GNS SCIENCE **2015** ANNUAL REPORT

150 YEARS *of* SCIENCE
For a better New Zealand

150 YEARS OF SCIENCE FOR A BETTER NEW ZEALAND

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Groundwater Geochemist

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Structural Geologist

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Ice Core Facility Coordinator

CELEBRATING THE PAST

James Hector
Geologist and Explorer
(1834-1907)

Jon Carey
Soil Mechanics Scientist

DEFINING THE FUTURE

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Nanotechnology Scientist

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Petrologist

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Seismologist

CELEBRATING THE PAST

2015 is a special year for GNS Science. It marks 150 years since our predecessor organisation – the New Zealand Geological Survey - was formed. In the 1860s, our founding decade, New Zealand's population was just over 100,000 and the first Cook Strait submarine telegraph cable was laid. The achievements in science and the improvements in living standards from that decade onwards have been remarkable.

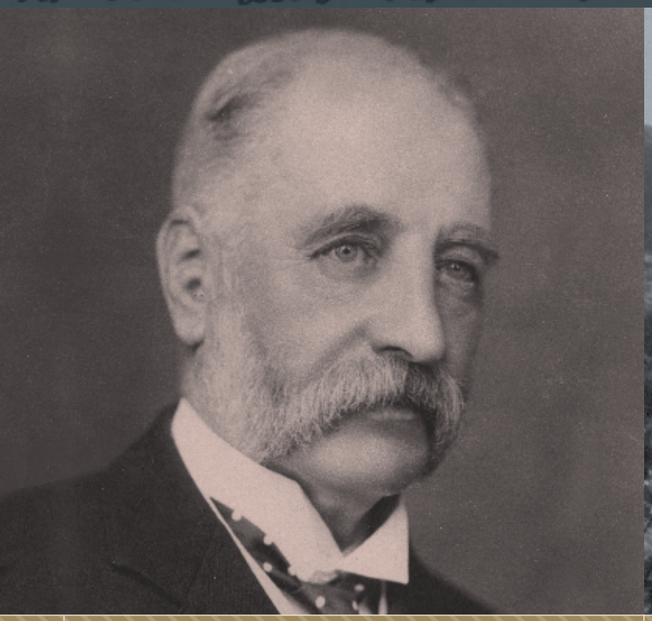
In our 150th anniversary year, we acknowledge earlier generations of scientists whose work has helped us understand the workings of planet Earth. We also celebrate a century and a half of science and innovation that has contributed to a better New Zealand. In this spread we feature a handful of key events that have helped define New Zealand and influence the way we live our lives today.

1869

One of James Hector's top priorities was to produce a national geological map, combining his own observations with those of Hochstetter, Haast, and Crawford. Hector's map, produced in 1869, was a remarkable achievement, meticulously showing the main geological features of the country. He produced revised versions in 1873 and 1884, but the overall pattern was little changed.

1940s

Trailblazing geologist Harold Wellman makes the astonishing observation that there had been 480 km of horizontal movement along the Alpine Fault in the South Island. An early proponent of plate tectonics, Wellman left a lasting legacy for generations of earth scientists not just in New Zealand, but internationally.



1865 NEW ZEALAND GEOLOGICAL SURVEY

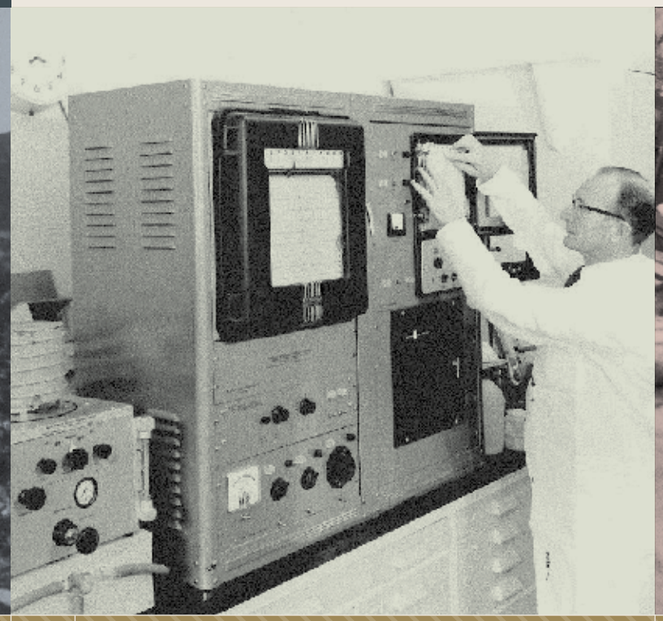
1865

James Hector was the first scientist employed by the New Zealand government in 1865 when he founded the New Zealand Geological Survey, the forerunner of GNS Science. Over the next 30 years, Hector and his small staff explored most parts of the country and evaluated many mineral prospects. Hector also set up the Colonial Museum (now Te Papa), the New Zealand Institute (now Royal Society of New Zealand) and other scientific organisations including the forerunners to MetService and Crown Research Institutes.

1903 MINES DEPARTMENT

1888

A magnitude 7.3 quake in north Canterbury on 1 September 1888 was accompanied by a 30 km rupture along the Hope Fault. Geologist Alexander McKay noticed a 2.6 m horizontal offset, marked by the offset fence shown in the photo above. This is believed to be the first time that horizontal offset along a fault rupture was observed anywhere in the world. The Hope Fault is one of New Zealand's most active faults. It branches off from the Alpine Fault and runs in nearly a straight line for 230 km to north of Kaikoura, where it continues offshore for at least 13 km.



1926 DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH (DSIR)

1951

Athol Rafter sets up a radiocarbon dating laboratory in Wellington, making the first measurements in the Southern Hemisphere. It is now the oldest continuously operating radiocarbon facility in the world. It was also the first lab in the Southern Hemisphere to measure radiocarbon by accelerator mass spectrometry in 1983. Housed at our Lower Hutt facility, it dates samples for clients all over the world and provides vital analytical services to a wide range of science disciplines in New Zealand from dating earthquakes and volcanic eruptions to measuring fossil fuel emissions in the atmosphere.

1953

On Christmas Eve 1953 a dam created from the products of the 1945 eruptions of Mount Ruapehu collapsed and released the ponded waters of the Crater Lake, forming a torrent of water and boulders down the Whangaehu River. The torrent (now known as a lahar) washed away the Tangiwai rail bridge killing 151 people who were on the Wellington to Auckland train. It was New Zealand's worst rail disaster and it gave birth to an international understanding of volcano-related flooding hazards. Research findings on this event led to the development of the lahar warning systems in place today.

DEFINING THE FUTURE

Hoki whakamuri, kia anga whakamua
Look to the legacies of the past, in order to forge the future

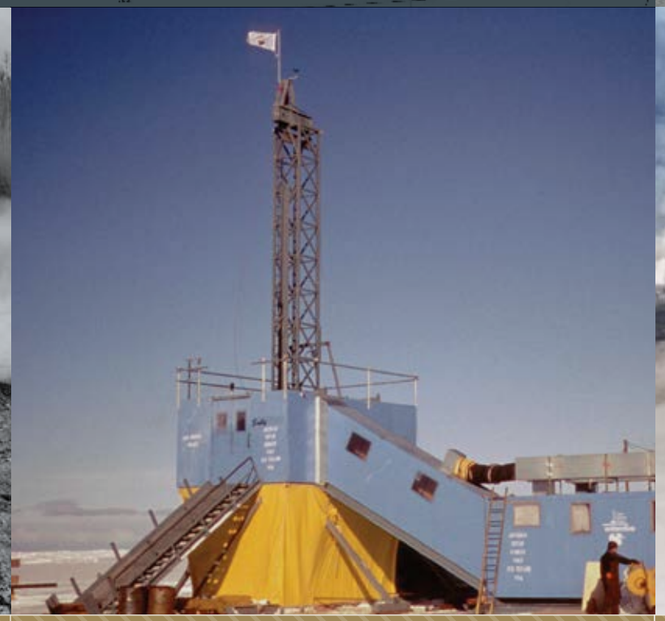
As we embark on our next century of service, we see science playing an ever more important role in the nation's economic development. Our research and other services will meet New Zealand's needs for achieving economic growth by making the tradable sector more productive; by improving sustainable use of natural resources; and in managing exposure to risks that could otherwise destabilise society, the environment, and the economy.

Our vision for the next decade is a cleaner, safer, more prosperous New Zealand. We will invest our effort into four nationally strategic initiatives to achieve that vision: geoscience knowledge, resilience to natural hazards, stewardship of the environment, and prosperity from geological resources.

1959 THE INSTITUTE OF NUCLEAR SCIENCES

1958

The Wairakei Power Station becomes only the second geothermal plant in the world and the first to harness liquid-dominated steam to produce electricity. Scientists with our predecessor organisations played a key role in its development. New Zealand remains a world leader in geothermal energy thanks, in part, to the continuing work of our scientists.



1986

The CIROS drilling project in Antarctica cored a sediment record down to 702 m below McMurdo Sound and discovered, among other things, a 30 million-year-old beech leaf. This was the first evidence that forest had once grown in Antarctica. CIROS was the largest single scientific project of the New Zealand Antarctic research programme, and initiated by Victoria University and the DSIR. It led to the successful Cape Roberts Project and ANDRILL, both aimed at deciphering the climate and ice sheet history of Antarctica.

2001

The EQC-funded GeoNet project starts. It provides real-time monitoring of geological hazards in New Zealand for civil defence, research, and public information. It has become an international exemplar of how to design and operate a national geohazard monitoring system. It has given rise to a vast amount of high quality data that are helping scientists better understand earthquakes, volcanoes, tsunami, and landslides.

1992 INSTITUTE OF GEOLOGICAL AND NUCLEAR SCIENCES

1995–96

Mount Ruapehu's eruptions startled the nation and prompted major changes in the way volcanoes are monitored and eruptions are managed. The eruptions also ushered in several new areas of research, especially the impacts of volcanic ash on infrastructure and the use of social science as a legitimate discipline within the earth sciences. The way scientists communicate about volcanic activity, hazards, and responses also changed significantly.

2008

At the United Nations in New York, New Zealand wins sovereignty to an extra 1.5 million square kilometres of ocean floor beyond our EEZ giving us jurisdiction over 1% of the Earth's surface. Our scientists played a major role in preparing the New Zealand case and supporting it at the UN. Our expanded marine estate will provide incalculable value for future generations of New Zealanders.

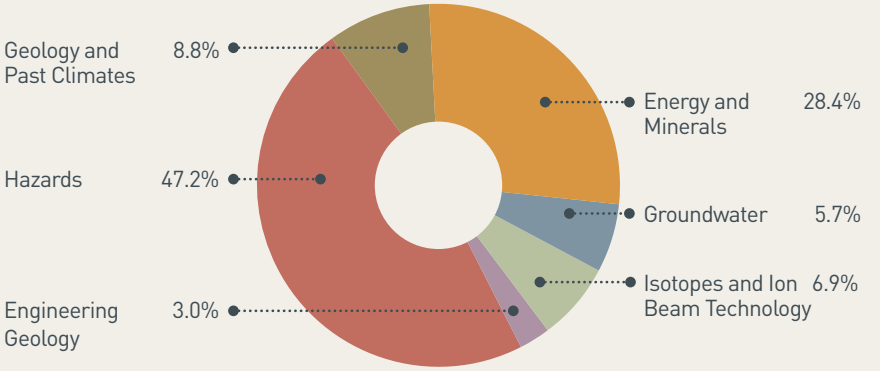
2005 GNS SCIENCE

2011

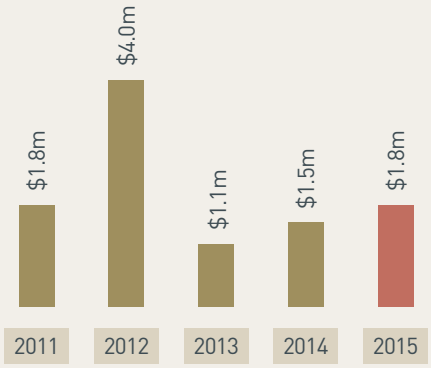
A magnitude 6.3 quake strikes Christchurch, killing 185 people and causing damage of $30 billion. It is New Zealand's most deadly natural disaster since the 1931 Hawke's Bay quake. However, it brings many advances in science and engineering that will make New Zealand safer. During the long aftershock sequence, our scientists played a leading role in providing advice to civil defence, government, and the insurance industry.

FINANCIAL HIGHLIGHTS

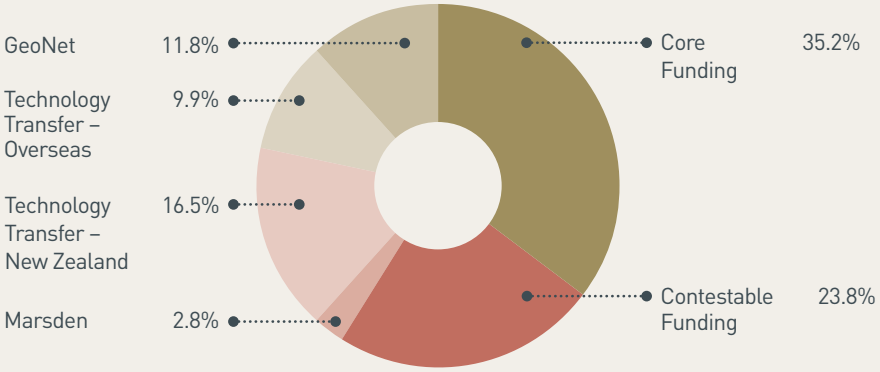
REVENUE BY SECTOR OUTCOME AREAS



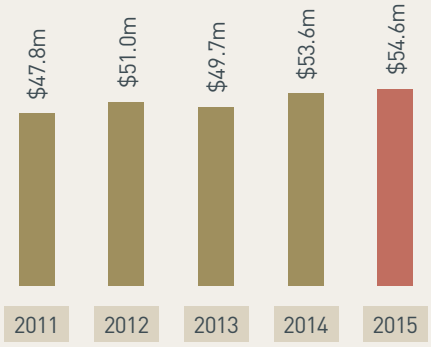
AFTER TAX PROFIT



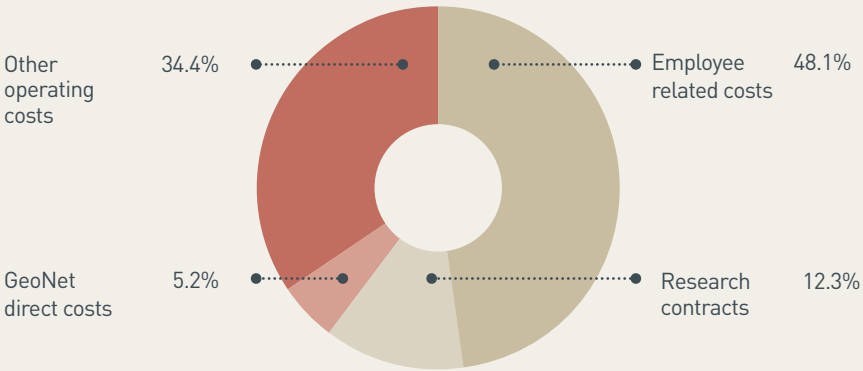
REVENUE SOURCES



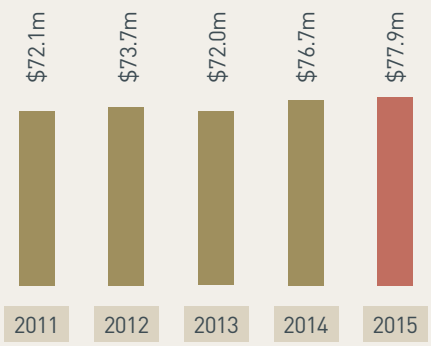
TOTAL ASSETS



EXPENSE ANALYSIS



REVENUE



THIS REPORT PRESENTS GNS SCIENCE'S OPERATING RESULTS FOR THE FINANCIAL YEAR ENDED 30 JUNE 2015. IT ALSO DEMONSTRATES HOW OUR ACTIVITIES ARE ALIGNED WITH OUR CORE PURPOSE AND THAT THEY SUPPORT THE ASPIRATIONS OF OUR CLIENTS AND END-USERS.

CONTENTS

TO FULLY UNDERSTAND THE JOURNEY WE WANT TO TAKE OVER THE NEXT 10 YEARS WE NEEDED TO KNOW OUR STRATEGY INSIDE OUT

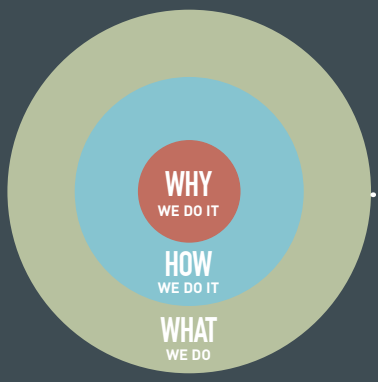
In setting out our strategy for the next 10 years, we have chosen to place our 'why' at the very centre of everything we do; it is our reason for being, but it also connects us to our stakeholders and defines how we contribute to our nation's wealth and wellbeing.

With 'why' at the heart of our strategy, we ensure everything we do drives towards delivering benefits for New Zealand and New Zealanders. In sharing this strategy with our science and corporate teams, we also ensure they understand how the work they do connects to the outcomes it supports and, in turn, the benefits it delivers.

'How' we work at GNS Science is shaped by our values – a clear understanding of our 'how' helps us to deliver on our 'what', which is defined by our Core Purpose and our place in the national innovation system. Together, our Values and our Core Purpose enable us to define a set of strategic principles to underpin each of our four core science strategies.

With our 'why', 'how', 'what' story clearly defined and understood, we are well placed to proactively adapt and respond to the changing world around us, to take advantage of the key opportunities that become available to us, and to make the best decisions we can using the resources available to us.

Finally, we are very much aware that we cannot set a course and expect it to remain valid for five or ten years. Our actions must be regularly and continuously adjusted using a comparison of actual and desired outcomes to ensure that we can adapt to our changing environment and make directional choices that will consistently move us toward future success.



OUTCOME

SCIENCE FOR A BETTER NEW ZEALAND

CLEANER
SAFER
MORE PROSPEROUS

WHY

Why is our reason for being; it connects the work we do to the benefits it delivers

VALUES

QUALITY
TEAMWORK
IMPACT
INTEGRITY
SUCCESS

HOW

How we work is defined by our organisational values

+

CORE PURPOSE

STATEMENT OF CORE PURPOSE
NATIONAL NEEDS
GLOBAL TRENDS

WHAT

What we do is defined by our core purpose

=

SCIENCE VISION

STRATEGIC PRINCIPLES

SHARPEN FOCUS
GROW PARTNERSHIPS
ENHANCE CAPABILITY
IMPROVE CULTURE
BUILD REPUTATION

Our Values and our Core Purpose define a set of Strategic Principles that are the foundation of each individual Core Strategy

WHY
WE DO IT

SCIENCE FOR A CLEANER NEW ZEALAND

Clean air and fresh water are valuable natural assets that are vital to our social, cultural and economic well-being. Those charged with managing the quality of air and water do so with the confidence that our science provides high quality, independent analysis on which to base their decisions.

There are about 200 mapped aquifers in New Zealand and groundwater presently accounts for about a third of all water usage. Our knowledge of individual characteristics of these aquifers grows as we gather more data through our active monitoring networks. At the national scale, we monitor about 110 sites quarterly as part of our National Groundwater Monitoring Programme (NGMP). We analyse each sample for more than 25 parameters which shows long-term trends in water quality. The NGMP is recognised as a nationally significant database and is accessible to both casual and registered users.

It provides a national baseline perspective on groundwater quality that enables us to differentiate between natural changes and those that are human-induced. Using this database and other information sources, we develop computer models and tools that are used to improve the management of freshwater in New Zealand. For example, our free software for interpretation of the state and trends in groundwater quality is being used in 74 countries and has been run nearly 7000 times since its first release in 2007.

The Ministry for the Environment relies on our data and expertise to compile its national report card on groundwater quality and quantity. We also provide advice and reviews to most regional councils on the operation of their regional groundwater monitoring networks. Having accurate information on long-term trends helps in seeing where changes are occurring, how quickly they are happening, and how they are related to land use. This is powerful knowledge in working out the best management strategies to ensure sustainability.

We offer value-added services such as land-use impact studies and independent input for resource consents. We are world leaders in the application of isotope and water dating techniques to determine the source, flow paths and transit times of water and key contaminants through groundwater systems. We also identify recharge areas, flow paths, mixing of ground and surface waters, seawater intrusion, and aquifer structure.

Above ground, we play an important role in helping to minimise air pollution in towns and cities. We do this by analysing tiny particles trapped on air filters that regional and city councils collect throughout New Zealand. Air pollution is believed to be responsible for about 2,300 premature deaths in New Zealand each year, as well as $8.4 billion in health costs and lost productivity annually. Reducing particulate matter levels in the air delivers major health benefits for local communities as well as the national economy.

The testing, using our ion beam analysis equipment, shows not only the chemical composition of air particulate matter, but also the relative contribution of different air pollution sources.

A typical filter analysis might show the main culprits being vehicle emissions, domestic heating, industrial sources, sea salt, and wind-blown soil. Councils use our results to develop mitigation measures and our ongoing measurements enable councils to track the effectiveness of their measures in reducing air pollution.

The major source of air pollution in New Zealand is combustion, most commonly from domestic heating and vehicle emissions. Combustion produces gases and particles that affect human health. Tiny airborne particles can cause a range of effects, from minor respiratory irritation to significant disease and shortening of life. The problem invariably worsens in winter when domestic heating is turned up and temperature inversions that trap dirty air become more prevalent.

Forensic isotope science

Our expertise in isotope analysis contributes to a wide range of environmental management. Using isotopes and water dating, we investigate sources of nutrients that contribute to toxic algae growth in rivers. In Southland our isotope methods are being applied to understand variations in the geochemistry of soils. The resultant element concentration maps are helping regional councils, scientists and the public understand the current state of our environment. The information will be particularly useful for studies of human health, food production, and tracing the origin of agricultural products.

Our capability in this area of science also helps the food and beverage industry check the authenticity and origin of their products to ensure they are 'true to label'. Typical examples are orange juice and honey. We test thousands of honey samples each year – mostly high value manuka honey – to check that they meet export criteria and verify that they are pure and not adulterated with cane sugar.

WHY
WE DO IT

SCIENCE FOR A SAFER NEW ZEALAND

New Zealand's location on an active plate boundary means nature's forces can change our world dramatically at any time. And as our population and cities grow, we become more at risk.

New Zealand is one of many countries which this year signed up to a new global agreement on disaster risk reduction that will guide actions to reduce risk from natural disasters over the next 15 years. Called the Sendai Framework, it is a voluntary, non-binding agreement that outlines seven clear targets and four priorities for action to prevent new and reduce existing disaster risks. Science is embedded throughout the text of the Framework and there is strong recognition of the need for enhanced understanding of disaster risk and risk-informed decision-making especially at government levels. The Framework aims for the following outcome:

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

GNS Science is uniquely placed to lead the science that will inform the development of a national strategy for disaster risk reduction and resilience to support the New Zealand government's work under the Sendai Framework.

Our research outcomes reduce the economic and social costs of natural hazards. They provide the robust evidence-base for determining priorities for action across the full range of disaster risk management options such as land-use planning, engineering standards, emergency response planning, and risk transfer through insurance.

We do this by improving the understanding of the processes that cause earthquakes, volcanic eruptions, landslides, and tsunami. We estimate the size, frequency and potential impacts of each of these geological hazards. With **earthquakes**, for instance, our work feeds into structural design standards in New Zealand. This means structures can be designed and built to withstand earthquake shaking for a given location. The cumulative effect of our work is a safer built environment and faster recovery in the event of a natural disaster.

In the science engine room, radiocarbon dating is playing a crucial role in determining the dates of past earthquakes on New Zealand's biggest faults such as the Alpine Fault and the Hikurangi subduction zone. Knowing the timing of past earthquakes improves our understanding of where and when future earthquakes will occur, and what their impacts are likely to be.

For example, hundreds of radiocarbon dates from our Rafter Radiocarbon Laboratory provided vital information that has revolutionised our understanding of the rupture history, of the Alpine Fault the South Island's largest source of earthquake hazard.

When it comes to **tsunami**, we have 350 pre-calculated propagation models showing how tsunami will travel across the Pacific and impact on our coast. When a large sub-seafloor earthquake occurs in the Pacific we quickly find the best matching model to get a first approximation of what the likely impacts will be in New Zealand. This is communicated to the Ministry of Civil Defence and Emergency Management and other agencies, as every minute of advance warning can make a difference in terms of public safety. As fresh information comes to hand on the size, location, depth and style of an earthquake we refine our model to give updated information on the arrival time and likely impacts of a tsunami.

New Zealand has 10 **volcanoes** that are either active or considered active, and they present a wide range of potential hazards. Taupo volcano is a world-beater in terms of the size of the eruptions it has produced, so it is little wonder that we take this threat seriously. We operate permanent surveillance at active and potentially active volcanoes to detect early signs of volcanic unrest. Our core research focuses on sub-surface processes and volcano plumbing, through to the impacts of eruptions on infrastructure and people. This enables us to develop eruption scenarios for emergency management and risk assessment models.

Unstable geological conditions, heavy rain, earthquakes, and human-induced landscape changes can trigger **landslides**. As a niche provider in geohazards, we combine our expertise in geomorphology and engineering geology to provide strategies for reducing the impacts of slope failures and landslides. We help with identifying and quantifying landslides and their triggers, designing safer slopes, risk assessments, monitoring unstable slopes, understanding landslide movement mechanisms, and advising on planning policy and social impacts.

Our expertise in **loss modelling** helps to quantify the impact of natural disasters on infrastructure and people. This provides quantitative estimates of likely damage and loss of assets and casualties, which is crucial for risk managers, hazard planners, and the insurance industry.

Disaster risk reduction and resilience can only be achieved through understanding how society interacts with natural hazards and disasters. Our social research seeks to understand what contributes to effective land-use planning for natural hazards, how agencies and the public understand and respond to threats, and the attributes of an effective recovery.

WHY
WE DO IT

SCIENCE FOR A MORE PROSPEROUS NEW ZEALAND

To bring benefits to New Zealand, we have become experts in our geological endowments. Our main focus in this regard is geothermal energy, petroleum, and minerals. They are important contributors to the wealth and security we expect as a first-world nation.

New Zealand is the fifth largest geothermal power generator in the world behind the USA, Philippines, Indonesia, and Mexico. For more than 50 years, the Wairakei Power Station has provided the country's most reliable source of energy. Geothermal energy is clean and cost-effective and it provides a consistent energy flow day and night, in any season and in any weather.

Our work increases investor and developer confidence by reducing technical risks of exploration. Our field investigations shed light on rock permeability and sub-surface fluid flow pathways. We are also developing ways to modify the internal surfaces of geothermal pipes to prevent the build-up of minerals that can reduce operational efficiencies at power plants. Internationally, we are at the forefront of exploring hotter and deeper geothermal resources – those between 3 km and 5 km deep.

The abundance of high temperature geothermal resources in the central North Island means geothermal is the lowest cost electricity generation option to build and operate. Thanks in part to our leadership and expertise in geothermal energy, New Zealand is making solid progress towards its goal of having 90% of our electricity supply generated by renewables by 2025.

Petroleum is New Zealand's fourth largest export commodity by value, with an annual value of about $2.2 billion. It is responsible for thousands of well-paid jobs and produces hundreds of millions of dollars in tax and royalty revenues for the government. Natural gas produces 19% of our electricity generation, second only to hydro. Our role in this sector is to improve the understanding of New Zealand's 18 sedimentary basins and their petroleum potential. The result is improved chances of petroleum discoveries and more efficient production from existing wells.

We provide industry, government agencies and other stakeholders with specialist evaluations ranging from geological assessments of onshore and offshore areas to post-drill analysis of wells. One of our niche capabilities is the use of isotope analysis to characterise the chemical nature of gases, oils, and source rocks. This helps exploration companies better understand petroleum reservoirs and their production potential.

In doing this, we draw on an unmatched 150-year institutional history of earth science expertise in New Zealand.

We also investigate unconventional energy resources such as gas hydrates off the North Island's east coast. Hydrates are gas-rich ice crystals that occur under the seafloor and are composed of methane and water. New Zealand has some of the most extensive gas hydrate deposits in the world.

A feature of New Zealand's accumulations is the relatively high number of 'sweet spots', where hydrates tend to concentrate. We estimate that if only a fraction of this resource could be recovered economically, it would be the main source of natural gas for New Zealand for many decades.

When it comes to **minerals**, our role is in identifying the extent and grade of mineral resources onshore and offshore in our extended Exclusive Economic Zone. This is crucial for appraising and managing these resources, and for mining with minimal environmental impact. A proportion of this work is provided at no cost as a public good. This includes digital map products that promote knowledge and understanding of mineral accumulations and their host regions.

Our on-land minerals include aggregate for roads and general construction, limestone for agriculture and cement production, gold, silver, iron sands, clay, and zeolite with a combined annual production value of $2 billion.

Seafloor deposits include phosphate, iron sands, and metal-rich accumulations associated with black smokers.These hydrothermal deposits occur along a chain of about 80 submarine volcanoes between New Zealand and Tonga, an area seen as a new frontier in mineral exploration and also an area of high environmental value. Since the mid-90s, we have been systematically exploring and mapping the volcanoes in this chain, which is one of the world's most active submarine volcanic arcs.

Our work sheds light on the size and economic potential of these mineral resources. Using our data, others can make informed decisions about whether these seafloor deposits should or could be harvested.

Perhaps under-appreciated is that New Zealand's mineral wealth comes from a very small footprint. For example, close to one third of household income on the South Island's West Coast comes directly or indirectly from mining, from a footprint of 14 km^2. This compares to the total area of the region of 23,000 km^2.

DELIVERING THE SCIENCE VISION

GNS Science has consistently delivered relevant science and technology in accord with Government expectations for development of New Zealand's geological resources, parallel growth of a society and economy that is resilient to natural hazards, and technological innovations that benefit the nation.

Our stand out achievements this year include the launch of Resilience to Nature's Challenges, one of the Government's 11 National Science Challenges focusing on resilience in engineering, infrastructure and society, and the successful sale of Meatvision intellectual property, which we jointly developed with Anzco Foods Limited.

Financial results and dividend

Total revenue grew by 1.5% to $77.9 million and was derived from research contracts (62%, 2014 59%), technology transfer (26%, 2014 29%) and our EQC contract to operate the GeoNet monitoring network (12%, 2014 12%). Direct Crown funding of $27.1 million accounted for 35% of total revenue (2014 35%).

Relative to the previous financial year, net profit before the sale of intellectual property fell to $0.8m from $2.0m due largely to the shortfall of technology transfer revenue, indicating the variable nature of this project work. However, the gain on the sale of Meatvision intellectual property drove a 13.3% improvement in after-tax profit to $1.75 million, representing a return on equity of 5.9%, compared to 5.4% for the previous financial year.

The GNS Science Board is pleased to declare and provide for a dividend of $250,000 to the shareholders.

Capital investment

GNS Science made capital investments of approximately $5.87 million during the financial year. The bulk of our science infrastructure investments were for new instrumentation in geochemical, geophysical and materials science instruments and facilities including a stable isotope mass spectrometer, broadband seismometers, an autotitrator, an atomic force microscope and a scintillation counter. IT capital expenditure was used to upgrade core computing infrastructure throughout the company, and to significantly increase our information storage capacity. We also began a significant upgrade of our National Isotope Centre laboratories at Gracefield that will be completed late in 2015.

Innovation and Research Highlights:

Nanoelectric Generators

GNS Science researchers were awarded a Marsden grant in November 2014 that could help New Zealand tap into a global market worth billions of dollars by using nanotechnology to develop electrical generators that are efficient at converting 'waste heat' into electricity. Most forms of energy generation produce low enthalpy heat which scientists have tried, with only partial success, to convert efficiently into electrical energy. Thermo-electric generators convert heat, or temperature differences, directly into electrical energy using a phenomenon called the Seebeck effect. However, conversion rates are stubbornly low – generally less than 10% – despite extensive efforts to lift performance. The three year project led by GNS Science will use nanotechnology to increase energy conversion efficiencies, leading to lower energy waste and reduced greenhouse gas emissions from energy production. The project will trial wafer-thin layers of bismuth, antimony, and zinc embedded onto the surface of generator components to greatly enhance thermal and electrical conductivity using ion beam technology to create the requisite electrical and physical properties.

Bay of Plenty freshwater resources

In a project announced in September 2014, scientists from GNS Science are teamed with Rotorua iwi Ngāti Rangiwewehi and the Bay of Plenty Regional Council for a two-year project to integrate cultural and scientific knowledge. The project extends work already underway to improve the understanding of freshwater resources on the western side of Lake Rotorua. Funded principally by the Ministry of Business, Innovation and Employment's Te Pūnaha Hihiko – *Vision Mātauranga* Capability Fund, the project will also receive co-funding from each of the collaborators. The focus is the Awahou groundwater catchment, which stretches from the western and northern shoreline of Lake Rotorua to the Mamaku Plateau, including the iconic Taniwha Springs. The overarching goal is to protect the quality and quantity of groundwater resources of this area for future generations but also to strengthen the cultural, social, environmental, and economic wellbeing of present and future generations.

New data for petroleum exploration

Announced in September 2014, a new four-year project led by GNS Science geologists will produce a series of freely available digital maps and a comprehensive database to help exploration companies pinpoint prospective areas to explore for oil and gas in New Zealand's offshore territory. The result will be an extensive body of information showing the current geological understanding of New Zealand's 18 mostly offshore petroleum basins. It will be the first time that such a wealth of knowledge has been available in a standardised format in one place. The project will bring together about six decades of existing information, augmented by new data, on potential subsurface habitats where petroleum is likely to have accumulated. Most of New Zealand's sedimentary basins are largely unexplored for petroleum, and a large discovery anywhere would dramatically improve New Zealand's

economic fortunes. The project's main output will be a workstation-ready 'digital atlas' comprising multiple layers of information such as sediment thickness, reservoir architecture, and source rock distribution in Geographic Information System format. Project milestones will be released in stages through GNS Science's Petroleum Basin Explorer web portal and as data packs.

Mineral exploration research
In September 2014, the Government awarded GNS Science $4 million to lead a four-year collaborative research project to improve the knowledge and understanding of New Zealand's gold deposits. The project will incorporate researchers from GNS Science and Auckland, Waikato and Otago universities, supported by mining companies which will supply some of exploration data. This project marks the first time all of New Zealand's key onshore minerals scientists have collaborated as a single nationwide research group. Overseas research associates will also contribute to the project. The scientists will study the geological factors that control the location of known gold deposits (why are they where they are) so geologists can use this information to identify other prospective areas. It will identify features within a prospect area that help direct exploration toward concentrations of gold. This information will encourage new exploration, increase the chances of discovering new gold deposits, and also reduce the financial risks for the industry. With high international profile, the resulting exploration models will influence gold exploration methods worldwide and help attract overseas investment in New Zealand mineral exploration.

Geothermal Laboratory upgrade
In August 2014, New Zealand's only full-service geothermal and groundwater laboratory was opened following completion of a $4 million capital upgrade. The new facilities at our Wairakei campus north of Taupo, house multiple specialist laboratories including the New Zealand Geothermal Analytical Laboratory, the GNS Science Extremophile Laboratory, and other specialist analytical facilities. There have been laboratories on the site since the 1940s and earlier facilities were integral to the development of the Wairakei Geothermal Power Station in the 1950s and 1960s. More recently, they have played a crucial role in the renaissance of geothermal energy since 2004. The laboratories have been completely overhauled to sustain GNS Science's international leadership in providing first-rate analytical services for the geothermal and groundwater industries.

Gas hydrate research
GNS Science, NIWA, Auckland University and Otago University are part-way through a six-year research programme to better understand New Zealand's offshore deposits of gas hydrates. Hydrates, which are seen as a potential future energy source, are a naturally occurring ice-like form of water containing large quantities of trapped natural gas. The accumulations occur under the seabed and extend in a solid band from offshore Marlborough to Poverty Bay. Researchers see this large deposit as world class in its quantity and quality, but it is not yet clear if it is feasible to commercially extract the natural gas. The project involves collecting and analysing geological and geophysical data to improve the understanding of the distribution of hydrates, and particularly where concentrated accumulations occur. A component of the research is aimed at developing baseline biological and ecological data around known seafloor seep sites that are associated with gas hydrate accumulations.

New geological timescale
GNS scientists have produced an updated geological timescale for New Zealand going back 540 million years to the Cambrian period. Geologists use timescales to date and classify rock formations, life forms, and geological events and rely on them to describe the timing and relationships between events that have occurred in the Earth's evolution. Timescales assign a geological age to rocks, fossils, and minerals and are used for working out rates of geological processes and events such as earthquakes, eruptions, submergence, uplift, erosion, sea-level change, climate history, biodiversity change, and organic evolution and play a crucial role in the search for petroleum and other minerals, and therefore their accuracy has economic implications. The new New Zealand Geological Timescale was produced by nine palaeontologists at GNS Science, and recalibrates the ages and boundaries between geological periods, epochs and stages.

Resilience to Nature's Challenges
The *Resilience to Nature's Challenges* National Science Challenge was formally launched in June 2015, ushering in a ten-year collaborative and holistic approach to understanding and managing natural hazards in New Zealand. *Resilience* is the sixth of the government's National Science Challenges to be launched and involves a consortium of 90 researchers from six universities, three Crown Research Institutes, and two private research organisations representing a new partnership approach to managing natural hazards and risks in New Zealand. The Challenge represents an enlightened combination of the earth and physical sciences, engineering, social sciences, governance, economics and business and enterprise that will build the next generation of researchers in natural hazards and risk reduction, with at least 20 post-graduate students being mentored between now and 2019.

Ocean bottom seismometer experiment
In June 2015, GNS scientists and their colleagues from the United States, Japan and New Zealand retrieved instruments that had been installed on the ocean floor using NIWA's deepwater research ship *Tangaroa* for over a year, as part of an international project to measure earthquake activity and movement of the seafloor where the Pacific Plate is being subducted beneath the eastern North Island. Offshore Poverty Bay is notable for a phenomenon known as slow-slip events or 'silent earthquakes', the focus of this project. Slow-slip events are similar to earthquakes in that they involve more rapid than normal movement across a fault. The main difference is that slow-slip events occur more slowly, over weeks or months, compared to regular earthquakes which occur in a matter of seconds. The successful project was the world's largest deployment of seafloor instruments specifically designed to study slow-slip events.

That slippery Australian Plate
In a February 2015 paper published in *Nature*, GNS Science researchers and colleagues from New Zealand, Japan, and the United States discovered a previously unknown slippery layer of rock under the Pacific plate. The discovery comes from a study that used 1200 portable seismographs placed in a long line between the Wairarapa and Kapiti coasts to build a 3D picture of geological layers down to a depth of about 100 km below the lower North

Island. The initial focus was the top 50 km of subsurface to see how the Pacific and Australian plates interact, but an unexpected discovery was a 10 km layer of slippery soft rock immediately below the subducting Pacific Plate that is weak enough to allow slow movement in any direction. This 'decoupling channel', sandwiched between the lithosphere and asthenosphere, helps explain some of the elusive nature of this deep part of the tectonic plate system that isolates some of the movement of the rigid lithosphere of the Pacific Plate from the flowing asthenosphere below.

GNS, Navy and Woods Hole join forces
The Royal New Zealand Navy joined forces with GNS Science researchers and scientists and engineers from the US-based Woods Hole Oceanographic Institution to deploy *Sentry*, one of the world's most sophisticated unmanned submarine vehicles in March 2015 to investigate two seafloor volcanoes in the Kermadec Arc using *HMNZS Wellington*. An autonomous underwater vehicle, *Sentry* is ideal for obtaining comprehensive information and understanding on the seafloor and the environment around these submarine volcanoes, providing valuable new information about the geology of the seafloor, the hydrothermal systems, deep-sea habitats, and the occurrence of mineral deposits. A new map compiled with *Sentry* is 40 times more detailed than that previously available, enabling a much better understanding of seafloor hydrothermal systems at a meaningful scale. The project is part of a multi-year research programme by GNS Science to map and understand tracts of seafloor in New Zealand's vast offshore territory totalling 5.7 million square kilometres. GNS Science, with support from its international colleagues has been systematically investigating the volcanic features and hydrothermal venting of the Kermadec Arc since 1999. During this time, collaborative teams have surveyed about 40 large submarine volcanoes along the Kermadec Arc as well as others near Tonga, Papua New Guinea and the Mariana Arc south of Japan.

Outreach Highlights

Alpine Fault insights
In May 2015, GNS Science researchers underlined the importance of earthquake preparedness in public presentations on the Alpine Fault at Franz Josef Glacier. An initiative of the GNS Science earthquake geology team, our scientists shared their insights about the Alpine Fault to give a clear picture of research that the team had undertaken on the 600 km-long fault that cumulatively represents several decades of study. The Alpine Fault has ruptured five times in the past 1100 years, each time producing large earthquakes of magnitude 7.0-8.0. The most recent rupture was in 1717, 298 years ago. The team found evidence of 24 Alpine Fault earthquakes going back 8000 years at Hokuri Creek in South Westland. Based on this and other allied work, average intervals between ruptures were about 300 years in south Westland.

Independent four year review
GNS Science was reviewed in late 2013 by an independent panel providing us with a valuable assessment of our current effectiveness and future potential in delivering on the purpose and outcomes set out in our Statement of Core Purpose. The panel found many positive features of how we operate and made five key recommendations for improvement: clarity of strategic direction, business performance, accountability for medium term business targets, establishment of a high performance culture and Māori engagement.

Our Strategic Plan for 2015-2025 directly reflects these key recommendations and we have made substantial progress towards implementing the changes required to realise benefits for the future. These include a new leadership structure with the senior executive team reduced from 13 to six and a number of new roles.

Health and Safety performance

Three of our 368 staff lost a total of three work days due to injury last year. This is a significant decrease from 2013-14, when 11 days were lost to injury. Over the course of the year, our Total Recordable Injury Rate was halved from 18.8 to 9.5 per million hours worked.

The Company has prepared for new legislation through our existing continuous improvement and best practice framework which supports a strong and developing safety culture.

Changes to the GNS Science Board

On 30 June 2015, Tom Campbell retired as Chairman after six years of service on the Board, five of those as Chair. During his tenure, the organisation has grown significantly in size and stature, with revenue growth of more than 28%.

We are grateful for Tom's guidance and leadership during his service to the Board and the Company.

Dr Claire McGowan also completed her term on 30 June 2015, and we thank her for five years as a Director and as a member of several Board Committees.

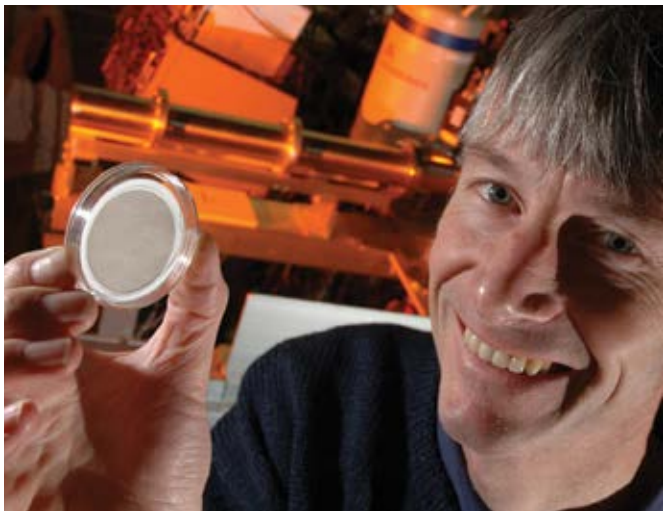
Dr Nicola Crauford joined us on 1 July 2015 as the new Chairman of the Board of GNS Science.

Dr Nicola Crauford
Chairman

Dr Michael McWilliams
Chief Executive

OUR VALUES

At GNS Science the way we work is defined by our values – values that clearly and succinctly describe key elements of our corporate philosophy.



Our values define the way we work and underpin our internal and external relationships; they are vital to ensuring we can deliver on our Core Purpose.

Our values:

- Show us what we can expect from each other and what others can expect from us
- Define how we will work to be successful
- Guide our relationships with our staff, our external partners and our stakeholders
- Guide our behaviour and decision-making
- Help us to demonstrate the behaviours, attitudes and actions for organisational success.

THEME	DISCOVER	COLLABORATE	APPLY	ADVISE	THRIVE
VALUE	QUALITY	TEAMWORK	IMPACT	INTEGRITY	SUCCESS
SUMMARY	We deliver excellent science and innovation	We partner with the best	Our work makes a profound difference to New Zealand	We are trusted, impartial and reliable	We are a safe, sustainable and clever company

GNS SCIENCE STATEMENT OF CORE PURPOSE

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.

Outcomes

GNS Science will fulfil its purpose through the provision of research and transfer of technology and knowledge in partnership with key stakeholders, including industry, government and Māori, to:

- increase resource security and economic benefit from the development and diversification of New Zealand's oil, gas, geothermal energy and minerals industries
- increase New Zealand's resilience to natural hazards and reduce risk from earthquakes, volcanoes, landslides and tsunami
- improve the sustainable management of and increase economic returns from groundwater resources
- create value for New Zealand industry through the use of isotope and ion beam technologies
- increase understanding of the geology and past climates of New Zealand, the Ross Dependency and Antarctica
- enhance the geotechnical engineering that underpins New Zealand's transport and energy infrastructure.

Scope of operation

To achieve these outcomes, GNS Science is the lead CRI in the following areas:

- geothermal energy, oil, gas, gas hydrates (including carbon sequestration)
- mineral and geobiological resources
- geological hazards, risk mitigation and societal 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 and isotope science and ion beam technology.

GNS Science will work with other research providers and end-users to contribute to the development of the following areas:

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

Operating principles

GNS Science will:

- operate in accordance with a statement of corporate intent and business plan that describes how GNS Science will deliver against this Statement of Core Purpose, and describes what the shareholders will receive for their investment
- meet its obligations as a Crown Company and remain financially viable, delivering an appropriate rate of return on equity
- develop strong, long-term partnerships with key stakeholders, including industry, government and Māori, and work with them to set research priorities that are well linked to the needs and potential of its end-users
- maintain a balance of research that provides for the near-term requirements of its sectors and demonstrates vision for their longer-term benefit
- transfer technology and knowledge from domestic and international sources to key New Zealand stakeholders, including industry, government and Māori
- develop collaborative relationships with other CRIs, universities and other research institutions (within New Zealand and internationally) to form the best teams to deliver its core purpose
- 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, international scientific issues and/or bodies as required
- seek advice from scientific and user advisory panels to help ensure the quality and relevance of its research
- establish policies, practices and culture that optimise talent recruitment and retention
- enable the innovation potential of Māori knowledge, resources and people
- maintain its databases, collections and infrastructure and manage the scientific and research data it generates in a sustainable manner, providing appropriate access and maximising the reusability of datasets
- seek shareholder consent for significant activity beyond its scope of operation.

This statement provides key guidance to the GNS Science board for developing its Statement of Corporate Intent, which sets out GNS Science's strategy for delivering against its core purpose. GNS Science's performance will be monitored against the outcomes and operating principles in this statement.

NATIONAL SCIENCE CHALLENGE

We proudly host one of the government's 11 National Science Challenges – Resilience to Nature's Challenges, Kia manawaroa – Ngā Ākina o Te Ao Tūro. Launched in June 2015, its focus areas include geological and weather hazards, fire, risk models and resilience in engineering and infrastructure and in society. It also includes coastal hazards and hazards caused by climate change.

The Challenge addresses a distinctively Kiwi issue with New Zealanders living daily with threats from active volcanoes, earthquakes, tsunami, landslides, tornadoes, cyclones, floods and droughts.

The Challenge's mission is: Understanding hazards, and how to mitigate, prepare, respond to and recover from disaster.

It was the sixth of the government's National Science Challenges to be launched and involves a consortium of 90 researchers from six universities, three Crown Research Institutes, and two private research organisations. It represents an enlightened combination of the earth and physical sciences, engineering, social sciences, governance, economics, and business and enterprise.

The Challenge has a 10-year lifespan and has been allocated funding of $19.6 million for its first four years. Eighteen months of planning went into its development and putting together its initial four-year work programme.

It will develop new science-backed approaches to resilience and fast-track their implementation, making New Zealand safer and more viable. As a result, New Zealanders will be able to better anticipate, adapt and thrive in the face of nature's challenges.

The area of resilience in New Zealand is not short of thorny issues, but the consortium brings together formidable capabilities to tackle some of these hard questions that are fundamental to our future as a thriving nation.

It will extend beyond defensive and adaptive approaches and will make New Zealand a safer place to live and a more attractive, lower risk investment opportunity. It will also give rise to the next generation of researchers in natural hazards and risk reduction, with at least 20 postgraduate students being mentored through their PhD degrees between now and 2019.

Its initial research focus will be in four topic areas to improve the resilience of:

- New Zealand's rapidly growing urban areas, especially Auckland
- New Zealand's rural sector and its underpinning economy
- the specific cultural and economic resources and challenges faced by Māori
- areas facing extreme and sometimes unsustainable hazard threat, particularly along our coasts and rivers.

In this last area – known as the 'edge programme' – the Challenge will tackle big unknowns such as the compounding impacts of global climate change on New Zealand's natural hazard profile.

The Challenge is hosted by GNS Science in partnership with NIWA, Scion, The University of Auckland, University of Canterbury, University of Otago, Massey University, Lincoln University, Victoria University of Wellington, BRANZ, and Opus International.

Learn more about the National Science Challenges at: http://sciencelearn.org.nz/Science-Stories/National-Science-Challenges

VISION MĀTAURANGA

GNS Science is committed to developing partnerships with Māori to identify iwi aspirations and work jointly towards realising them. We undertake a number of projects with Māori that contribute to the social, economic, and environmental wellbeing of Māori communities.

Marae-based iwi engagement

GNS Science and Hawke's Bay iwi, Ngāti Kahungunu, completed their pilot programme of two marae-based wānanga this year to explore the connections between earth science and mātauranga-a-iwi (traditional knowledge). Over three days of hands-on experiential learning, including field trips and discussion, both iwi and GNS Science participants developed a deeper understanding of issues that are critically important for iwi development and resilience, as well as for environmental sustainability.

The hands-on approach was identified as being a very effective way of demystifying the science behind topics such as oil and gas exploration, climate change, and natural hazards. Participant and Ngāti Kahungunu elder Aki Paipa praised GNS Science staff for the down-to-earth approach: "When we did the practical part of the workshops we went out into the field, and they explained things that we could relate to ... the different features of the land, what's happening to the whenua and what had happened in the past. I thought they did a really good job of helping lay people to get a glimpse of the scientific world." New funding through the Vision Mātauranga Capability Fund will allow this initiative to be extended to other regions over the next two years.

Partnership in tracking air pollution

GNS Science is working with Whakarewarewa Village in Rotorua and Ngāti Rangiwewehi at Ngongotaha to better understand air pollution issues – particularly on high pollution days. We have sampled air at our science facility, Te Mātāpuna o Papatūānuku 'GNS Science house', at Whakarewarewa Village since late 2014 and recently built a second sampling site at Ngongotaha, on the western side of Lake Rotorua.

The project is linked to our core-funded initiatives and Vision Mātauranga project in which GNS Science and Whakarewarewa Living Thermal Charitable Trust work together to demonstrate a framework for integrating related scientific data and mātauranga-a-iwi to better understand the air we breathe in Rotorua. We sample air twice a week onto special filters which we then analyse at our isotope facility for 30 different elements. This sheds light on where air pollutants are coming from.

The project will have mutual benefits, providing insights into Māori understanding of earth and physical sciences, corroborating historical volcanic events, extending Māori appreciation of earth science, and identifying new research opportunities.

The initiative is also helping the community to understand their local air quality and how their own activities such as burning timber treated with arsenic can affect what they breathe, and therefore their health outcomes. This multi-year project is on permanent display at the GNS Science house at Whakarewarewa Village and it is visited daily by New Zealanders and tourists.

STAFF AWARDS, HONOURS 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.

Earthquake geologist **Kelvin Berryman** was awarded the McKay Hammer by the Geoscience Society of New Zealand for the most meritorious contribution to geology published in the previous three calendar years.

Geophysicists **Ted Bertrand** and **Grant Caldwell** received an award for being co-authors on the best geophysics paper at the 38th Geological Resources Council annual meeting in Portland, Oregon for their paper on 'Imaging the roots of high-temperature geothermal systems using MT – recent results from the Taupo Volcanic Zone'.

Minerals geologist **Bob Brathwaite** was awarded the Lloyd Jones Award for service at the 2014 AusIMM Conference in Hamilton.

Paleontologist **James Crampton** had a newly discovered fossil mollusc from the late Mesozoic era (100 to 70 million years) named after him – *Abyssomelania cramptoni*. James was also elected vice-president of the International Palaeontological Association.

Marine geologist **Cornel de Ronde** won the Brian J Skinner Award from the Society of Economic Geologists for the best paper published in 2014 in *Economic Geology*. He also received this award in 2005. Cornel was also Honorary Lecturer for AusIMM in 2014 and gave presentations in Australia and Papua New Guinea.

Engineering geologist **Graham Hancox** won the People's Choice Award for a poster at the 12th Australia-New Zealand Conference on Geomechanics. His poster was entitled 'Engineering geology and stabilisation of the 2011 landslide which closed SH3 in the Manawatu Gorge, New Zealand'.

Marine geophysicist **Stuart Henrys** was appointed as the New Zealand representative on the governing council of the Australia-New Zealand IODP Consortium (ANZIC).

The **It's Our Fault** project received the New Zealand Planning Institute Wellington Branch Geok Ling Phang Memorial Award. The award is given to a person or organisation for a significant contribution to land use planning in the Wellington region. The IOF project received the award because it gave evidence-based information that influenced the outcome of the Hutt City Council's proposed plan change 29.

Hazards researcher **David Johnston** was appointed as a scientific representative and alternate delegate to the Open-ended Intergovernmental Preparatory Committee for the 3rd World Conference on Disaster Risk Reduction in Geneva in 2014.

Volcanologist **Gill Jolly** won a special commendation award at the 2015 Workplace Health and Safety Awards for developing a world-first system to work out the cumulative annual risk for scientists and technicians who work on active volcanoes.

New materials research scientist **John Kennedy** was appointed as a New Zealand Executive Committee member for the Asia Nano Forum.

Ion beam materials scientist **Jérôme Leveneur** was appointed Associate Investigator to the MacDiarmid Institute in recognition of the research work he has completed over the past two years.

Hydrogeology and water dating technician **Heather Martindale** won an award for the best poster at the 2014 NZ Hydrological Society Conference. Her poster was entitled 'Mapping groundwater and surface water interactions in the Hutt River using radon-222'.

Engineering seismologist **Graeme McVerry** was appointed a life member of the New Zealand Society of Earthquake Engineering (NZSEE). This is a very distinguished award and recognises Graeme's lifelong contributions and leadership at the forefront of engineering seismology.

Geologist **Nick Mortimer** was awarded the prestigious Hochstetter Lecturer for 2015. In his illustrated talks, Nick presented the scientific case that there are eight continents, not seven. The eighth being Zealandia, which is largely hidden because 94% of it is under the sea.

Antarctic researcher **Tim Naish** was awarded the Martha T Muse Prize for Science and Policy in Antarctica for his outstanding research into understanding Antarctica's response to past and present climate change.

Engineering geologist **Stuart Read** was elected as the Australasian Vice-President of the International Society for Rock Mechanics for the term 2015-2019. He was nominated by, and is an ex officio member of, the New Zealand Geotechnical Society Committee.

Seismologist **Martin Reyners** was awarded the New Zealand Geoscience Society's Geophysics Prize for 2014 for a paper in *Nature Geoscience* with co-authors Donna Eberhart-Philips and Stacey Martin.

Tectonic geologist **Rupert Sutherland** was appointed to the executive committee of the International Continental Scientific Drilling Program.

BEING A GOOD EMPLOYER

We are committed to building an organisation of talented, diverse and capable leaders and staff. Critical to this is providing a workplace environment where our people feel empowered, valued and supported.

Our human resource practices and initiatives are fair and equitable, encourage engagement and align with good employer principles. Our activities this year are summarised against the seven key elements of being a 'good employer' below:

BEING A GOOD EMPLOYER

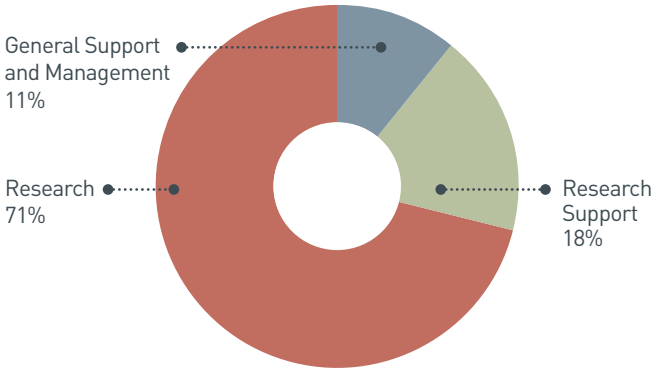
ELEMENT	OUR ACTIVITIES THIS YEAR
Leadership, accountability and culture	• Held leadership courses for emerging, new and existing leaders • Developed specific leadership workshops for managers to support a high performance culture • Ran our biennial staff survey, communicated results to staff and are implementing initiatives to improve engagement as suggested in the survey
Recruitment, selection and induction	• Extended advertising channels to attract the best candidates for our positions • Achieved accredited employer status with Immigration New Zealand • Developed recruitment resources to increase hiring managers' understanding of unconscious bias • Held three induction workshops to welcome new employees
Employee development, promotion and exit	• We ensure career development conversations are a key part of performance review process • Career development opportunities include project work, acting in roles, secondment, mentoring and coaching, as well as a comprehensive list of training courses • Staff develop and maintain their technical expertise by attending and/or presenting at national and international conferences, trade shows and workshops • 19 staff were successful in our annual progression round • Have an annual Workforce and Succession Planning process to ensure the right people with the right skills and experience are in the right jobs at the right time • All staff leaving our organisation are offered the opportunity to complete exit interviews (face to face or online)
Flexibility and work design	• We promote a balance between work and personal commitments by offering flexible working arrangements • 10% of staff work less than 30 hours per week
Remuneration, recognition and conditions	• Our annual remuneration review process includes comparing our remuneration data with market data to ensure fair and equitable remuneration for our staff • We are developing resources to recognise and reward performance • We develop our policies and procedures in consultation with staff and the PSA.

Harassment and bullying prevention	• We are committed to maintaining a safe working environment which is free from bullying, harassment and other undesirable behaviours • We promote a culture where staff experience mutual respect, trust and dignity • Our Code of Professional Practice provides clear expectations of workplace behaviour for all staff, visitors and students • Our harassment policy will incorporate bullying
Safe and healthy environment	• Developed an Employee Participation Agreement with the PSA and staff to encourage open communication and inclusiveness • Formal review of health and safety policies and procedures was strongly positive with minor changes suggested • Held health and safety management workshops for all people managers • Offered Resilience to Change workshops to all staff • Delivered a range of support services including: – An onsite Workplace Support Programme – Flu vaccinations – Ergonomic workstation assessments – Eye examinations – Regular medicals for all field and laboratory staff • We have tertiary ACC accreditation for our workplace safety management practices

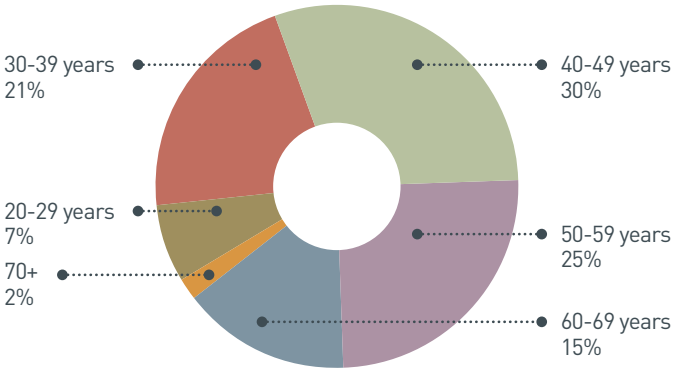
WORKPLACE PROFILE

Full-time equivalent (FTE) staff	Our FTE count at 30 June 2015 was 368 compared to 371 as at 30 June 2014
Annual staff turnover	Turnover for the year ended June 2015 was 5.6% compared to 6.1% in 2014
Gender profile	We have a 39/61 female/male ratio – similar to 2014 at 38/62
Age profile	The average age of our staff as at 30 June 2015 was 47.5 years, with the average age of females 44.7 years and average age of males 49.2 years
Disability	Our workplace profile has recently been updated to record this information at recruitment. We have one staff member who over the past 12 months selected this category.

Workplace categories



Age distribution



ENERGY AND MINERALS

OUTCOME

INTRODUCTION

Our activities in this area are designed to bring economic benefits to New Zealand by contributing to the security, development and diversification of New Zealand's oil and gas, geothermal, and mineral resources.

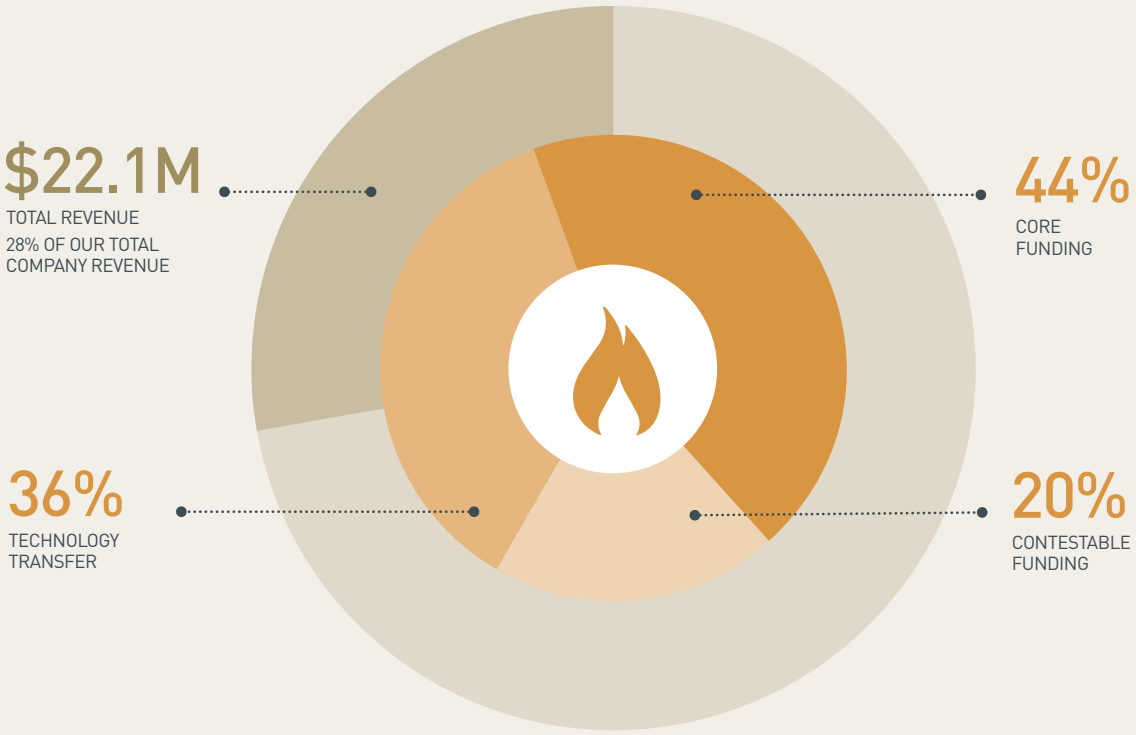
Our petroleum geoscience research and technology transfer focuses on mapping, analysing and quantifying the factors that control how petroleum forms, migrates, and is trapped in sub-surface structures. This aids the discovery of new oil fields, and optimises the management of existing fields.

In geothermal energy, our scientific advice to industry on physical and chemical properties of prospective and producing fields increases levels of confidence in exploration by reducing the risks associated with drilling and production.

For the minerals industry, we identify the extent and grade of offshore and onshore mineral resources. For New Zealand's marine territory, we work with national and international organisations to investigate the nature of the seafloor and sub-seafloor.

The aim is to provide quality information so government agencies and other organisations can make informed decisions about the potential resources and conservation needs of the Exclusive Economic Zone and its Extended Continental Shelf.

REVENUE SOURCES



GNS SCIENCE SHINES AT WORLD GEOTHERMAL EVENT

New Zealand's geothermal energy industry underlined its global leadership at a week-long World Geothermal Congress in Melbourne in April 2015. New Zealand and Australia were joint hosts, but it was the 200-strong Kiwi contingent who shone thanks in part to the efforts of our geothermal team from Wairakei. This is because our staff were prominent in every aspect of the event from serving on the organising committee to hosting post-conference field trips in the central North Island.

The five-yearly event rarely comes to this part of the world and this year it attracted 1500 delegates from 15 countries. The New Zealand pavilion, coordinated by New Zealand Trade and Enterprise, was three times larger than any other country pavilion in the exhibition area.

Our scientists gave 21 presentations, including keynote addresses, and were co-authors of 15 others. For a country that derives 75% of its electricity from renewable sources, and 16% from geothermal, we had plenty to shout about.

New Zealand is the fifth largest geothermal energy producer in the world with 1010 megawatts of installed geothermal capacity, double the amount we had a decade ago.

Energy and Resources Minister, Hon Simon Bridges, told delegates in the opening session at Melbourne that geothermal would be the major contributor to New Zealand meeting its target of generating 90% of electricity from renewable sources by 2025.

Nearly every geothermal energy development in the world in the past 20 years has some degree of New Zealand input, either by providing expert services or through training. GNS Science has been a provider of specialist expertise in many of these developments.

For us the event was an outstanding opportunity to build new relationships and strengthen existing collaborations. Our unequivocal message to all the delegates was that New Zealand is the 'go-to' place for leadership, innovation, and scientific expertise in geothermal energy.

The Congress highlighted the major role that GNS Science has played, and continues to play, in geothermal energy development, from the pioneer era of the 1950s to the present day.

After the formal part of the Congress, our staff hosted three four-day field trips where delegates visited a wide range of locations in the North Island from power stations to active volcanoes.

The next Congress is scheduled for Reykjavik, Iceland, in 2020 and we are using our experience in Melbourne to plan even more innovative ways to showcase New Zealand's geothermal know-how to the world.

Learn more about our geothermal research and consultancy services at: http://www.gns.cri.nz/Home/Our-Science/Energy-Resources/Geothermal-Energy

RECENT INNOVATIONS

(2013) Provided geoscience input into feasibility studies to harvest rock phosphate from the Chatham Rise (commercially funded)

(2013-2014) Sold nine major petroleum geoscience database products to industry to help in the quest for new petroleum discoveries (core funded)

(2014) Completed a $4 million state-of-the-art upgrade to our geothermal and groundwater laboratories at our Wairakei campus, giving us capabilities that are unique in the Southern Hemisphere (capital investment)

(2015) Collaborated with the Royal NZ Navy in the use of an autonomous underwater vehicle to explore submarine volcanoes in the Kermadec Arc (core funded)

(2015) Finished sampling and analysing 1012 hot springs in the central North Island to build a world-first catalogue of micro-organisms living in extreme environments, called the 1000 Springs Project (www.1000springs.gns.cri.nz) (supported by contestable funding)

MODELLING THE PETROLEUM GENERATION POTENTIAL OF THE TARANAKI BASIN

We have completed a landmark 3D model of the sedimentary architecture and structural framework of the sub-surface in the southern sector of the offshore Taranaki Basin. It has been produced at a scale and resolution rarely achieved for regional studies, either in New Zealand or elsewhere. It will be available as a workstation-ready datapack of mapped horizons with metadata reported via our web-based information portal, Petroleum Basin Explorer.

The newly completed dataset will help the exploration industry to better understand the geology of the southern Taranaki Basin and reduce the risk of drilling dry wells. It covers about 50% of the 55,000 km^2 Taranaki Basin. Our team of seismic interpreters, structural geologists, stratigraphers, and geomodellers at GNS Science compiled it from analyses of 20,000 line kilometres of seismic reflection data and information from 40-plus petroleum wells. We plan to release a similar 3D data product covering the northern section of the basin in 2016.

Over millions of years the sediment layers in the basin have been squeezed and stretched by tectonic processes and offset by faults and folds. Many of these structures have trapped petroleum migrating from deeply buried coaly sediments. Three-dimensional data products not only enable the user to visualise the sub-seafloor structures as they are today, but their evolution can also be simulated through time.

Reconstruction of sedimentary basins is one of the backbones of our work and as a research organisation we have the skills to develop larger and more comprehensive models than most other companies. This provides a fundamental understanding of how a basin has evolved, how its thermal history affected the generation of petroleum, and the elements critical to developing a viable petroleum system. We offer workshops and consultancy services to share this knowledge with industry and we share our insights at conferences every year.

Learn more about our petroleum geoscience activities at: http://www.gns.cri.nz/Home/Our-Science/Energy-Resources/Oil-and-Gas

WORLD-FIRST CATALOGUE OF 'EXTREMOPHILES'

Researchers at our Wairakei office have achieved a world-first by compiling comprehensive information on microbial biodiversity and chemical and physical conditions at 1012 hot springs and geothermal features in the Taupo Volcanic Zone. The resultant online database is an unprecedented resource for a wide range of end-users including biotechnology companies, Māori, central and local government, and scientists.

With our research partners at the University of Waikato, we have analysed fluids from each of the 1012 springs for 42 chemical parameters and 13 physical characteristics. Our scientists have also catalogued 26,500 bacterial taxa and 2000 archaeal taxa – or nearly 29,000 different microbial types.

The '1000 Springs Project' is the world's largest and most comprehensive catalogue of microbial populations and their hot spring environments in one geographical area. The southern-most spring in the survey is at Tokaanu and the northernmost is at White Island (Whakaari), off the Bay of Plenty coast.

Springs in the sample ranged from pH 0.0 to 9.7 and from 14°C to 100°C in temperature.

Springs showing a low diversity of microbes were generally highly acidic and were home to as few as 40 different taxa. 'High-diversity' springs tended to be more neutral in pH and hosted as many as 4700 microbial types.

We have finished determining the taxa diversity of the microbial communities in 880 of the 1012 springs. This is like going to a conference and collecting all the name tags from the reception desk. It tells you who is there, but it doesn't tell you much about them.

The next phase is undertaking the genomic analysis of selected high-priority springs. This involves the reconstruction of the genomes of individual community members and can be likened to obtaining the CVs of the above-mentioned conference-goers. This will be the really powerful part – it will not only identify what the microbes are capable of doing in their host ecosystems, it will also indicate what potential uses they might have in industry and science.

The genomic analysis will help in understanding the mechanisms these hardy 'extremophiles' have developed to thrive in conditions that would kill most ordinary life forms. Scientists liken extremophiles to 'fancy catalysts' that will live anywhere where they can get energy from a chemical reaction.

Already there are indications that many of the taxa in the collection will be globally unique, as they live in geothermal features that are globally unique. This 'uniqueness' factor adds to the value of the catalogue.

Learn more about the 1000 Springs Project at: http://www.1000springs.gns.cri.nz

ACHIEVEMENTS ENVISIONED IN OUR STATEMENT OF CORPORATE INTENT

Theme	Near-term goals	Progress/achievement
Geothermal energy		
Resource characterisation (11% of core funding)	Determine the physical and chemical nature of fluids and flow pathways in TVZ geothermal systems	Built geological framework model, undertook experimental geochemistry investigations and field tracer studies. Also used numerical modelling tools to resolve physical and chemical controls on fluid flow in TVZ geothermal systems.
	Improve access to geothermal physical, chemical, and microbiological data and nomenclature standardised	Completed first comprehensive, systematic catalogue of microbial community diversity in TVZ hot springs – the 1000 Springs Project. We have isolated new microbial species and continue to characterise the ecology of NZ's geothermal microbial ecosystems.
	Define geological, physical, chemical, and biological indicators for monitoring change in geothermal environments	Biological, chemical and physical data from 1000 terrestrial geothermal features logged, providing a baseline for future reference for ecosystem health and services monitoring.
Sustainable development (3% of core funding)	Determine chemical mechanisms for corrosion and scaling effects in geothermal power stations	Determined the solubility of stibnite to 400°C as function of pH and H_2S concentration. Biological mechanism for geothermal production well corrosion modelled. Used ion beam facility for study of arsenic – steel electrode corrosion properties in simulated brine up to 80°C.
	Evaluate economic value of the mineral resources in geothermal fluids	Completed cross-disciplinary studies integrating opportunities and barriers to commercial recovery of products from geothermal fluids. Have listed the best technical options and economic models to help in guiding future investment.
Oil and gas		
Petroleum systems (7% of core funding)	Continue quantification of critical parameters that control petroleum formation, migration, and confinement, calibrated with industry data and known resources in Taranaki	Completed digital remapping of southern Taranaki Basin, incorporating improved understanding of the impact of fault properties on the charging of offshore oil and gas fields, and presented results at the Advantage NZ Petroleum Summit 2015 with data delivered to industry using our PBE web portal. A PhD thesis by Cathal Reilly (based at GNS) highlights the tectonic evolution of the southern Taranaki Basin emphasising the impact of structures on trap formation, petroleum migration and charge. Completed several comprehensive ArcGIS projects covering petroleum source rock potential, seal rock distribution and quality, and petroleum occurrences in Taranaki and other NZ basins. Delivered to industry via the NZP&M 2015 Petroleum Exploration Data Pack.
	Advance understanding of the geological framework and prospectivity in the Northland, East Coast, Reinga, Pegasus and Canterbury and Great South basins	Released important information on East Coast source rock properties to exploration companies as a web-based database. Unveiled results of seismic mapping of Pegasus and Canterbury basins at the Advantage 2014 conference. Published new results from paleogeographic maps and seismic mapping from Great South Basin in the APPEA conference journal. Developed multi-client reports on prospectivity screening for Reinga/greater Taranaki (NW quadrant) and Great South/Canterbury (SE quadrant) offshore basins.
Frontier provinces (3% of core funding)	Transfer to industry our advanced understanding of the geological framework and prospectivity in the Northland, East Coast, Reinga, Pegasus, Canterbury and Great South basins	Integrated regional seismic mapping across the NW sector of the EEZ, as part of the newly-funded Atlas of Petroleum Prospectivity (APP) programme, to provide improved understanding of prospectivity in these frontier basins. Completed prospectivity screening reports on Reinga and Pegasus basins and delivered to industry via the NZ Petroleum & Minerals' Petroleum Exploration Data Pack. Recent advances in understanding the petroleum prospectivity of the Reinga and Canterbury basins, as well as prospects for oil from Cretaceous-Eocene coaly source rocks in New Zealand frontier basins, were presented at the Advantage New Zealand Petroleum Summit 2015.
Emerging energy technologies (3% of core funding)	Establish environmental and production parameters for east coast (NI) gas hydrate reservoirs	Mostly completed analysis of geophysical data and geological information to understand gas hydrate distribution for the east coast (NI) and have identified locations with potentially high gas hydrate saturations in high-quality host rock. Have also completed petroleum system modelling for parts of the east coast sedimentary basin with further studies planned. Established baseline data on biological communities at all currently known east coast seep sites, including an initial evaluation of the vulnerability of these communities to human activity.
Minerals		
Onshore prospectivity (2% of core funding)	Complete regional mineral resource assessment of the Southland area	Compiled and analysed geological and mineral resource data, together with results of past exploration, to show potential for undiscovered resources in a variety of mineral deposit types, particularly for hard rock deposits of gold, copper, lead-zinc and platinum, in addition to known placer deposits of gold, garnet, ilmenite and silica.
Submarine exploration (4% of core funding)	Organise international expedition to the Kermandec Arc and finalise proposal to drill Brothers Volcano	Conducted successful survey of Macauley Volcano in the Kermadec Arc in collaboration with the Royal New Zealand Navy and the Woods Hole Oceanographic Institute using the Sentry AUV while aboard the *HMNZS Wellington*. A proposal to undertake scientific drilling on Brothers Volcano has been approved by the International Ocean Discovery Program (IODP) and is in the process of being scheduled.
	Continue to map and survey the ancient Colville Ridge for mineral resources	Used the *Tangaroa* to complete successful survey of the Colville Ridge mapping about 20,000 km^2 of seabed and taking seafloor samples at key locations to determine the geology of the ridge.
	Determine the georesource potential of a second Rotorua lake in the Okataina Caldera	Worked with IXSurvey to determine the extent of sublacustrine geothermal activity. Two other lakes (Rotoma and Okataina) were mapped by the University of Waikato. GNS Science completed magnetic surveys on lakes Tarawera, Okataina, Rotoehu, and Rotoma.
Exploration pathfinders (1% of core funding)	Establish biogeochemical indicators of gold mineralisation in Coromandel	Sampled pine bark, needle litter, and fern fronds over the Luck at Last gold prospect in exotic forest, where the soils had been previously sampled in detail by an exploration programme. Multi-element analysis of plant material showed anomalies in many elements highlighting exploration targets, and demonstrating the usefulness of this method in gold exploration.

OUTCOME

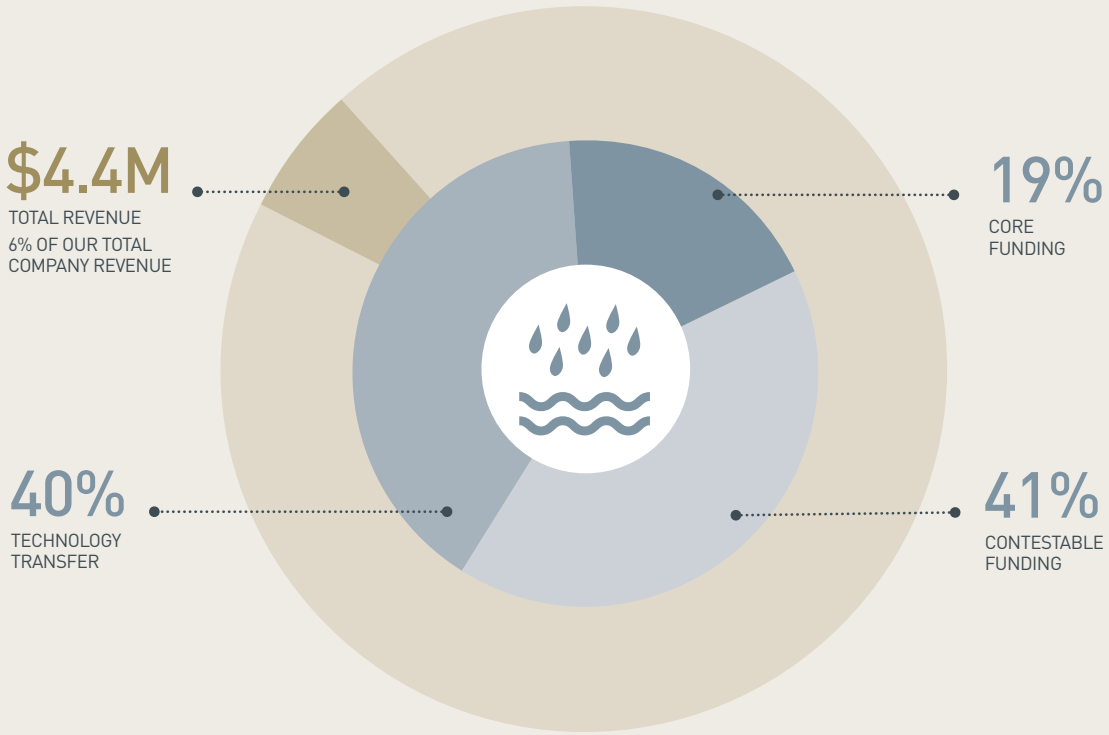
GROUNDWATER

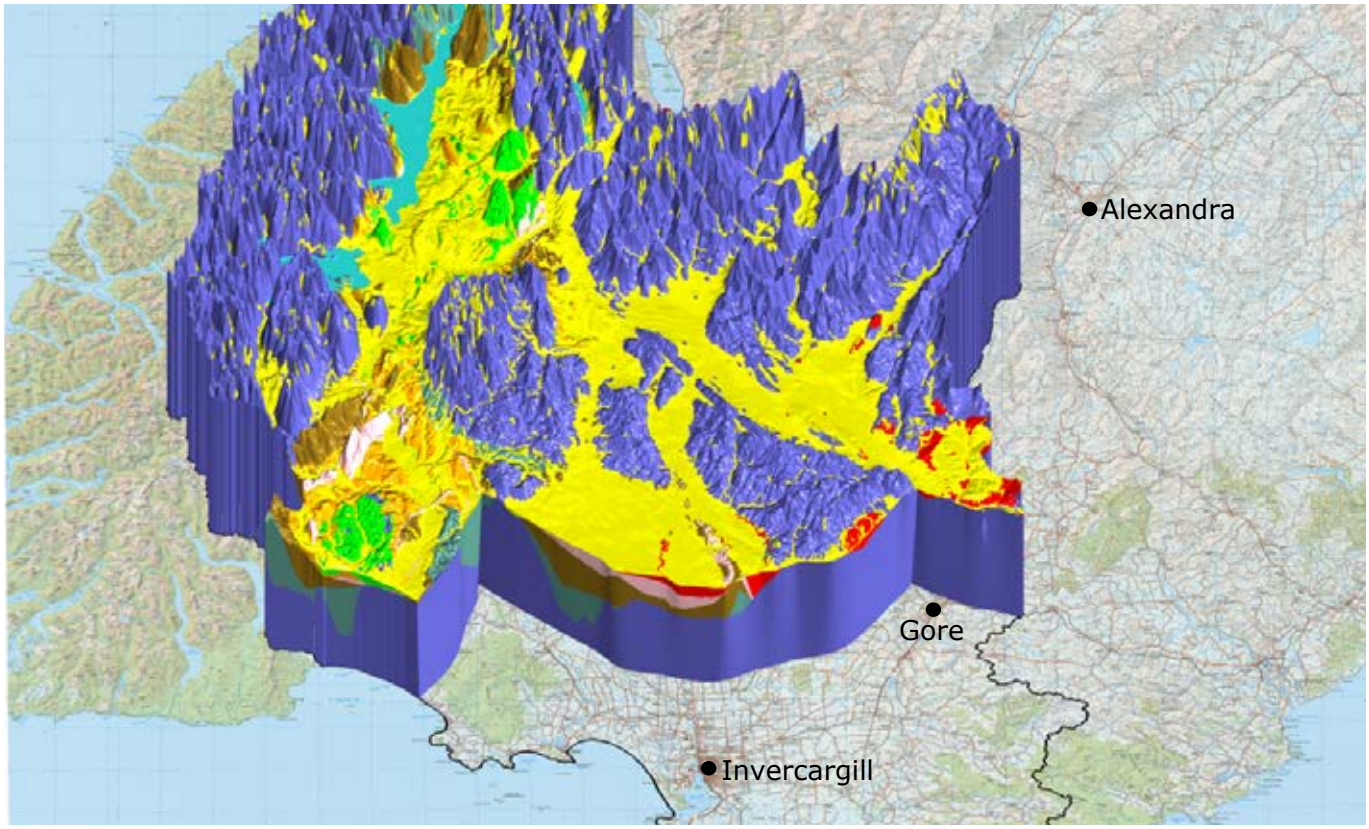
INTRODUCTION

Groundwater accounts for roughly 30% of New Zealand's water consumption. There is wide agreement that improved management of groundwater stems directly from a better understanding of the resource itself.

Our research and analytical capabilities are designed to significantly improve the understanding of aquifer systems and help in the effective management of groundwater resources. We use innovative methods to monitor, characterise and map New Zealand's aquifers. End-users rely on our aquifer maps and 3D models to ensure sound management of fresh water.

REVENUE SOURCES





IMPROVING MANAGEMENT OF FRESHWATER IN SOUTHLAND

We are part of a multi-agency initiative to improve the management of freshwater resources in Southland. The project is being built on a platform of increased scientific knowledge of the region's groundwater, surface water, lakes, estuaries, and rivers. The over-arching project is called Water and Land 2020 and Beyond, and it is made up of three science components.

The component we are leading is called Fluxes and Flows and our collaborators are Environment Southland and NIWA. The aim of our work is to provide policy-makers and the community with robust information to enable sound decisions on the use and allocation of fresh water and the management of land in Southland. Our participation in the project is co-funded through the MBIE-funded Tracer Validation Programme.

It will examine the interconnections between surface and groundwater and how they affect water quality and quantity. An outcome will be to provide a 'what if' tool to help answer questions such as: 'How much water do we have and where does it come from? How much groundwater is entering our rivers and where? Why are some areas more sensitive to land use than others? What if some provincial towns double in size by 2020?'

Our first task is to develop a three-dimensional geological flow model of groundwater for much of the region. The area covered by the investigation is 21,000 km^2 ranging from Te Anau in the west to the Catlins in eastern Southland. It includes the catchments of the Waiau, Aparima, Oreti, and Mataura rivers and encompasses 29 groundwater management zones.

We are using a range of investigative techniques to identify the origins of water and different underground flow paths, and quantify the interactions between groundwater and surface water in each of the catchments. We will also assess the role of hydrogeological processes in the way nutrients are transported.

Scientists will then develop a three-dimensional computer model of groundwater flow paths on the Southland Plains. The model will be used to simulate different management scenarios for use by the Regional Council and for engaging with the community.

An impetus behind the Fluxes and Flows project is the government's National Policy Statement for Freshwater Management of 2014, which requires regional councils to maintain or improve overall water quality within a region. The project represents a new model for delivering environmental science that will provide long-term benefits for the community.

Learn more about our groundwater activities at: http://www.gns.cri.nz/Home/Our-Science/Environment-and-Materials/Groundwater

ACHIEVEMENTS ENVISIONED IN OUR STATEMENT OF CORPORATE INTENT

Theme	Near-term goals	Progress/achievement
Groundwater (3% of core funding)	Delivery of national groundwater data to end-users	Set up new national protocols for data transfer to improve stakeholder access to national and regional datasets. Also deployed new interactive capability for access to the Groundwater and Geothermal database.
	New techniques to quantify reach-scale ground and surface water exchange fluxes in space and time	The use of radon gas and distributed temperature sensing has provided exciting new possibilities to characterise reach-scale ground and surface water interactions.

RECENT INNOVATIONS

(2013) Developed smartphone access to aquifer and geology databases in Bay of Plenty (contestable plus core funding)

(2013) Developed a modelling tool to better understand surface water-groundwater interactions in the Lake Taupo catchment (contestable plus WRC)

(2013) Improved sensitivity and doubled throughput in our Water Dating Laboratory, already the most accurate such laboratory in the world (core funded plus capital investment plus revenue from laboratory services)

(2013) Developed guidelines for councils to help protect streams, wetlands, and wells that receive inflow from groundwater

(2013-2014) Developed new computer techniques to process airborne electromagnetic data to derive information on the lateral size and depth of aquifers to help groundwater managers estimate the storage capacity of aquifers (contestable funding)

(2013-2014) Trialled temperature sensing techniques – satellite, airborne, and fibre optic – to show how they can complement each other for more cost effective characterisation of groundwater-surface water interactions over relatively large scales (contestable funding)

PROTECTING WAIKATO'S FRESH WATER

We are part of a multi-agency project to help improve the health of the Waikato and Waipa rivers and their catchments. The aim of the multi-year project, called Healthy Rivers: Plan for Change - Wai Ora: He Rautaki Whakapaipai, is to reduce the problematic amounts of sediment, bacteria, nitrogen and phosphorus entering into waterways.

It encompasses land extending from Lake Taupo to the Tasman Sea – an area of over a million hectares. This highly productive area of New Zealand contributes a significant portion of our land-based exports and 40% of our electricity generation through hydro and geothermal.

The ambitious project is unique in its size and scope and the fact that it is a partnership between the Waikato Regional Council and five river iwi partners. It also features a 'collaborative stakeholder group' representing stakeholders and the wider community. Specialist technical and scientific input is coming from various organisations including GNS Science and is coordinated by a Technical Leaders Group which provides strategic direction.

Our role is to characterise the groundwater in the two catchments. This includes three-dimensional geological modelling of the three zones in the catchment – upper Waikato, Waipa, and lower Waikato. The models identify factors important to the flow of groundwater such as aquifers and sub-surface layers that influence flow rates. Our modelling also shows the length of time water resides in various catchments. We are also summarising the main properties of the aquifers including water quality and providing information on links between ground and surface water.

In lakes and lake-fed rivers, the project is keeping track of total nitrogen, total phosphorus, nitrate and ammonia as well as biological indicators. Our work feeds into catchment and economic modelling which assesses the impact of land use on water quality to achieve the stated goals for the Waikato River. The project will refine existing models so they better represent the effects of underground flow paths and flow rates and how these vary across the catchment.

Information from the project will provide a more accurate picture of the current status of the rivers and the estimated time it will take to make improvements due to the various mitigation measures. The information will be used to develop objectives, policies and methods in the regional plan to manage the four contaminants and restore and protect the health and wellbeing of the two rivers and their catchments.

ISOTOPES AND ION BEAM TECHNOLOGY

OUTCOME 3

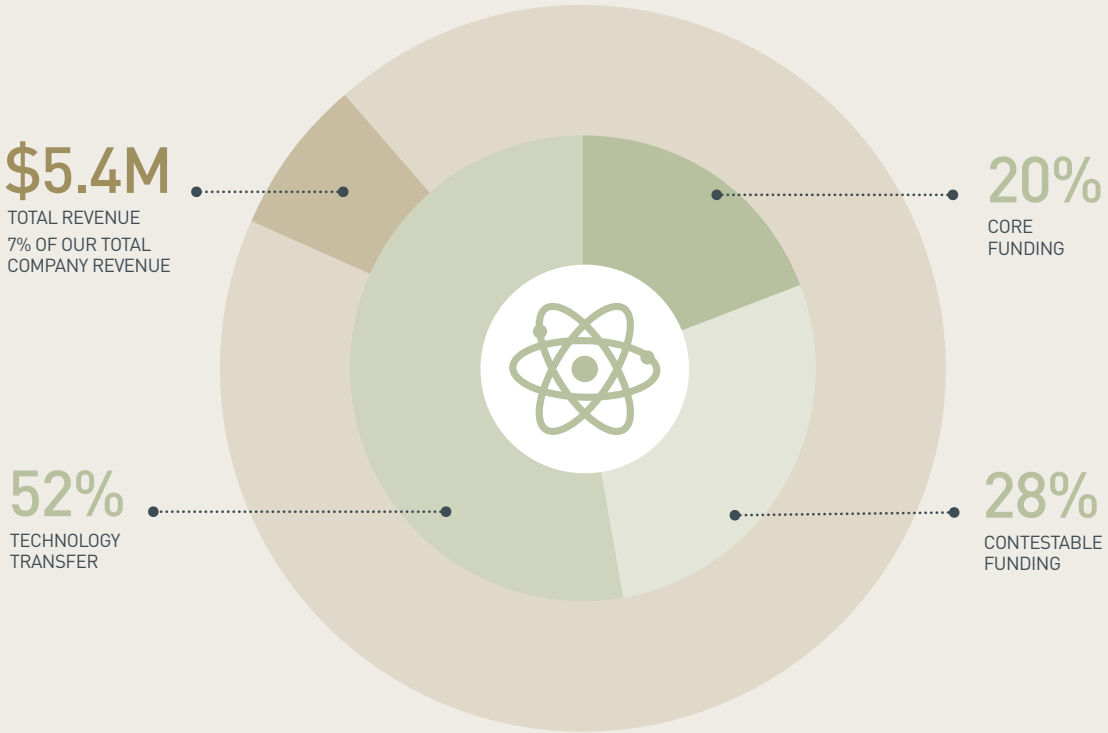
INTRODUCTION

Our isotope and ion beam technologies support the earth sciences in the broadest sense, as well as industries and environmental sciences. We use our ion beam technology to analyse fine-particle air pollution in urban areas so councils can make informed policy and mitigate poor air quality.

We also use this technology to develop materials with superior physical, electrical, magnetic, and optical properties by depositing other elements, atom-by-atom, onto the surface of the base material, usually a metal. This supports high-value manufacturing industries and the development of specialised nano-materials for industry.

Our isotope technology is used in age dating, environmental tracing, and food authentication.

REVENUE SOURCES



VERIFYING CO_2 EMISSIONS WITH RADIOCARBON MEASUREMENTS

Our scientists are setting the pace internationally by using radiocarbon measurements to verify fossil fuel emissions from large stationary industrial sources. They have shown that this novel use of radiocarbon measurements works by trialling it at the Kapuni Natural Gas plant in Taranaki.

At a series of sampling stations downwind from the Kapuni plant, they collect air samples and radiocarbon date the carbon dioxide in the samples. They also radiocarbon date grass from the same locations, as grass faithfully records the radiocarbon content of the carbon dioxide that has been photosynthesised from the atmosphere. The air samples provide excellent agreement with the known carbon dioxide emissions from the plant. The grass samples give slightly less accurate, but still useful, information on plant emissions. An advantage of the grass sampling is that it does not require sophisticated equipment.

The goal of the work is to use atmospheric measurements of radiocarbon in carbon dioxide to accurately quantify emissions of fossil fuel carbon dioxide. Currently, the only way carbon dioxide emissions are known is from self-reporting of fossil fuel usage. Once perfected, the radiocarbon method, which is objective and independent, could complement existing carbon accounting methods.

Radiocarbon occurs naturally in all living things, and decays radioactively over time, so that the time since death can be determined from the amount of radiocarbon remaining in the object being measured. Fossil fuels are so old that no radiocarbon at all remains. So carbon dioxide produced from fossil fuels contains no radiocarbon – carbon-14 – and can be readily distinguished from naturally produced carbon dioxide, which has a 'modern' amount of radiocarbon. With some clever maths, scientists are able to derive how much carbon dioxide in the atmosphere comes from fossil fuels and this reveals carbon dioxide emissions in tonnes per day.

The technique is being trialled on a region-wide basis in the US and Europe, but the Kapuni project is believed to be the first time it has been successfully applied to a 'point source' site. Several reasons make the Kapuni plant ideal for this trial. Plant operators have provided detailed emissions information on an hourly basis; the plant is surrounded by farmland which eliminates potential distortions from urban or other industrial sources; lastly, the flat terrain and well documented weather make it easy for scientists to model gas dispersion rates in the atmosphere.

ACHIEVEMENTS ENVISIONED IN OUR STATEMENT OF CORPORATE INTENT

Theme	Near-term goals	Progress/achievement
Air particulate pollution (1% of core funding)	Establish a database of sources for air particulate matter pollution in New Zealand urban areas (eg. Auckland, Wellington, Nelson, Christchurch)	Set up a database of air particulate pollution sources for Auckland, Hamilton, Wellington, Christchurch and Dunedin plus smaller centres (Whangarei, Pukekohe, Napier, Palmerston North, Masterton, Nelson, Blenheim, Alexandra, Invercargill). The database is publicly available for research opportunities from community health assessment to Southern Hemisphere atmospheric composition studies.
New materials (1% of core funding)	Applications of surface coating and sensor materials for industrial processes using ion beam technologies	Delivered two prototypes of a novel system to monitor the status of a secured opening (door, window, gate) to a New Zealand manufacturer for trialling. The patent-protected system uses novel sensors developed by GNS Science.
Isotope biogeoscience (industrial) (2% of core funding)	Isotope tracking of food (esp honey) and establishment of compound-specific applications for both stable isotope analyses and radiocarbon dating	Work in food traceability and label verification continues to expand, in particular with honey, orange juice, organic vegetables, chocolate, and palm oil. This supports export growth and boosts consumer confidence in food authenticity. Have applied compound-specific isotope analysis (CSIA) to assist with seafood farming consents and as part of a study to better understand nitrogen dynamics in Lake Taupo. Also developing capability in radiocarbon CSIA with samples as small as 100 micrograms of carbon. Ultimately hope to reduce this to 20 micrograms of carbon.

RECENT INNOVATIONS

(2013-2014) Worked with export honey industry to find out why manuka honey is failing authentication lab tests (core plus industry funded)

(2013-2014) Designed and built an ion implanter for the Australian Nuclear Science and Technology Organisation (funded by ANSTO)

(2014) Marked 60 years of atmospheric radiocarbon measurements in Wellington, the longest continuous 'clean air' record in the world (core funded)

(2014-2015) Installed a permanent air particulate sampler at Whakarewarewa Village in Rotorua allowing us to showcase our science to about 350,000 visitors annually (funded by our Strategic Development Fund)

SKY IS THE LIMIT WITH THE NEW GENERATION OF SENSORS

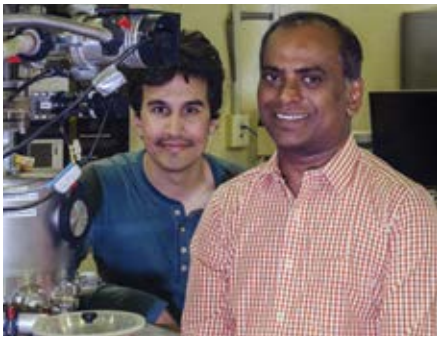
Our nanotechnology group is working with industry to develop a range of sensors and sensor systems for a variety of applications. Advances in electro-mechanical technology, wireless communications, and digital electronics have ushered in the age of the low-cost, low-power sensor. Our aim is to make networks of these versatile sensors accessible to individuals and small businesses.

Our initial focus has been on developing prototype magnetic sensors for security applications and electro-chemical sensors for environmental monitoring. Some of the components in our prototype sensor systems are off-the-shelf and we configure them in novel ways. Others are built from scratch using our knowledge of nanostructured materials. The advantages in this approach are superior performance, miniaturisation, and low cost.

Magnetic sensors can be used for monitoring the position of an object, such as doors or windows as they open, magnetic field mapping, or provide directions in conditions where GPS tracking and other technologies alone are inadequate.

We have also applied our design knowledge to develop a novel sensor system measuring the performance of buildings and infrastructure during earthquake shaking. As we have shown in trials, multiple displacement sensors in a building can show real-time movement in strong wind and moderate earthquakes. This tells engineers if the structure is performing as it was designed. Direct displacement measurement can potentially do this more efficiently and at lower cost than conventional accelerometer technology. We are now investigating how to use magnetic sensor technologies to achieve similar results in a much less intrusive way.

Within our hydrogeology group and as part of an international collaboration, we are also trialling various sensor and wireless networking technologies to monitor the quality and quantity of water in aquifers in conjunction with weather measurements. As part of this initiative, we have installed a network of sensors in a Hawke's Bay aquifer to measure a range of parameters. The low cost of the network opens the way for real-time monitoring of aquifers at a regional scale.



Other potential applications are in early detection of flooding, precision farming and enhanced management of forests and greenhouses. For flood applications, combinations of rain and water level sensors, together with temperature and wind sensors, can offer automatic warnings when pre-determined thresholds are reached. In forest and greenhouse management, dense networks can track any number of characteristics including trunk diameters, bark thickness, canopy, humidity, illumination, and CO_2 transpiration in real time. This enables quick and precise changes to optimise growing conditions.

NATURAL HAZARDS

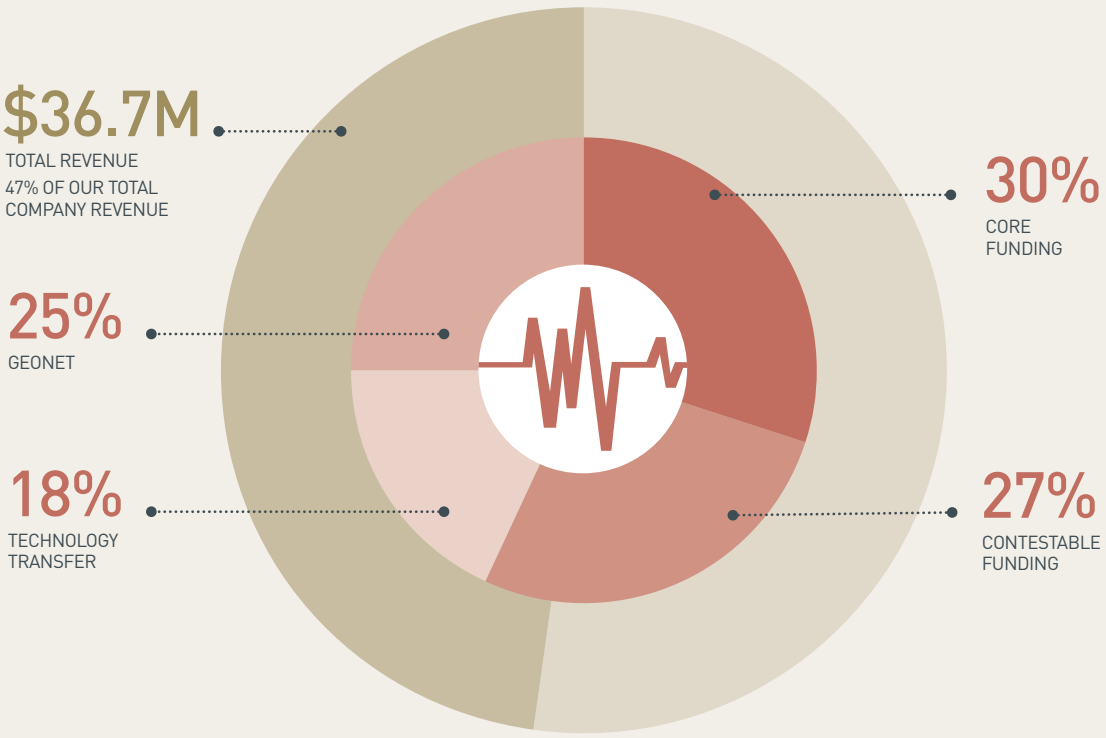
OUTCOME

INTRODUCTION

Our research and applied work in this area helps to reduce New Zealand's risks from earthquakes, volcanoes, landslides, and tsunami. The outcomes are increased resilience of society, buildings and infrastructure. This reduces loss of life as well as moderating insurance costs through better engineering and planning.

In partnership with the Earthquake Commission and supported by Land Information New Zealand, we operate GeoNet – the national network for monitoring geological hazards. Data from this network provide underpinning information for downstream geohazards research. We also host the Natural Hazards Research Platform – the multi-agency group that delivers most of New Zealand's government-funded applied hazards research. Finally, we undertake social science research to support the Ministry of Civil Defence and Emergency Management and other agencies to prepare for, and respond to, natural hazards.

REVENUE SOURCES



LANDMARK ALPINE FAULT PROBE BRINGS UP VITAL INFORMATION

The multi-national Alpine Fault drilling project at Whataroa in the South Island, jointly led by GNS Science, finished in early 2015 with the borehole reaching 893 m into the fault. This is the deepest anyone has ever drilled into a major fault in New Zealand. While short of its target depth of 1.3 km, the high-risk, high-reward project still yielded a large amount of useful information about the inner workings of the fault.

One of the main findings was the higher-than-expected heat at depth, with a thermal gradient of 140˚C per kilometre. Scientists believe this gradient is similar for several hundred kilometres along the length of the fault. This has implications for the way rocks behave inside the fault zone. It also raises the possibility of geothermal energy being developed on the West Coast. The weight of the adjacent Southern Alps influences the sub-surface stress state, water pressures and other parameters inside the fault zone. The aim of the project was to see how these effects change with depth.

Scientists have installed instruments at various depths inside the borehole as a permanent observatory to measure a range of physical and chemical phenomena. Since January, they have spent many months combing through the large amount of data obtained from inside the borehole. The cuttings and drill cores are being analysed at the University of Otago, Victoria University of Wellington, and at specialist lab facilities in the United States, Japan, and Germany.

Scientists believe it may be possible to recognise phenomena from the borehole data that may have earthquake forecasting use in the future. The project involved 120 scientists from 12 countries. It was funded by the International Continental Scientific Drilling Program (ICDP); the Marsden Fund of the Royal Society of New Zealand; GNS Science core funding; Victoria University of Wellington; University of Otago; and the governments of New Zealand (Ministry of Business, Innovation, and Employment), the United Kingdom (National Environmental Research Council), and the United States (National Science Foundation).

Learn more about the Deep Fault Drilling Project at: https://wiki.gns.cri.nz/DFDP

TWENTY YEARS OF PROGRESS SINCE RUAPEHU BLEW ITS TOP

Public safety levels at and near volcanoes have increased markedly as a result of a raft of science-based changes and improvements that followed the 1995-96 eruptions of Mount Ruapehu. The spectacular eruptions through Ruapehu's Crater Lake were a catalyst for many research projects. They also led to improvements in volcano monitoring and warning systems, and the development of multi-agency coordination to deal with volcanic hazards and risk.

One of the most visible post-eruption initiatives is the EQC-funded GeoNet project which started in 2001. Part of this was a modern volcano monitoring capability in Tongariro National Park. A robust communications network, also operated by GeoNet, has allowed for a large volume of data to be gathered from an array of seismic sensors, GPS instruments, acoustic sensors, web cameras, and lake temperature loggers.

A steady stream of data from these instruments underpins the real-time warning systems operated by Department of Conservation for visitor safety on the skifields. In addition to this, volcano teams under the aegis of the GeoNet project regularly visit key areas to collect water and gas samples for analysis, to gain extra insight into the mood of the volcanoes.

The eruptions also kick-started other initiatives, especially in the impact of volcanic ashfall on engineering lifelines and the use of social science to validate and refine awareness campaigns, education, and warning systems. In addition, the Civil Aviation Authority developed protocols on how to manage airspace during a volcanic crisis and helped to inform the global thinking in this area.

Natural hazards-based social science has been used to evaluate the messages that inform the public about volcanic hazards, and to make hazard maps more informative and more effective. It has also monitored the response of skiers during 'live tests' of the public warning systems on Mt Ruapehu to see how much they have learnt from freely available education material.

Another post-1996 development was the Central Plateau Volcanic Advisory Group. This group includes the Ministry of Civil Defence and Emergency Management, Department of Conservation, GNS Science, universities, regional and local authorities, iwi, emergency services, and the military. It has refined emergency response plans and education material, and has guided research where gaps have been identified. It has also created a vehicle for scientists to share their research findings.

It is sobering to reflect on the fact that the 1995-96 eruptions ejected a total of 60 million cubic metres of acidic ash and debris from the Ruapehu crater. However, a high erosion rate means there is almost no trace of the eruptions on the mountain today. Instead, the lasting outcomes have been improved emergency management procedures, real-time warning systems, better scientific monitoring to detect volcanic unrest, and a better understanding by New Zealanders of their vulnerability to volcanic eruptions.

Learn more about our volcano-related activities at: http://www.gns.cri.nz/Home/Our-Science/Natural-Hazards/Volcanoes

MULTI-AGENCY GROUP TO FOCUS ON THREATS FROM THE HIKURANGI MARGIN

A new umbrella group has been formed to coordinate and make accessible cutting-edge research on the Hikurangi tectonic boundary lying off the east coast of the North Island. This subduction zone is seen as one of the four or five major geological hazards that could seriously impact the whole country, similar to the Tohoku earthquake and tsunami in Japan in 2011.

There are multi-agency groups already focusing on two of the other big threats. The It's Our Fault Project targets the Wellington Fault, and the DEVORA research programme focuses on the hazards and risks posed by the Auckland Volcanic Field. Joining them is a new multi-agency initiative called 'East Coast LAB' – for Life at the Boundary. Its aim is to increase understanding of the Hikurangi Subduction Zone, which is the boundary between the Australian and Pacific tectonic plates, ultimately improving community resilience. The end result will be a reduced risk associated with the next earthquake and tsunami generated on the subduction zone, which is largely under the sea.

As well as earthquakes and tsunami, other hazards associated with the Hikurangi Subduction Zone include liquefaction, volcanism, and physical changes to the coast, such as subsidence and changing sea levels, that could seriously affect coastal communities. There are already more than a dozen pieces of research underway by various groups on the entire region, which stretches from Poverty Bay to Marlborough. The impetus for the new umbrella group is to improve the coordination among the researchers and identify gaps which may deserve extra attention.

The new initiative will also boost science education opportunities and see more engagement with the public. This latter aspect will see the public becoming more involved in individual research initiatives, including seeking innovative ways to better engage Māori and rural New Zealanders. A point of difference for this initiative is that it will have an education facility based at the National Aquarium of New Zealand in Napier.

'East Coast LAB' is well timed to pick up on growing international interest in the Hikurangi Subduction Zone. The National Science Foundation in the US has included it as one of its three primary focus areas worldwide for plate margin research. The other two are in Alaska and Cascadia, in northwestern United States. It means that during the next decade, many countries will invest money and people in studying this area. 'East Coast LAB' will help align the various strands of research and link them to communities and risk reduction so New Zealand gains maximum benefit.

The core members of 'East Coast LAB' are GNS Science, the Natural Hazards Research Platform, EQC, Massey University, NIWA, the Ministry of Civil Defence and Emergency Management, Napier City Council, National Aquarium of New Zealand and the regional councils and CDEM Groups of Hawke's Bay, Gisborne, Wellington, and Manawatu-Wanganui.

Find out more here: www.hbemergency.govt.nz/education/east-coast-lab

RECENT INNOVATIONS

(2013-2014) Developed rapid alert system to enable KiwiRail to focus quickly on areas where its rail network might have suffered damage in an earthquake (core funded plus contract with KiwiRail)

(2013-2014) Installed new monitoring equipment at White Island and Tongariro to improve the early detection of volcanic unrest (EQC funded)

(2013-2014) Publicised a range of future quake scenarios, and their likelihoods, within a few days of the Eketahuna and Cook Strait earthquakes (core funded)

(2014) Developed an online risk-based planning toolbox to help local government incorporate the consequences of natural hazards into land-use policy development (funded by EnviroLink)

(2014) Developed a new six-stage alert system for activity status of active volcanoes (funded by core funding and EQC)

(2015) Drilled almost 900 m into the Alpine Fault in the South Island and obtained a large amount of new information valuable to understanding fault rupture processes (collaboratively funded by project partners – see page 36)

(2015) Successfully recovered 35 ocean-bottom instruments that had spent 12 months on the seafloor off the Gisborne coast collecting data on the Hikurangi Subduction Zone (collaboratively funded by project partners)

ACHIEVEMENTS ENVISIONED IN OUR STATEMENT OF CORPORATE INTENT

Theme	Near-term goals	Progress/achievement
Hazard monitoring (18% of core funding)	Faster and better hazards information, including distributed cloud-based services, equipment renewal and improved remote volcano monitoring	Replaced and upgraded 120 aging instruments in the National Accelerograph Network with latest specification units, providing streamed seismic data over modern communications systems. Cloud-based computing and storage systems are also being fully used for GeoNet data, replacing the 'dual data centre' model and ensuring increased reliability and redundancy in case of server or site failures.
	Better understanding of volcanoes, earthquakes, landslides and tsunami, focusing on Cook Strait and Eketahuna seismicity, Tongariro and White Island	Continued making incremental advances in understanding these geological hazards through analysis of high quality data.
Geological hazards (4% of core funding)	Availability of enhanced asset data leading to wider uptake of the Riskscape tool by local authorities	Released updated version of RiskScape. Ran workshops with stakeholders to encourage sharing of asset data. Web portal and online asset repository updated and successfully used with the mobile real-time asset capture application in a number of international and domestic projects.
Risk and society (3% of core funding)	Continued support of Christchurch recovery through social science on psychosocial recovery, community resilience, public policy and land-use planning	Ongoing work with Ngai Tahu, CERA, ECan, Christchurch City Council and other agencies providing advice and research to help develop and monitor policy, as part of the earthquake recovery. Includes advice on land-use planning, resilience and wellbeing models, and community surveys.
	Domestic constituency and trusted partnerships to support international opportunities for NZ companies in natural hazards risk management	Continue to work closely with NZ companies in developing international opportunities. Successful multi-year projects underway in Indonesia and Vietnam. The Indonesian initiative is called Strengthened Indonesian Resilience – Reducing Risk from Disasters, or StIRRRD, and the project in Vietnam is called The Vietnam–New Zealand Dam and Downstream Community Safety Initiative – Phase 2 project.

ENGINEERING GEOLOGY

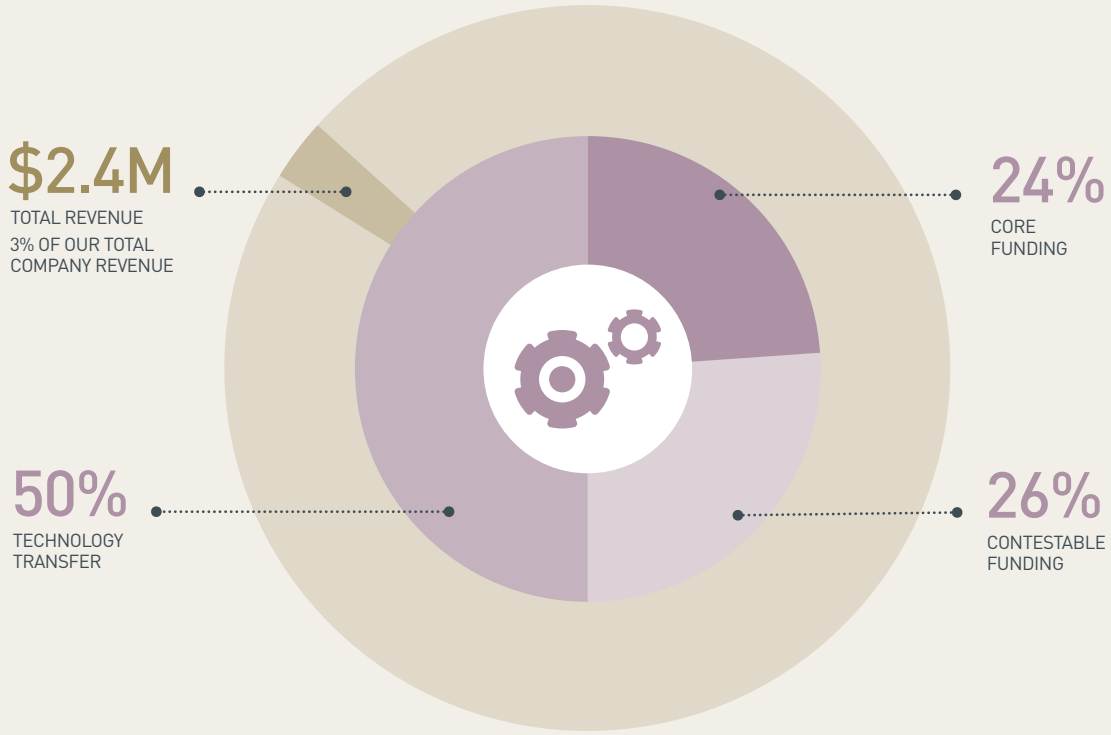
OUTCOME

INTRODUCTION

One of the silver linings of the Canterbury earthquake sequence is the large amount of new knowledge we have gained from investigating slope stability, liquefaction, and the impact of ground conditions on building performance. All of this is applicable to other parts of New Zealand.

We also continue with our traditional work that underpins the development and sound management of New Zealand's engineered infrastructure, particularly in the energy and transport sectors. This includes power generation and transmission facilities, water and gas networks, housing, and road and rail networks.

REVENUE SOURCES



ASSESSING LIQUEFACTION RISK IN HAWKE'S BAY

A major review of Hawke's Bay's earthquake-induced liquefaction risks, to be completed at the end of this year, will be the most comprehensive of its type in New Zealand. Outputs from the project, which we are undertaking with the support of the five Hawke's Bay councils and EQC, will have multiple uses in the region from guiding resource consent applications to urban planning and development. It will also be useful for civil defence operators.

The area covered by the project is flat, alluvial land from Eskdale in the north to Pakipaki south of Hastings and includes much of the Heretaunga Plains. It also includes the town of Wairoa in northern Hawke's Bay and three centres in central Hawke's Bay. For the cities of Napier and Hastings, we have developed a 3D geology model to a depth of 30 m based on borehole data and conventional surface geological studies.

We will produce liquefaction maps for each of the five council jurisdiction areas. They will update liquefaction studies undertaken in 1999 and 2003 and will show five levels of susceptibility from zero to four. The maps will be paired with an updated earthquake ground-motion model for potential earthquakes of various sizes and locations in Hawke's Bay.

In addition, using the RiskScape model we will overlay buildings and infrastructure in Hawke's Bay to determine damage severity for different earthquake scenarios. This will include estimates of replacement costs, casualties, economic losses, business disruption, and number of people affected by liquefaction.

As part of the project, we will make recommendations for improving resilience in the region. This may include land-use planning options, retrofitting of buildings and infrastructure, building redundancy into infrastructure, and education and preparedness.

The project will provide a sound basis for selecting areas that are suitable for future growth. Equally, it will identify both developed and undeveloped areas that may be at risk from unacceptable economic losses in an earthquake.

It will also lead to a greater appreciation of the likely impacts of liquefaction. This ingredient was missing in the Christchurch earthquakes of 2010 and 2011. The methodology being used in this project will be applicable to other parts of New Zealand.

http://www.gns.cri.nz/Home/Our-Science/Natural-Hazards/Research-Programmes/Regional-RiskScape

RECENT INNOVATIONS

(2011-2014) Completed a series of major reports on slope stability and rock fall risk to help with zoning for Port Hills area of Christchurch (funded by Christchurch City Council, CERA and the Natural Hazards Research Platform)

(2011-2014) Provide ongoing monitoring and assessment of geological hazards for the 307 km-long Maui Gas Pipeline (commercially funded)

(2014) Developed a risk assessment tool for the NZ Transport Agency to help rank the geological hazards along the Milford Highway (funded by NZTA)

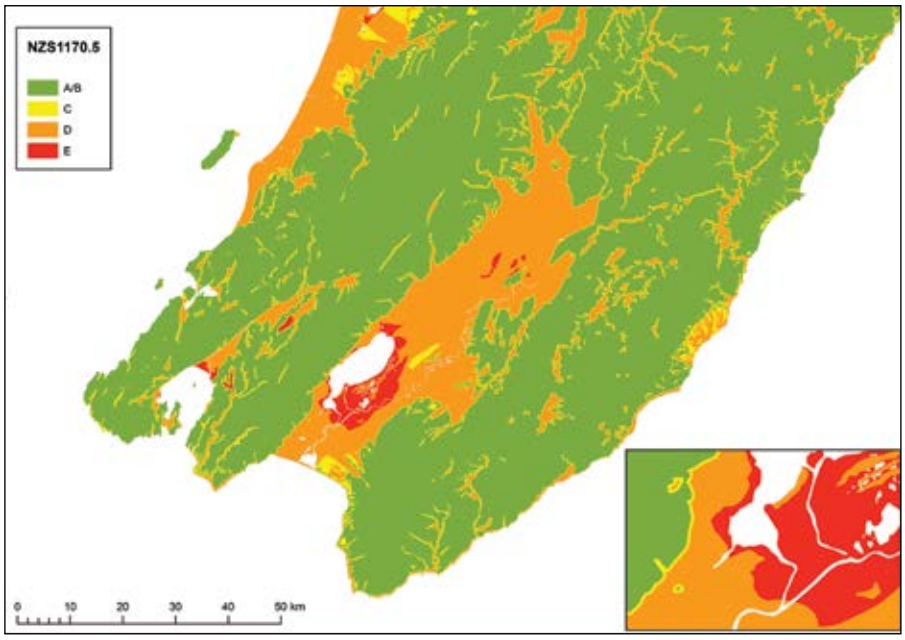
(2015) Revised and updated the Kapiti region liquefaction susceptibility map using a geomorphic map of much greater precision. The new map shows an 80% reduction in the area of the region prone to severe liquefaction compared to the existing map (funded by the It's Our Fault project)

ACHIEVEMENTS ENVISIONED IN OUR STATEMENT OF CORPORATE INTENT

Theme	Near-term goals	Progress/achievement
Resilient buildings and infrastructure (2% of core funding)	Calibrate liquefaction and lateral spreading models, and develop residential and infrastructural loss models, based on Canterbury data	Completed a major study of liquefaction hazard for Hawke's Bay using the liquefaction models and loss data from Christchurch for calibration.

EARTHQUAKE SHAKING AMPLIFICATION MAPS

This year our engineering geologists and seismologists produced an updated 'site class map' that indicates the expected level of amplification from earthquake ground-shaking throughout New Zealand. It updates an earlier version of this map and shows the thickness of soil over bedrock. Based on the recently completed quarter-million scale geological map of New Zealand, the map provides a 'first pass' indication of a building's likely structural design requirements for a particular site.



The degree of amplification of seismic waves is strongly linked to the underlying soil or rock type. Soils and loosely consolidated material will amplify earthquake shaking much more than solid rock sites. This means that deep and/or soft soil sites are likely to be subjected to damaging earthquake shaking more frequently than sites built on rock. The New Zealand Structural Design Standard accommodates this by determining the level of 'strengthening' required in a building according to the soil class of the site the building is located on.

The map shows five soil classes ranging from A, which is strong rock, to D (deep or soft soil) and E (very soft soil). The map can be used as an initial guide for planning purposes, but cannot be used for site-specific applications. This is because it is a generalised map based on geological mapping rather than site-specific geotechnical studies. A key feature of the map is the rate at which it can be updated as new information comes to hand.

Its aim is to give an informed estimate of the seismic response of soils where a structure is planned. As you move through the classes from A to E, construction costs increase. By referring to the map, it is possible to know at an early stage in planning, the likely engineering requirements, and therefore costs, a structure will need for a given site.

The Site Class map is being used in RiskScape, a tool that calculates potential economic losses and casualties at a given site from a variety of hazards. It therefore enables risks to be compared and ranked. The map is also used by GeoNet to calculate the speed of seismic waves as they propagate through the sub-surface. We make the map available electronically for use in Google Earth, and also as a GIS shape file.

GEOLOGY AND PAST CLIMATES

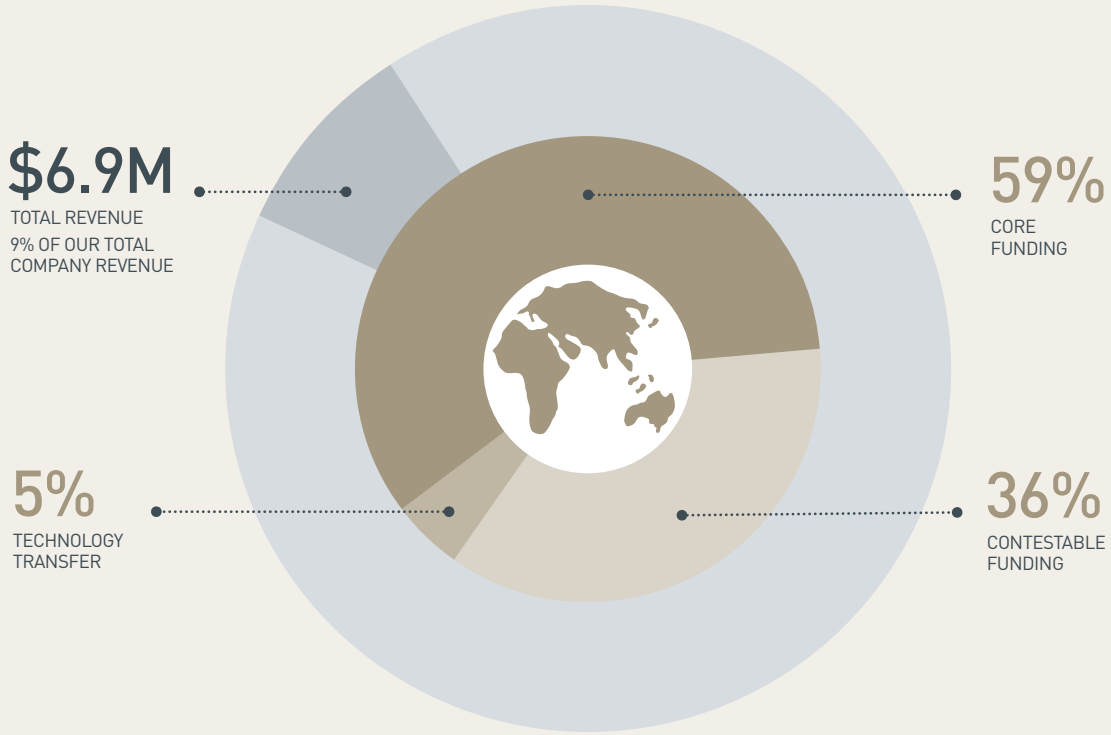
OUTCOME

INTRODUCTION

Our research increases the understanding of the geology and past climates of New Zealand, the Ross Dependency and Antarctica. We provide region-wide geological, geochemical, and geophysical information to improve knowledge of the dynamic processes occurring at, and adjacent to, the tectonic plate boundary.

As well as on-land mapping, we work to understand the geological makeup of our Exclusive Economic Zone and the Extended Continental Shelf. This region represents 96% of our soverign territory, but remains poorly mapped and explored. Finally, our activities in Antarctica help to guide government policy development in climate change and environmental issues.

REVENUE SOURCES



ANTARCTIC MODELLING POINTS TO ICE SHEET INSTABILITY

Modelling of interactions between the ocean and ice sheets has shown that temperature changes in the oceans around Antarctica could result in an abrupt rise in global sea level.

The research concludes that changes in salinity and temperature of seawater around the edge of Antarctica are making the ice sheets much more prone to melting.

The work is part of a research programme on past Antarctic climates led by GNS Science and involving scientists from Victoria University of Wellington and the University of New South Wales. The aim is to quantify how the Antarctic ice sheet will respond to future environmental warming.

The project team used sophisticated ice sheet and climate models to recreate the Antarctic ice sheet as it came out of the last ice age about 14,500 years ago, when the ocean and the atmosphere warmed quickly. Results indicate that rapid melting led to an increase in global sea levels.

Marine geological data from other studies were used as proxies for environmental changes in the Southern Ocean that helped interpret the model results, which together indicated that the ocean around Antarctica became more stratified, or layered, when reinvigorated ocean circulation brought warmwater southwards from the Northern Hemisphere. As this warm water upwelled against the Antarctic continental shelf, it melted the ice sheet faster and triggered a chain of events that accelerated ice sheet retreat.

When this took place 14,500 years ago, it led to a rapid loss of ice that contributed nearly three metres to global sea level rise in just 300 years. Observations of the ocean around Antarctica during the past 20 years show that seawater is once again becoming more stratified.

At the surface the water is getting colder and less salty. At the same time, the deeper ocean is warming, and is already accelerating the decline of glaciers on the smaller and less stable East Antarctic Ice Sheet.

It is still unclear if the ice sheet will react to these changing ocean conditions as rapidly as it did 14,500 years ago. However, with 10% of the world's population living less than 10 m above present sea level, this study highlights the importance of this research to better define the complex relationship between Antarctica and the Southern Ocean.

The next phase of work, already underway, aims to predict the future changes that may occur in the Antarctic ice sheet, and the effects this may have on sea level over coming centuries. These predictions help guide government policies both nationally and internationally.

Learn more about our climate research at: http://www.gns.cri.nz/Home/Our-Science/Environment-and-Materials/Climate-Change

RECENT INNOVATIONS

(2011-2014) Recovered and analysed 763 m of ice core from Roosevelt Island in Antarctica to determine annual climate conditions going back many thousands of years (collaboratively funded by the nine participating countries)

(2013) Determined how the ocean circulation around NZ worked during a time interval of slightly warmer than present climate (core funded)

(2014–2015) Developed touring exhibition of 70 million year-old dinosaur footprints visiting NZ centres in 2014 and 2015 (funded by New Zealand Oil & Gas plus venue contributions)

(2015) Fully calibrated the geological stages and series that comprise the NZ Geological Timescale to the current International Geological Timescale for the first time (core funded)

(2015) Dated glacier moraines in the Southern Alps using the cosmogenic isotope ^{10}Be showing that during the last glaciation (65,000 to 18,000 years ago) there were at least eight major episodes of glacier expansion to maximal size. This indicates more variability of atmospheric temperature during the glaciation than previously realised (core funded plus support from international collaborators)

ACHIEVEMENTS ENVISIONED IN OUR STATEMENT OF CORPORATE INTENT

Theme	Near-term goals	Progress/achievement
Isotope biogeoscience (2% of core funding)	Atmospheric verification of fossil fuel CO_2 emissions	Recent focus of quantification and attribution of atmospheric fossil fuel CO_2 emissions has been on reconstructing past emissions using the radiocarbon content of tree rings. We are trialling this method by investigating Auckland and Wellington urban fossil fuel and natural CO_2 emissions.
	Initiate applications for *in-situ* ^{10}Be dating of geological exposures and erosion	The joint GNS-VUW capability to process and measure samples for cosmogenic isotope dating of landscape evolution is being applied at Lake Ohau, Lake McRae, and Antarctica.
Paleoclimate (8% of core funding)	Recover and interpret NZ sedimentary records and Antarctic ice cores for climate reconstruction and testing of climate models	Completed isotope analysis of the remaining 263 m of ice core from Roosevelt Island. Ages of the ice from 0 to 50,000 years are well understood. Further analysis is needed to determine the age profile of the lower part of the core. Analysis of Lake Ohau cores has produced an annually resolved climate history for the past 1300 years.
Biostratigraphy (2% of core funding)	Refine age control of geological intervals relevant to petroleum exploration	Completed a new age-calibration of the New Zealand Geological Timescale, integrating paleontological, isotopic and paleomagnetic data from NZ strata with the latest International Geological Timescale. Results refine the ages of NZ stratigraphic units (in millions of years), determine the synchrony of geological events, and improve estimates of the rates of geological processes.
Regional geology (7% of core funding)	Publish the second edition of the 1:1M Geological Map of NZ	New 1:1M-scale geological map of NZ produced on DVD and on web services presenting a simplified summary of the 21 individual maps in the QMAP series.
	Complete geological datasets and 3D models for the Dunedin and Napier-Hastings urban areas	Compiled drillhole dataset for Dunedin area and finished preliminary 3D model for Napier-Hastings urban areas.
	Publish geological map of Tongariro National Park	Map of Tongariro National Park in final stages of completion.
Tectonics, structure and landscape evolution (12% of core funding)	Improve understanding of crustal motion, especially slow-slip events	Successfully recovered 40 seabed instruments after a 12-month deployment in Poverty Bay measuring small sub-seafloor quakes and tectonic phenomena. Have deployed more seafloor instruments in the same area prior to scientific drilling in 2018, offshore from Gisborne.
	Improve the national gravity model	In conjunction with Geoscience Australia, LINZ, University of Otago and Callaghan Innovation, GNS Science completed an absolute gravity survey of key locations in both the North and South Islands. These data will be used to calibrate New Zealand Primary Network gravity sites and the New Zealand aerogravity survey.
	Recover and interpret rock record across Alpine Fault	Recovered cuttings and core from 893 metre-deep Alpine Fault drillhole at Whataroa. Samples are currently being analysed at the University of Otago, Victoria University of Wellington, and at specialist facilities in the US, Japan, and Germany.

BASELINE GEOCHEMICAL SURVEY OF SOUTHERN NEW ZEALAND

We have completed a pilot project to collect baseline geochemical and isotope measurements from soils throughout Southland and southern Otago. Our geologists collected the hand-augered soil samples at a grid spacing of 8 km across the two provinces.

The resultant 'element concentration maps' will help scientists, governments and the public understand the current state of our environment. The information will be particularly useful for studies of human health, food production, mineral exploration, and tracing the origin of agricultural products.

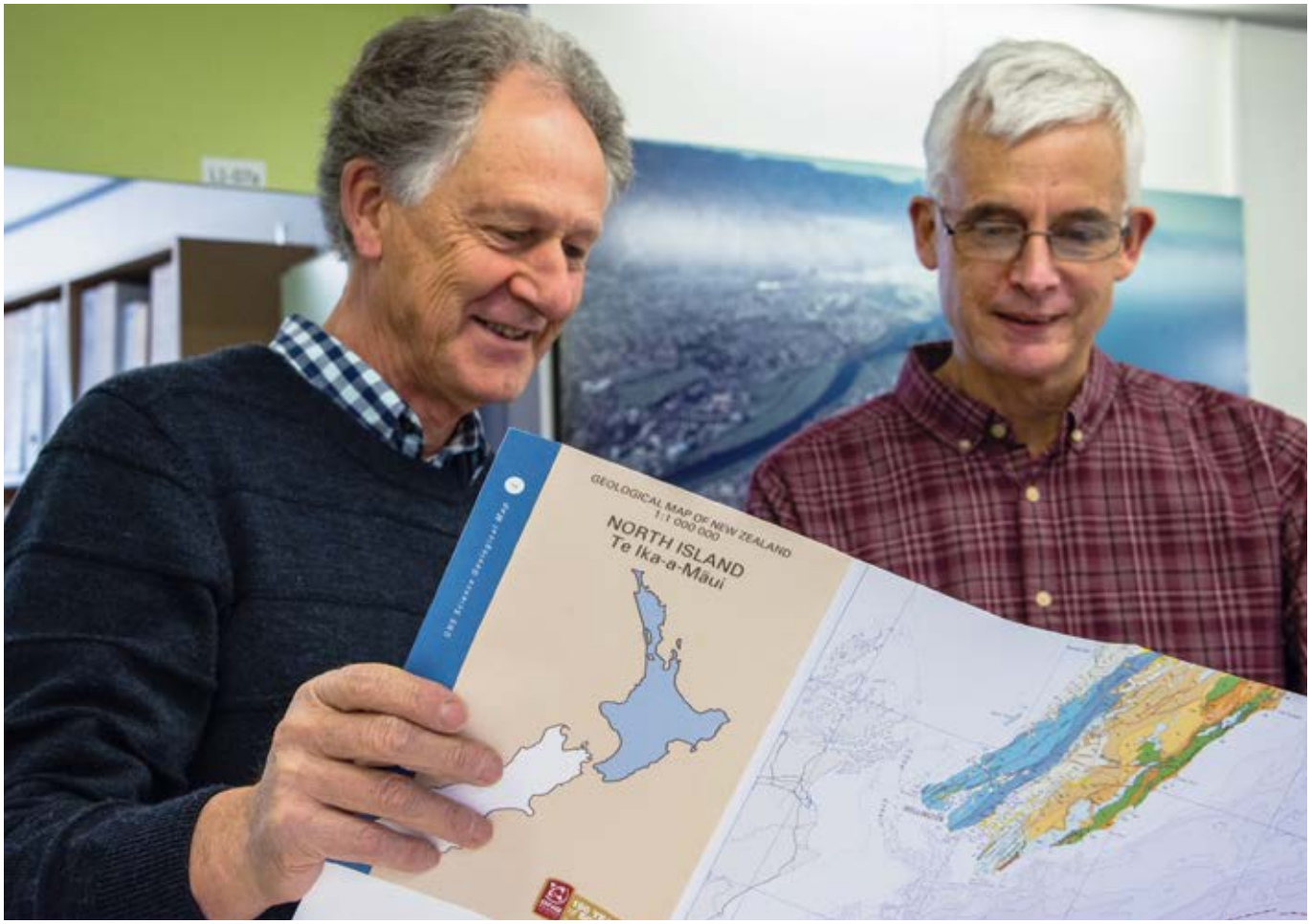
At each of the sample sites across the two provinces, we collected soil samples from 0 to 30 cm and 50 cm to 70 cm depths. We analysed the samples for 66 elements and oxides and several isotopes and have produced a e geochemical atlas of the area. The element concentration maps in the atlas show some elements such as antimony, chromium, copper, iron and sodium have higher concentrations in specific parts of southern New Zealand. In many cases we think this reflects the influence of the varying underlying geology where the rocks beneath the soil we sampled are a major contributor to the local geochemical signal.

Other elements such as cadmium, lead and sulphur are not as obviously linked to the geology and may reflect human influence on our soils through, for example, the application of fertilisers or release of industrial pollutants.

Now that the pilot is complete, we are undertaking a follow-up project to better understand the natural versus human contribution to the geochemical landscape, including new, close-spaced sampling and analysis of Dunedin City soils. We will use the geochemical atlas as an exemplar to generate enthusiasm for sampling other cities, other regions and nationally.

Our partners in this project have been the universities of Otago, Canberra and New South Wales, and Environment Southland. The data will be freely available on our national rock and geoanalytical database.

Learn more about our geochemical survey at: http://pet.gns.cri.nz



ANNIVERSARY GEOLOGICAL MAP HITS THE SPOT

A century and a half after the production of the first geological map of New Zealand, GNS Science has published what could be regarded as the ultimate update map – a new one to one million-scale geological map of the whole country.

Available in print format and also as digital data on a DVD and through web services, the new map presents a simplified summary of the 21 individual maps in the recently completed QMAP series – for 'quarter million scale map'. The anniversary product supersedes the 1:1 million geological map of New Zealand released in 1972.

It is published as full-colour separate North and South Island maps, with each on a folded A0-sized sheet and each sheet having a detailed geological legend. A 100-page supporting text is currently in production and is expected to be available early in 2016.

The new maps include offshore islands such as the Kermadec and sub-Antarctic islands, areas that were beyond the scope of the QMAP series. A point of difference is that full colour maps are becoming much less common with the advent of digital products.

While national in scale and summarising the country's geology, the two maps present enough detail to provide useful geological information on specific areas.

In some parts of the country the difference between the 1970s map and the new product is modest. However, in other places there are marked differences. Fiordland and Northland, in particular, are two regions where geological understanding has advanced significantly in recent decades, and this is reflected in the new maps.

Both map sheets are available in digital vector GIS data format as a combined dataset on DVD. This includes comprehensive information about the mapped rock units, their stratigraphic affiliation, and deposition or emplacement age. Attribute information on faults includes name, age, amount of displacement and type of movement. The maps and DVD can be ordered through GNS Science's publication sales team.

Learn more about our mapping work at: http://www.gns.cri.nz/Home/Our-Science/Earth-Science/Regional-Geology

SCIENCE OUTLOOK

Dr Kevin Faure
Director of Geological Resources Division

GNS Science plays a key role in the understanding of New Zealand's resource potential and attracting exploration and investment in the resources sector. We provide scientific knowledge that enables New Zealand to discover oil and gas to minimise our dependence on imported fuels. Our research also ensures that the country increases its use of renewable energy. We do this by assisting geothermal energy providers with technical knowledge to maintain geothermal fields and to ensure that New Zealand can increase geothermal electricity generation when required.

New Zealand needs to know what mineral resources it has to be able to provide the raw materials to support a vibrant economy. Our role is to provide unbiased and sound scientific research, geological data and maps, and reports to our end-users: industry, academia, the public, and government agencies. We have a long track record in producing high quality research - fundamental and applied - for a prosperous, healthy and safe New Zealand.

Supercharging the geothermal energy industry

Geothermal generation produces about 16% of New Zealand's electricity and we are proud to be contributing to this industry. Two of the main challenges facing the industry are improving the efficiency of existing field management operations and developing reliable assessments of new geothermal resources.

The New Zealand government has given us funding to meet these challenges. The 'geothermal supermodels' research programme is focussed on developing the next generation of geothermal numerical modelling software to support decision-making and efficient and sustainable use of geothermal resources.

The aim is to combine specialist models from geology, geophysics, geochemistry and reservoir simulation to provide a geothermal supermodel. Like much of our research, collaboration is at the heart of this project. It is led by GNS Science and The University of Auckland and involves input from regional councils and geothermal development companies in New Zealand, Japan and the Philippines, plus researchers from the United States, Australia, Switzerland, Iceland and Italy.

As well as improving the ability to simulate individual geothermal systems, the research will offer regional councils the ability to assess the future impact on neighbouring geothermal systems. Outputs will also enable geothermal researchers to develop models of a geothermal system that include all known facets from rainfall at the surface, to the magmatic heat sources in the basement rocks. These models will give geothermal operators unprecedented ability to assess deep energy sources in the central North Island for future geothermal development.

New frontiers in petroleum exploration

Oil and gas production in New Zealand comes from just one area – the Taranaki Basin. Local petroleum production contributes billions of dollars per year to the nation's economy. Our Exclusive Economic Zone contains at least 17 other sedimentary basins that are only lightly explored for oil and gas. One large discovery has the potential to dramatically improve our economic fortunes.

In the past 12 months the New Zealand government awarded us funding for a four-year programme to investigate the full extent of our petroleum endowment. We are doing this by synthesising the wealth of existing and new data, and knowledge within GNS Science and other open-file sources, to produce a nationally significant dataset that summarises in one place, for the first time, the present understanding of our geologically complex offshore petroleum basins.

The results of this research will provide information to the government to decide where exploration permits should be and show where new data could be collected. It will also enable new investors to quickly appraise the exploration potential of sedimentary basins.

Oceans of opportunity

As an island nation with a marine jurisdiction 14 times the size of California, New Zealand has continental-scale marine resources, responsibilities and opportunities. Our role is to survey the seabed in New Zealand's vast offshore estate, a task that is large by any measure.

During the past 12 months we completed seven research voyages within our marine territory. Our focus has been collecting seismic data along the North Island's east coast and in sedimentary basins in the Tasman Sea. We have also continued investigations of the submarine volcanoes and sea-floor hydrothermal vents along the Kermadec Arc.

These expeditions, and those in the future in the same areas, provide information on New Zealand's oil and gas and gas hydrate potential and seafloor minerals, also known as massive sulphide deposits.

Doing research at sea is expensive, requiring large and sophisticated infrastructure, so partnerships are crucial. An important partner for us is the International Ocean Discovery Program (IODP), which is one of the largest earth science organisations in the world. The IODP JOIDES Resolution Facility Board has committed to drilling on the Hikurangi margin in 2018 to investigate the physical controls on subduction earthquakes, including very slow moving (days to months) slip events and tsunami.

This landmark project will be the world's first under-sea drilling probe to investigate slow-slip earthquakes, and it will take place about 50 km east of Gisborne.

From late 2015 to the end of 2016, we will participate in seven national and international marine surveys in New Zealand waters. The cumulative cost of these voyages is well over $25 million, and thanks to the consortium approach to these expeditions New Zealand will bear only a portion of that cost.

SCIENCE OUTLOOK

Dr Chris Daughney
Director of Environment and Materials Division

New Zealand's natural environments are key to our culture and national identity. Our water, air and land resources support our health and wellbeing, and underpin major sectors of the economy such as agriculture and tourism.

GNS Science undertakes basic and applied research in environmental and earth sciences, providing data, models and knowledge to a wide range of end-users and stakeholders. Our expertise in geology provides essential information for environmental management. For example, groundwater is housed within geological formations known as aquifers, which supply about one third of the nation's water needs.

Our expertise in isotope science also supports many aspects of environmental stewardship. For instance, by highly accurate measurement of the isotopic composition of water in aquifers, rivers and lakes, we can determine where and how long ago that water fell as rain. We also use isotope methods to identify the source and fate of nutrients as they move through soils and waterways. We provide this information to regulators, policy makers and the New Zealand public to support sound and sustainable environmental management across the nation.

Empowering improved fresh water management

New Zealand's water resources are under increasing pressure from abstraction, land use intensification, and climate change. The government has introduced new policies and regional plans to ensure that the nation's valuable water resources will be sustainably managed for future generations. Our science plays a key role in achieving these management aspirations.

Empowering improved fresh water management will require more measurement and monitoring. Over many decades we have worked to characterise, map, monitor and model New Zealand's main aquifer systems. For the past few years our research has had greater emphasis on novel methods that allow aquifer systems to be mapped and characterised much more quickly and cost-effectively.

Over the next decade these new techniques will move into mainstream use by regional councils and other environmental managers. For example, rather than the current approach of relying on measurements from a few widely spaced monitoring stations, soon national-coverage data from satellites will be routinely used to map the amount of water that is replenishing our aquifers.

Similarly, in the near future fibre optic cables will be commonly used to measure the exchanges of water between rivers and the underlying aquifers with very high spatial and temporal resolution.

We are also developing advanced sensor materials and network systems. All of these next-generation techniques will provide much richer data to assist regional councils in managing aquifer systems.

Empowering improved fresh water management will also require new methods for interpreting and communicating the key information from ever-larger datasets. There is an expectation that environmental monitoring information will be delivered in real time. We are also facing the expectation that the key information will be conveyed using pathways and formats that are specifically adapted for a wide range of stakeholders. Part of this involves the use of data mining algorithms to rapidly transform large datasets into useable information. We envisage that the application of these new methods for collecting, synthesising and disseminating information will soon be used across New Zealand to support fresh water management.

Increasing value from authentication

New Zealanders are becoming more discerning about the things they buy and consume. We want to know that a product is really what is claimed on the label, and we want to be assured that its production has not harmed the environment. Global markets are showing similar trends. Over many years GNS Science has been developing and using isotope and multi-element analytical techniques for product authentication.

Our work over recent years on techniques for authentication of manuka honey has supported this export industry, worth about $130 million annually. We are developing other authentication applications that will provide similar assistance to other products and services, helping to capture greater returns for New Zealand in global markets.

We also measure the radiocarbon content of atmospheric carbon dioxide to determine how much of this greenhouse gas has been produced by burning of fossil fuels, as opposed to from other sources. In coming years, we expect authentication work will become increasingly important. In particular, measurements that provide direct evidence for sustainable production practices can provide an opportunity to capture greater value from exports of our biological products into global markets.

Materials science for sensors and surfaces

GNS Science has a long history of research into nanotechnology and advanced materials for a wide range of applications. In recent years, our main focus has been in two areas: sensor devices and systems, and functional surfaces. Both of these application areas have rapidly expanding global markets that are already worth billions of dollars. We have created a niche for ourselves through the use of ion beam and related techniques.

With these techniques we are able to precisely and consistently modify the near-surface region of metallic and other substrates, to increase hardness, wear resistance, hydrophobicity or other characteristics, or to enhance performance in sensor applications.

We are working closely with a number of New Zealand manufacturers, such as the Gallagher Group in Waikato, to develop and prototype the devices needed for security systems, food processing, energy savings, medical applications, and other markets.

We anticipate that the niche capabilities we bring to this research area will enable New Zealand companies to succeed in global markets, which will ultimately deliver benefits for the nation.

SCIENCE OUTLOOK

Dr Gill Jolly
Director of Natural Hazards Division

Our research in the Natural Hazards Division encompasses a very broad set of scientific disciplines. Our main focus is on delivering trusted advice to stakeholders so they are able to make robust decisions on reducing risk associated with landslides, volcanoes, earthquakes and tsunami. A significant portion of our teams are also involved with understanding the underpinning earth system processes: what controls the location and timing of earthquakes and volcanoes; how does the landscape respond to tectonic, environmental and climatic processes; and where can we find important resources for the country.

Our approach is to team up with the best researchers in New Zealand and internationally, to collaborate closely with our stakeholders and to deliver the best quality science to underpin our advice to all of New Zealand. We will continue to build multidisciplinary teams to answer key questions and deliver significant impact for the country.

The future of GeoNet

Over the last 15 years, GeoNet has become a household name in New Zealand. It is an international exemplar of how to monitor geological hazards and provide timely information to the people who need it. For example, New Zealanders can now see where an earthquake occurs and the magnitude of the shaking in their neighbourhood within seconds on their mobile devices.

Over the next 15 years, it is difficult to envisage where technology will take us. In 2000, it would have been hard to imagine that nearly everyone from school children to grandparents would have access to the internet in the palm of their hands. But GeoNet is well equipped to be at the leading edge of delivery of hazards information to everyone in New Zealand, when and where they want it.

Looking forward, GNS Science envisages that, in partnership with EQC, the Ministry of Civil Defence and Emergency Management and other stakeholders, the GeoNet project will continue to go from strength to strength. The thirst for trusted knowledge will require us to develop and deliver better real-time forecasts for all geological perils and their impacts so the public can be better prepared for impending events and know how to respond when an adverse event does happen.

Understanding and communicating multi-hazard risk

Critical to a resilient society is the ability to understand and mitigate the risk from the range of hazards we encounter. Individuals, community leaders and society as a whole need sound information on which to base decisions: what are the priorities for action and what methods do we have to reduce our risk?

Understanding geological processes and the hazards they pose to society is the first step to quantifying risk: if we can discover new insights into when, where, why and how a volcano erupts, an earthquake strikes, landslides occur or a tsunami is triggered, we can build models to compare risks between different perils.

Risk can be treated by a range of mitigation methods: avoid, transfer, reduce, or accept. The research that GNS Science undertakes underpins decisions about which treatment option is the most optimal: do we avoid a lahar by not building in potential pathways for future events; can we transfer the risk by insurance, and if so, how can insurers better assess the premium we should pay; can we strengthen our buildings in areas of high earthquake activity, thus lowering the likelihood of business interruption? Or do we have the discussion with our communities that we are comfortable to accept a certain level of risk from a low probability, high impact event such as a Tohoku-size tsunami, so long as we build in safeguards such as good evacuation planning?

Looking forward, GNS Science is uniquely placed to inform the national conversations on natural hazards risk. We will develop multi-hazard risk models, we will engage with decision-makers to guide the most effective methods for risk mitigation and we will improve our knowledge of how best to communicate risk to all New Zealanders.

Mapping our landscape

From 1993 to 2012, we undertook a major project to map the geology of New Zealand. It resulted in 21 maps at the scale of 1:250 000 using modern analytical techniques. The maps and the accompanying text describe and illustrate the tectonic history, geological resources, geological hazards and engineering geology of each area. So what do we do next; have we not finished mapping?

This is a question that modern geological surveys around the world have been grappling with for several years. GNS Science has risen to the challenge and we have started several initiatives that will probe the surface and subsurface of our country.

Our urban areas are critical to our economic growth. As we saw in Christchurch in 2010-11, our infrastructure and buildings are only as resilient as the ground on which they stand. If we can characterise the sub-surface structure better, we can understand the potential for liquefaction, the impacts of ground-shaking on steep slopes, and the sustainable resources that we need to ensure our communities thrive. Over the next 10 years, we will progressively build three dimensional models of our major centres to better inform urban growth.

We have also initiated an ambitious programme to sample and geochemically analyse the soil beneath our feet. The chemistry of soil reflects both the type of underlying rock and the impact of environmental factors such as pollution or climate change. We have successfully completed a pilot study of southern New Zealand to test the methodology, and we plan to roll this project out across the country. This will provide us with deeper knowledge to understand the underlying resources and give us a baseline against which we can track environmental change.

SELLING OUR TECHNOLOGY TO MULTI-NATIONALS

This year we chalked up a milestone by selling home-grown meat scanning technology to a multi-national. We developed the technology with our joint venture partner, ANZCO Foods, a major player in the New Zealand meat processing industry.

Developed under the Meatvision brand, the scanner uses GNS Science-developed software to make instantaneous measurements of fat content of red meat on conveyer belts before the product leaves the processing plant for overseas markets. The technology has advanced quality control in New Zealand's red meat industry, saving millions of dollars a year. Multi-national precision instrument-maker, Mettler Toledo, paid an undisclosed sum for the technology in June 2015.

Red meat is sold internationally based on its fat content – a measurement known as 'chemical lean' or CL and different markets require different CL measurements. If a consignment falls outside a required CL standard, there can be financial claims against the exporter.

The scanner systems were developed by our Environment and Materials division in Lower Hutt. Prior to the introduction of the real-time meat scanner, the industry took small samples of meat from export boxes for testing in a laboratory – a process that was expensive and time-consuming. At the heart of the scanner is Dual Energy x-ray Absorptiometry (DEXA) technology used in airport scanners and in medicine for bone density scans.

ANZCO Foods provided the industry knowledge and experience to ensure the technology would work for the industry. Its meat plant at Eltham, Taranaki, championed the technology, ran trials and provided feedback on its performance.In the early stages of development, the project received government funding to assist innovative manufacturing.

The scanner has been earning royalties and saving millions of dollars annually for the New Zealand meat processing industry since it was introduced about 10 years ago. Even though we have sold the technology, the scanners will continue to benefit the New Zealand meat industry for years to come.

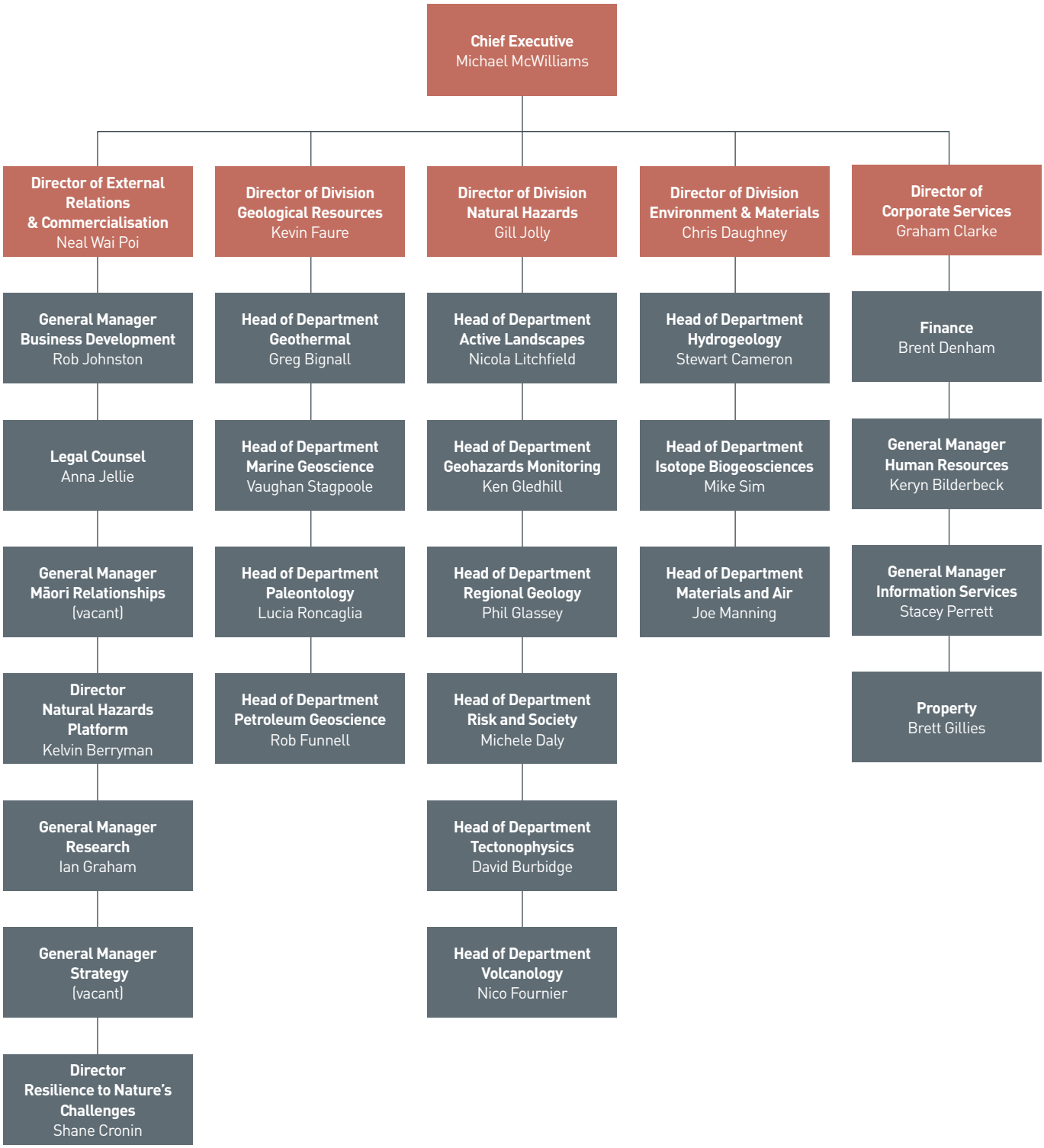
Mettler Toledo is now selling the application through a range of fat analysis systems called Eagle FA which are engineered, marketed, sold, and serviced through its Eagle Product Inspection subsidiary.

Today there are numerous scanners operating in Australian and New Zealand meat plants, and Eagle FA scanning systems are also being used in a dozen countries including the United States, Ireland, Germany, Mexico, Australia, Uruguay, United Kingdom, and Canada.

We regard the Eagle FA scanner as a classic story of a smart New Zealand invention that is being used all over the world. It has been a great example of researchers and industry working together.

Revenue from the sale will be reinvested in the development of further new technologies.

ORGANISATIONAL STRUCTURE



BOARD OF DIRECTORS

Dr Nicola Crauford [1]
Chairman
BSc, PhD, CPEng
Wellington
(Appointed 1 July 2015)

Nicola has extensive management and governance experience gained in private and state owned companies. She is a director of Watercare Services Limited, Orion New Zealand, the Environmental Protection Authority, Wellington Water Limited and the Wellington Rural Fire Authority. Nicola is a member of the Local Government Risk Management Agency Establishment Board. She was formerly a member of Transpower's executive team and a director of Genesis Energy.

Hon Ken Shirley [2]
Deputy Chairman
BSc
Wellington
(Appointed 1 July 2010)

Ken is a former Minister of Fisheries, Associate Minister of Agriculture and and Forestry, and Health. He is Chief Executive of the NZ Road Transport Forum, a Director of the Motor Industry Training Organisation, and a member of the Human Rights Review Tribunal. He is a former Chief Executive of the Researched Medicines Industry Association, the NZ Forest Owners Association, and Organics Aotearoa NZ.

Professor Steve Weaver [3]
BSc Hons, PhD, DSc, FGS, FNZIC, FRSNZ
Christchurch
(Appointed 1 July 2010)

Steve is Deputy Vice-Chancellor (Research) and former Head of the Department of Geological Sciences at the University of Canterbury. He has 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 REANNZ Ltd, Brain Research NZ, the Canterbury Medical Research Foundation and the New Zealand Brain Research Institute. 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.

Belinda Vernon [4]
BCom
Auckland
(Appointed 1 July 2011)

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.

James Johnston [5]
LLB
Wellington
(Appointed 1 July 2013)

James is a commercial lawyer and Chairman of Partners at Rainey Collins Lawyers, where he heads the Business & Personal Legal Services Team. He is a former Chairman of the New Zealand Law Foundation and was the Lead Legal Counsel for the Ngāti Porou Treaty Settlement negotiations with the Crown. James is also the Chairman of the Samuel Marsden School Management Board, and is an External Specialist Advisor to the Ministry of Justice Legal Aid Services Group. He is a past Chairman of Toi Whakaari, the New Zealand Drama School. James is a New Zealander of Ngāti Porou descent.

Sarah Haydon [6]
BSc, ACA, CInstD
Auckland
(Appointed 1 July 2014)

Sarah is a director of The Co-operative Bank Limited, a Council member of Unitec, Chair of Cavalier Corporation Limited, Chair of New Zealand Riding for the Disabled Association Inc, an Executive Committee Member of Waste Disposal Services, and a trustee of a charitable trust. 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.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EXECUTIVE TEAM

Dr Michael McWilliams[1]
Chief Executive
PhD, Australian National University

Mike leads the GNS Science Executive, directs the management of the Company and is responsible for strategy, policy, investment and science programmes. Before joining GNS Science in September 2013, he served as Chief of the Division of Earth Science and Resource Engineering at CSIRO between 2008 and 2013. There he led the development and transfer of new technologies to solve national challenges in the Australian energy and minerals sectors. He was Professor of Applied Physics and Director of the John de Laeter Centre for Isotope Research from 2006 to 2008. Mike was a scientist and teacher at Stanford University for 29 years, beginning as a postdoctoral scientist and culminating as Professor of Geological and Environmental Science.

Dr Neal Wai Poi[2]
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-focussed 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 Kevin Faure[3]
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.

Dr Chris Daughney[4]
Director, Environment and Materials Division
PhD, McGill University, Montreal, Canada

Chris leads the Environment and Materials Division, which includes research teams and commercial service units in Hydrogeology, Air Quality, Isotope Biogeosciences and Materials Science. Chris 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.

Graham Clarke[5]
Director of 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, human resources, information services, property, procurement, health and safety, risk management and internal audit. A chartered accountant, Graham worked for KPMG in New Zealand and the UK, and joined GNS Science in 1994. Graham is a director of Meatvision Limited, one of our joint venture operations

Dr Gill Jolly[6]
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 130 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. Her current research includes volcanic risk assessments and volcanic crisis management. She was formerly a director of the Montserrat Volcano Observatory in the West Indies.


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PERFORMANCE INDICATORS

These indicators include those specified in our Statement of Corporate Intent.	**Actual 2015**	Budget or Expected Range 2015	Actual 2014
Financial performance indicators and targets			
Return on equity	**5.9%**	8.0%	5.4%
Revenue per FTE ($000s)	**212**	214	207
Profit[1] per FTE ($000s)	**20.2**	24.0	19.9
Equity ratio	**56.0%**	63.3%	54.2%
Capital renewal ($000s)	**5,860**	7,800	5,995
Human resources indicators			
Full-time equivalents (FTEs):	**368**	360-380	371
Scientists and specialists	**262**	255-260	260
Science support	**66**	50-60	54
General support and management	**40**	55-60	57
Distribution of science effort (FTEs):			
Research	**179**	150-160	161
Technology transfer	**149**	155-160	153
Staff turnover	**5.6%**	6%-8%	6.1%
ACC workplace safety accreditation	**Tertiary**	Tertiary	Tertiary
Injuries, causing missed work days, per million work hours	**3**	<10	11
Staff engagement (% proud to work at GNS Science)	**73%**	>80%	*
Research collaboration indicators			
Joint peer-reviewed publications with New Zealand or international institutions (calendar year):			
Number	**261**	>220	210
Percentage with international institutions	**67%**	65%-69%	65%
Percentage with other New Zealand institutions	**22%**	22%-26%	23%
Percentage with only GNS Science co-authorships	**11%**	7%-11%	12%
Number of visiting researchers hosted	**89**	60-100	90
Value of research contracts to other research organisations ($000s)	**9,800**	>7,000	9,269
Value of research contracts from other research organisations ($000s)	**4,525**	2,200-2,800	2,708
Number of graduate scholarships funded	**16**	25-35	33
Number of graduate students supervised	**115**	100-120	141
Research indicators			
Research science effort (FTEs):	**179**	150-160	161
by scientists	**143**	125-130	133
by science support staff	**36**	25-30	28
Peer-reviewed science papers and book chapters (in preceding calendar year)	**265**	290-330	275
Number of research monographs and maps (in preceding calendar year)	**3**	0-4	4
Other journal papers and publicly available science reports (in preceding calendar year)	**78**	50-90	74
Publication rate (peer-reviewed science papers/monographs/chapters per research FTE)	**1.9**	>2.0	2.1
Number of citations of publications for each of the five preceding calendar years:			
2014	**6,542**	>4,500	-
2013	**6,002**	>4,500	6,002
2012	**6,361**	>4,500	6,361
2011	**5,298**	>4,500	5,298
2010	**5,704**	>4,500	5,704
2009	**4,525**	-	4,525
Use of science - h_1-score (number of publications with at least this same number of citations)	**90**	>80	84
Scientist visibility - h_2-score (number of staff with an h-score of least this same number)	**22**	17-21	20

These indicators include those specified in our Statement of Corporate Intent.	**Actual 2015**	Budget or Expected Range 2015	Actual 2014
Technology transfer indicators			
Commercial revenue ($000s)	**29,713**	>34,000	31,576
Technology transfer effort (FTEs)	**149**	155-160	153
Commercial revenue per technology transfer FTE ($000s/FTE)	**199**	213-219	206
Technology and knowledge transfer			
(a) Commissioned reports (ca. 55% technology transfer revenue)	**286**	270-300	261
(b) Earthquake (M>4) reports (ca. 28% technology transfer revenue)	**637**	>500	585
Tsunami, landslide and volcanic eruption reports	**8**	5-10	7
(c) Laboratory analysis reports (ca. 11% technology transfer revenue)	**20,821**	>20,000	20,025
IP licensing (incl technologies, products, services) in New Zealand and overseas:			
Number	**33**	25-50	29
Value ($000s)	**402**	1,000-2,000	1,223
Client feedback average score (out of 10)	**6.5**	7-8	7.0
Projects achieving outcomes or creating opportunities for Iwi/Māori	**15**	20-30	26
Database use:			
Number of databases accessible to the public via the web	**29**	>30	26
Registered external users of GNS Science data	**5,479**	>3,000	5,909
Number of unique users accessing the GNS Science website:			
per annum	**541,531**	>300,000	488,565
daily peak	**4,994**	>1,000	18,149
Number of users accessing the GeoNet website:			
per annum	**4,879,681**	>3,000,000	5,392,974
daily peak	**294,209**	>100,000	655,032

* no staff climate survey carried out for the 2013/14 year

[1] profit is before interest, tax, depreciation and amortisation

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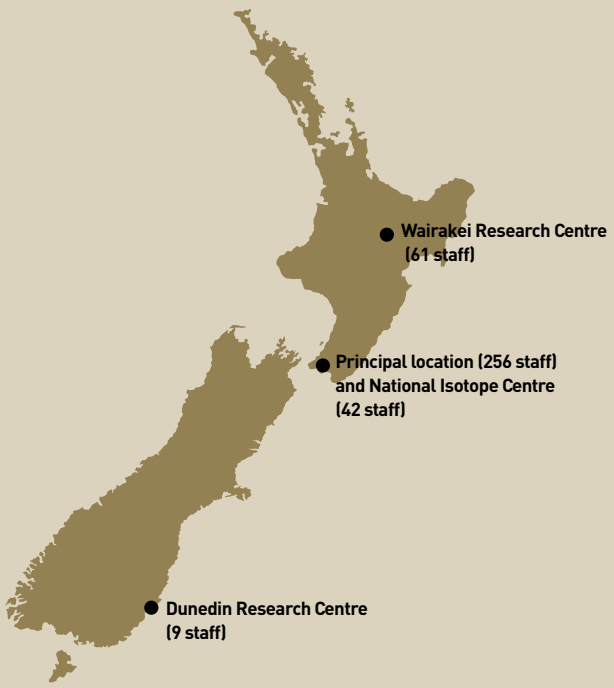
Our office locations and staffing



Directors

Dr Nicola Crauford
(Chairman)

Hon Ken Shirley
(Deputy Chairman)

Sarah Haydon

James Johnston

Belinda Vernon

Prof Steve Weaver

Executive

Chief Executive
Dr Michael McWilliams

Director
External Relations
and Commercialisation
Dr Neal Wai Poi

Director
Natural Hazards
Dr Gill Jolly

Director
Geological Resources
Dr Kevin Faure

Director
Environment and Materials
Dr Chris Daughney

Director
Corporate Services
Graham Clarke

General Manager
Business Development
Rob Johnston

General Manager
Human Resources
Keryn Bilderbeck

General Manager
Research
Dr Ian Graham

Legal Counsel
Dr Anna Jellie

Director, Natural Hazards
Research Platform
Dr Kelvin Berryman

General Manager
Information Services
Stacey Perrett

Director
Resilience to Nature's
Challenges
Prof Shane Cronin

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ANZ

Auditor

Trevor Deed
Deloitte
On behalf of the
Auditor-General

Solicitors

Minter Ellison Rudd Watts

Websites

www.gns.cri.nz
www.geonet.org.nz
www.globeclaritas.com

Designed and produced by Scenario.co.nz

PHOTOGRAPH ACKNOWLEDGEMENTS

C James Hector – City of Vancouver Archives

C/IC Portraits – Steven Boniface

IC James Hector – NZ Geological Survey

IC Displaced fence on Hope Fault – Alexander Mckay, NZ Geological Survey

IC Athol Rafter – Graham McCallum, Institute of Nuclear Sciences

IC Harold Wellman – Wellman family album

IC Tangiwai rail disaster – Morrie Peacock, MP-0059-11-F. National Library of NZ

IC Wairakei steam bore – Don Gregg, DSIR

IC Cape Roberts project – GNS Science

IC Mt Ruapehu erupts in 1995 – Fairfax Media

IC Technician Shawn Hateley servicing monitoring equipment at the summit of Mt Ruapehu – Richard Johnson, GNS Science

IC CBD damage, Christchurch earthquake – Margaret Low, GNS Science

P2 SH1 south of Taihape – Margaret Low, GNS Science

P5 Huka Falls, Waikato River – Margaret Low, GNS Science

P6 Mt Ruapehu Crater Lake – Dougal Townsend, GNS Science

P9 Wairakei Geothermal field – Margaret Low, GNS Science

P13 Bill Trompetter with an air filter in the Ion Beam Lab – Kate Whitley, GNS Science

P13 Karyne Rogers prepares to analyse a honey sample in the Stable Isotope Lab – Margaret Low, GNS Science

P15 Photo – Gerry le Roux, Sciencelens Ltd

P16 Hands-on geology in Hawke's Bay – Kyle Bland, GNS Science

P21 Wairakei geothermal field – Margaret Low, GNS Science

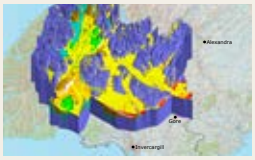
P22 GNS Science delegates at WGC – Farrell Siega, MRP

P23 Sugarloaf and Mt Taranaki (Egmont) – Rob Tucker (robtucker.co.nz)

P24 Matt Stott collecting extremophiles at Waiotapu thermal wonderland – Jean Power, GNS Science

P26 Uwe Morgenstern sampling water at Kaitoke – Kate Whitley, GNS Science

P27 Johannes Kaiser in the GNS Science water dating laboratory – Margaret Low, GNS Science



P28 A vertically exaggerated geological model of Southland developed by the GNS Science groundwater modelling team.

P29 Waikato River – Lloyd Homer, GNS Science

P30 Nanotechnology Laboratory, National Isotope Centre – Margaret Low, GNS Science

P31 Ion Beam Laboratory, National Isotope Centre – Margaret Low, GNS Science

P32 Jocelyn Turnbull at Kapuni, Taranaki – Johannes Kaiser, GNS Science

P33 Jérôme Leveneur and John Kennedy – Margaret Low, GNS Science

P34 The GeoNet media room – Gerry le Roux, Sciencelens Ltd

P35 Mt Tongariro erupting 2012 – Brad Scott, GNS Science

P36 Alpine Fault drilling project, Whataroa – Julian Thomson, GNS Science

P37 Mt Ruapehu erupting June 1996 – Lloyd Homer, GNS Science

P39 Napier Port – Margaret Low, GNS Science

P40 Neville Palmer undertaking geodetic measurements in the Wellington region – Margaret Low, GNS Science

P41 Chris Massey surveys the Young River landslide, Southern Alps – Graham Hancox, GNS Science

P42 Heretaunga Plains, Hawke's Bay – Lloyd Homer, GNS Science

P44 Geology field trip in coastal Taranaki – Kyle Bland, GNS Science

P45 Mt Ruapehu – Dougal Townsend, GNS Science

P46 Cape Hallett – Rebecca Roper-Gee, Antarctica NZ Pictorial Collection

P47 Adam Martin collects soil cores in Fiordland – Rose Turnbull, GNS Science

P48 Map compilers Steve Edbrooke and Dave Heron with the 1:1 million geological map – Margaret Low, GNS Science

P51 The IODP scientific drill ship *Joides Resolution* – William Crawford, IODP/TAMU

P53 Ion implanter beam line at the National Isotope Centre – Margaret Low, GNS Science

P55 Wellington City – Graham Hancox, GNS Science

P56 GNS Science technician Tushara Prakash with an Eagle-FA meat scanner – Margaret Low, GNS Science

P59 Board of Directors portraits – Steven Boniface

P61 Executive Team portraits – Steven Boniface