STATEMENT OF CORPORATE INTENT

2014-2015

Mai i te rangi, ki te nuku o te whenua,
ka puta te ira tangata i te po,
i te whaiao, i te ao mārama.
Ko Te Pū Ao mātou.

From the sky and the land,
came people from the night,
to the old world, to the world of light.
We are GNS Science.

Statement of Corporate Intent 2014-2015

Abbreviations

ACC	Accident Compensation Corporation
CRI	Crown Research Institute (any of the companies established in 1992 to replace DSIR)
DoC	Department of Conservation
DSIR	Department of Scientific and Industrial Research (disestablished in 1992)
EECA	Energy Efficiency and Conservation Authority
EEZ	Exclusive Economic Zone
EQC	Earthquake Commission
EPA	Environmental Protection Authority
ESR	Institute of Environmental Science and Research
IAEA	International Atomic Energy Agency
ICDP	International Continental Scientific Drilling Program
IODP	Integrated Ocean Discovery Program
IPCC	Intergovernmental Panel on Climate Change
LINZ	Land Information New Zealand
MCDEM	Ministry of Civil Defence and Emergency Management
MBIE	Ministry of Business, Innovation and Employment
MFAT	Ministry of Foreign Affairs and Trade
MfE	Ministry for the Environment
MoE	Ministry of Education
MoH	Ministry of Health
MoT	Ministry of Transport
MPI	Ministry for Primary Industries
NZP&M	New Zealand Petroleum and Minerals (a division of MBIE)
NZTA	New Zealand Transport Agency
OECD	Organisation for Economic Co-operation and Development
RSNZ	Royal Society of New Zealand

1 Introduction

1.1 Statutory framework

This *Statement of Corporate Intent* is prepared by the Board of Directors of the Institute of Geological and Nuclear Sciences Limited (GNS Science) pursuant to the Crown Research Institutes Act 1992. By agreement with the Ministry of Business, Employment and Innovation, the 2015 and subsequent triennial revisions of this document will have 5-year scopes, supplemented by annual *Statements of Performance Expectations*.

We trace our history back to 1865 as the *New Zealand Geological Survey*. This entity merged with the DSIR's *Geophysics Division* and *Institute of Nuclear Sciences*, as well as parts of *Physics and Engineering Laboratory* and *Chemistry Division,* and was incorporated as a limited liability company on 1 July 1992. We operate primarily under the CRI Act, the Companies Act 1993, and the Crown Entities Act 2004. Shares in the Company are held on behalf of the Crown by the Minister of Science and Innovation and the Minister of Finance.

In 2014-2015 Direct Crown Funding is expected to provide 34% of our total revenue, with the remainder coming from contestable research contracts (22%) and technology transfer[1] (44%) to a wide range of government agency, local body and private-sector users.

1.2 Our rationale

Planet Earth is a mass of 6 billion trillion tonnes, held together by gravity and heated internally by radioactivity and externally by solar radiation. Gravity and heat drive plate tectonics and the processes that generate and store the energy, minerals, and water that underpin wealth and life, and create the fertile regions that sustain our industries and people. Plate tectonics also create the volcanoes, earthquakes, tsunami, floods and landslides that threaten the industries and people that they sustain.

We meet New Zealand's need to discover and understand these earth processes and materials. We facilitate the application of this research in accord with the CRI Act, through our technology transfer services that create wealth, protect the environment, and improve the safety of people. With our predecessors, we are now entering our 150th year of fulfilling this trusted role of delivering independent scientific advice.

For these reasons we are also key to six of the National Science Challenges. We will lead Resilience to Nature's Challenges with our knowledge of natural physical hazards and their societal risks and impacts. The Sustainable Seas and Deep South Challenges will benefit from our knowledge of seabed and sub-seafloor geology, and from our records of past climates that can verify numerical models of future climate. Our understanding of soil degradation, groundwater and geomicrobiological systems are germane to the Our Land & Water and New Zealand's Biological Heritage Challenges, and our ion-beam capability in materials science will add value the Innovative Technologies Challenge.

In addition, we are stewards for the following national facilities (see also Section 6):

- GeoNet, the national network for monitoring geological hazards
- Natural Hazards Research Platform
- National Isotope Centre
- National Groundwater Monitoring Programme and database
- National Paleontology, Petrology and Minerals collections and databases
- National Geological and Geophysical Maps and databases.

[1] The term "technology transfer" refers to the transfer of information to our public and private-sector stakeholders, through consultancy, product commercialisation, access to data, and education

2 Core purpose

2.1 Purpose

Our 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[2].

2.2 Outcomes

We will fulfil our purpose through the provision of research and transfer of technology and knowledge in partnership with key stakeholders, including industry, government and Iwi/Māori, to:

A. increase resource security and economic benefit from the development and diversification of New Zealand's oil, gas, geothermal energy and mineral industries

B. improve the sustainable management of and increase economic returns from groundwater resources

C. create value for New Zealand industry through the use of isotope and ion beam technologies

D. increase New Zealand's resilience to natural hazards and reduce risk from earthquakes, volcanoes, landslides and tsunamis

E. enhance the geotechnical engineering that underpins New Zealand's transport and energy infrastructure

F. increase understanding of the geology and past climates of New Zealand, the Ross Dependency and Antarctica.

2.3 Scope of operation

To achieve these outcomes, we are the lead CRI in the following areas:

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

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

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

[2] This statement was approved by Cabinet in 2010

3 Values and operating principles

In fulfilling our national role, we espouse the values of:

- excellence of scientific enquiry and innovation
- formation of the best teams through global recruitment and collaboration
- gaining benefit for New Zealand through applications of our science
- placing priority on the health and safety of our staff and of visitors to our sites
- financial discipline to provide for future capital needs and ensure our on-going viability.

We operate in accordance with the principles stated in the CRI Act and in our Statement of Core Purpose. In particular:

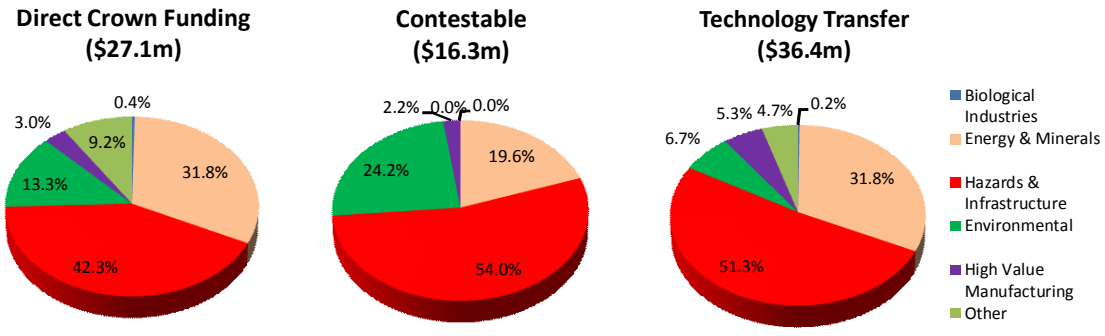
- our long-term relationships with Crown and private sector stakeholders show that our research benefits New Zealand
- we continue to maintain strong, long-term partnerships with Crown and other key stakeholders, including industry, government and Iwi/Māori; we work with them to set research priorities that are well linked to their needs; revenue from technology transfer to key New Zealand stakeholders shows quantitatively the level at which we promote and facilitate the application of the results of our research and technological developments
- our environmental research, geohazards public advisory system, support of graduate students, provision of free scientific information on our web-site and in popular publications, and our schools and museum outreach programmes, show that we exhibit a sense of social responsibility
- the proportions of our effort in technology transfer and in more fundamental research show that we continue to maintain a balance of activities that both provides for the near-term requirements of our sectors and demonstrates vision for their longer-term benefit
- we continue our collaborative relationships with other CRIs, universities and other research institutions (within New Zealand and internationally) to form the best teams
- we provide advice on matters of our expertise to the Crown, in both responsive and pro-active ways, especially to MCDEM, MBIE, MFAT, MfE and MPI, as well as directly to our shareholding Ministers
- we continue to be available for representing New Zealand's interests on behalf of the Crown through contributions to science diplomacy and international scientific issues, and participation on committees and other bodies as required
- we use scientific and user advisory panels to help ensure the quality and relevance of our research plans; these have been extended from advice at research programme level to advice at Senior Management and Board level.

4 Relationship of work to the Government's priority areas

The partitioning of our work across the Government's priority research outcome areas, as represented by projected revenue streams, is given in Table 1 and the following charts.

Table 1: Projected revenue in each of the Government's priority research areas

Government Priority Research Outcome Areas	Direct Crown Funding ($k)	Contestable MBIE & Marsden ($k)	Technology Transfer ($k)	Total ($k)	Statement of Core Purpose Areas
Biological Industries	98	0	75	170	C
Primary	*0*				
High value food	*98*				
Energy & Minerals	8,621	3,189	11,573	23,125	A
Energy Resources	*3,093*				
Sustainable Energy	*3,448*				
Mineral Resources	*2,080*				
Hazards & Infrastructure	11,466	8,768	18,668	38,558	D,E
Hazards & Infrastructure	*10,352*				
Urban Development	*1,114*				
Environmental	3,610	3,933	2,435	9,870	B,C,F
Antarctica	*812*				
Climate & Atmosphere	*1,981*				
Land & Freshwater	*427*				
Terrestrial Ecosystems	*390*				
High Value Manufacturing	815	362	1,916	2,826	C
Novel Materials	*815*				
Other	2,505	0	1,721	5,206	A,B,D,E,F
Collections & Infrastructure	*2,505*				
TOTALS	**27,115**	**16,252**	**36,388**	**79,755**	



5 Key stakeholders

Our key stakeholders are:

- Crown shareholders - Minister of Science and Innovation and Minister of Finance
- other Ministers, through their Ministries and Departments, specifically:
  - Minister for Canterbury Earthquake Recovery (CERA)
  - Minister for Economic Development (MBIE) and Minister for Tertiary Education, Skills and Employment (Universities)
  - Minister of Foreign Affairs (MFAT, NZAID)
  - Minister for Climate Change Issues (MfE)
  - Minister for the Environment (MfE)
  - Minister of Conservation (DoC) and Minister of Housing (MBIE - Building and Housing Information)
  - Minister of Energy and Resources (MBIE - NZP&M)
  - Minister of Civil Defence (MCDEM)
  - Minister for Building and Construction (MBIE) and Minister for Land Information (LINZ)
- public-good research funding agencies (MBIE, RSNZ, EQC, Callaghan Innovation)
- local government entities (the 78 regional, district, unitary and city councils)
- commercial clients and other research users in New Zealand and overseas
- the New Zealand public including Iwi/Māori
- New Zealand and overseas collaborators (universities, CRIs, Callaghan Innovation)
- employees.

Our stakeholder strategy involves continual engagement with key staff members interacting with stakeholders throughout the year. This builds the relationships and embeds stakeholder needs within our internal culture and thinking. Consideration of the needs of New Zealand as a whole, and of these stakeholder groups, underpins the activities outlined in this document.

6 National facilities

We have stewardship for the following national facilities. These underpin our achievement of our core purpose and support many other research and technical users:

- GeoNet, the national network for monitoring earthquakes, volcanoes, tsunami, landslides, and tectonic deformation, that provides timely advice on these events to government agencies and to the public
- the Natural Hazards Research Platform, to coordinate the related research programmes of its members: GNS Science, NIWA, University of Canterbury, Massey University, Opus International Consultants and The University of Auckland
- the National Isotope Centre, the country's only accelerator mass spectroscopy and ion-beam technology facility that, with its associated laboratories, supports environmental, climate, and materials research
- the National Groundwater Monitoring Programme and Database that provides the national view on groundwater quality, links the quality with human influence, and develops best-practice methods for sampling, monitoring, and data interpretation
- the National Paleontology, Petrology and Minerals Collections that underpin New Zealand's earth science research, resource development, and hazard assessment
- the National Geological and Geophysical Maps and Databases that underpin New Zealand's earth science research, resource development, and hazard assessment.

7 Strategic issues

We are finalising the development of a new long-term strategic plan that focuses on core priorities for New Zealand, not only for the coming five years but also out to 2024. It will shape an enduring *Statement of Corporate Intent* beginning in the 2015-2016 financial year to satisfy our *Statement of Core Purpose* and at the same time to provide a basis for its revision. The following issues are key to these tasks.

7.1 High performance culture

A key strategic issue is sustaining and enhancing a high performance culture. The new plan will inform and guide three important efforts:

- a review of organisational design to determine if structural changes might yield a performance dividend
- enhanced leadership development programmes to improve commercial skills, leadership ability and diversity
- new incentives for staff to pursue research opportunities aligned with our strategy.

7.2 National and international impact

A key strategic issue is ensuring that we have national and international impact that brings significant benefit to New Zealand. We will develop and apply extant and new science capability in clearly defined areas to achieve this. Our plan will also set the research agenda through clearly articulated pathways for revenue growth. As part of this we will lead and participate in National Science Challenges and in other government-funded collaborative opportunities including Centres of Research Excellence and the Marsden Fund.

7.3 Leveraging intellectual property

A key strategic issue is more effective commercialisation of our intellectual property. A fundamental component of our plan will provide incentives for the growth of our IP portfolio.

7.4 Iwi/Māori engagement

A key strategic issue is the need to maintain and enhance engagement with Iwi/Māori. Establishing new alliances requires thoughtful and bilateral understanding of expectations. To ensure that we make real and timely progress we will design and implement 2-3 additional projects with Iwi in areas of mutual interest and strategic importance.

7.5 Collaboration and National Science Challenges

A key strategic issue is leadership and participation in the National Science Challenges. We will lead the *Resilience* challenge and we will participate in other Challenges where we have the requisite capability and infrastructure. Through these, and other collaborative research and commercialization opportunities, we will make further progress in removing barriers to science and technology partnerships. Consistent with our mandate, we will collaborate with industry and government to benefit New Zealand where we have the skills and capacity.

7.6 Knowledge transfer

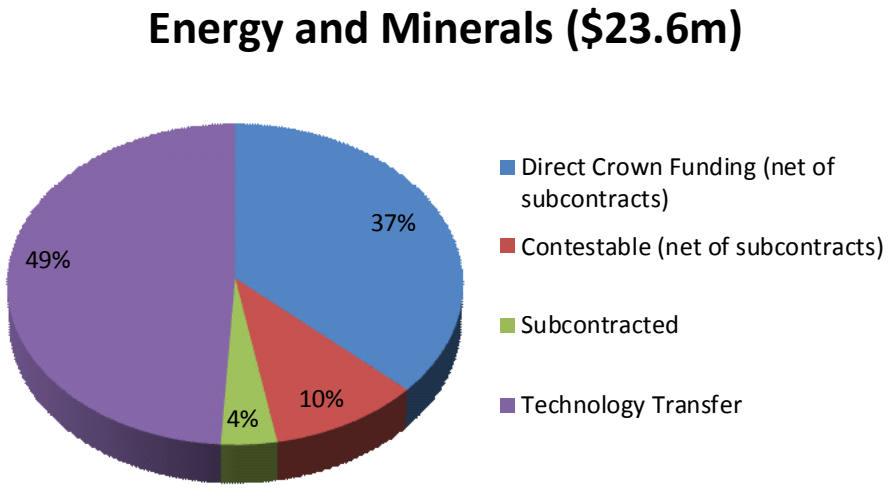
A key strategic issue is ensuring that we have an efficient process to transfer technology and knowledge to end users. We have made significant progress in reducing barriers to accessing Crown-funded data while at the same time deriving revenue from value-added data products. We will continue to work to lower those barriers while providing tailored and high-value knowledge and services to the economic sectors we face.

Strategy on a page: Goals of research and technology transfer

Science areas	Themes	Near-term goals (1-2 yrs)	Mid-term goals (3-6 yrs)	Long-term goals (7-10 yrs)	SCP outcomes
Oil and gas	Petroleum systems	Continued quantification critical parameters that control petroleum formation, migration, and confinement, calibrated with industry data and known resources in Taranaki	Key petroleum systems parameters evaluated in basins outside Taranaki to reduce subsurface geological uncertainties in searching for oil and gas	Establishment of a more substantial basis for quantifying and predicting petroleum resources in NZ Quantification of geological factors affecting reservoir performance and flow deliverability	Resource security and economic benefit from oil, gas, geothermal and mineral resources
	Frontier provinces	Transfer to industry of our advanced understanding of the geological framework and prospectivity in the Northland, Reinga, East Coast, Pegasus, Canterbury and Great South basins	Advanced understanding of the geological framework and petroleum prospectivity in the inner Bounty, Solander, Challenger, New Caledonia basins	Advanced understanding of the geological framework and petroleum prospectivity in the Northeast Slope, Campbell, Pukaki, Monawai, outer Bounty basins	
	Emerging energy technologies	Environmental and production parameters established for east coast (NI) gas-hydrate reservoirs	Identification and ranking of gas-hydrate exploration targets leading to scientific drilling of the resource	Sufficient understanding of the gas hydrate resource for commercial extraction to begin	
Geothermal	Resource characterisation	The physical and chemical nature of heat sources, fluids and flow pathways in TVZ geothermal systems determined Accessibility to geothermal physical, chemical and microbiological data improved and nomenclature standardised	Candidate geothermal systems delineated and modelled from source to surface Improved modelling tools integrated to better simulate geothermal system processes and effects Microbial extremophile cultures available for industrial biotechnologies	Comprehensive delineation of the physical and chemical nature of New Zealand's geothermal resources to guide exploration and development Geothermal data, incorporating geochemistry, geophysics, and microbial diversity is comprehensive, rigorously collected, accessible and well managed	
	Sustainable development	Definition of geological, physical, chemical and biological indicators for monitoring change in geothermal environments Chemical mechanisms determined for corrosion and scaling effects in geothermal power stations Economic value of the mineral resource in geothermal fluids evaluated	Interaction, function and resilience of surface and near surface characteristics of geothermal systems determined Geochemical and materials science solutions investigated for power station efficiency issues and for materials used in geothermal environments Resource, social, policy and economic analysis applied to increase uptake of geothermal direct use opportunities	Management protocols and practises developed to sustain geothermal resources based on sound data, protocols and modelling tools. Innovative technologies and processes developed for novel heat applications, new industries, and improved power station performance	
Minerals	Onshore prospectivity	Regional mineral resource assessment of the Southland area	Enhanced knowledge of prospectivity in NZ from Australian counterpart geological formations	Comprehensive assessment of New Zealand's onshore mineral potential and prospectivity	
	Submarine exploration	Organize international expedition to Kermadec arc and proposal to drill Brothers Volcano Continue to map and survey the ancient Colville Ridge for mineral resources Determination of the georesource potential of a second Rotorua lake in the Okataina Caldera	Provision of new geophysical and geochemical offshore information to government and industry Determine prospectivity of the Colville Ridge; begin assessment of prospectivity of the Harve Trough Determination of the georesource potential of two other Rotorua lakes in the Okataina Caldera	Greater knowledge of mineral (esp massive sulphide) deposition and potential of the Kermadec arc Assessment of the Colville Ridge and Havre Trough backarc as areas worthy of increased exploration Comprehensive assessment of the Rotorua Lakes for their georesource potential	
	Exploration pathfinders	Biogeochemical indicators of gold mineralisation in Coromandel established	Understanding of key pathfinders for South Island platinum group element mineralisation	Determine key NZ-relevant geochemical and geophysical pathfinders to mineral deposits	
Groundwater		Delivery of national groundwater data to end users New technique(s) to quantify reach-scale ground and surface water exchange fluxes in space and time	Coupled groundwater-surface water model calibrated for at least one NZ catchment using field data Implementation of improved mechanisms allowing users to access and transfer groundwater data	Development and wider application of innovative techniques to map, characterise and model aquifer systems in space and time	Improved management and increased economic return from groundwater
Isotope and ion-beam technology	Air particulate pollution	Establish a database of sources for air particulate matter pollution in New Zealand urban areas (e.g. Auckland, Wellington, Nelson, Christchurch)	Develop a national air particulate matter speciation network to track sources, identify health risks, and infer impacts on climate change to underpin environment policy	Extend elemental speciation network to other environmental sectors (water, land) to examine and assess pollution source and environmental impact relationships for economic sustainability and policy	Economic value created for industry through the use of isotope and ion-beam technologies
	New materials	Applications of surface coating and sensor materials for industrial processes using ion beam technologies	Recognition as an established provider of functional coatings and sensors for high value manufacturing using ion beam technologies	Leading provider of functional coatings and sensor materials for industrial applications including energy, environment and biotechnology	
	Isotope biogeoscience (industrial)	Isotope tracking of food (esp honey) and establishment of compound specific applications for both stable isotope analyses and radiocarbon dating	Isotope tracking of other primary export products and of biosecurity incursions	Isotope tracking of primary export products and biosecurity incursions internationally recognised	
Geohazards	Hazard monitoring	Faster and better hazards information, including distributed cloud-based services, equipment renewal and improved remote volcano monitoring	Updated operations of the GeoNet facility, targeted improvements in sensor network coverage and a move to impact-based reporting of hazards events	Capability improvements, including network coverage, borehole sensors, warning systems, and provision of high-precision geospatial information	Increased resilience to natural hazards and reduced risk from earthquakes, volcanoes, landslides and tsunamis
	Geological hazards	Better understanding of volcanoes, earthquakes, landslides and tsunami, focusing on Cook Strait and Eketahuna seismicity, Tongariro and White Island	Consistent probabilistic estimates of earthquake, volcano, landslide and tsunami occurrence, providing the hazard component of the risk equation	Establishment of internationally tested time-varying hazard assessment methods for earthquakes, volcanoes, landslides and tsunami	
	Risk and society	Availability of enhanced asset data leading to wider uptake of the Riskscape tool by local authorities Continued support of Christchurch recovery through social science on psychosocial recovery, community resilience, public policy and land-use planning Domestic constituency and trusted partnerships to support international opportunities for NZ companies in natural hazards risk management	Enhanced Riskscape tool demonstrating vulnerability of different infrastructure in different parts of NZ Identification of success factors so that individuals and organisations are motivated and able to prepare, respond, and recover from natural hazard events NZ companies undertaking international activities in SW Pacific and SE Asia in disaster risk management and engineering mitigation	Social science research that leads to engaged communities and better understanding of cultural and economic needs for disaster management systems Our NZ partnership recognised internationally as a provider of disaster risk management and engineering mitigation expertise	
Geotechnical engineering	Resilient buildings and infrastructure	Calibration of liquefaction and lateral spreading models, and development of residential and infrastructural loss models, based on Canterbury data	Knowledge from Canterbury earthquake research, especially with respect to shaking and liquefaction, applied effectively to other parts of the country	Use of an all-hazards approach to assessing risk to buildings and other infrastructure in major cities and the identification of priority mitigation options	Enhanced geotechnical engineering
Geology and global change	Isotope biogeoscience (environmental)	Atmospheric verification of fossil fuel CO_2 emissions Initiate applications for *in-situ* ^{10}Be dating of geological exposures and erosion	Enhanced understanding using ^{14}C of the timing and synchronicity of past regional climate events relevant to contemporary climate change.	Significant applications of cosmogenic nuclide techniques for surface dating and erosion research Applications of isotope techniques to policy and management of CO_2, nutrients, and water	Enhanced scientific understanding of geology and past climates
	Paleoclimate	Membership in international drilling consortia secured Recovery and interpretation of NZ sedimentary records and Antarctic ice cores for climate reconstruction and testing of climate models	Long-term membership of drilling consortia secured through government, CRI and university funding Analyses of ice and sediment records from Antarctica to SW Pacific to establish roles of polar and tropical forcing on climate during periods of global warmth	Continued participation in international drilling consortia Improved understanding of local impacts of global warming in the coming centuries	
	Biostratigraphy	Refined age control of geological intervals relevant to petroleum exploration	Development of the Fossil Record File and databases as repositories on the biological and environmental history of the SW Pacific	Full integration of NZ and International Geological Timescales for the last 500 million years	
	Regional geology	Publication of the 2nd edition of the 1:1M Geological Map of New Zealand Geological datasets and 3D models completed for the Dunedin and Napier-Hastings urban areas Geological map of Tongariro National Park published	Synthesis of NZ's crustal basement petrology, structure and origin Enhanced QMAP Seamless GIS geological map database Geological maps and 3D models of seven urban and resource areas completed	Adoption of international standards for digital geoscience datasets Detailed geological map datasets and 3D models for NZ's urban and prospective resource areas Comprehensive regional geology understanding integrated with geophysical and geochemical surveys	
	Tectonics, structure and landscape evolution	Improved understanding of crustal motion, especially slow slip events Improved national gravity model Recovery and interpretation of rock record across Alpine fault	Acquisition of data to prepare for deep drilling Documentation of historical landscape response to earthquakes and volcanism Recovery and interpretation of Hikurangi sedimentary records	Scientific deep- drilling completed on the Alpine Fault and Hikurangi subduction interface Improved understanding of rupture phenomena related to Alpine Fault and Hikurangi subduction	
All science areas	Iwi/Māori partnerships	Strategic partnerships with key Iwi stakeholders, and collaboratively set priorities in relevant areas	Long-term research programs which contribute to the research aspirations of Iwi and Maori communities	Capability & capacity developed with Iwi that contribute to innovation and the Māori economy	Science contributing to Iwi/Māori aspirations
	Public knowledge of research results	Enhanced material to support science teachers, and popular books and videos for the public Staff talks to public and private organisations	Enhanced material to support science teachers, and popular books and videos for the public Funding grants for outreach from external agencies	Enhanced material to support science teachers, and popular books and videos for the public NZ geoscience information on mobile devices	Better informed public, tertiary education sector, and Parliament
	Graduate education	Delivery of tertiary geoscience courses and provision of student supervision and scholarships	Crown support for CRI-based graduate education that leads to greater employment opportunities	A seamless science education, research and innovation system	

8 Outcome A: Economic benefits from geological resources

Outcome A: to increase resource security and economic benefit from the development and diversification of New Zealand's oil, gas, geothermal and mineral resources



Our programme of research and technology transfer of geological resources has the following components:

- oil and gas (petroleum systems, frontier provinces, emerging technologies)
- geothermal (resource characterisation, sustainable development)
- minerals (onshore minerals, deep sea minerals).

Government policy focuses on the need for New Zealand to discover, use, and benefit from its geological endowments of energy resources (*New Zealand Energy Strategy 2011-2021*). Without significant improvements in energy conservation and efficiency, New Zealand cannot meet future electricity demand from renewable sources alone, particularly during dry-year limitations on hydro-generation, and cannot meet demand for transportation fuel from existing local oil production.

Increased geothermal energy production is consistent with longer-term societal preferences for renewable and low green-house gas emitting energy sources. The geothermal environment also nurtures enzymes that can contribute to a variety of industrial processes.

We provide the science underpinning to MBIE's (NZP&M) minerals strategy focused on improving knowledge of resources on- and off-shore, and as a research organisation we are engaged in discovery of both mineral and gas-hydrate deposits in New Zealand's vast Exclusive Economic Zone.

We are not actively engaged in research on coal because, apart from modern geological mapping, our assessment of locations, quantities and grades of coal resources was completed many years ago, and CRL Energy Ltd is now undertaking modern research on, for example, coal gasification and combustion, and their environmental impact.

8.1 Oil and gas (petroleum systems, frontier provinces, emerging technologies)

The **benefits** to industry that will accrue from our research include:

- knowledge of New Zealand's basins with petroleum potential, based on independent scientific advice
- reduced subsurface geological uncertainties for explorers

The **benefits** for New Zealand that will accrue from our research include:

- growth in New Zealand's economy via increased royalties, taxes, regional employment, industrial expansion, export earnings, and import substitution derived from sustainable and environmentally responsible petroleum extraction
- improved security of energy supply (electricity and transport fuels) from the development and diversification of New Zealand's oil and gas resources
- transition to a low-carbon economy through the use of natural gas instead of coal to minimise detrimental effects on the environment.

Situation

Our petroleum research and technology transfer focuses on conventional oil and gas resources, unconventional petroleum resources, and carbon dioxide geo-sequestration to mitigate the atmospheric effects of fossil fuel use.

We are the only New Zealand entity with comprehensive research programmes, specialist nationwide knowledge and multi-disciplinary skills in the geological and geochemical processes that have formed our sedimentary basins and the petroleum accumulations within them.

Our research benefits both the public of New Zealand and the petroleum industry in optimising exploration efficiency and increases the chances of new discoveries being made. Our work underpins MBIE's (NZP&M) efforts to attract investment for new exploration. Our research capabilities align with the *New Zealand Energy Strategy 2011-2021*, and are essential for the implementation of MBIE's *Petroleum Action Plan*. We occupy an important niche in building technical capability and critical mass, with former staff and our co-supervised students helping to grow the relatively small industry in New Zealand.

A major part of our research has been centred on the Taranaki Basin, due to industry needs and because this area contains most of the data and samples from which new exploration concepts can be formulated. However, with the expanding focus of MBIE and industry, our attention is increasingly turning to frontier petroleum basins as and when new data and samples become available[3].

Our research is also positioning New Zealand to be a fast follower in the global exploitation of gas hydrate deposits. Gas hydrates are a potential new source of energy comprising a frozen form of natural gas bound in an ice-like structure. They are found at appropriate pressures and temperatures in many parts of the world, primarily at shallow depths below the sea-bed, and are estimated to embody more energy than all known conventional oil and gas fields. Our resources may be among of the largest in the world, with the most promising deposits potentially being significantly greater than the Maui field. Research is needed to provide an understanding of these systems, to identify and rank exploration targets and, ultimately, to help achieve production of natural gas from them by 2021. Success would unlock for New Zealand a new source of indigenous fuel leading to energy self-sufficiency and security, and potentially the creation of a new export industry.

[3] This plan is in accord with a recommendation of our Strategic Science and User Advisory Panel

Work programme

Theme 1: Petroleum systems

Our petroleum systems research will address fundamental problems and geological uncertainties associated with the search for oil and gas in New Zealand's sedimentary basins. We focus on mapping, analysing and quantifying the geological, geophysical and geochemical parameters that control how petroleum forms, migrates and accumulates. We aim to improve prediction of petroleum accumulations and to expedite their discovery. We add value to knowledge of the Taranaki Basin to assist in the search for new discoveries there. We also use this knowledge and undertake research in other areas, to identify the next petroleum basin for development in New Zealand.

Although we now focus on helping the industry to find new reserves, we plan to eventually contribute to production efficiency, by identifying and modelling critical factors controlling reservoir performance and flow. This will aid appraisal and development of new fields, optimise management of existing fields, and ultimately maximise the volumes of petroleum extracted.

Theme 2: Frontier provinces

Our frontier provinces research will establish the geological fundamentals for discovering petroleum in the largely unexplored offshore sedimentary basins. The research delineates and semi-quantifies critical parameters for ranking the prospectivity of these frontier basins. This provides the technical basis for helping government and industry to prioritise future research and exploration investment.

Our initial focus is on completing interpretations of the East Coast/Pegasus Basin and the Northland/Reinga Basin, and undertaking new studies of the Canterbury/Bounty/Great South basins. The results will also be integrated with refined models of the tectonic evolution of New Zealand [see *Outcome F*]. This knowledge improves predictions of the timing and volume of oil and gas generation throughout the region.

Later, our focus will move to the other frontier basins, namely, Solander Basin, Challenger Plateau, New Caledonia Basin, Northland Plateau, Campbell Plateau basins, Pukaki basins, Monawai Basin, and the outer Bounty Trough. This will require new data from international academic research voyages, or industry non-exclusive speculative surveys, through MBIE's Petroleum Action Plan. Priorities for these basins will be determined in consultation with the relevant Ministries and the industry's Petroleum Strategic Advisory Panel.

Theme 3: Emerging technologies

We will investigate key aspects of the gas-hydrate petroleum system on the Hikurangi Margin, to assess the distribution and quality of the potential reservoir, and to provide baseline environmental information associated with their presence and future extraction. We are compiling critical parameters for modelling gas production in order to provide a quantitative assessment of the resource. We are also investigating gas hydrate distributions in other parts of our EEZ.

In partnership with Australian agencies, we have applied our parallel petroleum and structural geology research skills to investigate storage and environmental impacts of geo-sequestration of carbon dioxide in underground reservoirs, especially in deep saline aquifers and disused oil and gas fields. This work provides us with an on-going capability to advise Government on the implementation of geo-sequestration in New Zealand.

8.2 Geothermal

The **benefits** to industry that will accrue from our research include:

- renewable electricity generation at low risk and with low carbon dioxide emissions
- increased direct geothermal use and distributed electricity generation
- use of geothermal microbes for biofuel production and bio-remediation

The **benefits** to New Zealand that will accrue from our research programme include:

- new industries and applications, with economic growth in the regions and for Iwi/Māori
- provision of environmental indicators for informing policy and sustainable management.

Situation

Geothermal energy is an indigenous, renewable resource that provides long-term, reliable base-load electricity generation, with relatively low cost and environmental impact. It now supplies 14% of New Zealand's electricity, and is expected to supply 20% within the next ten years. Its direct use for heating is even more efficient, and consistent with the OECD's International Energy Agency's implementation of its Geothermal Implementation Agreement.

While we expect a plateau in the installation of new geothermal generation, the long lead-time between research and it application makes it imperative that we, as the only national research provider with the required breadth of experience and disciplines, continue our research to support the eventual development of low-temperature and new deep resources.

Work programme

Theme 1: Resource characterisation

Our research will increase investor and developer confidence by reducing technical risks of exploration drilling. Our field investigations define geothermal systems with respect to permeability, flow pathways, and fluid-rock interaction. We are investigating the temperature distribution in the crust between the deepest wells and the bottom of the permeable zone, and through geology, geophysics, and modelling, we are discovering the mechanisms that control the flow of fluids and heat at 3-7 km depth. High temperature and pressure laboratory experiments simulate the chemistry of these systems at even greater depths. Additionally, we are delineating low-temperature systems to support their sustainable development. Finally, we are advocating a deep 4-km well drilled in partnership with industry and the International Continental Scientific Drilling Program (ICDP).

Theme 2: Sustainable development

Exploitation of geothermal energy should have minimal environmental impact. In addition to electricity generation, the direct use of geothermal heat has potential to grow significantly. We are quantifying environmental and ecological impacts of geothermal extraction, including ground deformation, induced seismicity, alteration of thermal features, groundwater-geothermal interaction, ecological adaptation, and sustainability of microbiological biodiversity. A knowledge-base of the microbial ecology of geothermal systems will help us to discover the determinants of microbial biodiversity, to understand how microbes alter geothermal features, and to identify unique microbial strains with industrial uses.

We will develop management regimes, engineering protocols and socio-economic policies to support sustainable and environmentally sound utilisation of geothermal resources. Chemical research to reduce scaling and corrosion, and other innovative technologies will improve the viability of the industry. Social science research will help us to understand perceptions of geothermal use and resource management, and implications for future development.

8.3 Minerals

The **benefits** for industry that will accrue from our research include:

- knowledge of New Zealand's mineral province potential, based on independent scientific advice
- reduced mineral exploration risk
- environmentally responsible approaches to mineral extraction

The **benefits** for New Zealand that will accrue from our research include:

- economic growth from increased royalties, taxes, employment, export earnings and import substitution
- knowledge of the economic potential and environmental risks of geological resource recovery

Situation

Our role in minerals research is in identifying the extent and grade of mineral resources onshore and in our extended EEZ, in accord with MBIE's (NZP&M) minerals strategy. Our leading role is in developing tools to locate these resources, assessing their size and grade, and formulating models to predict their occurrence. These are essential contributions both for implementing MBIE's strategy, and for the identification and management of these resources by industry.

Work programme

Theme 1: Onshore minerals

Commencing in Otago and the West Coast[4], we are providing government and industry with newly interpreted geochemical, aeromagnetic and other information on mineralised terranes. Regional mineral resource assessments of Southland and Marlborough will provide local and central governments, and industry, information on regional mineral potential. Regional research of our continental basement will aim to attract exploration and emphasises that, geologically, New Zealand was once a part of mineral-prospective eastern Australia. Studies of selected commodities (e.g. ironsands, clays, Platinum Group Elements, Rare Earth Elements) and localised deposits (e.g. gold at Reefton) complement the regional work.

Successful testing and adaption of standard overseas exploration methods to New Zealand conditions (e.g. high relief and rainfall, dense vegetation, moderate exposure of outcrops), and development of new ways of defining exploration targets, will support industry's exploration goals. We will gain a better understanding of the processes that produce mineral deposits through innovative use and integration of available geochemical and geophysical data. This research is underpinned by further development of relevant mineral databases.

Theme 2: Deep sea minerals

We will undertake research on mineral prospects and deposits, principally seafloor massive sulphides, within the EEZ by acquiring high-resolution water-column data and seafloor bathymetric and geophysical maps, and undertaking petrological, geophysical and geochemical analyses[4]. The surveys depend upon international collaborative use of state-of-the-art technologies, such as manned submersibles, AUVs (autonomous underwater

[4] This plan is in accord with a recommendation of our Strategic Science and User Advisory Panel

vehicles) and ROVs (remotely operated vehicles). They will provide information of sufficient quality that government agencies and industry stakeholders can make informed decisions on developing our offshore mineral resources. A new initiative, using knowledge and equipment gained from the submarine realm, is to investigate central North Island lake-beds for geothermal activity and mineralisation.

8.4 Indicators, collaborations and end-users

Key indicators of science quality

- Peer-reviewed journal papers
- Industry conference papers and invited conference presentations
- Invitations to participate in international industry fora and research consortia
- Invitations to run international short-courses and field workshops
- Feedback from stakeholders (conservation, government, Iwi/Māori and industry)

Key indicators of impact of technology transfer over a three-year period

- Reduced subsurface exploration uncertainty associated with oil and gas exploration
- Increased exploration activity in frontier regions by oil companies
- Enhanced geothermal generation quantity and efficiency, mitigation of environmental impacts, and public acceptance of geothermal extraction
- Increased mineral exploration activity in New Zealand and its EEZ

Key research collaborations

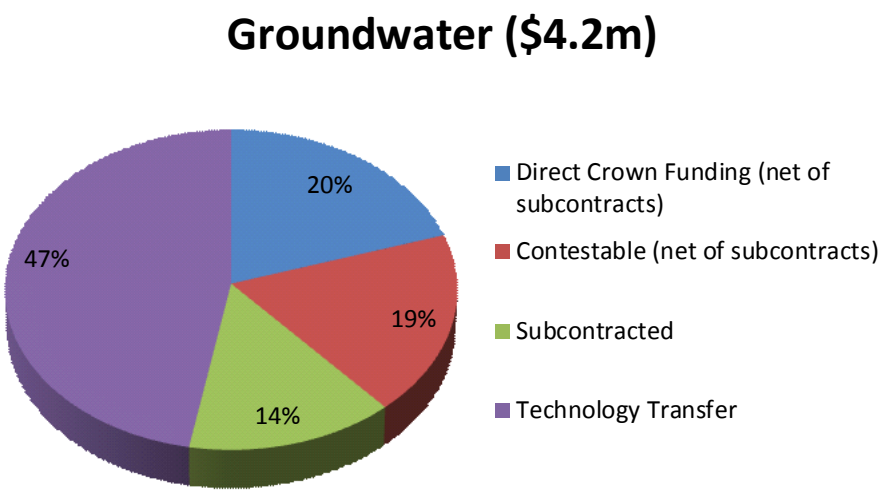
- MBIE (New Zealand Petroleum & Minerals)
- New Zealand universities and Crown Research Institutes (e.g. NIWA, Scion)
- Australia-New Zealand Integrated Ocean Drilling Program (IODP) consortium
- Overseas universities (especially in Australia, Canada, Chile, France, Germany, Japan, Switzerland, UK, USA)
- Overseas research institutes (especially in Germany, Japan, Korea, Australia, USA)
- Private sector partners in New Zealand and overseas

Key end-users

- Central government agencies (especially MBIE; also DoC, EECA, EPA, MPI, MfE)
- Local government (especially Environment Bay of Plenty, Environment Waikato)
- Petroleum industry (exploration companies, utility companies, consultants)
- Research organisations and companies interested in carbon sequestration
- Geothermal production companies
- Iwi/Māori trusts and landowners with geothermal interests
- Biotechnology sector (biofuels, chemicals, drug discovery and enzyme providers)
- Mineral exploration and production companies
- New Zealand universities

9 Outcome B: Sustainable management of groundwater

Outcome B: to improve the sustainable management of and increase economic returns from groundwater resources



9.1 Groundwater

The **benefits** to New Zealand that will accrue from our research include:

- improved water management strategies through gaining a better understanding of New Zealand's groundwater resources and through scientifically defensible data sets, methods and models.

Situation

Groundwater accounts for roughly 30% of New Zealand's consumptive water use and is essential for environmental integrity, social well-being and economic productivity. The total asset value of our groundwater is about $11 billion. Use of this asset is also an important factor in adaptation to climate change. Limits of sustainable allocation and/or capacities to assimilate pollutants have already been exceeded in many of the nation's aquifers. Stakeholders are calling for improved water management strategies, and there is consensus that improved management must stem from better understanding of the groundwater resource itself.

Government reforms following from the 2009 Cabinet Paper *"New Start for Fresh Water"* highlight the need for our research, and include a new *National Policy Statement for Freshwater Management 2011,* a fund for remediation of degraded water bodies, and the ambitious work programme proposed in *Freshwater Reforms 2013 and Beyond.* All of these will rely on our research, which aims to assess the quantity and quality of groundwater resources across the country.

Work programme

Our research will significantly improve understanding of aquifer systems and will deliver tools for more effective management of groundwater resources. We have designed our research to impart to resource managers and users best practice methods for groundwater mapping, monitoring, data interpretation, modelling and reporting. Adoption of these methods by regional authorities will support justifiable and sound management decisions related to groundwater resources.

We will continue to operate the Water Dating Laboratory (WDL) and the National Groundwater Monitoring Programme (NGMP) and to provide data and interpretations to regional authorities. The NGMP provides a national perspective on groundwater quality, identifies spatial and temporal trends in groundwater quality and relates them to specific causes.

In the medium term we will develop regional three-dimensional spatial and temporal models of geology and groundwater flow and transport. Our long-term goal is to characterise New Zealand's aquifers and to map and model them in this way at the national scale, using innovative approaches and a consistent data format.

9.2 Indicators, collaborations and end-users

Key indicators of science quality

- Peer-reviewed journal papers
- Invited presentations at industry and science conferences
- Positive feedback from sector advisory groups regarding direction and delivery
- Invitations to run international short-courses and field workshops

Key indicators of impact of technology transfer over a three-year period

- Increased application of geological and geochemical aquifer models by regional authorities to improve groundwater management

Key research collaborations

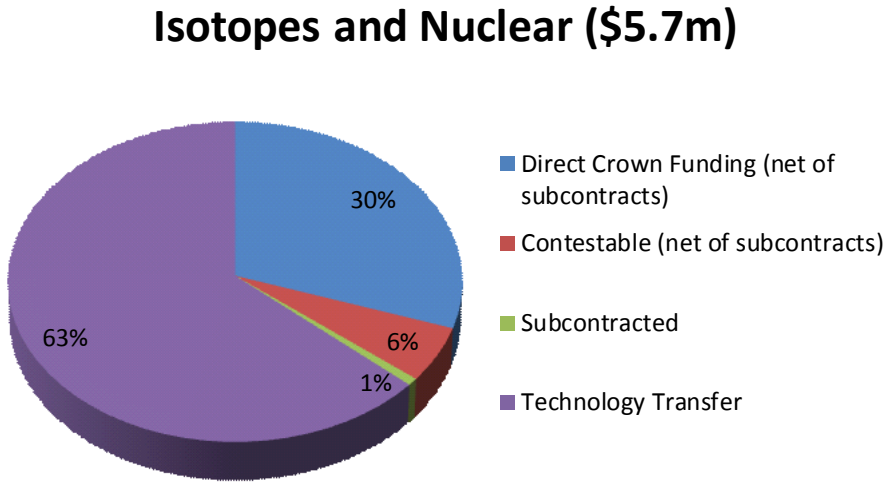
- New Zealand universities
- Other research organisations (e.g. ESR, Lincoln Agritech Ltd, private entities)
- Overseas universities

Key end-users

- 15 regional authorities
- Central government agencies (MfE, MPI, MoH, MBIE)
- Other research organisations

10 Outcome C: Value from isotopes and ion-beam technology

Outcome C: to create value for New Zealand industry through the use of isotope and ion-beam technologies



New Zealand's position on nuclear-based energy and defence is well known. However, there are other uses of nuclear science that have economic and environmental benefits, without creating societal concerns. We focus on isotope and ion-beam applications that support the earth sciences in the broadest sense, and that use that infrastructure to gain other benefits[5]. We do not monitor radiation, which is done by ESR's National Radiation Laboratory, nor do we engage in radiotherapy research, which is done by the universities and the health sector. Our programme of research and technology transfer to industry has three components:

- air particulate matter pollution
- new materials
- isotope biogeoscience (industrial; see Outcome F for environmental aspects).

10.1 Air particulate pollution

The **benefits** to New Zealand that will accrue from our research include:

- ability of regulatory authorities to implement effective strategies for air pollution mitigation that result in improved health outcomes for New Zealanders.

Situation

Air particulate matter is a recognised health and environmental hazard, with two-thirds of New Zealanders living in urban areas that experience episodes of degraded air quality. Regulatory authorities are required to manage air quality in their regions (local air-sheds) to

[5] This approach is supported by our Strategic Science and User Advisory Panel

meet regulatory standards. Our research underpins MfE's *National Environmental Standards for Air Quality* as applied to local government, and informs MfE, MoH and NZTA about the sources of air pollution for exposed populations. The determination of particle composition is crucial to identifying both anthropogenic and natural sources of air particulate matter.

Work programme

We will continue measuring the elemental composition of air particulates with ion-beam technology, and identify sources, of local, regional and trans-boundary particulate matter pollution. We will broaden our research to urban areas throughout New Zealand to identify sources of air pollution. We will then extend our capability to include source-specific particle number, size distributions and hazardous chemicals to better identify the health risks to exposed populations. In the long term, we will establish a source-fingerprint database of air particulate matter. This will require systematic sampling at multiple sites to cover geographical and meteorological diversity, seasonal trends and trans-boundary air pollution events. This database will provide the baseline to underpin policy implementation. We will also transfer our expertise into related areas. These include air particulate matter in ice cores, where the focus is on southern hemisphere circulation and the effect of carbonaceous aerosols on climate, and identifying the components and sources of sediment load in rivers.

10.2 New materials

The **benefits** for industry that will accrue from our research include:

- development of new materials for industry that will add significant value to the New Zealand economy.

Situation

Our nationally unique capability of accelerator ion-beam technology allows us to alter a material's properties by depositing other elements, atom by atom, within and on its surface. The primary drivers for this work are the private-sector high-technology enterprises for whom we are developing innovative nanomaterials. We are a member of the MacDiarmid Institute of Advanced Materials and Nanotechnology centred at Victoria University of Wellington and a member of the Materials Accelerator operated by the University of Auckland.

Work programme

The main current application of our unique ion implantation capability is the development of magnetic nanocluster bands comprising nanometre-size clusters of magnetic atoms (e.g. iron, cobalt, samarium), embedded in an insulating matrix (e.g. silica). Magnetic nanocluster bands have novel uses in magnetic sensors, miniature motors and data storage devices, with a potential global market of about $4 billion. Expansion of this market is inhibited by the difficulty of controlling fabrication of these materials without using highly toxic methods that are difficult for manufacturers to employ. Our techniques overcome these hurdles. The research can generate significant revenue for New Zealand because there are established domestic companies, including our end-user collaborators, that manufacture or use high-performance magnets and devices. These linkages will provide a credible, rapid pathway to market. We plan to be an established provider of technology to industry of high-value sensors for security, non-destructive testing and environmental applications. We also see potential applications of ion-beam coatings and ion implantations for the heavy-metals industry (e.g. titanium and related alloy materials), biotechnology and medicine and, further out, possibilities for enhanced electrical energy storage.

10.3 Isotope biogeoscience (industrial)

The **benefits** for industry that will accrue from our research include:

- distinction of petroleum constituents generated in different geological environments
- development of techniques for authenticating sources of exported agricultural products (especially honey).

Situation

We are working toward national mapping of isotopes leading to better understanding stocks and flows of carbon, nutrients and water. Applications of this work include support for oil and gas exploration (see Outcome A), and agricultural product authentication.

Globalisation of food industries and export increasingly requires food provenancing and security of market access. Global population growth and the government's new goal via the *Business Growth Agenda* to double the real value of exports by 2025 place increasing pressure on the export sector to enhance production and value from global trade. Isotopes have emerged to have a significant role in diminishing the impact of non-tariff trade barriers on the volume and value of our international trade.

Work programme

Analysis of carbon, hydrogen and oxygen isotopes forms a key part of the isoscapes that are increasingly supporting the authentication of sources of biological products. At present our main industrial applications of this capability are for distinguishing petroleum constituents generated in different geological environments for the oil and gas industry, and for devising standards relevant to New Zealand varieties of honey to distinguish them from counterfeit varieties in the export market.

The high-end use of manuka honey for food and medicinal uses has become a key example of the need for appropriate standards, and highlights the fact that research support of industry and in-market stakeholders can be substantial for a mid-size industry with rapid growth potential.

We undertake carbon isotope analysis for adulterant sugar detection, especially for manuka honey. In addition, in partnership with Callaghan Innovation, we undertake research on chemical profiles of NZ honey and nectars, and in partnership with the University of Waikato, research on activity mechanisms of high UMF manuka honey. It is important to understand that isotope and other authentication is regulated within trade agreements, and depends on international CODEX and established protocols such as those of the Association of Analytical Chemists (AOAC). To ensure our research is relevant for the industry we maintain regular engagement with National Beekeepers Association, Federated Farmers Bee Industry Group, Bee Products Standards Council, and the UMF Honey Association.

10.4 Indicators, collaborations and end-users

Key indicators of science quality

- Peer-reviewed journal papers
- Invited presentations at industry and science conferences and workshops
- Invited presentations at government conferences and workshops
- Invitations to run international short-courses and field workshops
- Enhanced throughput, precision, reliability and versatility of accelerator mass spectrometry and stable isotope ratio mass spectrometry measurements

Key indicators of impact of technology transfer over a three-year period

- Implementation of mitigation strategies for air pollution that reduce maximum PM10 concentrations below the National Environmental Standards
- Industry interest or adoption of technologies for ion implanted materials
- Improved mitigation of agricultural and industrial pollution

Key research collaborations

- Crown research institutes (e.g. Landcare Research, NIWA)
- Callaghan Innovation Research Limited
- University of Waikato
- New Zealand and overseas universities, CSIRO
- IAEA Regional Cooperative Agreement, Republic of Korea

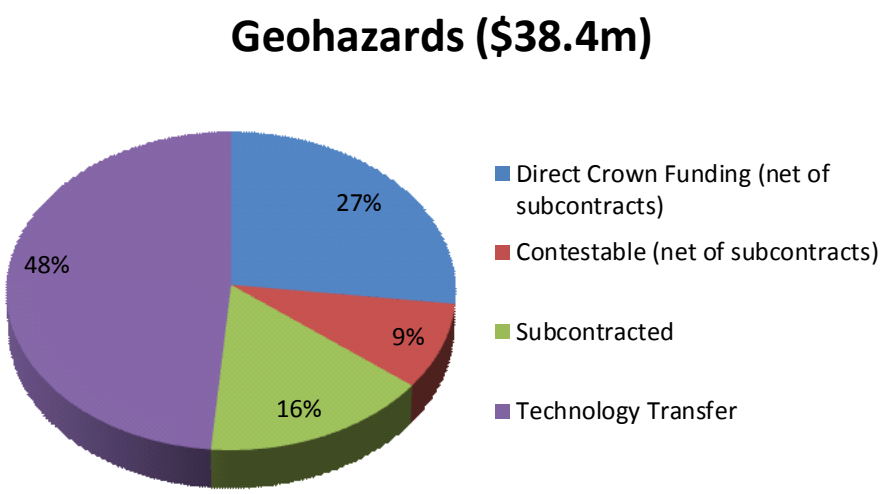
Key end-users

- Farmers and industry organisations
- Central government agencies (e.g. MPI, MfE, MoH)
- New Zealand Transport Agency
- Regional and City councils
- Nanomaterial production industry
- Sensor manufacturing industry
- New technology industries
- Honey producers and exporters
- Other research organisations

11 Outcomes D and E: Hazards and geotechnical engineering[6]

Outcome D: to increase New Zealand's resilience to natural hazards and reduce risk from earthquakes, volcanoes, landslides, and tsunamis

Outcome E: to enhance the geotechnical engineering that underpins New Zealand's transport and energy infrastructure



The **benefits** to New Zealand that will accrue from our research include:

- reduction in risk and downstream effects from geological hazards
- increased resilience for New Zealand's buildings and infrastructure
- reduced loss of life, injury and trauma
- reduced insurance costs through better planning and engineering design.

The *Civil Defence and Emergency Management Act 2002*, and lessons from national and international disasters, are changing natural hazard management in New Zealand and other countries exposed to these perils. In partnership with EQC and LINZ, we operate GeoNet, the national network for monitoring earthquakes, volcanoes, tsunami and landslides. The data from this network provide critical underpinning information for all downstream research.

We host the Natural Hazards Research Platform and therefore, in addition to our geological hazard research, we carry responsibility for ensuring the Platform's success through effective research collaboration among its participants and effective research uptake by our end-users.

We provide key input for the formulation of the *New Zealand Loadings Standard* that is used in the design of all major buildings and infrastructure built in New Zealand. In addition, our research is used by international reinsurers for modelling their exposure to risk in New Zealand and hence the required levels of premium.

[6] Outcomes D and E are discussed jointly because essential and urgent needs arising from the Canterbury earthquake sequence are focussing our geotechnical expertise on hazards issues

Because risk is the product of hazard and vulnerability, we are also engaged in engineering vulnerability research to underpin our advice to building and infrastructural asset owners. Finally, we undertake social science research to underpin our advice to MCDEM and other agencies, and to promote appropriate societal preparation for, and response to, natural hazards. The Canterbury earthquake sequence that commenced in 2010 will, for many years, give this area a national focus whose long-term importance cannot be overstated.

Our programme of monitoring, research and technology transfer comprises:

- hazard monitoring
- hazard assessment
- risk and society
- resilient buildings and infrastructure.

11.1 Hazard monitoring

Situation

The GeoNet Project, funded by EQC and LINZ under long-term contracts, includes the communications infrastructure to transmit data to distributed data management and processing centres, and round-the-clock operation of these centres for civil defence advisory and emergency response purposes. In addition, all geohazards research for New Zealand, whether done here or overseas, relies heavily upon data from this network.

GeoNet comprises a broad infrastructure:

- seismographs to measure the magnitude, location and characteristics of earthquakes
- satellite navigation receivers to measure crustal strain build-up and release
- seismic, geochemical, geodetic and remote sensing techniques for early detection and monitoring of volcanic unrest
- capability for nationwide landslide monitoring and response
- strong motion recorders to monitor building and bridge performance in earthquakes
- water-pressure sensors to detect the presence and height of tsunami waves
- data management and processing centres
- communication networks and on-call 24/7 duty staff.

Work programme

Now that increased real-time coverage of the Canterbury region is in place we are enhancing coverage of the upper South Island, and monitoring of White Island and Tongariro volcanoes that have entered periods of unrest and eruptive activity. Our priorities are still to improve speeds for earthquake location and increase the depth of derived information, for example immediate ShakeMap information and short-term earthquake probabilities. End-user linkages, technical research, and public outreach remain important activities.

We also aim to maintain our leading-edge capability by updating technology through time, improving “best-practice”, and enhancing operations in all areas of the GeoNet facility. These are all possible if current resource levels are maintained in real terms.

At the same time significant research projects, especially scientific drilling, will be supported. If more investment were available, capability improvements would be possible, such as more borehole sensors for seismic tremor research, ocean bottom sensors, very fast earthquake location, local tsunami warning, earthquake early warning, and very precise geospatial information availability.

11.2 Hazard assessment

Situation

Research conducted under the Natural Hazards Research Platform has the goal of mitigating the impacts of natural hazards for New Zealand. The research themes we lead focus on developing quantitative models of geological processes such as earthquake, volcano, landslide and tsunami activity. The aim is to understand the processes driving the geological hazards and hence the estimation of the future likelihood and size of their occurrence. The research results are used directly for applied research projects such as improvements to engineering design standards and multi-hazard risk assessments for the insurance industry. Our work-plans are still strongly influenced by requirements resulting from the Canterbury earthquakes, and the need to apply the lessons learnt to other parts of the country.

Work programme

Data gathered by GeoNet and specific field projects will continue to be analysed using methods developed both in New Zealand and overseas to understand why volcanoes, earthquakes, landslides and tsunami occur at which locations, at which frequencies, and in which magnitude range. From this fundamental understanding and assessment of each hazard, quantitative comparisons between different hazards (a “multi-hazards” approach) will be developed using probabilistic modelling methods for individual and integrated perils.

11.3 Risk and society

Situation

The scope of the Natural Hazards Research Platform includes research on how well society is prepared for and responds to geological hazards, as well as weather-related perils for which NIWA undertakes the physical science research. Policy and planning research builds knowledge about good practice and increases the uptake of hazards knowledge by policy makers, land-use planners, communities and Iwi/Māori through the adoption of appropriate land-use practices and public policy.

Community resilience research explores the relationship between risk perception, risk acceptance, evaluation of personal competencies and capabilities, and preparedness at community, organisational and individual levels. Emergency management research directly assists the CDEM sector in developing strategies to improve procedures, and crisis management methodologies, including warnings. Disaster recovery research assists community recovery by improving our understanding of the process.

The Platform research is aligned with the National CDEM Strategy, and with other strategies of government agencies, responsible for reduction, readiness, response and recovery from natural hazard events and processes.

Work programme

Geological hazard models provide the hazard component of the risk equation. We will continue enhancement of the RiskScape multi-hazard impact and risk assessment tool, along with related models. Risk models include data on different vulnerabilities in different parts of New Zealand and on the age and quality of buildings and infrastructure. These models are developed through continuous engagement with users, namely emergency management authorities, response planners, and lifeline utility operators. Outputs will underpin emergency management and response decisions with consistent, rational, risk-informed information, enabling prioritisation of both mitigation and response planning measures. As a consequence New Zealand will have an evidence base upon which to

prioritise expenditure for enhancing overall resilience to natural hazards through reduction of both social and economic impacts of at-risk communities.

Social science and land-use planning related to natural hazards are a distinctive part of our research. We will identify success factors so that individuals and organisations are motivated and able to prepare, respond, and recover from natural hazard events. The outcome will be the creation of well-prepared and resilient communities. A key to success is the participation of communities in the scoping and design of the research and application of research findings to evidence-based policy and practice. This will be done both formally through advisory groups and through direct discussions with specific research users at an individual project level.

We will use the knowledge about hazard events and the risks they create to: (i) engage with communities of all types and stakeholders at all levels to better understand functions, needs, cultural and economic contexts; (ii) develop improved disaster management strategies; (iii) develop improved organisational systems to recover economic competitiveness after hazard events; (iv) develop quantitative assessment of options for hazard mitigation, advocating the appropriate mix of reduction, readiness, response and recovery activity.

11.4 Resilient buildings and infrastructure

Situation

Engineering geology is an essential underpinning component of all infrastructure projects, including those addressing geotechnical problems clearly related to natural hazards. With the relatively recent realisation that New Zealand needs to make a significantly increased investment in national infrastructure, more research to inform these large investment decisions is essential. The recent Canterbury earthquakes have highlighted these issues[7].

Our work supports engineering consultancies through the provision of engineering geological information on, for example, geological structures and rock properties that underpin national standards. We also provide the key ground shaking parameters used in formulating the *New Zealand Loadings Standard* and hence the design of all major buildings and infrastructure in this country.

Work programme

Our projects include site-specific investigations to inform construction design, advising on the safest locations for lifeline networks (e.g. for transport, electricity, gas, water), and regional assessments based on a common problem (e.g. low soil strength).

Our capability in ground-structure interaction, a key area of research if structures and lifelines are to remain operational during and after strong shaking, will over the next several years be largely diverted to issues arising from the Canterbury earthquake sequence. New knowledge gained from this research will be applicable to other parts of the country. The research, with many collaborators, will involve slope stability issues in the Port Hills, impacts of liquefaction on underground services, and impact of ground conditions on building performance. Building design philosophy will be revisited to achieve acceptable levels of impact from strong ground motions.

[7] This has also been noted by our Strategic Science and User Advisory Panel

11.5 Indicators, collaborations and end-users

Indicators of science quality

- Peer-reviewed journal papers
- Invitations to run international conferences, short-courses and workshops
- Invited presentations at science and industry conferences
- Invited presentations at government conferences and workshops
- Data uptake by researchers (science and engineering)
- Success in obtaining New Zealand or international research funding

Indicators of impact of technology transfer over a three-year period

- Improved planning for rapid response to geohazard events
- Improved infrastructure design for earthquake protection
- Enhanced warning systems and mitigation strategies for volcanic eruptions and tsunami
- Advanced qualitative and quantitative landslide hazard assessment and mitigation
- More sustainable land use and greater economic resilience to geological hazards
- Results of research embedded in design codes and standards (e.g. NZS 1170.5 & NZS 3604)

Key research collaborations

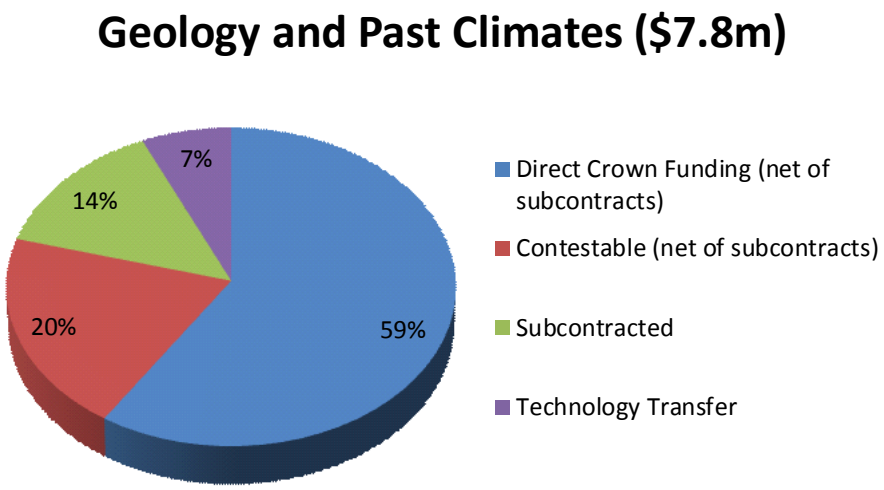
- End-users who provide data to be combined with our data
- New Zealand universities
- NIWA
- Central government agencies (LINZ, DoC, MCDEM, New Zealand Defence Force)
- Joint Centre for Disaster Research (Massey University – GNS Science partnership)
- Equipment and service providers

Key end-users

- Central government agencies (MBIE, DoC, LINZ, MPI, MCDEM, MFAT, MoH, MoE)
- Local government (regional councils, territorial authorities, Local Civil Defence Emergency Management Groups, Local Government New Zealand)
- Emergency management sector (MCDEM, Local Civil Defence Emergency Management Groups, MetService, hazards consultancies)
- International agencies (international data centres, Pacific Tsunami Warning System, overseas universities and research organisations)
- Engineering industry (surveyors, large infrastructure projects, structural engineering and geotechnical consultancies, Lifeline Engineering Group)
- Transport sector (Civil Aviation Authority of New Zealand, airlines, Maritime New Zealand, New Zealand Transport Agency, infrastructure operators)
- Building industry (MBIE, BRANZ, Standards New Zealand, construction companies)
- Energy sector (DamWatch, production companies, utility and infrastructure operators)
- Insurance sector (EQC, ACC, underwriters and re-insurers, insurance companies)
- Education sector (schools, polytechnics and universities)
- New Zealand researchers (e.g. universities, CRIs)
- New Zealand public (radio, television, electronic and print news media, general public)

12 Outcome F: Understanding geology and past climates

Outcome F: to increase understanding of the geology and past climates of New Zealand, the Ross Dependency and Antarctica



The **benefits** to science that will accrue from our research include:

- provision of geological, geochemical and geophysical knowledge, maps and information for all researchers whose work enhances geological resource evaluation and geohazard assessment

The **benefits** to New Zealand that will accrue from our research include:

- sustainable infrastructure and land-use planning taking into account local geology and New Zealand's active tectonic environment
- the national surveying datum and precision surveying methods underpinned by geodetic research and monitoring
- evidence for government policy, and industrial and social response to climate change and other environmental issues, leading to enhanced environmental and societal well-being.

A crucial role for the earth sciences is to explore New Zealand and its territories. This leads to compilations of onshore and offshore geological, geochemical and geophysical maps of our region, and understanding of the dynamic processes acting at and adjacent to the tectonic plate boundary. This knowledge of the rocks, structures and processes that form New Zealand and its territories, including the foundations of our cities, underpins much of our other research. Key aspects are the definition of the nation's territorial and cadastral boundaries, and the geological makeup of New Zealand's vast EEZ and Extended Continental Shelf. This off-shore region represents 96% of our territory, but remains poorly explored with its geological structures and resources being largely unknown.

It is also of great importance, both globally and within New Zealand, to understand the Southern Hemisphere environmental history that is recorded in rocks, fossils, and ice. In particular, key Southern Hemisphere data on past global climate-change events, including ancient "climate shocks" are important for global climate models. Some of these shocks are comparable in scale, rate and drivers to inferred post-industrial anthropogenic greenhouse

warming. Research in paleoclimate uses a wide range of capabilities, including paleontology, stratigraphy and geochemistry.

Another key component is isotope biogeochemistry that uses accelerator mass spectrometry (AMS) and isotope ratio mass spectrometry (IRMS). Our national AMS and IRMS facilities support our capability to develop 2D and 3D 'isoscapes' at catchment to continental scales. These compile measurements of isotopes as natural tracers of the development of environments across space and through time. Isoscapes also underpin hydrology, petroleum exploration, forensics and biological product-authentication.

Our programme of research and technology transfer has the following components:

- isotope biogeoscience (environmental)
- climate change
- paleontology and biostratigraphy
- regional geology
- tectonics, structure and landscape evolution.

12.1 Isotope biogeoscience (environmental)

Work programme

We are working toward national mapping of isotopes ("isoscapes") leading to better understanding stocks and flows of carbon, nutrients and water. Environmentally, this research connects efforts to understand past climate and environments with present-day environmental issues. Our carbon-cycle research focuses on soil carbon dynamics and verification of fossil fuel CO_2 emission inventories using radiocarbon as a tracer. This work will support the New Zealand emission trading scheme and future global agreements. Analysis of the hydrogen and oxygen isotope composition of precipitation underpins ice-core research for climate change models. In the future, an array of such isoscapes will support outcomes in the area of monitoring global change.

12.2 Climate change

Work programme

We will improve understanding of past climate changes in the Southern Hemisphere by: (i) quantifying the relative roles of high- and low-latitude drivers on climate change in the New Zealand region; (ii) identifying factors that govern the stability of the Antarctic Ice sheets and the magnitude of related sea-level changes; (iii) identifying how past periods of global warming affected regional climate and ocean circulation; and (iv) enhancing knowledge of the carbon cycle that underpins carbon accounting for productive and natural ecosystems.

We will undertake biostratigraphic and paleoenvironmental interpretation of onshore and offshore sedimentary records, and physical, chemical and isotopic analysis of ice cores from New Zealand and Antarctica. This will contribute data, interpretations and expertise to numerical modelling of climate and the carbon cycle. The research will make extensive use of information from the New Zealand Fossil Record File and the National Paleontology Collection. Participation in international scientific drilling consortia, in particular ANDRILL and the Integrated Ocean Drilling Program (IODP) is critical to our research.

12.3 Paleontology and biostratigraphy

Work programme

We will ensure the New Zealand Fossil Record File (FRF) and National Paleontology Collection (NPC) and associated databases are curated to best international standards and are used by a wide range of in-house, academic, business and private researchers. We will undertake paleontological and taxonomic research of fossil groups of greatest relevance to paleoclimate and biostratigraphic applications. We will undertake biostratigraphic research to improve calibration of the New Zealand geological timescale, especially for the interval of most relevance to both paleoclimate research and the petroleum sector, i.e. the past 80 million years.

12.4 Regional geology

Work programme

We will continue to enhance the recently released nationwide 1:250,000 geological mapping QMAP seamless GIS dataset to incorporate Active Fault Database data and emerging international standards for terminology and data model design. We will adopt national and international standards in the PETLAB National Rock and Geoanalytical Database. We will also be undertaking detailed geological mapping of urban centres (Napier-Hastings, Dunedin, Auckland) and areas of proven or potential geological resource (Otago and West Coast). Complementary research into the age and origin of basement rocks, involving petrological, geochemical and geochronological analysis, will lead to improved understanding of crustal processes. This research provides fundamental underpinning information for our other outcomes, and for many external research programmes. Knowledge transfer is principally via published scientific journal papers, geological maps and GIS data files.

12.5 Tectonics, structure and landscape evolution

Work programme

Information on current and past crustal motion will be acquired from land and marine geological and geophysical surveys, investigation of ancient and active faults, analysis of earthquake occurrences over all magnitudes, and GPS and other satellite observations. Research will include investigation of offshore structure and tectonic history, onshore active deformation patterns, and the nature of subduction, rifting and continental collision. We will use numerical modelling to consider the interactions between active tectonics, volcanism, landscape evolution, climate, sea level, and human activity. This information underpins other geoscientific research programmes within and external to GNS Science of direct benefit to New Zealand, and includes a unique bridge between plate tectonics and global change that feeds into environmental management and policy development. The research leverages considerable co-funding through widespread national and international collaborations.

12.6 Indicators, collaborations and end-users

Key indicators of science quality

- Peer-reviewed journal papers and geological maps
- Invited presentations at science conferences and government workshops
- Invitations to prepare and referee IPCC reports
- Invitations to run international short-courses and field workshops
- Success in obtaining New Zealand or international research funding
- Success with IODP/ICDP drilling proposals

Key indicators of impact of technology transfer over a three-year period

- Geological map sales and data downloads
- Accurate surveying methods and a national surveying datum underpinning land title
- Development of long-term national and regional strategies for mitigation of and adaptation to the effects of anthropogenic global warming
- Use of results in primary, secondary, and tertiary education

Key research collaborations

- Antarctica New Zealand
- Climate and socio-economic modellers in New Zealand and overseas
- Community Surface Dynamics Modelling System (US)
- National and international scientific drilling partnerships (IODP, ICDP, ANDRILL)
- International paleoclimate researchers
- Crown Research Institutes (especially Landcare Research, NIWA)
- National Science Foundation (US) research programmes
- New Zealand universities
- Partners in the Joint Antarctic Research Institute (Victoria University of Wellington, NIWA, University of Otago, University of Canterbury)

Key end-users

- Energy and mineral exploration and production companies
- Industry, utility companies and consultancies
- IPCC
- International science community
- Central government agencies (LINZ, MPI, MCDEM, MBIE - especially NZP&M, MFAT, MfE)
- Regional Councils and Territorial Authorities
- Iwi/Māori
- Other GNS Science and university research programmes, especially those on petroleum, mineral wealth, groundwater and natural hazards

13 Additional outcomes: Outreach and education

We contribute to outcomes additional to those given in our Statement of Core Purpose.

13.1 Science and society

It is essential that we communicate the results of our science to the public. This is not only from a sense of social responsibility as required by the CRI Act, but also because public understanding of science will result in better decision-making in the government and private sectors in order to create economic, societal, and environmental benefits for New Zealand.

Work programme

Our communications programme comprises seven main elements:

- provision of public information of both immediate and enduring interest, through our public websites (www.gns.cri.nz and www.geonet.org.nz) and social media
- provision information on our achievements of immediate interest to the news media
- curriculum-linked material and lesson-plans to primary and secondary schools, through engagement with teachers nationwide, and face-to-face with local schools
- authorship of books for mainstream publishing houses
- providing museum visitors with object-focused information and up-skilling curators in the museum sector, especially with Te Papa Tongarewa
- organisation of the monthly Wellington and Lower Hutt Café Scientifique events having science staff available to speak to a wide range of audiences upon invitation.

Key indicators of impact of knowledge transfer over a three-year period

- Website visitor numbers and downloads
- News media exposure
- Museum exhibition visitor numbers
- Number of teachers using our material

13.2 Graduate education

Our capabilities and facilities support earth science, isotope and ion-beam education in universities and make a key contribution to graduate education in New Zealand in areas, especially in areas where new employment opportunities can be created through linkages with our commercial clients. With Massey University and Victoria University this involves joint staff appointments.

Work programme

Our graduate education programme comprises three main elements:

- supervision of MSc and PhD students at all New Zealand universities
- teaching of post-graduate courses that would not otherwise be taught
- provision of student scholarships.

Key indicators of impact of technology transfer over a three-year period

- Number of students taught or supervised
- Number of universities benefiting from our support.

14 Research and technology-transfer performance indicators

Tables 2-5 give the performance indicators upon which we will report annually. Other information, of a commercial-in-confidence nature, will be included in quarterly reports to the shareholders.

The following metrics will measure our success in being a good employer.

Table 2: Human resources indicators

	Actuals 2013	Expected range
Full-time equivalents (FTEs)	360	360-380
Scientists and specialists	252	255-260
Science support	51	50-60
General support & management	57	55-60
Distribution of science effort (FTEs)		
Research	147	150-160
Technology transfer	156	155-160
Staff turnover	6.5%	6%-8%
ACC workplace safety accreditation	Secondary	Tertiary
Injuries, causing missed work days, per million work hours	0	<10
Staff engagement (% proud to work for GNS Science) [1]	84%	>80%

[1] this will not necessarily be measured every year

We design our work programme taking into account the global state of scientific knowledge and our connectivity in collaborating nationally and globally to compensate for our low staff numbers in some areas. The following metrics will measure our success in these collaborations, and our overall performance in the basic and targeted research that underlies our technology transfer.

Table 3: Research collaboration indicators

	Actuals 2013	Expected range
Joint peer-reviewed publications with NZ or international institutions		
Number	214	>220
Percentage with international institutions	67%	65%-69%
Percentage with other NZ institutions	24%	22%-26%
Percentage with only GNS Science co-authorships	9%	7%-11%
Number of visiting researchers hosted	101	60-100
Value of research contracts to other research organisations ($000)	8,195	>7,000
Value of research contracts from other research organisations ($000)	2,514	2,200-2,800
Number of graduate scholarships funded	36	25-35
Number of graduate students supervised	100	100-120

Table 4: Research indicators

	Actuals 2013	Expected range
Research effort (FTE)	147	150-160
by scientists	122	125-130
by science support staff	25	25-30
Peer-reviewed science papers and book chapters (preceding cal yr)	310	290-330
Research monographs and maps (preceding cal yr)	2	0-4
Other journal papers and publicly available reports (preceding cal yr)	55	50-90
Publication rate (reviewed papers/chapters/monographsper research FTE)	2.6	>2.0
Number of citations of publications for each of the five preceding cal yrs	>4,525	>4,500
Use of science: h_1-score (# of publications with at least this same number of citations)	75	>80
Scientist visibility: h_2-score (# of staff with an *h*-score of at least this same number)	19	17-21

For over a decade our strategy has been to design our work programme around end-user needs. Our technology-transfer indicators will measure our relationships with these commercial, central-government and local-government clients and achievement of excellence for them.

Table 5: Technology-transfer indicators

	Actuals 2013	Expected range
Commercial revenue ($000)	32,355	>34,000
Technology-transfer effort (FTEs)	156	155-160
Commercial revenue per tech-transfer FTE ($000/FTE)	207	213-219
Technology & knowledge transfer		
(a) Commissioned reports (ca. 55% tech-transfer revenue)	278	270-300
(b) Earthquake (M>4) reports (ca. 28% tech-transfer revenue)	585	>500
Tsunami, landslide and volcanic eruption reports	7	5-10
(c) Laboratory analysis reports (ca.11% tech-transfer revenue) (stable isotopes >10000, geothermal >7500, radiocarbon >1800, water >650)	20,000	>20,000
IP licensing in NZ and overseas of technologies, products and services		
Number	29	25-50
Value ($000)	1,197	1,000-2,000
Client feedback average score (out of 10)	7	7-8
Projects achieving outcomes or creating opportunities for Iwi/Māori	25	20-30
Database use		
Number of databases accessible to the public via the web	30	>30
Registered external users of GNS Science data	3,187	>3,000
Users accessing the GNS Science website		
Total number	341,610	>300,000
Daily peak	11,647	>1000
Number of users accessing the GeoNet website		
Total number	4,482,380	>3,000,000
Daily peak	170,687	>100,000

MBIE seeks the following information in respect of projected deployment of our Direct Crown Funding.

Table 6: Deployment of Direct Crown Funding

Category	Government Outcome Areas	Direct Crown Funding ($k)	Measures of performance that are underpinned by Direct Crown Funding as specified in Tables 3, 4 and 5
Direct Crown Funding total		**27,115**	Percentage of publications with other institutions Value of research sub-contracted out to other organisations Graduate scholarships funded Graduate students supervised Research effort (FTEs) Reviewed science papers, monographs & maps Publication rate (papers/research FTE) Use of science - h_1 Registered users of collections/data
GNS Science (non-NSC) research and sub-contracts	Biological Industries	98	
	Energy & Minerals	7,121	
	Hazards and Infrastructure	4,966	
	Environmental	1,385	
	High Value Manufacturing	565	
	Sub-total	**14,135**	
GNS Science National Science Challenge Research (indicative, under negotiation)	Resilience	6,500	
	Sustainable Seas	1,500	
	Deep South	1,500	
	Land and Water	425	
	BioHeritage	300	
	Innovative Technologies	250	
	Sub-total	**10,475**	
Public science collections & databases		**2,505**	

Collection & database names

- National Earthquake Information Database
- New Zealand Geomagnetic Database
- Active Faults Database of New Zealand (web map also available)
- Strong Motion Database
- Geological Map of New Zealand (web map also available)
- Geothermal Groundwater Database
- Petroleum Basin Explorer (PBE)
- New Zealand Stratigraphic Column File (non-digital)
- New Zealand Gravity Station Network (web map also available)
- New Zealand Geothermal Use Database
- Other web maps (6)
- PETLAB: National Rock and Geoanalytical Database (web map also available)
- Mineral Resources of New Zealand (3 databases)
- New Zealand Fossil Record File (web map available) (with GSNZ)
- New Zealand Fossil Spores and Pollen Catalogue
- National Paleontological Collection
- New Zealand Stratigraphic Lexicon
- Cenozoic Mollusca of New Zealand
- New Zealand Geoscience Bibliography
- GNS Science Photo Library
- GNS Science Data Repository

15 Financial performance indicators

We will operate in a financially responsible manner and remain financially viable. We budget to generate an appropriate rate of return on equity. Table 7 gives the financial performance indicators upon which we will report annually. Other information, of a commercial-in-confidence nature, will be included in quarterly reports to the shareholders.

Table 7: Financial performance indicators and targets

Year ending 30 June	2014 forecast	2015 budget	2016 outlook	2017 outlook
Return on equity [1]	7.0%	8.0%	8.0%	8.0%
Revenue per FTE ($000)	208	214	218	222
Profit per FTE ($000) [2]	21.5	24.0	25.4	26.4
Equity ratio [3]	59.9%	63.3%	66.1%	68.1%
Capital renewal ($000)	6,000	7,800	7,300	7,900

[1] after development expenditure

[2] profit is earnings before interest, tax, depreciation and amortisation

[3] ratio of shareholder's funds (or total equity) to total assets expressed as a %, as determined by the Company's accounting policies and set out in the balance sheet

16 Reporting

16.1 Quarterly and half-yearly reports

Quarterly reports will be provided confidentially to our shareholders and will state financial performance for the quarter and year-to-date against budgets, provide updated year-end forecasts, and provide a commentary on performance for the period. The commentary will focus on material variances and how these are being addressed. The reports will also comment on major achievements for the period and the outlook for the next period.

The half-yearly report will be delivered to shareholders within two months of the end of the first half of each financial year and will include:

- a commentary on performance for the period
- a description of scientific and technological highlights for the period
- unaudited income statement, balance sheet, and statement of cash flows, with notes
- certification by the Board that the Company has operated in accordance with the Crown Research Institutes Act 1992 and Companies Act 1993 during the period.

16.2 Annual Report

The annual report will be delivered to shareholders within three months of the end of each financial year. It will report on the operations during the financial year of the consolidated Company and, separately, of any subsidiaries. It will comply with the reporting provisions of the Public Finance Act 1989, the Companies Act 1993, the Crown Research Institutes Act 1992, and the Crown Entities Act 2004.

The report will include:

- performance against financial targets in the SCI for the year, and the comparative figures for the previous year, together with reporting on science performance in both metric and narrative form
- a commentary on performance for the period
- an account of deployment of Direct Crown Funding

- a description of scientific and technological highlights for the period
- a description of other highlights for the period
- audited income statement, balance sheet, statement of cash flows, and accounting policies together with notes to the accounts
- the auditor's report on the financial statements
- a statement of responsibility to accompany the financial statements
- certification by the Board that the Company has operated in accordance with the Crown Research Institutes Act 1992 and Companies Act 1993 during the year.

16.3 Other information to be reported

We will supply any other information required by the shareholders, pursuant to Section 20 of the Crown Research Institutes Act 1992.

17 Commercial value, dividend policy, and compensation

17.1 Commercial value

Section 16(3) of the CRI Act requires the Company to furnish an estimate of the current commercial value of the Crown's investment. The GNS Science Board is satisfied that the net asset position (or total equity) as at 30 June 2013 is a fair and reasonable indication of the commercial value of the Group. The net asset position as shown in accordance with the company's accounting policies for 30 June 2013 was $27.2 million.

17.2 Dividend policy

Our dividend policy is that all funds surplus to the Company's investment and operating requirements, as determined by the principles outlined below, will be distributed to the shareholders. In determining surplus funds consideration will be given to:

- providing for capital investment requirements (including equity investments) without recourse to the Crown for equity injections to the Company
- opportunities for internal development expenditure
- the Company's working-capital requirements (including subsidiaries and businesses in which equity is held)
- the short, medium, and long-term financial viability of the Company, including its ability to repay debt
- risks of meeting our financial targets
- the obligations of the Directors under the Companies Act 1993 and other statutes.

The Board will detail, in a submission to shareholding Ministers, within two months of the end of each financial year:

- the amount of dividend (if any) recommended to be distributed to the shareholders
- the percentage of tax-paid profits that the dividend represents.

Table 8: Forecast levels of shareholders' equity and proposed dividends

Year ending 30 June	2014 forecast	2015 budget	2016 outlook	2017 outlook
Equity ($000)	29,512	31,710	34,355	37,219
Dividends ($000)	250	250	-	-

17.3 Compensation

Where the Crown wishes us to undertake activities or assume obligations that will result in a reduction of our profit or net worth, the Board will seek compensation sufficient to allow the Company's position to be restored.

No compensation is currently being sought from the Crown.

18 Accounting, investment, procurement of services, and other business policies

18.1 Accounting policies

The Institute of Geological and Nuclear Sciences Limited is established under the Crown Research Institutes Act 1992 and the Companies Act 1993. Our subsidiary companies, Isoscan Limited, Isoscan Food Limited, Geological Surveys (New Zealand) Limited, GNS Science International Limited and Geological Risk Limited are established under the Companies Act 1993. Our principal activities are to undertake geoscience and isotope science research, development and consultancy, predominantly in New Zealand.

The Company's financial statements have been prepared in accordance with the Public Finance Act 1989, the Crown Research Institutes Act 1992, the Companies Act 1993, the Financial Reporting Act 1993, the Crown Entities Act 2004, and in accordance with New Zealand generally accepted accounting practice. They comply with New Zealand equivalents to International Financial Reporting Standards (NZ IFRS) and other applicable Financial Reporting Standards, as appropriate for profit-oriented entities. The financial statements also comply with International Financial Reporting Standards (IFRS).

The financial statements of the Group and Company are prepared on an historical cost basis, except that derivative financial instruments are recognised both initially and subsequently at their fair value.

The financial statements are presented in New Zealand dollars and all values are rounded to the nearest thousand dollars. The functional currency of the Group is New Zealand dollars.

Subsidiaries are those entities controlled by the Company. Control is achieved where the Company has the power to govern the financial and operating policies of an entity to obtain benefits from its activities. The financial statements of subsidiaries are included in the consolidated financial statements using the purchase method of consolidation. The effects of intra-group transactions are eliminated in the consolidated financial statements.

Investments in subsidiaries are recorded at cost in the Company's financial statements.

Joint ventures are contractual arrangements with other parties, in which the Company or its subsidiaries have joint and several liability in respect of costs and liabilities and shares in any resulting output. The Company's share of the assets, liabilities, revenues and expenses of joint ventures is incorporated into the consolidated financial statements on a line-by-line basis using the proportionate method.

In applying the Company's accounting policies, there is the requirement for judgements, estimates and assumptions to be made about the carrying amounts of some assets and liabilities. The estimates and assumptions are based on historical experience and other relevant factors. Actual results may differ from these estimates. The areas where critical estimates and judgements have been made include property, plant and equipment, intangible assets, impairment of assets and liabilities, employee benefits, and the valuation of work in progress.

Further detail in respect of the accounting policies for the Company and Group are set out in the GNS Science Annual Report for the year ended 30 June 2013. No significant changes in accounting policies are envisaged between the above policies and the budget and forecast information included in this document.

18.2 Shareholder consent for significant transactions

The Board will obtain prior written consent for any transaction or series of transactions involving full or partial acquisition, disposal or modification of property (buildings, land and capital equipment) and other assets with a value equivalent to or greater than $10 million or 20% of the Company's total assets (prior to the transaction), whichever is the lesser.

The Board will obtain prior written consent of shareholding Ministers for any transaction or series of transactions with a value equivalent to or greater than $5 million or 30% of the Company's total assets (prior to the transaction) involving:

- acquisition, disposal or modification of an interest in a joint venture or partnership, or similar association
- acquisition or disposal, in full or in part, of shares or interests in a subsidiary, external company or business unit
- transactions that affect the Company's ownership of a subsidiary or a subsidiary's ownership of another entity
- other transactions that fall outside the scope of the definition of the Company's core business or that may have a material effect on the Company's science capabilities.

18.3 Investments in capital assets

We will invest in capital equipment and facilities that will enhance our ability to develop our business and provide an appropriate rate of return on the investment. Return on investment will be monitored in order to provide a basis for future investment decisions.

18.4 Procurement of services

We will assess the procurement of services, facilities and resources that may be shared among the Crown Research Institutes. This assessment will involve working with the other CRIs to identify any duplications of effort where cost savings, efficiencies, or quality improvements may be achievable.

18.5 Databases and collections

The Company has policies on the management of its data and collections.

In managing our data and collections we will comply with applicable legislation, including the Official Information Act 1982, the Commerce Act 1983, the Crown Research Institutes Act 1992, and the Privacy Act 1993.

We will make our scientific datasets and collections publicly available using the suitable Creative Commons license, except:

- when data or collections were obtained or created for a third party; in this circumstance we will maintain any agreed confidentiality or restriction on use until the data or collection has entered the public domain
- when Creative Commons licence terms are not appropriate; for example, where access fees are necessary to sustain our business by giving us a return on investment from our own resources.

Whenever possible we will adopt international, national, or industry standards applicable to the data. When this is not possible, we develop organisational standards.

We allocate a portion of our Direct Crown Funding for maintaining our databases and collections, and facilitating their wider use.

We will not dispose of, without the prior permission of the shareholders, any of the following Nationally Significant Databases and Collections for which we have accepted responsibility:

- National Petrology Reference Collection and PETLAB Database
- National Groundwater Monitoring Programme
- New Zealand Fossil Record File (with Geoscience Society of New Zealand)
- Regional Geological Map Archive and Data File
- New Zealand Paleontological Database and Collection
- National Earthquake Information Database
- New Zealand Geomagnetic Database
- New Zealand Volcano Database.

We will not dispose of any other database or collection we consider to be of national significance without first discussing this with the shareholders. Regard will be held to the CRI Act and the Public Records Act when disposing of any database or collection.

We will advise shareholders of any dispute regarding the terms of access and use of any Nationally Significant Database or Collection. The Company will make all reasonable attempts to settle the dispute with the disputing party. We will refer the matter to shareholders in the absence of any agreement within 30 days of notification of a dispute. Any decision by the shareholders will be binding on the Company.

19 International agreements

The co-operation agreements and arrangements that we have with international organisations are set out below. The Company will inform shareholding Ministers in writing should it plan to dissolve any formal international agreement for which we have responsibility.

The Company officially represents New Zealand on the following international bodies to ensure New Zealand input to planning groups and the development of international standards. In some cases, membership is in part financially supported by government agencies (e.g. MFAT, MBIE):

- Australia New Zealand Minerals and Energy Council Chief Government Geologists Conference
- Australian Institute of Nuclear Science and Engineering
- International Atomic Energy Agency Regional Co-operative Agreement
- Incorporated Research Institutions In Seismology
- International Consultative Group on Food Irradiation.
- International Energy Association Geothermal Experts Group
- OECD International Energy Agency Geothermal Annex (GNS Science holds the Secretariat)
- Pacific Tsunami Warning and Mitigation System (Intergovernmental Oceanographic Commission, UNESCO)
- United Nations Comprehensive Test Ban Treaty Working Group
- UNISDR Scientific and Technical Advisory Group.

We are a Member of, or represent New Zealand, on associations of the International Council of Scientific Unions, and other international scientific committees:

- International Association of Geochemistry and Cosmochemistry (IAGC)
- International Association of Seismology and Physics of the Earth's Interior (IASPEI)
- International Association of Volcanology and Chemistry of the Earth's Interior (IAVCEI)
- International Atomic Energy Agency (IAEA)
- International Continental Scientific Drilling Programme (ICDP)
- International Geological Congress (IGC)
- International Union of Geological Sciences (IUGS)
- International Union of Geodesy and Geophysics (IUGG)
- Scientific Committee on Antarctic Research (SCAR)
- Scientific Committee of Integrated Research on Disaster Risk (IRDR)
- Southern California Earthquake Center (SCEC).

In addition, we have Memoranda of Understanding with overseas institutions. These usually provide for the exchange of staff between institutions on collaborative programmes:

- International Atomic Energy Agency
- Cooperative Research Centre for Greenhouse Gas Technologies (Australia)
- Geoscience Australia
- Chilean National Commission for Scientific and Technological Research
- China Earthquake Administration (formerly State Seismological Bureau), China
- China Geological Survey
- Hebei Bureau of Prospecting and Development of Geology (China)
- Institute of Geology and Institute of Mineral Resources (China)
- Ministry of Geology and Mineral Resources, China
- Nankai University (China)
- University of La Reunion (France)
- Helmholz Centre Potsdam GFZ German Research Centre for Geosciences
- Institute of Report Sensing and Digital Earth (China)
- Geological Survey of Japan
- Japanese National Institute of Advanced Industrial Science and Technology
- Japan Marine Science & Technology Centre
- New Energy and Technology Development Organisation, Japan
- Jeonnam Regional Environmental Technology Development Centre (South Korea)
- Korean Institute of Geology, Mining, and Minerals
- Korean National University
- Seoul National University (Korea)
- Instituto del Mar del Peru
- Oxford University (UK)
- Ocean Technology Foundation (USA)
- United States Geological Survey (USA)
- University College London (UK)
- University of Hawaii (USA).

20 Signatures

Tom Campbell, Chairman
Date: 26 June 2014

Ken Shirley, Director
Date: 26 June 2014