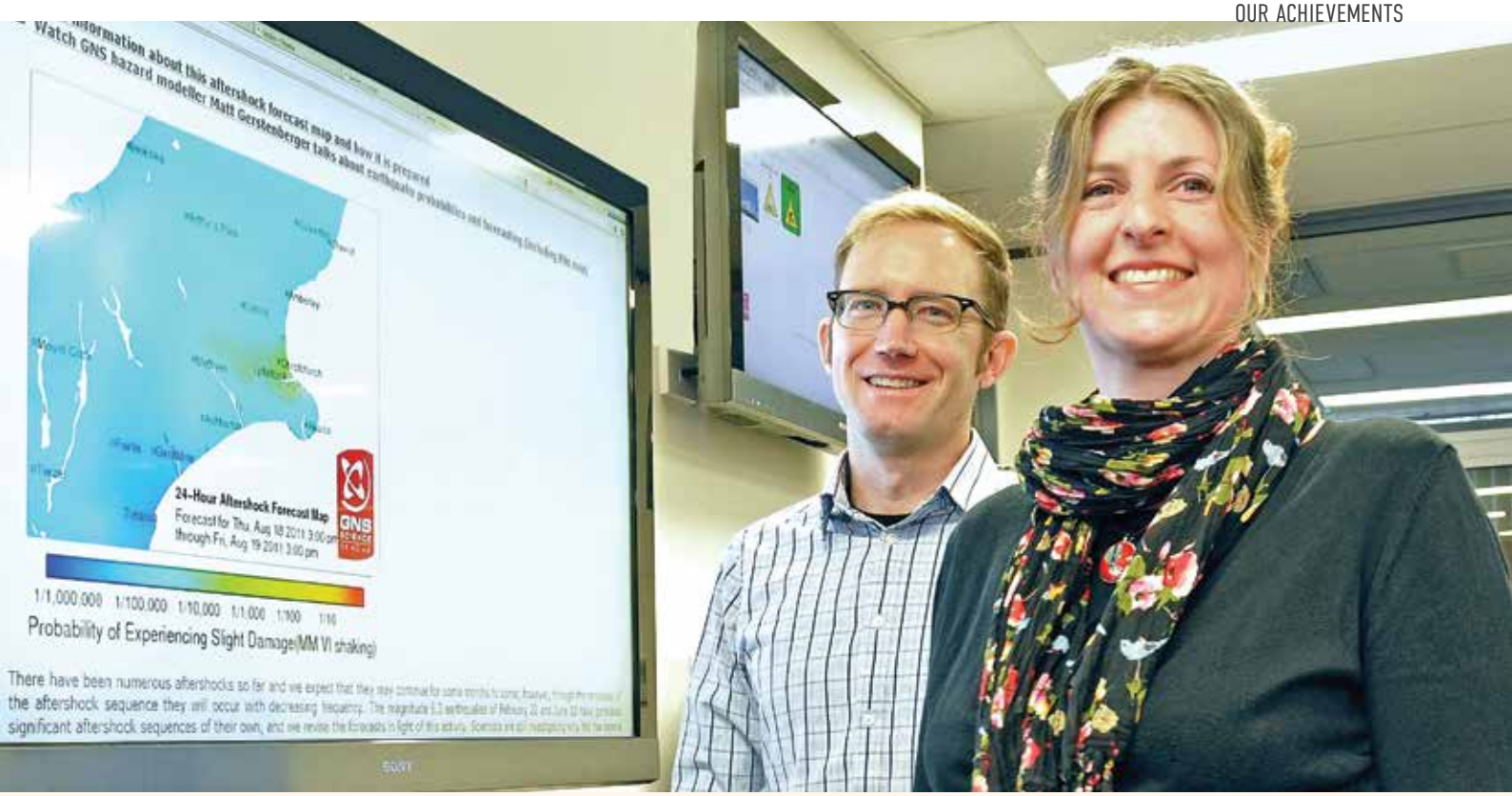
It was very pleasing to see how well our staff performed in the science response to the magnitude 7.8 Kaikoura earthquake of November 2016. Within hours of the main shock, more than a dozen of our scientists and technicians were on the ground in North Canterbury and Marlborough making vital observations and installing scientific equipment to record post-quake activity. Others remained in Wellington to analyse data and liaise with a wide range of stakeholders including government Ministers, the civil defence and emergency response community, regional councils, the engineering community, the media, and the public.

It was one of the best-recorded large earthquakes anywhere in the world, which has enabled scientists to undertake analysis to an unprecedented level of detail. It began in North Canterbury and propagated northward for about 170km along both well-known and previously unknown faults. A world record 22 faults ruptured within two minutes. It moved northeastern parts of the South Island 5m closer to the North Island, while uplifting parts of coastal Marlborough by as much as 8m.

Such was its complexity that it defied conventional understanding about the way large ruptures propagate through the Earth's crust. One of the outcomes of the post-quake analysis for New Zealand, and the rest of the world, is more accurate earthquake models. These feed into engineering standards and civil defence planning which will be more attuned to the impacts of large earthquakes as a result.

BETTER AND FASTER INFORMATION ABOUT GEOHAZARDS

In the past year, we have been working on a range of initiatives that will ensure



New Zealanders are better equipped with both long-term and real-time information about geological hazards. Funding for the improvements to New Zealand's geological hazards monitoring – known as Enhanced Geohazard Monitoring (EGM) – was part of this year's Government Budget.

The Government's investment of $19.5 million over four years will enhance New Zealand's earthquake, tsunami, landslip and volcano monitoring capability. A critical part of our EGM work will be to increase the number of specialists monitoring information provided by our national geohazard monitoring network operated by GeoNet. As well, improvements will be made to GeoNet's network, operations centre and monitoring tools.

As part of these improvements, we'll be evaluating new tsunami modelling software to improve the accuracy of forecasting arrival times, wave heights, and inundation levels. We'll also be looking at software that provides enhanced geohazard information to the desktops of those making decisions about how to respond to an event.

These enhancements will significantly improve our ability to accurately assess geohazards in real time, particularly tsunami. They will also enable us to communicate information more effectively to the Ministry of Civil Defence and Emergency Management (MCDEM), Ministers and officials, the media, scientists, and the public.

To further improve communications, we are working with other agencies on developing mobile phone messaging alerts during natural disasters. We have also successfully redeveloped our GeoNet website in the past year so it delivers information in a more targeted and timely way.

This important EGM work builds on the existing GeoNet infrastructure, developed jointly by the Earthquake Commission (EQC) and GNS Science over the past 16 years. GeoNet continues to benefit from the support of EQC, including funding of $12 million per year. This has enabled GeoNet to become the trusted source of advice for MCDEM and New Zealanders, through the app and website. We also acknowledge the outstanding work of our Geological Hazards and GeoNet teams over what has been an exceptionally busy year for them.

BIG SCIENCE COMES TO NEW ZEALAND

One of New Zealand's largest ever Earth science projects got underway this year with the US scientific drilling ship *JOIDES Resolution* starting the first of six research voyages in what will be a year-long deployment in our ocean territory. The project is taking place under the auspices

GNS SCIENCE HAS DELIVERED A STRONG FINANCIAL PERFORMANCE THIS YEAR.

Total revenue was

$86.3 MILLION,

an increase of

$4.1 MILLION

on the previous year.

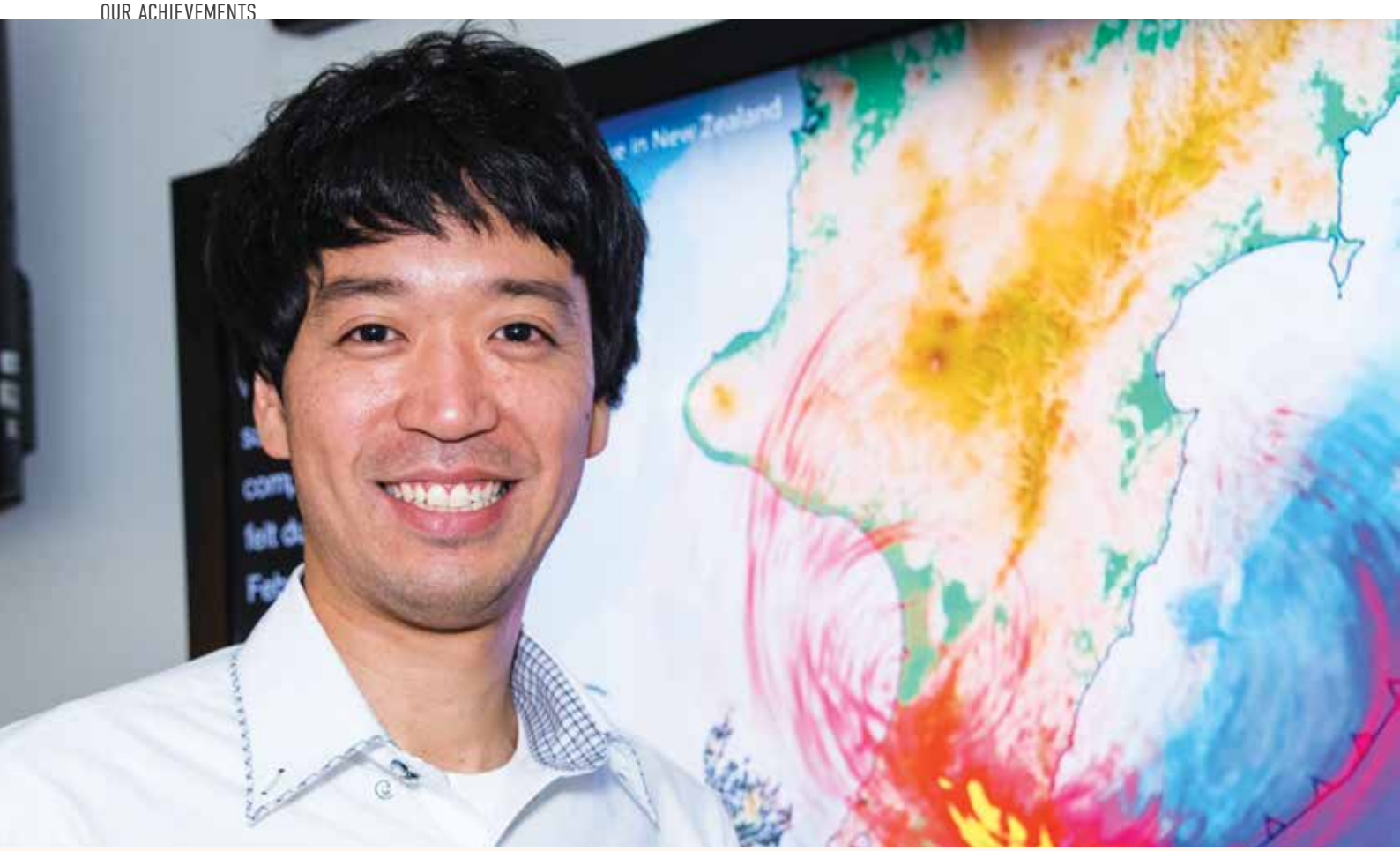
After-tax surplus was

$3.7 MILLION,

which was

$1.5 MILLION

ahead of budget.



of the 23-nation International Ocean Discovery Program (IODP) – the world's biggest marine geoscience initiative.

Staff from GNS Science are co-leading two of the expeditions and are heavily involved in all the others. Each two-month voyage has a different science focus ranging from the forces that generate earthquakes on the tectonic plate boundary to the east of the North Island to probing the inside workings of a submarine volcano northeast of the Bay of Plenty. Two of the voyages are dedicated to getting a clearer picture of climate change impacts in Antarctica and the Southern Ocean.

Overall, the voyages represent an international investment in science of around $120 million and will bring over 200 scientists into the region to undertake research that will continue well beyond the expeditions. The entire project is believed to be the largest project-specific international investment in New Zealand science in a single year ever. GNS Science is proud to be a key player in this initiative which will acquire volumes of new scientific knowledge that will have wide-ranging benefits for decades to come.

EXPLORING THE UNDERSEA CONTINENT OF ZEALANDIA

We featured the submerged continent of Zealandia in the opening pages of this document, and for good reason. At the time of writing, the first of the six IODP voyages to explore this vast undersea plateau was almost completed. In terms of discovery, the voyage has delivered more than expected. After obtaining cores from the continental crust under the Tasman Sea, scientists on the research ship *JOIDES Resolution* found that Zealandia's geography has changed more dramatically and more recently than anyone had thought.

Previously it was believed that Zealandia separated from Australia and Antarctica about 80 million years ago. It then subsided deep under the ocean and was lost. However, preliminary observations from this first IODP voyage suggest large parts of Zealandia were much closer to the ocean's surface than previously thought, or even above water. The implications of this are substantial. It may help explain how unique plants and animals of the southwest Pacific were able to disperse and evolve.

This finding underlines how Zealandia is ideally positioned for testing ideas on how the Earth works and how the southwest Pacific evolved over time. For instance, the formation of the Pacific Ring of Fire brought massive changes to the way the planet functions. New volcanoes formed and new mountain ranges grew – changes that had long-term effects on global climate. Subsequent IODP voyages over the next nine months will investigate other aspects of Zealandia.

STRATEGIC REVIEW

This year we canvassed stakeholders and staff on their views of GNS Science and found that we were nationally and internationally respected for the excellence of our science. The quality and relevance of our work meant we had built strong relationships with key customers. The review also supported the view that we currently undertake too broad a range of activity.

To address this, we started our Strategic Review project with the aim of focusing efforts on science areas where we have

strength, significant influence, and where there is room to grow our capability and impact for New Zealand.

To provide context for our work we analysed central government roadmaps and strategies to identify opportunities and consulted with similar organisations about their strategic review processes. We held a series of staff workshops to develop a Science Road Map that linked GNS Science's vision with New Zealand's strategic needs. This work is putting us in a strong position to start setting priorities for the near term so we can maximise GNS Science's contribution to New Zealand.

MĀORI ENGAGEMENT

The work of GNS Science has many synergies with the interests of Māori and there is a mutual willingness to share experience and expertise. Areas where this is demonstrably strong include geothermal energy, aquifer management, volcanic hazards, identification and management of mineral resources, and air quality. In addition, we work closely with numerous iwi and trusts providing one-day and multi-day workshops for mutual sharing of information on a range of Earth science topics. Through these activities, we are closely aligned with the New Zealand Government's 'He kai kei aku ringa' strategy which identifies key actions for realising the potential of Māori land and water assets. We spell out how we will create mutual value in our 30-page Māori Strategy – Te Rautaki Māori. This is an organisation-wide strategy that sets out a framework to make 'Te Ao Māori' aspects of our work more visible, understandable and accessible to our staff and to Māori.

CROWN RESEARCH INSTITUTES MARK THEIR FIRST 25 YEARS

GNS Science is one of seven Crown Research Institutes who are celebrating 25 years of producing excellent science for New Zealand this year. The CRIs were formed in 1992 from the former Department of Scientific and Industrial Research. Collectively CRIs employ more than 3400 staff across 50 sites in New Zealand. They play an ever more crucial role in New Zealand's economic development and wellbeing. Their mission is to look to the future – what are the opportunities and challenges for New Zealand – how can we better protect, enhance and develop New Zealand's future wealth and wellbeing? Along with the other CRIs, GNS Science is always keen to engage with New Zealanders, and share our research and how it is applied. The GNS Science Board and management team are proud to have delivered 25 consecutive years of excellent applied science to New Zealand. We encourage you to read through the following pages to learn more about our broad range of activities and the vigilant attitude that typifies GNS Science staff. This has enabled us to deliver outstanding results year after year.

BOARD AND STAFF

Belinda Vernon retired from our Board in June 2017 after six years' service. We thank Belinda for her energetic and insightful contributions, and especially for her leadership of the Board Health and Safety Committee. In August 2017 we welcomed Paul White onto our Board. Paul is a management consultant and professional director and lives in Rawene in Northland. His 30 years of experience in Māori development and the public sector will be invaluable to GNS Science. He is from the Ngāi Tupoto hapū of the Te Rawara iwi.

In January 2017 Ian Simpson started as Chief Executive. He joined us after seven years as chief executive of the Earthquake Commission, the last six of which were spent leading EQC's response to the 2010/2011 Canterbury earthquake sequence. In his first eight months in this new role, Ian has brought a big picture vision for our organisation and has demonstrated an inclusive management style that is well suited to GNS Science. Under his leadership, we are confident GNS Science will prosper and grow. We also thank Neal Wai Poi for stepping in as Acting Chief Executive for nearly 12 months prior to Ian Simpson's arrival. We wish Neal well as he moves on to other things.

Finally, we express our thanks to the dedicated staff of GNS Science who have delivered yet another year of outstanding science across our many sector areas.

Dr Nicola Crauford
Chairman

Ian Simpson
Chief Executive

STAKEHOLDER COMMENTARIES

Twelve key stakeholders give a perspective on their relationship with GNS Science and our contribution to their sector.

DR BEN MACKEY

Hazards Analyst (Geologic)

Otago Regional Council, Dunedin

The Otago Regional Council (ORC) works with communities to manage natural hazards across the Otago region. Over the past decade the ORC has engaged GNS Science to provide high-quality advice and geospatial data pertaining to geologic hazards. These products are used to better prepare communities for natural events, and are integrated into district and regional planning instruments.

Examples include the identification and hazard assessment of alluvial fans, landslides, liquefaction susceptibility, and active faults. In addition, GNS Science staff have provided advice and reporting following individual storm and landslide events, and have represented ORC as an expert witness in hearings.

A major recent project has been the inclusion of land instability hazard maps in the Dunedin City Council's revised District Plan, for which the ORC provided technical advice. Over a period of several years GNS Science's Dunedin scientists have collated and reconciled existing landslide information in the district into a useable digital format. When legacy information was found to be unsuitable for modern planning purposes, the project culminated in a full re-mapping and assessment of landslides, documenting over 2,000 landslides across nearly 700 km^2 of Dunedin terrain.

With the growing importance of natural hazard information in resource management and land development there is an established need for high-quality, defensible, and scientifically sound data which can be understood by a wide audience. GNS Science has met these expectations for ORC on multiple projects.

JUSTIN LESTER

Mayor of Wellington

GNS Science has a broad and effective reach in helping to make the Wellington region more resilient to geological hazards. Over the years it has partnered with Wellington City Council and other key agencies in numerous science-based initiatives, many of which are ongoing.

The cumulative effect of this applied geoscience work is hard to measure precisely, but it has almost certainly made a huge dent in the potential economic and physical losses we are likely to experience in future large geohazard events. As well as hardening Wellington to the impact of such events, this work will help the city recover faster.

One of these initiatives is the long-running It's Our Fault project, which GNS Science has ably led since 2006. It pools the efforts of a large number of specialists across many disciplines to reduce the vulnerability of the Wellington region to the impacts of a large earthquake.

The outputs of It's Our Fault have been taken up in the insurance, engineering, geotechnical and civil defence communities, and by local government. The need for such a project has never been more apparent with the 2016 Kaikoura earthquake sending a strong and timely reminder that there is plenty to do in this area.

GNS Science's expertise in engineering geology has been valuable to the Council with the large number of landslips affecting Wellington over the past year. It has also been a key part of the successful Tsunami Blue Lines initiative, now being adopted in other coastal cities internationally.

FIONA McTAVISH

General Manager, Strategy and Science

Bay of Plenty Regional Council

The Bay of Plenty is an exciting place to live but our region is subject to natural hazards including tsunami, volcanic activity, coastal processes (such as erosion), extreme rainfall and landslides.

Bay of Plenty Regional Council (BOPRC) has a responsibility to control land use to avoid or mitigate the effects of natural hazards. Land use control is important because it can help ensure lives and property are not allowed to remain needlessly in the way of these hazards.

In June last year the BOPRC approved Change 2 (Natural Hazards) to the Bay of Plenty Regional Policy Statement (RPS). This change, which inserts risk-based natural hazard provisions into the RPS, helps people preparing regional, city and district plans, and considering resource consent applications.

The involvement of natural hazard planning expertise from GNS Science helped drive this innovative and robust policy approach. The risk-based approach and engagement strategy developed for the RPS was based on the GNS Science risk-based planning toolbox for natural hazards, available online.

With GNS Science's risk-based planning toolbox, BOPRC has translated a comprehensive risk approach to the management of natural hazards into a formal, regional-level strategic policy instrument for the first time. This process has been ground-breaking in New Zealand, and in 2017 was awarded the New Zealand Planning Institute's Best Practice Award for a Regional Plan.

PAUL ROBERTSON

Senior Compliance Officer

Ministry for Primary Industries

Stamping out the black market paua industry in New Zealand is a constant challenge for the Ministry for Primary Industries (MPI), and successfully prosecuting people who offend in this area is often a long and drawn out process. The onus is on MPI to meet an often very detailed burden of proof. This requires an intensive and highly accurate accumulation of evidence.

One of our most recent and challenging investigations involved the illegal poaching of almost 700kg of paua from Motiti Island in the Bay of Plenty that fuelled a black market operation lasting 13 months.

A major issue was proving that paua seized from a lock-up shed in Mt Maunganui had been illegally taken and had not been bought from a legitimate source. Some of the defendants who lived in Tauranga claimed they sourced their paua from licensed fish dealers in Bluff and Napier.

Enter GNS Science isotope chemist, Dr Karyne Rogers and her team, who used a special type of forensic science – stable isotope analysis – to pinpoint exactly where the paua had been poached from. In a nutshell, their work proved beyond reasonable doubt that the paua didn't come from the source the offenders claimed it was from – precisely what we needed to prove our case. The professionalism and enthusiasm that GNS Science brought to this piece of work was nothing short of outstanding. In fact the work they undertook was ground-breaking.

DEBORAH COLLINS

Divisional Manager, Partnerships, Humanitarian and Multilateral

Ministry of Foreign Affairs and Trade

The Ministry of Foreign Affairs and Trade (MFAT) manages New Zealand's international development cooperation, which aims to increase prosperity and stability in developing countries in the Pacific and beyond. Reducing the risk from disasters and increasing resilience is an important part of this, and we work with GNS Science on a range of projects.

In central Vietnam we are partnering with GNS Science and New Zealand's Damwatch Limited to implement a $5.8 million project to strengthen dam safety, using expertise in water engineering and natural hazard management. This project aims to halve the death toll and reduce economic losses by 30% by 2021 from flooding on the Ca River.

In eastern Indonesia, MFAT is working with GNS Science and the University of Gadjah Mada on a $7.5 million project to strengthen local government disaster resilience and reduce risks for 3.75 million people in 10 districts.

We are collaborating with GNS Science and the Government of Vanuatu to establish a modern volcanic hazard monitoring and mitigation system. The same expertise is building the capacity of the University of West Indies Seismic Research Centre to monitor volcanoes in the Caribbean.

Through these and other partnerships with GNS Science, New Zealand is providing world-leading disaster expertise to some of the most vulnerable places in the world.

ALAN JOHNSON

Environmental Science and Monitoring Manager

Marlborough District Council

Marlborough District Council has worked collaboratively with GNS Science on several projects over the past year in geohydrology and liquefaction risk. The results have contributed to a better understanding of Marlborough's natural resources, and their associated management issues.

The Christchurch and Kaikoura earthquakes raised questions about the suitability of certain parts of the Lower Wairau Plain for building or human settlement. To assist Council to assess the risk, GNS Science has used the 5,500 well logs stored in our database to map the sediment types in three dimensions for the coastal area beneath the Lower Wairau Plain.

GNS Science went one step further and transformed selected 3D images into digital displays to improve public understanding of the geology in the Wairau Plain. They have also reconstructed the geomorphic history of the Wairau Plain to elucidate aquifer processes.

These visualisation tools are helping Council specialists see patterns that they may not have spotted in conventional static hydrological graphs. GNS Science is also developing methods to assess changes in aquifer chemistry over time, which is ground-breaking technology.

GNS Science continues to help Council refine its understanding of the reservoir size of the Wairau Aquifer. This work is a pre-requisite for setting environmental thresholds to maintain ecological flows of groundwater-fed springs during droughts.

DR DAVID DARBY

Manager, Commercial Analysis & Investment

Energy & Resource Markets Branch

Ministry of Business, Innovation and Employment

My team leads the responsible development and regulation of New Zealand's petroleum and mineral resources. Our operational arm, known externally as New Zealand Petroleum & Minerals, is responsible for promoting investment in New Zealand's resource sector as well as allocation of exploration and production permits. Through direct involvement with the sector, we understand New Zealand's energy needs and resource development opportunities.

GNS Science is a key partner for us. We draw heavily on their research and technical expertise to champion increased knowledge of our resources. The research projects – whether in minerals, petroleum, or geothermal – led by GNS Science provide essential high-quality information on New Zealand's resource estate, encouraging investment in traditional and renewable energy and resource opportunities.

Significant recent projects we have conducted in partnership with GNS Science include the regional geochemical surveys on the South Island, which will provide new information on our natural environment, and potentially on the new resources it may hold. Similarly, the National Well Audit is providing a systematic framework for New Zealand's petroleum wells by capturing the in-depth knowledge provided by leading researchers at GNS Science. They are an intrinsic part of the New Zealand resources sector, playing a vital role to ensure that our resources are recognised and developed in a sustainable, economically viable manner.

BRIAN McMATH

Business Development Manager

NZ Product Accelerator

Collaboration amongst New Zealand universities and Crown Research Institutes is a key Government initiative for helping New Zealand industry benefit from the capability that exists in these organisations. The NZ Product Accelerator is a Ministry of Business, Innovation and Employment (MBIE) funded programme led by The University of Auckland partnering with Auckland University of Technology (AUT), Scion, Massey University, Victoria University of Wellington, and GNS Science.

The NZ Product Accelerator's role is to assist New Zealand industries to develop new products by tapping into the technical expertise that exists in the partner organisations. GNS Science is a key contributor to the programme and has been working with the other partners to increase export revenues for New Zealand industries.

We have been able to introduce a number of companies to GNS Science's Ion Beam Analysis and Research Laboratory and this has resulted in projects as varied as coating food processing equipment to prevent microbial build-up to functionalising plastic surfaces. Their range of testing equipment has been well utilised by many companies.

The NZ Product Accelerator has been highly successful in generating economic benefit for New Zealand and we would not have achieved this without the contribution from GNS Science.

WARREN MANNINGTON

Reservoir Strategy Manager

Contact Energy Limited

New Zealand pioneered the geothermal industry with the development of the Wairakei geothermal field in the 1950s. Wairakei was the second geothermal power station in the world and the first to utilise a liquid dominated geothermal system.

Contact is proud to be building on the legacy of the Wairakei development and we continue to have a close relationship with GNS Science, whose predecessor organisation DSIR was involved in the original development at Wairakei. Geothermal is an industry that benefits greatly from collaboration and we utilise the skilled and experienced geothermal team at GNS Science to provide this. The GNS Science team is also highly respected in the geothermal community.

We have used GNS Science to provide independent technical advice as part of obtaining and maintaining our suite of resource consents for the Wairakei, Tauhara and Ohaaki geothermal fields. Contact makes extensive use of the New Zealand Geothermal Analytical Laboratory, part of GNS Science's facility at Wairakei. It's great to have a world-class facility like this on our doorstep.

Advancement of the technology for the development of geothermal resources is a focus area for Contact and GNS Science led research programmes such as the Geothermal Resources of New Zealand, Super Models and Waste to Wealth; these deliver key benefits to us. Continuing industry-directed targeted research will ensure the sustainable and renewable future of the New Zealand electricity industry.

GRAEME BLICK

Group Manager, Positioning and Resilience

Land Information New Zealand

GNS Science and Land Information New Zealand (LINZ) have had a long-standing partnership as part of its GeoNet programme. Together the organisations implemented New Zealand's network of Continuously Operating Reference Stations (CORS). These receive information from Global Navigation Satellite Systems like GPS which can be used to tell us the exact position of points and to show movement of the Earth's crust.

As well as contributing to the GeoNet programme, the national network called PositioNZ provides the backbone of the positioning infrastructure that surveyors, engineers and the construction industry use every day to get precise coordinates on where things are.

The CORS network also helped provide essential information for recovery from the 2016 Kaikoura earthquake. Following the quake, LINZ worked with GeoNet to carry out additional surveys across the areas affected. GNS Science also provided LINZ with a model of the earthquake to enable us to determine the extent and size of the impact on LINZ's geodetic network and cadastre – vital information for the country's surveyors.

LINZ has also worked with GNS Science to establish the sea level monitoring component gauges that are used by GeoNet for the tsunami warning system. LINZ uses this network for producing tide predictions, giving information for professional skippers as well as recreational boaters, and fishers.

JAMES WARBRICK

Chairman

Whakarewarewa

Whakarewarewa – The Living Thermal Village is delighted to work with GNS Science as one of its partners. This relationship with GNS Science has produced an outcome that has exceeded expectations. The recovery of a geothermal system that had become severely depleted in the late 1970s and early 1980s has been attributed to the closing of bores that were draining it of power.

Our relationship with GNS Science has most recently been expressed by our partnership in producing MBIE proposals for research under the geothermal banner and air particulate projects focussing on ion beam analysis in commercial environments.

The Whakarewarewa geothermal field is unique on a world scale, made even more so because the Te Arawa, Tūhourangi and Ngāti Wāhiao people have lived amidst the boiling geysers and pools for generations, and the tourism legacy has thrived because of it. While working in isolation might result in survival, working together can take people beyond survival and onto prosperity, whereby our way of life so treasured in Whakarewarewa can be maintained for generations to come.

Ko te ao e matapoporetia ana ki roto o Whakarewarewa, ka toitū tonu, whakatipuranga atu, whakatipuranga mai me te aha, nā tō rourou, nā taku rourou ka ora ai te iwi nā aua waiariki kua muia rātou e te hunga tūruhi.

SARAH STUART-BLACK

Director, Ministry of Civil Defence & Emergency Management (MCDEM)

MCDEM has a long-standing working relationship with GNS Science and GeoNet. It covers business-as-usual work programmes across the 4R's (reduction, readiness, response, and recovery), but most notably during responses to geological hazard events.

We have a Memorandum of Understanding with GNS Science for the provision of threat advice related to geological hazards (earthquakes, volcanoes, tsunami and landslides). MCDEM rely on GNS Science as a trusted and reliable source of critical advice and information. We have worked with them over many years to develop and improve the processes, planning, and communications for sharing threat information.

The Tsunami Experts Panel (TEP) is led by GNS Science to provide MCDEM with official advice on tsunami threats posed to New Zealand. MCDEM, as the official warning agency for tsunami, calls on the expertise of GNS Science if the situation requires expert judgement, or if the parameters of a tsunami event are unclear.

GNS Science research expertise is used heavily in our risk management and public education programmes. Our strong relationship with GNS Science is supported by continued and regular engagement. This relationship ultimately helps to keep the public safe when emergencies occur.

VISION MĀTAURANGA

GNS Science is committed to developing partnerships with Māori to deliver mutual benefit. We collaborate with Māori organisations on a number of projects that contribute to the social, economic, cultural and environmental wellbeing of New Zealand.

This year we were awarded government funding of $480,000 for four new projects in the 2017 round of Te Pūnaha Hihiko – Vision Mātauranga Capability Fund. The Fund aims to strengthen relationships between Māori and scientists.

The projects run for two years and are aligned with four themes.

The successful GNS Science projects are:

Working with Ngāti Hauā Iwi Trust to collate freshwater scientific, Mātauranga and policy knowledge about the Piako River catchment on the Hauraki Plains and make it available within an interactive, user-focussed tool.

The information will enable Ngāti Hauā to more readily make informed decisions about freshwater resource management in the Piako River catchment for both the health of the environment and the iwi. As part of the project there will be hands-on marae-based workshops to share scientific knowledge, and to facilitate learning through experience.

Working with Whakarewarewa Village Charitable Trust in Rotorua to better understand the health effects of hydrogen sulphide.

The gas, famously responsible for Rotorua's distinctive odour, is one of the two main gases found in the village. The project will use information from a database resulting from three years of air particulate sampling at Whakarewarewa Village. Hydrogen sulphide is 1.2 times denser than air and can be fatal at high concentrations. Long-term exposure due to emittance from the ground is likely to cause chronic health problems such as asthma. As well as improving Māori understanding of the science of the gas, the project will also help to improve the health of the Village workforce.

Working with Hauraki iwi Ngāti Hako to integrate scientific information and Mātauranga to better understand and realise the mineral resources in the iwi's rohe (tribal region).

The project will develop a pathway to unlock the region's mineral potential as well as economic opportunities. Findings will be shared through a series of hui. One of the outputs will be a database of the region's mineral resources identifying their attributes and economic significance.

Working with Rotorua iwi Ngāti Rangiwewehi to identify 'kaitiaki' flow regimes for Awahou Stream near Rotorua.

This is a new water management concept for spring-fed catchments that will bring together science and Mātauranga. One of the outputs will be a water resources capability plan, which will be promulgated to other iwi and water suppliers. It is expected to help other iwi with their water resources capability development.

RECOGNITION FOR OUTREACH INITIATIVE

Our GeoCamp outreach initiative received national recognition as a category winner in the 2017 Deloitte Energy Excellence Awards. The hands-on science camp for intermediate-aged students and their teachers won the Community Initiative of the Year Award.

The judges at the Deloitte Energy Excellence Awards said the GeoCamp initiative had delivered broad community benefits, reflected by a significant amount of positive feedback from teachers, students and community stakeholders. "The GeoCamps have made a real difference in young people's lives, as well as teaching the teachers and making communities more aware of the environment around them."

The aim of these fortnight-long camps is to enthuse 10-13 year olds about the possibilities of science and give them confidence that science is something they can understand and participate in.

GeoCamps have been a cornerstone of our Geological Resources Division's outreach and communications initiatives since 2011.

We have run successful GeoCamps in Napier, New Plymouth, and Kaitaia. They were conceived and developed by three of our staff – Julian Thomson, Richard Levy and Kyle Bland.

The earlier GeoCamps were mainly sponsored by the Todd Foundation and the two staged in Northland in 2016 and 2017 were supported by Statoil and the Far North Rural Education Assistance Programme.

Each GeoCamp caters for up to 35 students and teachers from about six schools in the local community. The aim is to create an experience as close to doing 'real science' as possible, driven largely by the participants themselves. And, by 'teaching the teachers' the GeoCamp experience inspires them to develop similar initiatives in their own schools.

Teacher feedback shows that the two-week experience sparks immediate changes in teacher practice and confidence levels. A secondary goal of GeoCamps is to improve the scientific literacy of the public.

Each GeoCamp consists of a mix of classroom activities and field sessions which are tailored to local geography and issues affecting the local communities. Topics include coastal processes, landscape evolution, environment change, ecology, geological resources, and geological hazards. Themed sessions include 'every rock tells a story', 'where is carbon in the environment?', 'fluids in the ground', 'greenhouses gases', 'elements and compounds', and 'seeing the unseen'.

As part of the programme our staff give public presentations in the evening and at the end of the two-week programme the students put on a public expo to share some of their new knowledge and skills with their community.

As well as GeoCamps, our external communication and engagement portfolio includes museum exhibits, digital media, public-interest publications, public presentations, and open days for senior science students at schools.

DRIVING INNOVATION AND ECONOMIC GROWTH

Our business is defined by our Statement of Core Purpose and understanding our place in the national innovation system.

PURPOSE

- GNS Science's Purpose is to undertake research that drives innovation and economic growth in New Zealand's geologically based energy and minerals industries, that develops industrial and environmental applications of nuclear science, that increases New Zealand's resilience to natural hazards and that enhances understanding of geological and earth-system processes.
- GNS Science will fulfil its Purpose through the provision of research and consultancy services and knowledge in partnership with key stakeholders including industry, government and Māori to achieve the following outcomes.

STATEMENT OF CORE PURPOSE OUTCOME STATEMENTS	
OS1	Increase resource security and economic benefit from the development and diversification of New Zealand's oil, gas, geothermal energy and minerals industries
OS2	Increase New Zealand's resilience to natural hazards and reduce risk from earthquakes, volcanoes, landslides and tsunami
OS3	Improve the sustainable management of and increase economic returns from groundwater resources
OS4	Create value for New Zealand industry through the use of isotope and ion beam technologies
OS5	Increase understanding of the geology and past climates of New Zealand, the Ross Dependency and Antarctica
OS6	Enhance the geotechnical engineering that underpins New Zealand's transport and energy infrastructure

TO ACHIEVE THESE OUTCOMES, GNS SCIENCE IS THE LEAD CROWN RESEARCH INSTITUTE IN:

- geothermal energy, oil, gas and gas hydrates (including carbon sequestration)
- mineral and geobiological resources
- geological hazards, risk mitigation and social impacts of natural hazards
- earth-system processes and landscape evolution
- groundwater processes and quality
- the geological component of global environmental processes and climate change
- application of nuclear technology and isotope science and ion beam technology.

GNS SCIENCE WILL WORK WITH OTHER RESEARCH PROVIDERS AND END-USERS TO CONTRIBUTE TO THE DEVELOPMENT OF:

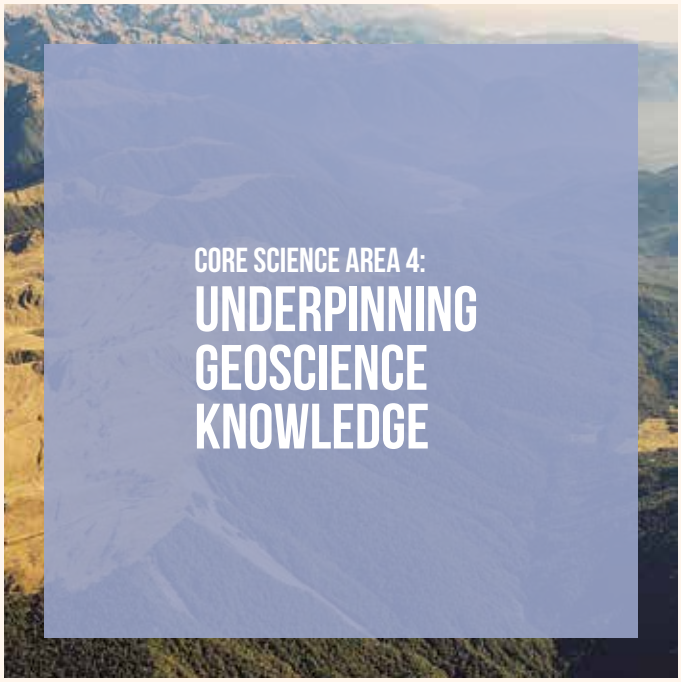
- high-value manufacturing
- freshwater management
- hazards management
- ocean floor exploration
- climate change adaptation and mitigation
- Antarctica.

GNS SCIENCE WILL:

- operate in accordance with a Statement of Corporate Intent and business plan that describes how we will deliver against this Statement of Core Purpose, and describes what the shareholders will receive for their investment
- meet our obligations as a Crown company and remain financially viable
- develop strong, long-term partnerships with key stakeholders, including industry, government and Māori, and work with them to set research priorities linked to the needs of end-users
- maintain a balance of research that provides for near-term needs of end-users and also demonstrates longer-term vision
- transfer technology and knowledge from domestic and international sources to key New Zealand stakeholders
- develop collaborative relationships with other research institutions to form the best teams
- provide advice on matters of its expertise to the Crown
- represent New Zealand's interests on behalf of the Crown through contribution to science diplomacy
- seek advice from advisory panels to help ensure the quality and relevance of our research
- have policies, practices and culture that optimise recruitment and retention
- enable the innovation potential of Māori knowledge, resources and people
- maintain databases, collections and infrastructure sustainably and provide appropriate access
- seek shareholder consent for significant activity beyond our scope of operation.

SCIENCE ACHIEVEMENTS
RELATED TO OUR 2016-17 STATEMENT OF CORPORATE INTENT

OUR CORE SCIENCE AREAS



SCIENCE FOR A CLEANER NEW ZEALAND

CORE SCIENCE AREA	IMPACT AREA	IMPACTS AND MEASURES OF SUCCESS	PROGRESS/ACHIEVEMENT
SCIENCE FOR A CLEANER NEW ZEALAND **Air, Water & Land** Relates to SCP Outcome 3	Improved freshwater management **SCI Impact 4**	Tracer validated numerical models and 'smart' tools for accurate, rapid, and cost-effective mapping of aquifers have led to a better understanding of key aquifer systems and a demonstrable improvement in the management of groundwater and interconnected surface water systems. By 2017, 'smart' aquifer characterisation tools are being used by regulators for decision making.	Tracer-validated models have revealed complex variations in temporal age distributions of groundwater at catchment scale. This has important implications for drinking water security, where a mean age of more than one year is typically considered safe for consumption. 'Smart' tools for improving groundwater and aquifer management have been trialled and validated; these include: radon and distributed-temperature-sensing for better quantifying groundwater-surface water fluxes; halon age tracers; data-worth for management risk; data estimation using machine learning methods; data transfer standards; and use of satellite datasets. These and other initiatives are assisting regional councils throughout New Zealand with understanding aquifer systems, and developing related water management policies.
	Improved air quality regulations **SCI Impact 7**	A better understanding of the drivers of air quality in NZ regarding particulate matter has resulted in more realistic pollution thresholds and regulations, leading to improved community health. By 2017, air particulate source apportionment data are being used for setting new air pollution standards.	GNS Science research has been used extensively for analysis of the health impacts resulting from air particulate matter pollution in New Zealand. Data has been used by the Ministry for the Environment and Statistics NZ to identify the relative health impacts of different particulate matter sources across the country. The Parliamentary Commissioner for the Environment has since produced a report that drew heavily on these to illustrate the relative impact of $PM_{2.5}$ from anthropogenic sources and the implications for human health. The report called for a $PM_{2.5}$ National Standard.

SCIENCE FOR A SAFER NEW ZEALAND

CORE SCIENCE AREA	IMPACT AREA	IMPACTS AND MEASURES OF SUCCESS	PROGRESS/ACHIEVEMENT
SCIENCE FOR A SAFER NEW ZEALAND **Hazard Monitoring** Relates mainly to SCP Outcome 2	Meeting society's information needs **SCI Impact 10**	Information on the location and size of an event has continued to meet the public's need for immediate knowledge, allaying some fears and focussing attention where warranted. By 2017, there is complete integration of mobile and website felt reporting.	The GeoNet app and website have been integrated into the Felt Rapid system, which now provides a quick and understandable process for users, resulting in a large increase in submitted Felt Reports. Felt reports are submitted by the public via the GeoNet App and describe how people felt a particular earthquake. They are extremely useful for seismologists in the hours following an earthquake. This is particularly the case when a quake is centred where our instruments may be sparse. Data from Felt Reports feeds into ShakeMap, which provides near real-time maps of shaking after a quake. ShakeMaps are used by engineers, councils, and the civil defence sector for quick information on where damage is likely to be most severe.
Societal and Economic Resilience Relates mainly to SCP Outcome 2	Better-informed policy development **SCI Impact 15**	Land-use planning, emergency management, and economic risk research results have become embedded in policy at all levels of government, leading to increased societal resilience to geohazards. By 2017, the Resilient Auckland initiative on Auckland's growth has made informed choices on the basis of geohazard risk and resilience analysis.	Bay of Plenty Regional Council's application of the GNS Science on-line risk-based toolbox won the 2017 NZ Planning Institute Best Practice Award for a Regional Plan (see page 12). This toolbox has also been incorporated into the Thames-Coromandel District Plan natural hazards chapter, and has been cited in numerous district plans. The past 12 months has seen the publication of four papers summarising a decade of collaborative research in the Devora project and several workshops held with Auckland Council staff. GNS Science has been commissioned to develop tsunami evacuation zones for Auckland, and staff are contributing to a working group for Cell Broadcast, the new national alerting option for all cell phones being rolled out in late 2017.
	Enhanced recovery from hazard events **SCI Impact 16**	Policies that include effective provisions from natural hazard planning, with practical provisions to develop resilience (e.g., through communication, engagement and training) have resulted in communities that can respond effectively in a disaster and have the capacity to recover over time. By 2017, a volcanic ash and health response plan, with Massey University and Ministry of Health support, has been devised.	We have helped develop new guidelines for households and the public on respiratory protection from volcanic ash, and we have offered advice on how to clean up after a volcanic event. These guidelines are being hosted on a new GeoNet extranet. Other guidelines for the impact on agriculture and infrastructure are in development.

SCIENCE FOR A MORE PROSPEROUS NEW ZEALAND

CORE SCIENCE AREA	IMPACT AREA	IMPACTS AND MEASURES OF SUCCESS	PROGRESS/ACHIEVEMENT
SCIENCE FOR A MORE PROSPEROUS NEW ZEALAND **Renewable Geothermal Energy** Relates to SCP Outcome 1	Enhanced efficiency **SCI Impact 18**	Regular uptake by the geothermal industry of advanced geoscience information relating to deep or near-surface geothermal systems, improved modelling and monitoring tools, and improvements to process efficiency issues, has resulted in a more profitable sector, providing an increased contribution to New Zealand's energy needs. By 2017, advanced models and scientific information are being used by geothermal exploration companies to reduce risk, and by production companies to increase production, advancing New Zealand's goal of 90% renewable electricity generation by 2025.	We have developed numerical reservoir and geological models of the Ngawha geothermal system to assist Top Energy with planning an expansion of its 25MW Ngawha Power Station, which supplies about 70% of the Far North's electricity. We have provided advice on well location which has reduced risks associated with drilling geothermal wells. We have also supplied Mercury Energy with new modelling software, which is being used to refine their reservoir management strategy and improve the efficiency of the geothermal development at Rotokawa Power Station, northeast of Taupo.

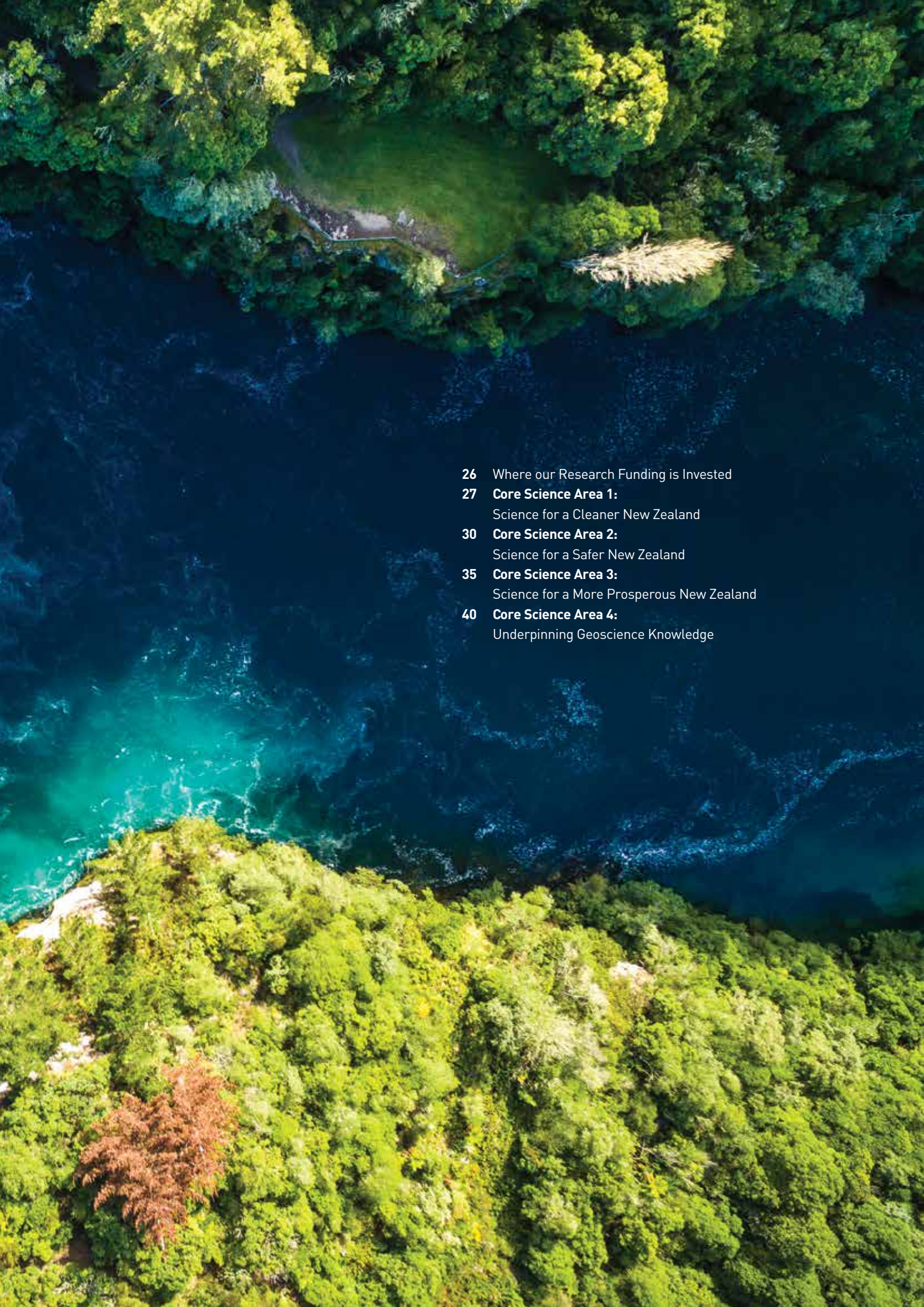
UNDERPINNING GEOSCIENCE KNOWLEDGE

CORE SCIENCE AREA	IMPACT AREA	IMPACTS AND MEASURES OF SUCCESS	PROGRESS/ACHIEVEMENT
UNDERPINNING GEOSCIENCE KNOWLEDGE **Geoscience Information** Relates to all SCP outcomes	Advanced learnings **SCI Impact 32** Informed risk management **SCI Impact 33**	Maps, map products, archived data, samples and other geoscientific information have been used to support multidisciplinary research and discovery, and to guide learning across a broad spectrum. Seamless and layered digital geological, geochemical and geophysical map products have been integrated and used by environmental agencies (leading to optimal land use and soil quality enhancement), infrastructure (leading to reduced construction costs and risk mitigation), and the resource exploration industry (leading to commodity discovery and extraction).	Information from our geoscience databases and collections is publicly available through maps, reports, digital media and websites. Annual user interactions range from millions of earthquake web page visits to tens of thousands of map application visits, plus searches for fossil descriptions, groundwater composition, rock and mineral properties, and geological map information. There is significant, and increasing, uptake of this information. Our eight Nationally Significant Databases and Collections, and many other important databases, provide decision support for natural hazards, geological resource prospectivity and sustainability, environmental protection, geoengineering, land-use planning, and infrastructure development. Examples of national benefit include information offered in response to the 2016 Kaikoura earthquake, which helped in assessments of the building code, and state highway closure and vulnerability. In addition, our data feeds into mineral and petroleum prospectivity data packs, which central government agencies use for promotional purposes to attract industry investment in New Zealand (see page 14).

TARGETED PROJECTS

	PROJECT TITLE	DESCRIPTION	PROGRESS/ACHIEVEMENT
SCIENCE FOR A CLEANER NEW ZEALAND **Past, Present & Future Climates** Relates to SCP Outcome 5	**Sea-level rise Impacts**	Improve regional relative sea-level rise projections for Hawke's Bay and evaluate the impact of these changes on our natural coastal environment, groundwater systems, and liquefaction risk.	Global sea level is currently rising at about 3mm a year and is projected to increase between 0.5 and 1.2m above the present level by 2100, although new information about Antarctic ice sheet melt suggests these estimates are low. Sea-level change along the New Zealand coastline will vary from these mean values due to variable tectonic uplift. We completed a pilot study of the Heretaunga Plains to identify the likely range of sea-level rise to 2300 and the potential impact on the local aquifer and liquefaction. Preliminary findings suggest that aquifer salinisation mechanisms such as surface leakage following inundation and increased inland groundwater levels may pose higher risks than conventional subsurface salinisation processes. We have presented the findings of this study to Hawke's Bay stakeholders, including local and central government, iwi, and NGOs. The information will be used for land-use planning.
SCIENCE FOR A SAFER NEW ZEALAND **Understanding Hazards** Relates to SCP Outcome 2	**Operational Earthquake Forecasting Framework**	Develop an automated Operational Earthquake Forecasting (OEF) framework that will continually forecast earthquake probabilities for all of New Zealand, and which seeks to address identified issues related to data and models currently in use.	To date we have provided quake forecasting information in the wake of big quakes. They require manual decisions and interaction among scientists. OEF will allow us to quickly communicate externally during a crisis as well as provide continuous information to inform of large risk increases, even when not preceded by a large quake. We have developed a hybrid forecast model that is capable of providing forecasts on time frames from one day to 50 years. We have also worked with groups of end-users to help us develop more useful ways of communicating OEF and to provide these stakeholders with information to help them make decisions during times of increased risk. This framework will allow us to run automated forecasts in the future.
SCIENCE FOR A MORE PROSPEROUS NEW ZEALAND **New Materials & Processes** Relates to SCP Outcome 4	**Non-stick Coatings**	Develop a non-stick coating system capable of modifying surfaces, to demonstrate ion beam technology on a semi-commercial scale.	Carried out research to modify surfaces at the atomic/molecular level using ion beam techniques. This pilot project has demonstrated our capability to modify large surfaces of metals, glass, and plastics with a five-times scale-up compared to what was previously being achieved. We are in discussion with New Zealand companies on how this new technology can be deployed.
New Materials & Processes SCP Outcome 1	**Green House Gas Converting Bacteria**	Explore the ability of extremophilic bacteria to capture methane and carbon dioxide emissions and convert them into valuable products.	We have shown in our laboratory investigations that a methane consuming bacterium can efficiently convert waste methane gas emissions and make high-protein or high-carbohydrate biomass that can subsequently be used for biofuels production or converted into valuable feedstocks. By doing this, we have demonstrated the potential for extremophilic organisms to consume industrially-produced methane and carbon dioxide and make useful products. Further work is needed to show if these microorganisms can be used to convert these greenhouse gases at an industrial scale.
UNDERPINNING GEOSCIENCE KNOWLEDGE **Zealandia Revealed** Relates to SCP Outcomes 1, 3, 4, 5	**Soil Geochemical Mapping**	Determine causes of chemical element variation in soils of southern New Zealand to provide baselines for agriculture, health, environment and resource discovery applications.	We use chemical and isotope analysis of soils in southern NZ to trace human impact and natural variation across rural and urban areas. The work has also resulted in a geochemical atlas of element concentration across Dunedin city. Based on this work, further surveys have been commissioned by local and central government for environmental and mineral exploration purposes. There is potential for a national geochemical baseline survey.
Zealandia Revealed Relates to SCP Outcome 2	**Enhanced geodetics**	Build geodetic capability in New Zealand to better measure and understand tectonic deformation and sea-level rise.	Achieved this by enhancing New Zealand's semi-continuous GPS network and recruiting an extra geodetic scientist to boost our capability in geodesy. We deployed extra instruments after the 2016 Kaikoura quake. Data collected from this initiative will be used to improve our understanding of post-seismic deformation and to inform estimates of future seismic hazard in the North Canterbury-Marlborough region. Our post-Kaikoura quake advice helped to inform the Government's response to possible seismic hazard across the upper South Island.

OUR SCIENCE



26 Where our Research Funding is Invested

27 **Core Science Area 1:**
Science for a Cleaner New Zealand

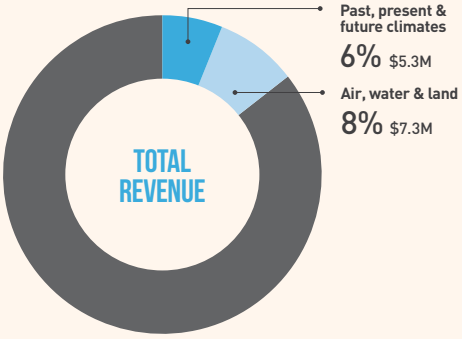
30 **Core Science Area 2:**
Science for a Safer New Zealand

35 **Core Science Area 3:**
Science for a More Prosperous New Zealand

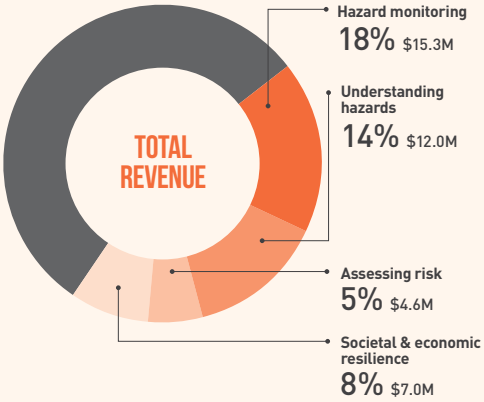
40 **Core Science Area 4:**
Underpinning Geoscience Knowledge

WHERE OUR RESEARCH FUNDING IS INVESTED

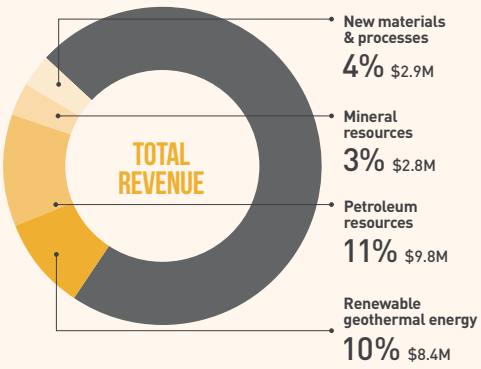
CORE SCIENCE AREA 1
SCIENCE FOR A CLEANER NEW ZEALAND



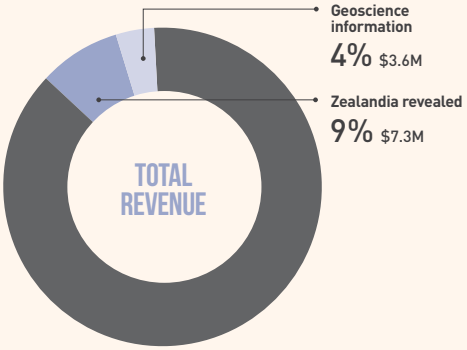
CORE SCIENCE AREA 2
SCIENCE FOR A SAFER NEW ZEALAND



CORE SCIENCE AREA 3
SCIENCE FOR A MORE PROSPEROUS NEW ZEALAND



CORE SCIENCE AREA 4
UNDERPINNING GEOSCIENCE KNOWLEDGE



CORE SCIENCE AREA 1:

SCIENCE FOR A CLEANER NEW ZEALAND

We develop ways to investigate, monitor and protect some of New Zealand's most precious natural resources. Our research helps us understand the impacts of our urban lifestyles and our rural land use on our air and our freshwater. Our climate work leads to greater understanding of the scale of the potential changes that we may need to adapt to as a result of climate change.

TEMPERATURES VERSUS ICE SHEETS

Melting of Antarctica's ice sheets due to a warmer world is unlikely to be happening evenly across the continent. Some parts of the ice sheet will be affected by warming sooner than others. In the next few centuries, the ice sheets could melt enough to cause a sea level rise of several metres.

A research team supported by GNS Science used an ice sheet model to simulate the flow of Antarctica's ice to examine the response of the entire ice sheet to increases in ocean and atmospheric temperature.

They found that, while most of West Antarctica melts when ocean temperatures increase by less than 2°C, a large region of ice in the Recovery Basin in East Antarctica also melts in response to a similar amount of ocean warming. This large marine-based region behaves more like the West Antarctic Ice Sheet, is more vulnerable to rising ocean temperatures than to increased air temperatures, and may therefore contribute to sea-level rise sooner than was previously expected.

Observations from Earth's past environmental records and present monitoring systems show that the West Antarctic Ice Sheet is most vulnerable to warming temperatures and that melting of this region can contribute up to 3.5m to global sea-level rise. This vulnerability is due to the fact that the West Antarctic Ice Sheet sits on ground located well below sea level and is highly susceptible to increases in the temperature of the ocean that surrounds the continent.

In the next few centuries, the ice sheets could melt enough to cause a sea level rise of several metres.

The much larger East Antarctic Ice Sheet appears to be more stable than the west. However, much of this large ice sheet is also grounded below sea-level and has the potential to contribute a correspondingly greater amount to global sea-level rise. Knowing more about how this ice sheet, covering two thirds of the continent might respond to future warming is a research area that is gaining more attention.

NEW MODELLING TOOLS FOR GROUNDWATER MANAGEMENT

Our scientists are leading the development of a range of new computer modelling tools to improve the management of New Zealand's aquifers. Interactions between aquifers and our rivers, lakes, wetlands and estuaries are complex. Groundwater models are essential tools in the effective management of New Zealand's freshwater resources. However, the models currently used by the groundwater industry are too data hungry, slow and costly to be practical. And they are unable to provide accurate information consistently.

Groundwater specialists see the deficiencies in existing modelling methods as detracting from the efficient management of New Zealand's aquifers. There are about 200 known aquifers in New Zealand and groundwater currently accounts for about one third of all freshwater usage.

Both the approach and the expected outputs from this three-year MBIE-funded project are believed to be world leading. With one year to run, a number of initial decision support tools from the project are already being incorporated into models being used by regional councils around New Zealand, to help improve land and water management.

During development the new 'smart models' are being ground-truthed in Southland, Waikato and Wellington regions where end-users are assessing their performance and providing vital feedback. Central government and iwi have been providing input through the life of the project. Model testing is also taking place with international partners so the fully developed products will have applications in many countries.

Scientists estimate the new models, which will be fully available from late 2018, will deliver improvements and other benefits valued at about $350 million a year to New Zealand.

There are about

200

known aquifers in New Zealand

Assisting us with the development are specialists from universities and other Crown Research Institutes as well as several environmental consulting companies. Research organisations from Australia and Germany are also contributing.

CORE SCIENCE AREA 2:

SCIENCE FOR A SAFER NEW ZEALAND

We discover the secrets that lie beneath New Zealand's landscapes and oceans to help protect our people and property from the ever-present threats that we face in our location on an active plate boundary. Our knowledge leads to improvements in disaster preparation and planning, and better decision-making with land-use planning, building standards, risk management and insurance.

MAJOR RESILIENCE INITIATIVE FOR WELLINGTON

GNS Science is participating in a region-wide initiative to increase the resilience of Wellington's infrastructure to earthquakes. Called the Regional Resilience Project, it pools the efforts of GNS Science, engineering and infrastructure company Aurecon, Wellington's infrastructure providers and regional and local authorities. A milestone for the project will be in the first half of 2018 when a business case will be presented to central Government to determine the level of support the project will receive.

The moderate damage sustained in the Capital during the magnitude 7.8 Kaikoura earthquake has added impetus to the project. At the heart of the Resilience Project is the expected economic impact resulting from damage to lifeline services from a Wellington Fault earthquake, if it were to occur tomorrow. It then explores the benefit-cost of programmes to improve lifeline resilience and reduce economic impacts.

GNS Science's contribution to the project is a series of time stamped service outage maps. They show the estimated level of service available across the region immediately following a magnitude 7.5 earthquake on the Wellington Fault, and how service levels change in time as full service is restored across the region. We have produced maps for each lifeline – roads, potable water, wastewater, electricity, telecommunications, rail, fuel, gas, ports, and airport.

The development of the outage maps was an innovative process that began with the creation of network models in RiskScape, a damage modelling tool we developed in conjunction with NIWA. RiskScape was used to generate damage maps due to fault rupture, ground shaking, liquefaction, landslides, and subsidence. We then worked with lifeline groups to understand recovery strategies and the significant impact of interdependencies between lifelines on outage times, such as pumping stations relying on electricity.

The outage maps are an essential input to a software tool for modelling the economic resilience of infrastructure called MERIT, which we developed in conjunction with Market Economics and Resilient Organisations. MERIT accounts for business and population responses to infrastructure outages. Together, these two modelling tools will provide robustness to the detailed case being prepared for central Government.

REFLECTIONS ON THE KAIKOURA EARTHQUAKE

Last November's magnitude 7.8 Kaikoura earthquake was the largest on-land quake to hit New Zealand since the Hawke's Bay earthquake of 1931. It set records galore including 22 fault ruptures and fault 'step-overs' of 22km. Large chunks of mountainous country were pushed up instantaneously by 6m, which is sobering to reflect on.

It was the sixth magnitude 7-plus quake in New Zealand since 2003, raising the possibility that New Zealand is in a period of heightened earthquake activity reminiscent of earlier periods of elevated activity from 1848 to 1863 and from 1929 to 1942. New Zealand's short earthquake record makes it hard for scientists to know if the current trend will continue.

The rupture began near Waiau in North Canterbury and ripped through the landscape at about 2km-a-second and ended up off Cape Campbell in Marlborough. It travelled 170km in about 74 seconds.

One of the unusual features of the quake was the long length of 'step-overs' between faults. It is well known for ruptures to jump 5km between faults, but the Kaikoura rupture included jumps of up to 22km – not previously seen anywhere in the world.

The direction of rupture – southwest to northeast – focused a large amount of seismic energy toward the north. This manifested itself as strong shaking in Wellington where it caused higher-than-expected damage, especially to a number of highrise buildings in the CBD. There were 300 million hits on the GeoNet website in the first 48 hours after the quake, with people in many countries eager to be updated on the quake and its aftershock sequence.

From day one, GNS Science has been involved in a broad range of post-quake activities to help with the recovery. Here is a sample of our activities.

We advised on the extent of tectonic uplift and subsidence and its likely influence on water flows and sedimentation in the Kowhai River to assist with maintaining flood protection schemes. We also advised on post-quake coastal uplift to assist with dredging of the Kaikoura Harbour.

We produced aftershock forecasts and a seismic hazard model for central New Zealand immediately after the quake. In the initial period, these were updated almost daily. As the aftershock sequence played out, they were updated weekly, then monthly and more recently every two months. They have been an important input into local and central government decision-making and the rebuilding of infrastructure.

We worked with Environment Canterbury in identifying dams formed by landslides that represented a potential threat to life and property. We closely watched up to 20 of these and advised on downstream risks and the potential for dam failure. We are still closely watching one dam in the Kaikoura back country after several failed after heavy rain in April. This work has involved drone surveys, laser scans, and 3D computer modelling and will also look at the long-term effects of the huge volumes of sediment being added to river systems.

In the weeks following the quake, staff from our GeoNet division deployed 21 additional seismic instruments in North Canterbury and Marlborough to augment our permanent geophysical networks in the region. The extra instruments provided greater precision in recording the size, location and depth of aftershocks. This information has helped seismologists gain a clearer understanding of this complex quake and develop aftershock forecasts and seismic hazard models to feed into government decision-making and the rebuild.

We have been working with the North Canterbury Transport Infrastructure Recovery Alliance to assess vulnerable stretches on the road and rail corridor along the Kaikoura coast. This involves estimating the volume of landslide debris that could come down in earthquake and non-earthquake triggered events.

GNS Science is also part of a Government-convened expert panel that is advising on possible changes to engineering standards for buildings in Wellington's CBD. This is as a direct result of higher-than-expected damage to some high-rise buildings in the Capital.

EXPLORING THE IMPACTS OF AN ERUPTION IN AUCKLAND

Modelling a hypothetical eruption in Auckland has improved the understanding of how people and infrastructure will be affected and how long it would take to recover from such an event. A major study we led explored the implications of a two-month-long unrest and eruption sequence on evacuations and infrastructure. Subsequent studies have assessed in detail the impact on transport, and restrictions in water and electricity supply, and telecommunications.

Our study is the first complete eruption scenario developed for Auckland since the 1990s and it updates and expands earlier work by scientists in this area. It also represents a new approach of looking beyond direct physical damage to assessing a range of consequences.

It is focussed on a new volcanic vent in Manukau Harbour, adjacent to Mangere Bridge. As well as the emergence of a new volcano, it features several pyroclastic surges, a series of small volcanic earthquakes, ash fall, lava flows, and ballistic blocks hurled into the air. All are considered realistic possibilities, though it is unlikely they would all be happening at once.

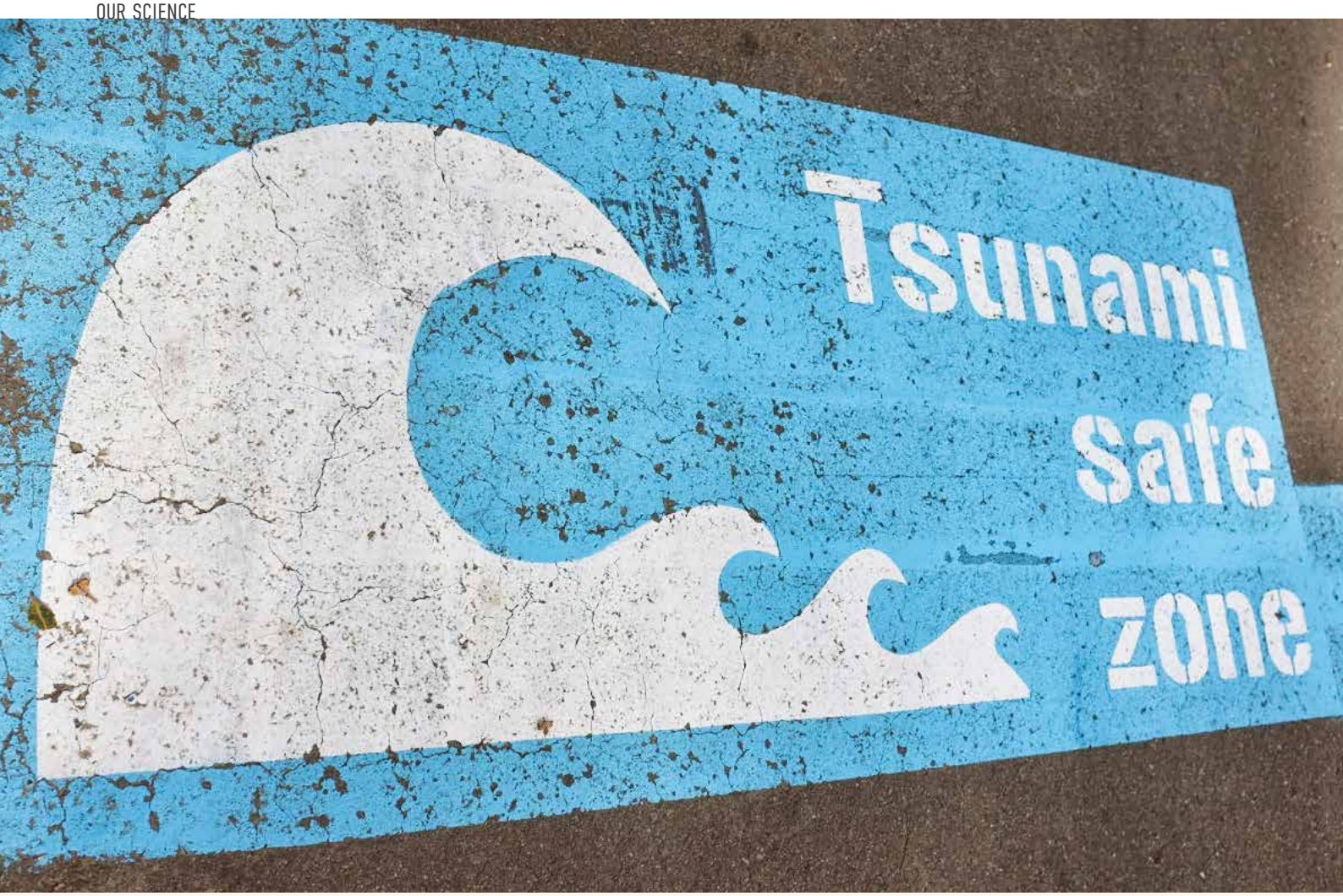
The eruption scenario includes pyroclastic surges – turbulent ground-hugging flows of super-hot rock and gas – that caused complete destruction within 2.5km of the vent. Even out to 6km from the vent, they caused damage to most structures. In the model, the suburb of Mangere Bridge was buried 2m deep in volcanic material and the eruption formed a cone 900m across, changing the area's geography permanently.

The study, published in the *Journal of Volcanology and Geothermal Research*, was written by researchers from GNS Science, the University of Canterbury, Massey University, The University of Auckland and power company Vector. The scientists have emphasised that it is not a 'how to guide' for managing a drawn-out eruption. Rather, it lays a comprehensive framework for further work in this area.

The Auckland Volcanic Field covers

360km^2

This work is part of an ongoing series of investigations into volcanic risk and hazard in Auckland, all of which is helping the region become better prepared for a volcanic event. The Auckland Volcanic Field covers 360km^2 and includes more than 50 vents. Volcanoes have erupted in the field more than 55 times in the past 190,000 years, without any obvious patterns although there have been periods where eruptions have clustered in time.



CITIZEN SCIENCE HELPING WITH TSUNAMI PREPAREDNESS

Much has been achieved in tsunami awareness and response action since the 1960 Chilean tsunami struck New Zealand without warning and caused significant damage. Surveys have shown that public education and awareness programmes are helping to improve public understanding of tsunami risk and the correct response actions. However, there is room for improvement and scientists are evaluating citizen science as an avenue for boosting public awareness.

In a recent example, a group of high school students in Hawke's Bay worked with scientists on tsunami preparedness and awareness as part of their NCEA assessments. The project was developed by GNS Science, East Coast LAB (Life at the Boundary), along with teachers from Napier Girls' High School. It encouraged students to take part in science and learn more about issues within their community, and it has provided valuable information for the scientists.

During the project, the students learnt about the Hikurangi plate boundary, earthquake and tsunami risk to communities along the North Island's east coast and recent research that has been undertaken by GNS Science.

This research shows that community understanding of natural hazards has improved over time but there are still concerns that many people are not aware of the risks, and nor do they know of the natural warning signs or how to respond to a natural hazard event.

The students carried out two surveys, one looking at tsunami awareness and preparedness and the second looking at tsunami evacuation routes. The students' results correlated with a 2015 study by GNS Science that showed that many people do not understand the difference between local and distance-source tsunami events.

Many people do not understand the difference between local and distance source tsunami events.

The information collected as part of this project will be used by our scientists who are evaluating citizen science as a tool for increasing opportunities for New Zealanders to become more involved in science activities.

CORE SCIENCE AREA 3:

SCIENCE FOR A MORE PROSPEROUS NEW ZEALAND

We discover the answers to unlocking the opportunities offered by New Zealand's abundant natural energy and mineral resources. Our research supports sound investment decisions that maximise economic returns and minimise environmental impacts. Our highly specialised work in isotope and ion beam technologies leads to the development and application of new materials with significant economic potential across a range of industries.

PUSH FOR WIDER USE OF GEOTHERMAL ENERGY

GNS Science is leading a sector push to double industry's use of geothermal direct heat by 2030. One of the aims is to replace coal and natural gas in industrial settings and make the country's energy use greener and more sustainable.

At present New Zealand uses about 7.5PJ of energy a year from direct heat from geothermal resources. A Geoheat Strategy launched this year sets out steps to build steadily towards 15PJ. As well as increasing the amount of geothermal used by industry, the initiative would create about 500 new jobs.

The Strategy is outlined in a 27-page document recently released under the banner of the New Zealand Geothermal Association, with GNS Science as a major contributor. It notes that benefits will accrue by increasing the 'depth of understanding' in industries which may not fully appreciate the advantages of using a renewable steam source instead of fossil fuels.

It focuses on the higher-temperature central North Island and Northland geothermal resources, but doesn't discount lower-temperature resources in other regions. While the emphasis is on promoting commercial and industrial use, there is also potential for growth in domestic use.

Direct heat is already used successfully in timber drying, commercial-scale glasshouses, milk processing, tissue paper manufacturing, aquaculture, honey processing, and tourism (hot pools).

The Strategy sets out five priority actions during the next year to lay the foundations for further developing the use of direct geothermal heat. This will involve working closely with regional economic development initiatives such as the 'Bay of Connections' strategy aimed at increasing the uptake of geothermal direct heat.

At present New Zealand uses about 7.5PJ of energy a year from direct heat from geothermal resources.

It will bring together information to provide interested parties with a clear value proposition, including 'green' branding for products. The driving forces behind the Strategy have been Brian Carey and Melissa Climo of GNS Science, and Simon Bendall of environmental and planning consultancy Mitchell Daysh.

NORTH TARANAKI COASTAL OUTCROPS VITAL TO UNDERSTANDING PETROLEUM SYSTEMS

For several decades, GNS Science has run field trips for industry clients to the world-renowned outcrops along the north Taranaki coast. These multi-day trips concentrate on superbly exposed coastal outcrops of deepwater sandstone and mudstone rocks, deposited about 10 million years ago and uplifted out of the ocean only about two million years ago. This makes them highly unusual, and the rare insights they offer are valued globally by geologists working on similar deep-water deposited rocks. They also provide outcrop analogues for working petroleum systems to the south beneath Taranaki Peninsula.

Industry specialists get tangible benefit from getting up close to these formations and hearing the accumulated knowledge from our scientists who guide the field trips. The success of these trips is, to a large extent, based on decades of scientific investigations by our scientists along with colleagues from universities, who have collectively built up an impressive set of publications on this region. The publications deal with aspects of the stratigraphy, sedimentology and seismic character of these rocks and their equivalents beneath Taranaki Peninsula and the adjacent offshore.

Much of that work has been led by two of our Principal Scientists, Drs Peter King and Greg Browne. In April, Peter King retired after 33 years with GNS Science and its predecessor organisations, including the New Zealand Geological Survey.

Peter had a formidable scientific output and his work was highly regarded by industry specialists and academics, not only in New Zealand but internationally. His scientific contributions were key to developing the Taranaki outcrops into what is now a world-renowned example of deepwater sedimentary rock deposits. Peter had a desire to understand the big-picture story, how the rocks related to the overall tectonic evolution of the Taranaki Basin, as well as understanding the basin-wide controls on sedimentation patterns. Many of his publications reflect those broad interests, and reinforce Peter's comprehensive understanding not only of Taranaki Basin, but all of Zealandia.

GNS Science continues the work that Peter was involved in, both in understanding the prospectivity of New Zealand's sedimentary basins and in running field trips for industry clients.

FINE TUNING THE SEARCH FOR GOLD

GNS Science leads a research project on New Zealand's gold deposits aimed at attracting new mineral exploration and increasing exploration success. The project characterises geological features that can be used in mineral exploration to target new gold deposits. Outputs from this project, which supports the Government's Business Growth Agenda, have encouraged additional and better focussed exploration for gold.

The main focus is proven gold-producing areas – Otago, Coromandel, and the West Coast. About 12,000kg of gold valued at about $700 million is extracted each year in New Zealand from two large hard rock mines plus a large number of small to medium sized alluvial operations.

THE MBIE-FUNDED PROJECT IS ANSWERING QUESTIONS SUCH AS:

- Why are gold deposits where they are?
- Are there features we can identify that indicate the potential size of a prospect?
- How do we find the recoverable minerals within the prospect?

The project combines the talents of specialists at GNS Science and the universities of Auckland, Waikato, and Otago as well as overseas collaborators. It has enabled us to develop techniques and procedures for the use of portable X-ray fluorescence and infra-red spectral analyses of minerals. Exploration companies have adopted these techniques as routine exploration tools and have increased the effectiveness of their prospecting as a result.

Elsewhere mining companies have used the project's 3D analysis of geological formations to help encourage new investment in the search for gold.

NEW SILICON-BASED MATERIALS JOIN THE PUSH TOWARD QUANTUM COMPUTING

Our nanotechnology group is making steady progress towards its goal of developing isotopically pure materials for use in quantum computing and solar cells. Quantum computing, currently an area of vigorous research worldwide, promises a new era of much faster computing. Some commentators believe it will launch a new industrial revolution. But this can only be achieved with isotopically pure silicon wafers.

Once developed, quantum computing is likely to lead to powerful new drugs and new materials for agriculture, industry, and materials science. This area of science has been dubbed 'the space race of the computer era'.

At present about 6% of commercially available silicon wafers is made up of other isotopes such as silicon-29, which won't allow a quantum computer chip to work.

Developing a material that has exceptional purity of silicon-28 is our mission. Isotopically pure silicon is extraordinarily rare and hugely expensive to obtain. This is unlikely to change any time soon. So our nanotechnology group is developing a technique to modify standard silicon wafer materials so they behave like wafers that are pure silicon-28.

With support from MBIE's Smart Ideas Fund, we aim to demonstrate it is possible to modify the surface of a wafer so it has ultra-high levels of silicon-28.

Our aim is to open the way for inexpensive production of pure wafer materials to accelerate the development of quantum computing.

We are currently working closely with the University of Melbourne to develop the technique. Our intention is to make pure wafer materials for the Australian Centre for Quantum Computation and Communication Technology, one of a handful of world-leading centres dedicated to this quest.

CORE SCIENCE AREA 4:

UNDERPINNING GEOSCIENCE KNOWLEDGE

We discover, collate and make available a vast amount of geoscience information that informs decision-making in a wide range of areas – from hazards mitigation and land-use planning, to petroleum exploration and freshwater management. Historic information has as much value today as when it was first collected as new analysis techniques evolve and new uses for the information emerge. Our databases will be a vital resource in the discovery and exploration of Zealandia.

VALUE FROM LANDSLIDE DATABASE

Since records first began in New Zealand, more people have been killed by landslides than by earthquakes, volcanic eruptions and tsunami combined. There have been more than 700 deaths from landslides against the tally for the other three perils of 620. Partly in recognition of this, GNS Science maintains the New Zealand Landslide Database, which holds all data routinely collected on landslides.

It is the most comprehensive landslide database in New Zealand and regular end-users include councils, engineers, and researchers from New Zealand and international universities.

Councils and engineers use the data for hazard assessments and land-use planning.

The database currently holds records of about 40,000 landslides dating back to the 1890s and a further 150,000 landslides will be added by the end of 2017. At least 10,000 of these occurred during and after the Kaikoura earthquake of November 2016. For each landslide, the database lists up to 26 attributes. This includes location, geology, the type of landslide movement, the triggering event, volume and area, and damage consequences where this is available. The vast majority are rainfall or quake triggered events. Others have no obvious trigger, and invariably involve a combination of factors.

Publicly available on the GNS Science website, the database can be interrogated with any combination of attributes. Typically this might include geology type, slope angle, vegetation, location and damage impact. Users can then readily build a profile of hazard and risk for a particular part of New Zealand.

Of New Zealand's main centres, Wellington is by far the most prone to landslides. The middle part of 2017 became known as 'the winter of 1,000 landslips'. A combination of factors, including several wetter than average months, has resulted in a sharp rise in the number of landslips in the Capital. Barely a week went by in the colder months of 2017 without landslips causing road blockages, and in some cases prompting evacuation of homes.

GNS Science has been working with the Wellington City Council to plot higher-risk areas of the Capital, which can then be used to inform monitoring and prioritise mitigation efforts. While this initiative will not be an immediate fix, it will help to improve the safety and economic resilience of Wellington in the longer term. The rapid increase in urbanisation in the 1940s and 50s saw many slopes being modified for roading and housing in New Zealand cities. At the time, the impact of these modifications on the landscape was not fully appreciated.

OUR PEOPLE

44 GNS Science at a Glance
45 Honours, Awards and Distinctions
46 2017 Excellence Award Winners
48 Being a Good Employer
50 Workplace Profile
51 Organisational Structure
52 Board of Directors
54 Executive Team


KATHMANDU

GNS SCIENCE AT A GLANCE

GNS Science, Te Pū Ao, is the Crown-owned science company in New Zealand that focuses on geological resources, environmental and industrial isotopes and geological hazards. We apply this scientific knowledge to create and preserve wealth, to protect the environment and to improve the safety and wellbeing of people.

THE BENEFITS WE DELIVER FOR NEW ZEALAND INCLUDE:

- wealth and security from energy, mineral, and water resources
- mitigation of the economic and social effects of geological hazards
- development of new technologies such as nano-scale devices and non-invasive scanning.

THESE BENEFITS ARISE DIRECTLY FROM OUR RESEARCH INTO PROCESSES AND ENDOWMENTS WITHIN THE EARTH'S CRUST INCLUDING:

- rocks, minerals, and groundwater
- earthquakes, volcanoes, landslides and tsunami
- hydrocarbons and geothermal energy
- geobiology and climate history
- gravitational and electromagnetic fields
- natural isotopes and radiation.

SCOPE AND GOVERNANCE

We operate as a limited liability company owned by the New Zealand Government, and with an independent Board of Directors. Each year we invest most of our tax-paid profit in scientific equipment and infrastructure. This ensures our capabilities keep pace with, or lead, international standards.

Our clients include:

- New Zealand central government agencies
- regional and local government
- overseas government agencies
- oil and gas exploration companies
- geothermal energy exploration and operating companies
- hydroelectricity operating companies
- the onshore and offshore minerals exploration industries
- meat, dairy, wool, timber, and horticulture processing industries
- insurance and reinsurance companies
- engineers, developers, and infrastructure companies
- museums
- research organisations in New Zealand and overseas.

STAFF AND REVENUE

Our 374 staff are located in Lower Hutt (80%), Taupo (17%), Dunedin (2%) and Auckland (1%).

Our revenue is generated from:

- direct government grants for research (approximately 35%)
- contestable research contracts (15-20%)
- consultancy services, product development, and analytical services for the private sector, and for central and local government (30-35%)
- Operating GeoNet, largely funded by the Earthquake Commission (10-15%)

Visit our website: www.gns.cri.nz

HONOURS, AWARDS AND DISTINCTIONS

GNS Science is privileged to have exceptional staff who make an extraordinary contribution to New Zealand. In the past year, a number of our staff were recognised for their outstanding contributions to science.

Environmental scientist **Troy Baisden** was one of five researchers nominated by the New Zealand Government as a Lead Author for the upcoming Intergovernmental Panel on Climate Change (IPCC) Special Report on Climate Change and Land.

Hazards stakeholder manager **Kelvin Berryman** received a Lifetime Membership by the NZ Society of Earthquake Engineers. This honour is bestowed on practitioners who have made a significant contribution in the field of earthquake engineering

Antarctic researcher **Nancy Bertler** won the award for Wellingtonian of the Year – Science, acknowledging the quality and relevance of her research and also the energy and great attitude that she brings to the research community. Nancy has also joined a task group formed by the four territorial authorities in Wellington to discuss the challenges of sea-level rise and a coordinated response.

Marine geochemist **Cornel de Ronde** was awarded the Joubin James visiting Professor Award by the University of Toronto (for late 2018). This follows his award as visiting Professor at ETH Zurich – the Swiss Federal Institute of Technology.

Geodesy and satellite imagery specialist **Ian Hamling** was awarded the 2017 Hamilton Award (Royal Society Early Career Research Excellence Award for Science). This annual award is for the encouragement of early-career researchers for scientific research in New Zealand.

Geophysicist **Wiebke Heise** was elected to the working group committee of the international Electromagnetic Induction community at a workshop in Thailand.

GIS specialists **Dave Heron** and **Biljana Lukovic** and Senior Scientist **Graham Leonard** won Best Practice Non-statutory for the project Vanuatu Mainstreaming Disaster Risk Reduction with partners Beca, NIWA, and Vanuatu Meteorology and Geohazards. The award was presented by the NZ Planning Institute.

Risk modellers and seismic engineers **Nick Horspool, Andrew King, Sheng-Lin Lin** and **SR Uma** won the Best Research Award for a poster from the NZ Society for Earthquake Engineers on 'Damage and losses to residential buildings during the Canterbury Earthquake sequence'.

The GNS Science **Materials Science Team** have been named as a partner in the recently announced New Zealand Institute for Minerals to Materials Research. NZIMMR has been funded as the third Rural Research Institute and will be based on the West Coast starting in January 2018, with $11 million funding over four years.

The GNS Science **GeoCamp Team** won the Community Project of the Year Award in the 2017 Deloitte Energy Excellence Awards.

Palynologist **Dallas Mildenhall** marked 50 years of service with GNS Science and its predecessor organisations.

Natural hazards planner **Wendy Saunders** won Best Practice District or Regional Plan in recognition of planning excellence from the NZ Planning Institute for her Natural Hazard Risk input into the Bay of Plenty Regional Policy Statement (see page 12).

Radiocarbon scientist **Jocelyn Turnbull** was appointed to the World Meteorological Organisation's Greenhouse Gas Science Advisory Panel and to the Ministry for the Environment's Atmosphere and Climate Technical Advisory Group.

Engineering seismologist **Chris Van Houtte** and his PhD supervisor Tam Larkin were awarded the 2016 Otto Glogau Award by the NZ Society of Earthquake Engineers for the best paper over a three-year period.

Geophysicists **Laura Wallace** and **Stuart Henrys**, and five other joint authors, won the New Zealand Geophysics Prize for a paper titled *Slow slip near the trench at the Hikurangi subduction zone.*

GNS SCIENCE 2017 EXCELLENCE AWARD WINNERS

These awards are presented annually to celebrate staff for conspicuous achievement and outstanding contributions to the organisation. Staff are nominated by their peers and a group of senior staff select the category winners. There were 30 nominations across all five categories.

IAN HAMLING

Science Excellence

Ian's expertise in Satellite Radar Interferometry (InSAR) has made an enormous impact on GNS Science's geological hazard investigations. This includes deformation associated with earthquakes, volcanic processes and anthropogenic activities. His work addresses fundamental research challenges about the effect of magma and faulting on the deformation of New Zealand's crust. In the four years he has been in New Zealand, Ian has produced a high output of research in top-notch science journals. He was lead author on one of the first major earthquake analysis research papers to be published after the 2016 Kaikoura earthquake. The paper received a huge amount of international media coverage.

DARREN D'CRUZ

Excellence in Support

Darren's graphic design work covers every area of GNS Science's activities, from promoting the company to visually communicating science. His skill in visual communication is unique to the Company. As well as developing clever and stunning visuals that communicate really well, Darren goes well beyond 'business as usual' in his day to day work. Whether it's sharp-looking corporate publications, new logos, refreshed websites, marketing collateral, or material for the nanotechnology and geothermal energy industries, staff know they can count on Darren to deliver standout results.

DINOSAUR FOOTPRINTS TEAM

Excellence in Science Communication

This award was won by a team of scientists who designed and built a travelling exhibition that has been seen by an estimated 500,000 people in New Zealand. Called 'Dinosaur Footprints – A Story of Discovery', the exhibition toured New Zealand for two years. It tells the story of how dinosaurs once roamed New Zealand and a few of them left their footprints on the Nelson coast 70 million years ago.

The exhibition has raised public awareness of science and paleontology in particular. The team who developed the exhibition are John Simes, Lucia Roncaglia, Greg Browne, Deanne Houghton, Marianna Terezow and Hamish Campbell.

DANIEL MOHNHOFF & RICHARD SYKES

Excellence in Commercial Services

The award recognises the leadership and scientific expertise of Richard in completing a large geochemical study of oils and source rocks for a petroleum exploration company operating overseas. Richard developed the proposal and led the technical component of the project. It involved co-ordinating analysis from three laboratories, interpreting the results, and compiling a 100-page report with Daniel. The project was on time, on budget and received significant praise from the client. The project exemplifies the high quality and technical expertise that characterises many of the consultancy projects that Richard and his team have delivered over the past decade.

JULIAN THOMSON

Excellence in Making a Difference

Julian's forte is making videos and other communication material covering a wide range of GNS Science activities. His short videos about the impacts of the 2016 magnitude 7.8 Kaikoura earthquake were extremely popular worldwide, especially with the media. His two most popular videos – on the Papatea Fault rupture and the Dart River landslide – have been viewed 840,000 and 700,000 times respectively. Julian not only gives GNS Science a voice to the public, but also works effectively to educate future generations of scientists and curious adults alike. He does an outstanding job of presenting science that is friendly and approachable without being "dumbed down".

BEING A GOOD EMPLOYER

We are committed to developing an organisation where our staff have equal access to opportunities and can perform at their best. Our diverse workforce provides us with opportunities to connect and collaborate at both national and international levels. We regularly review and implement policies and programmes that support and develop our staff.

The alignment between our key people policies and practices and the seven elements of being a good employer are outlined below:

BEING A GOOD EMPLOYER

ELEMENT	OUR ACTIVITIES THIS YEAR
Leadership, accountability and culture	• Quarterly 'Straight Up' communication sessions with staff run by the Executive Leadership Team. • Provided development opportunities for leaders including introducing a Fundamentals of Management programme. • Hosted our annual GNS Science Excellence Awards where winners were presented at our Wellington client function.
Recruitment, selection and induction	• Welcomed new staff at our organisation-wide induction workshops. • Streamlined our electronic onboarding process. • Renewed our Employer Accreditation with Immigration New Zealand.
Employee development, promotion and exit	• Piloted a new performance development template and educational resources to support both managers and staff in their performance conversations. • Provided development opportunities in areas including: fundamentals of management, project management, effective facilitation, Te Reo Māori sessions, 360 feedback, secondments and coaching. • Facilitated our annual progression round. 17 staff members were successful in their application to move up our Science Career Path. • Analysed and reported on exit interview responses and turnover trends.
Flexibility and work design	• Maintained flexible work practices and policies, including providing for flexible working arrangements for staff. • Approved 17 requests for flexible working arrangements under Part 6AA of the Employment Relations Act. • 10% of our staff work part time hours.

Remuneration, recognition and conditions	• Completed a Pay and Employment Equity Review project in partnership with the PSA. • Undertook the annual remuneration review process. • Career, Performance Development and Remuneration framework project in progress. • Worked closely with staff, managers and the PSA to manage change programmes, develop policies and to improve our practices as a good employer.
Harassment and bullying prevention	• Ran Creating a Respectful Organisation workshops across all sites. • Our Chief Executive hosted Pink Shirt Day with money raised donated to the Mental Health Foundation.
Safe and healthy environment	• Implemented a new Health Safety and Environment online system. • The Executive Team facilitated a number of wellbeing initiatives throughout the year including Dry July and Step Challenge. • Provided a range of support to promote health and wellbeing including an employee assistance programme, flu vaccinations, eye examinations, retirement planning workshops, regular medicals for all field and laboratory staff, healthy hearts health checks for other staff, ergonomic workstation assessments and additional support after the Kaikoura earthquake.

EQUAL EMPLOYMENT OPPORTUNITIES STATEMENT

We are committed to being an equal employment opportunity (EEO) employer through our organisation-wide EEO good employer practices relating to recruitment and selection, development, promotion/career progression, management and retention of all staff.

WORKPLACE PROFILE

FULL-TIME EQUIVALENT (FTE) STAFF

Our FTE count at 30 June 2017 was 374 compared to 361 as at 30 June 2016.

374 staff

AGE PROFILE

The average age of our staff is 47.7 years. Average age of females 45.2 years. Average age of males 49.3 years.

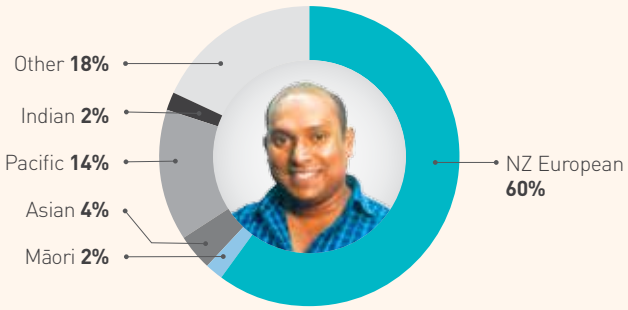
47.7 Years average age

ANNUAL STAFF TURNOVER

Resignations and retirements in the year to 30 June 2017 amounted to 6.3% of the workforce (7.4% in 2016).

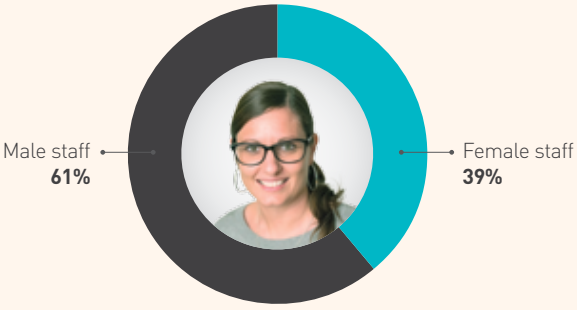
ETHNICITY OF RECRUITS

(self-identified – 2016/17)



GENDER PROFILE

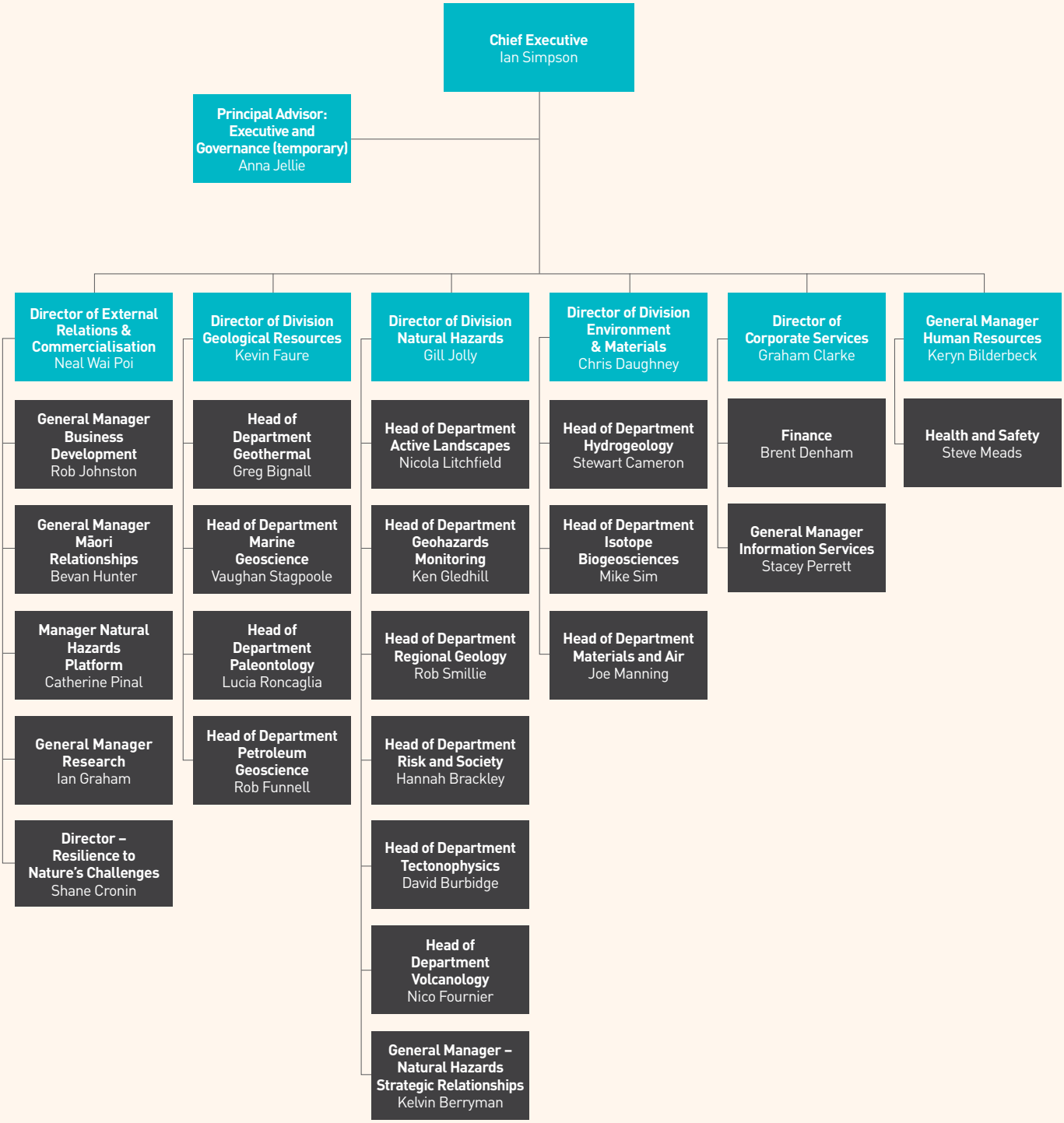
We have a 39:61 female/male ratio (38:62 in 2016).



DISABILITY (SELF-IDENTIFIED)

0.2% of our employees have declared having a disability. We are committed to valuing the diversity of our people and recognise, respect, value differences and do not discriminate.

ORGANISATIONAL STRUCTURE (AT SEPTEMBER 2017)



STRONG GOVERNANCE

BOARD OF DIRECTORS: Our experienced directors are committed to enhancing the organisation and its reputation. Their diverse backgrounds ensure that there is sound oversight of all aspects of our operation.

DR NICOLA CRAUFORD

Chairman,

BSc (Hons), PhD, FEngNZ, CPEng, FAICD, CFInstD

Wellington

(Appointed 1 July 2015)

Nicki is a professional company director with extensive governance and senior management experience including executive roles in the oil and gas and electricity sectors in New Zealand and the United Kingdom. She is currently Deputy Chair of Fire and Emergency New Zealand and a director of Watercare Services, Wellington Water, Orion New Zealand and the Environmental Protection Authority.

SARAH HAYDON

Deputy Chairman,

BSc, FCA, CMInstD

Auckland

(Appointed 1 July 2014)

Sarah is a director of Ports of Auckland Limited, The Co-operative Bank Limited and a Council member of Unitec. She is the Chairman of Cavalier Corporation Limited and New Zealand Riding for the Disabled Association Inc. She is a chartered accountant and has worked for BP in the UK and also on international project work, and was CFO at OfficeMax New Zealand. Sarah has an extensive background in strategic planning, finance, general management and organisational development. She has led large teams of people and has strong HR and people skills.

DR JOHN SHARPE

BSc, MSc (Tech), PhD, MInstD

Hamilton

(Appointed 1 September 2016)

John has held a number of executive leadership and director roles in early-to-mid-stage technology companies in New Zealand and the USA. Trained in the physical sciences, he has spent much of his career developing and commercialising biomedical equipment and other sensor technologies with applications in primary industries, life sciences research, and human health. He has also been involved in state-owned and industry research organisations carrying out science and undertaking business development activities.

PROFESSOR STEVE WEAVER

BSc Hons, PhD, DSc, FGS, FNZIC, FRSNZ

Christchurch

(Appointed 1 July 2010)

Steve was formerly Deputy Vice-Chancellor (Research) and Head of the Department of Geological Sciences at the University of Canterbury. He has also held academic appointments at Birmingham, London and Nairobi Universities. He is a Fellow of the Royal Society of New Zealand and a board member of Research & Education Network New Zealand (REANNZ) Limited and a member of the Governance Group of the Resilience National Science Challenge. Steve has published extensively on the geology of New Zealand, Antarctica and East Africa, specialising in igneous petrology, volcanology, isotope geochemistry, tectonics and environmental science.

CHRIS BUSH

BE (Chem)(Hons), CMInstD

New Plymouth

(Appointed 1 January 2016)

Chris is an experienced oil and gas professional with 30-plus years spent in both upstream and downstream sectors including roles in New Zealand and overseas. He runs his own consultancy providing strategy and risk management advice to the energy sector and other capital-intensive industries, and has particular expertise in health and safety in major hazard facilities.
He has held a number of director roles and was previously Chair of the Petroleum Exploration and Producers Association (PEPANZ) and of the Be Safe Taranaki Trust.

BELINDA VERNON

BCom

Auckland

(Appointed 1 July 2011 – Retired June 2017)

Belinda is a consultant with a background in accounting, shipping and conservation. She is a Member of the Maritime NZ Authority and has previously worked in senior accounting roles in the shipping industry. She was a Member of Parliament between 1996 and 2002 and is Chair of the Auckland Philharmonia Foundation. She is an active volunteer with the Motutapu Restoration Trust.

EXPERIENCED LEADERSHIP

EXECUTIVE TEAM: GNS Science's leadership team brings a wide range of skills to the management table. They are committed to maintaining the highest standards of professionalism to enable us to meet our business and science objectives.

IAN SIMPSON

Chief Executive

BSc (Hons), Manchester University
MBA INSEAD, France

Ian joined GNS Science in January 2017. Prior to his appointment he spent seven years at the Earthquake Commission (EQC) where he led the response to the 2010/2011 Canterbury earthquake sequence, one of the world's largest natural disaster insurance events. Prior to his time at EQC Ian spent four years as General Manager, Finance at the Accident Compensation Corporation. ACC was Ian's first job in New Zealand. He was born and grew up in the north of England. After graduating from Manchester University he worked for BP in London and Melbourne for eight years before joining Diageo PLC where he held a range of corporate finance roles in both the UK and Europe. He completed an MBA at INSEAD in France between his positions at Diageo.

DR NEAL WAI POI

Director, External Relations & Commercialisation

PhD, The University of Auckland

Neal leads External Relations & Commercialisation at GNS Science and was appointed in May 2015. He has over 20 years' international experience in industry-focused research and development and commercial technology transfer, with skills in negotiation and strategic management. Before coming to GNS Science, he worked with CSIRO, most recently as Group Manager Strategic Alliances. He also worked at Simonsen AS as commercial manager and Rio Tinto Aluminium as a research and development manager.

DR GILL JOLLY

Director, Natural Hazards Division

MA, University of Cambridge, PhD, Lancaster University, FGS, CGeol

Gill has led the Natural Hazards Division since August 2014. It consists of 144 staff who undertake research and consultancy in earthquakes, volcanoes, landslides, tsunami, geological mapping, engineering geology, earthquake engineering, risk modelling and social sciences. Gill is a volcanologist and joined GNS Science in 2006. Her background is in magma physics and lava flow dynamics, but she has had a diverse career including mineral exploration, environmental geochemistry and 3D geological modelling of ore deposits. She was formerly a director of the Montserrat Volcano Observatory in the West Indies.

DR CHRIS DAUGHNEY

Director, Environment and Materials Division

PhD, McGill University, Montreal, Canada

Since 2012, Chris has led the Environment and Materials Division, which includes research teams and commercial service units in hydrogeology, air quality, isotope biogeosciences and materials science. Chris joined GNS Science in 2002 and specialises in aqueous environmental geochemistry. His areas of interest include the chemical evolution of groundwater at the catchment scale, geomicrobiology and the use of tracer methods for evaluating in situ rates of water-rock interaction.

DR KEVIN FAURE

Director,
Geological Resources Division

PhD, The University of Cape Town

Kevin leads the Petroleum, Geothermal, Paleontology and Marine Geoscience Departments. He specialises in stable isotope geochemistry and has researched and published on ore deposits, submarine volcanoes, gas hydrates and geothermal springs. He joined GNS Science in 1997 and has previously worked as an exploration and mining geologist in South Africa, and as a research scientist at the Geological Survey of Japan.

GRAHAM CLARKE

Director,
Corporate Services/
Chief Financial Officer

Chartered Accountant

Graham leads the Corporate Services Division, which provides the full range of functions to support the Company's internal operations including finance, information services, property, procurement, risk management and internal audit. A chartered accountant, Graham has been with the Company since 1994, having previously worked for KPMG in New Zealand and the UK.

DR ANNA JELLIE

Principal Advisor,
Executive and Governance,
Legal Counsel

PhD and LLB,
University of Otago

Anna provides legal and commercial advice to GNS Science. She joined us from Fonterra where she spent eight years as Corporate Counsel advising on legal issues across the Fonterra business. Her key practice areas while at Fonterra were innovation and intellectual property. Prior to joining Fonterra, Anna worked in private legal practice at major New Zealand law firms, where she specialised in commercial and intellectual property law. She also graduated with a PhD in Biochemistry from the University of Otago.

KERYN BILDERBECK

General Manager,
Human Resources

Keryn joined our Human Resources team in 2010 and was appointed to the position of General Manager, Human Resources in March 2015. Keryn oversees the full range of human resource functions and organisational health and safety across the Company. Keryn has a background in Organisational Development and worked in government and university sectors prior to joining GNS Science.