STATEMENT OF CORPORATE INTENT

2011-2014

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 2011-2014

Abbreviations

ACC	Accident Compensation Corporation
CRI	Crown Research Institute (any of the companies established since 1992 to replace DSIR)
DBH	Department of Building and Housing
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
ERMA	Environmental Risk Management Authority
IAEA	International Atomic Energy Agency
ICDP	International Continental Scientific Drilling Program
IODP	Integrated Ocean Drilling Program
IPCC	Intergovernmental Panel on Climate Change
LINZ	Land Information New Zealand
MAF	Ministry of Agriculture and Forestry
MCDEM	Ministry of Civil Defence and Emergency Management
MED	Ministry of Economic Development
MFAT	Ministry of Foreign Affairs and Trade
MfE	Ministry for the Environment
MSI	Ministry of Science and Innovation
NZTE	New Zealand Trade and Enterprise
OECD	Organisation for Economic Co-operation and Development

1 Introduction

1.1 Background

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 section 16 of the Crown Research Institutes Act 1992.

This document specifies how we will measure our performance and, as recommended by the Report of the Crown Research Institute Taskforce (February 2010), also specifies how we plan to use our Core Funding, the funding we receive directly from the Crown that is a contribution toward the revenue we need to fulfil our purpose.

We are a Crown Research Institute (CRI). 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 Crown Research Institutes Act 1992, 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.

1.2 Distinctive character

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 host our industry and people. They also cause the volcanoes, earthquakes, tsunami, floods and landslides that threaten our industry and people.

We are the research institute that meets New Zealand's need to discover and understand these earth processes and materials in our region. We facilitate the application of this research in accord with the CRI Act, through technology and information transfer, product development, and consultancy services that create and preserve wealth, protect the environment, and improve the safety and well-being of people. With our predecessors, we have been fulfilling this role for over 140 years.

In 2011-2012 Core Funding is expected to provide 36% of our total revenue, with the remaining 64% coming from the provision of contestable research (19%) and technology transfer (45%) to a wide range of government agency, local body and private-sector users.

1.3 Values

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

- excellence of scientific enquiry and innovation
- application of science for the benefit of New Zealand
- national and international recruitment and collaboration to form the best teams
- financial discipline to provide for future capital needs and to ensure on-going viability

2 Core purpose

Our Statement of Core Purpose was approved by Cabinet in 2010.

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 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, 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.

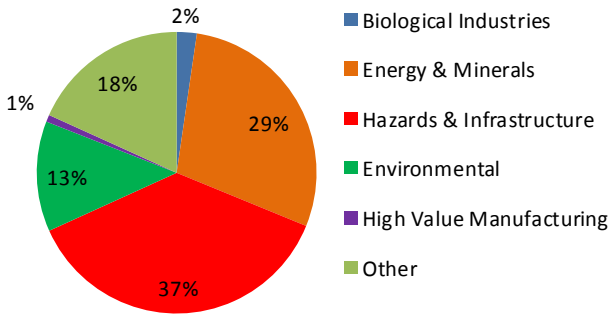
3 Relationship of work to the Government's priority areas

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

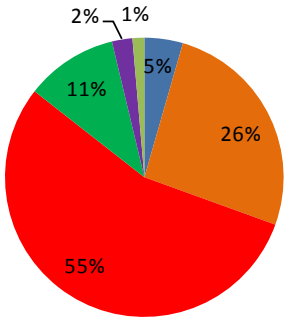
Table 1: Revenue in each of the Government's priority research areas

Government Priority Research Outcome Areas	Core Funding ($k)	Contestable & Tech Transfer ($k)	Total ($k)
Biological Industries	630	2,132	2,762
Primary	*315*		
High value food	*315*		
Energy & Minerals	7,820	12,390	20,210
Energy Resources	*3,247*		
Sustainable Energy	*2,893*		
Mineral Resources	*1,680*		
Hazards & Infrastructure	10,054	26,216	36,270
Hazards & Infrastructure	*9,837*		
Urban Development	*216*		
Environmental	3,437	5,091	8,528
Antarctica	*360*		
Climate & Atmosphere	*2,258*		
Land & Freshwater	*468*		
Terrestrial Ecosystems	*350*		
High Value Manufacturing	216	1,131	1,348
Novel Materials	*216*		
Other	4,958	654	5,612
Collections & Infrastructure	*4,282*		
Capability	*676*		
TOTALS	**27,115**	**47,614**	**74,729**

Direct Crown Funding ($27.1m)



Contestable & Tech Transfer ($47.6m)



4 Key stakeholders

Our key stakeholders are:

- Crown shareholders and other Crown Ministers
- public-good research funding agencies
- commercial clients and other research users in New Zealand and overseas
- iwi/Māori
- collaborating CRIs, universities and research associations in New Zealand
- overseas research organisations
- employees

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

5 National facilities

To achieve outcomes listed in our Statement of Core Purpose, we host several national research facilities:

- GeoNet, the national network for monitoring earthquakes, volcanoes, tsunami, landslides, and tectonic deformation
- the Natural Hazards Research Platform
- the National Isotope Centre to support environmental, climate, and materials research
- the national groundwater monitoring programme and database
- the national paleontology, petrology and minerals collections
- the national geological and geophysical maps and databases
- other nationally significant earth-science databases.

6 Operating principles

We will operate in accordance with the principles stated in the CRI Act 1992 and in our Statement of Core Purpose. In particular:

- Our connections with Crown and private sector stakeholders show that our research will benefit New Zealand
- We will continue to maintain strong, long-term partnerships with Crown and other key stakeholders, including industry, government and iwi/Māori – our work with them to set research priorities that are well linked to their needs, and the revenue to be acquired from technology transfer to key New Zealand stakeholders, show that we will promote and facilitate the application of the results of our research and technological developments, and enhance our work with iwi/Māori for mutual benefit
- Our environmentally-focussed research, geohazards public advisory system, financial and in-kind support of graduate students, provision of other free scientific information on the web-site and popular publications, and our schools and museum outreach programmes, show that we will exhibit a sense of social responsibility
- The planned proportions of our effort and revenue show that we will continue to maintain a balance of research that both provides for the near-term requirements of our sectors and demonstrates vision for their longer-term benefit
- We will continue our collaborative relationships with other CRIs, universities and other research institutions (within New Zealand and internationally) to form the best teams
- We will provide advice on matters of our expertise to the Crown, in both responsive and pro-active ways, especially to MCDEM, MED, MFAT, MFE and MSI, as well as directly to our shareholding Ministers
- We will 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 will use scientific and user advisory panels to help ensure the quality and relevance of our research plans; these will be extended from the former research programme level to advise Senior Management and the Board directly.

7 Key strategic factors

Our operating environment gives rise to five key strategic factors.

Culture – We will continue to foster a vibrant research culture in an environment where revenue from technology and information transfer increases faster than funding for research.

The CRI Taskforce noted that CRIs need to have "work programmes that allow scientific endeavour and excellence to flourish" [1]. The culture of research ("open enquiry, publication when new knowledge is found or a problem is solved") differs from that of technology transfer ("confined scope, on time, on budget"). Over the last ten years non-Crown revenue, mainly from technology transfer, grew by an average of 15% per year, while Crown revenue, mainly for research, grew by 5% per year. This reflects the Crown's smaller increase in science investment in real terms and in relation to GDP. If this trend continues, technology transfer will increasingly dominate our activity and maintaining a research culture will require greater attention. We will do this internally by continuing to recruit the best scientists we can from the global pool, and externally by encouraging other sectors to commission more research.

Public-good role – We will continue to enhance our relationships with Crown agencies.

The CRI Taskforce highlighted the desirability of Crown agencies purchasing CRI services at fair prices and on a long-term basis for the public good [2]. This recommendation addresses a long-standing issue where some of those agencies' budgets have had difficulty providing on-going support for capabilities we hold in the national interest. We will therefore pursue the opportunities that this recommendation is opening, and maintain on-going dialogue in order to improve relationships with key agencies.

Capabilities – We will continue to maintain and enhance our world-class capabilities.

We have world-leading and nationally important capabilities in all of the resources, nuclear and hazards areas. It is important that we maintain and enhance these capabilities, even when circumstances such as staff retirements, global skill-shortages, and limited research funding make this challenging. The Core Funding proposed by the CRI Taskforce [3], and which comes in to effect from 1 July 2011, will give the company control over this issue for the first time. The allocation and management of this funding will be of prime importance.

Productivity and financial viability – We will continue to improve our productivity to ensure continued financial viability as the national and global economies recover.

Our profitability is strongly dependent upon the effective use of staff time, charged at competitive rates. To ensure on-going viability, we will preserve and enhance our revenue streams and improve the productivity of our staff. At the same time, the Board intends to maintain an appropriate level of borrowing.

Collaboration – We will continue our close collaboration with universities, other CRIs, consultants and overseas partners in order to form the best teams to deliver outcomes for our end-users.

We have joint research projects with all eight New Zealand universities, and with five of the CRIs. Our overseas collaborations bring into New Zealand both international scientific knowledge, and access to major capital infrastructure e.g. research vessels, sensor arrays for seismic surveys, and oceanic and continental drilling facilities**.**

[1] Report of the Crown Research Institute Taskforce, 2010, paragraph 5.11, p38

[2] Report of the Crown Research Institute Taskforce, 2010, Recommendation 10

[3] Report of the Crown Research Institute Taskforce, 2010, Recommendation 5

8 Criteria for selecting projects

8.1 Crown and MSI research contracts

We expect Core Funding (36%) and MSI research contracts (19%) to provide 55% of our total revenue. The agreement with the Minister of Science and Innovation provides certainty over the former, and the latter depends on replacement of existing contracts in a contestable environment.

The criteria for deploying these funding streams over the coming three years include:

- the global state of scientific knowledge in each area and the likelihood of this knowledge being increased by further research
- the foreseeable needs of existing and future users of the results of the research for the benefit to New Zealand
- advice received from the external science and user advisory panels
- the availability of human and capital resources to undertake such research.

8.2 Technology transfer projects

We expect the remaining 45% of our revenue to come from technology and information transfer, to a wide range of government, local body and private-sector commercial clients. The total amount of this revenue is much less certain, and private-sector contracts are usually of a commercial-in-confidence nature.

The criteria for assessing which technology transfer opportunities to pursue include:

- the relationship of the project to our core purpose and our key strategic factors
- the business case (resources, technical risk, commercial risk, market options)
- likely longer-term returns and outcomes for New Zealand and for the Company
- intellectual property content and protection
- exit strategy for any joint ventures entered into

8.3 Matauranga Māori projects

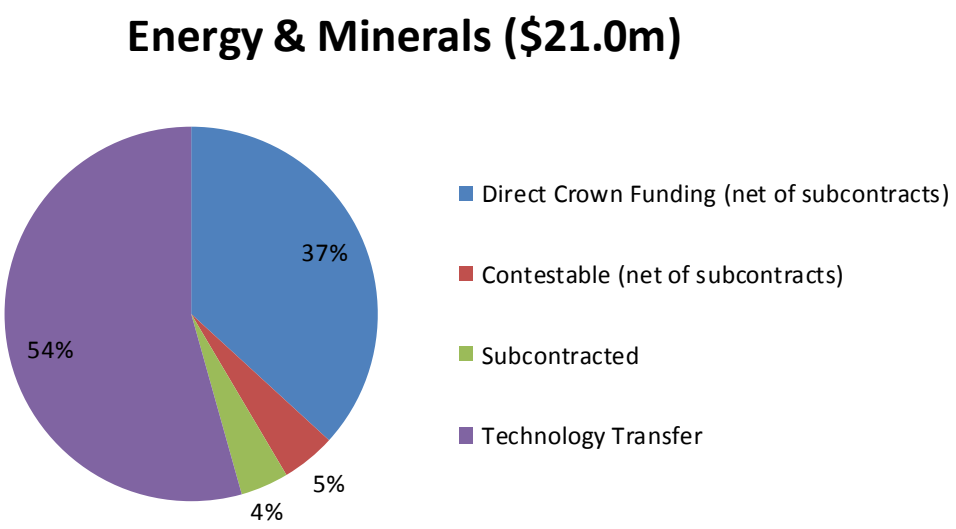
We aim to provide a platform and strategy for the effective engagement of Māori, and Māori knowledge, to enhance our work. Our focus is in three key areas:

- capture and utilisation of traditional and distinctive Māori knowledge;
- recognition of the creative potential for the development of new knowledge;
- identification and enhancement of commercial and economic opportunities and outcomes for Māori, GNS Science and New Zealand.

Many of our projects contribute to environmental, economic and social outcomes for Māori (iwi, hapū, runanga, marae) in, for example, the areas of climate change, geothermal microbiology, and hazard planning. These interactions are driven through science initiatives, and in response to signals from funding agencies and commercial clients.

9 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



9.1 Geological resources

Situation

Government policy is focused on the need for New Zealand to benefit from its geological endowments of energy and mineral resources. Currently developed energy sources for electricity and transportation fuel cannot meet the country's future needs because of dry-year limitations on hydro-generation, and declining oil and gas reserves. There are also societal preferences for renewable and low green-house gas emitting energy sources, such as geothermal energy and biofuels, which are within our scope. We are not actively engaged in research on coal as an energy source because, apart from modern geological mapping, our resource assessment of locations, quantities and grades of coal was completed many years ago, and CRL Energy Ltd is undertaking research on, for example, coal gasification and combustion.

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

- Oil, gas, and carbon dioxide geo-sequestration
- Gas hydrates
- Geothermal energy
- Geomicrobiology
- Minerals

9.2 Oil, gas, and carbon dioxide geo-sequestration

Situation

We undertake research into the processes that result in economic deposits of oil and gas to support the petroleum industry. This research underpins our work with MED to attract investment to New Zealand for new oil, gas, and gas-hydrate exploration, in order to buffer the high costs of oil importation and to eliminate the potential need for LNG imports. Our research also supports industry to optimise resource exploration efficiency to maximise chances of new discoveries being made. These capabilities are essential for implementing the *New Zealand Energy Strategy* (March 2011) through MED's *Petroleum Action Plan*.

Work programme

This research addresses fundamental geoscientific problems, uncertainties and risks associated with the search for oil and gas in New Zealand's sedimentary basins. The focus is on mapping, analysing and quantifying the critical geological, geophysical and geochemical parameters that control how petroleum forms, migrates and is trapped in subsurface rock structures. This is done by using seismic reflection, bore-hole and analogue outcrop data to define and characterise subsurface petroleum source, reservoir and seal rocks, within a framework of evolving basin structure and sediment dispersal and deposition through geological time. The aim is to improve prediction of new petroleum accumulations and to expedite their discovery. This will enhance New Zealand's energy security and economy. In the longer-term we will endeavour to secure funding to identify the most significant sedimentary and structural geological factors that determine petroleum reservoir performance and flow deliverability. This will aid appraisal and development of new fields, optimise reservoir management of existing fields, and ultimately maximise extraction of petroleum. In partnership with Australian agencies, we will apply parallel skills to investigate the feasibility of carbon dioxide storage in sedimentary basins including depleted oil and gas fields.

9.3 Gas hydrates

Situation

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 in a stable form at appropriate pressures and temperatures in many parts of the world, primarily beneath the sea-bed, and are estimated to embody more energy than all known conventional oil and gas fields. New Zealand's resources, at shallow depths below the sea-bed, are potentially among of the largest in the world, with the most promising deposits being ten times greater than the Maui field.

Work programme

We will improve understanding of New Zealand's gas-hydrate resources, and the environmental issues associated with their presence and extraction. In the immediate future we will acquire new data from selected offshore regions that will be used to assess the distribution and quality of potential reservoirs, provide baseline information on the environmental impact of gas hydrates, and compile critical parameters for gas production modelling. The longer-term goal is to identify and rank exploration targets, to undertake scientific drilling to characterise the resource and, finally, to help achieve production of natural gas from gas hydrates by 2021. This would unlock a new source of indigenous fuel leading to energy self-sufficiency and generation of a new export industry.

9.4 Geothermal energy

Situation

Geothermal energy is an indigenous, renewable resource that can provide long-term, reliable base-load electricity generation, with less environmental impact and lower development costs than almost any other source of energy. Geothermal resources are continuing to supply an increasing fraction of New Zealand's electrical energy needs, having risen from 7% to 11% over the past five years. There is the real possibility that electricity generation from geothermal resources could supply up to 20% of New Zealand's electricity demand in the next decade. The renewable nature of the resource, with low greenhouse gas emissions, and the potential for direct use of the heat being ten times more efficient that electricity generation, makes it especially attractive in the longer term to stakeholders concerned with renewable energy targets and global warming issues. Its use is consistent with the OECD's International Energy Agency's implementation of its Geothermal Implementation Agreement. In the longer term, we are the only national expert able to underpin the geothermal industry and its quest for new deep and low-temperature resources.

Work programme

Our big-picture and field-specific investigations based upon geological, geophysical, and geochemical analyses will provide a comprehensive definition of New Zealand's geothermal systems and resources with respect to their permeability, flow pathways, and mineralogy. These will also include investigation of the potential utilisation of deep geothermal resources through geological and geophysical mapping, to gain a greater understanding of the physical and chemical natures of the deep fluids and their flow pathways. This will give developers a high level of confidence and will reduce exploration risks for deep drilling programmes. Together, these activities will enhance New Zealand's energy security and economy.

This research will be supported by our immediate goal of bringing into operation our new laboratory that simulates the chemistry of geothermal systems at the extreme temperature and pressures encountered deep within the earth's crust. A medium-term goal is to re-establish New Zealand's lead role in research that enhances geothermal systems in partnership with industry as part of the International Partnership on Geothermal Technology.

In the longer term, we hope to drill a deep well, over 4 km, in partnership with industry and the ICDP (International Continental Scientific Drilling Program) to initiate research on New Zealand's true-deep potential resource. We also hope to have our research applied for the direct utilisation of low enthalpy and low temperature geothermal resources. We anticipate this use will be increased by at least 20% (i.e. an additional 2PJ, to 12PJ use), and at least three sites will be demonstrating successful low enthalpy electricity generation by 2025.

9.5 Geomicrobiology

Situation

The unusual physical and chemical conditions in geothermal environments nurture globally rare microorganisms and microbial ecosystems. Biodiversity discoveries and advances in biotechnology require in-depth investigations of the microbial ecology, phylogenetics, cultivation and metal-microbial interactions of geothermal and terrestrial environments. Our focus on geothermal microorganisms complements our expertise in geothermal systems. New Zealand's microorganisms and associated enzymes have the potential to benefit global biotechnological industries in addition to advancing our understanding of these unique environments. As a consequence there are major opportunities in providing organic products for energy industries, and in applying geomicrobiological discoveries in the biotechnology

sector such as bioremediation, novel drug discovery, research enzymes and processes that may assist in biofuel production.

Work programme

We will continue to develop a knowledge-base of microbial ecosystems and microbial ecology of geothermal systems in New Zealand. These data will assist in understanding the drivers that define microbial community makeup, how microbes alter geothermal features, and identify unique microbial strains. The results of this research will assist in comprehensively describing the biodiversity of geothermal features and systems. An additional benefit of this research will be the ability to apply, with collaborators, the microbial cultures and/or their components for use in biotechnologies such as bioremediation, biofuels production, industrial enzymes, drug discovery and/or nutraceuticals. Our immediate goal is to identify the top twenty candidate geothermal features for microbial diversity analysis.

In the longer term we intend to provide a web-enabled GIS database of the Taupo Volcanic Zone geothermal features with data that incorporates geochemistry, geophysics, and microbial diversity. Our geomicrobiology staff, with their collaborators and the biotechnology sector, will be investigating New Zealand's geothermal microorganisms for industrial applications. In the longer term the GIS database will be expanded to include offshore EEZ and New Zealand territories in Antarctica. By then the extremophile microbial collection will be actively used by biotechnology companies to solve industrial inefficiencies, and global health and environmental issues.

9.6 Minerals

Situation

MED has a major present focus in its mineral strategy of improving knowledge through data acquisition to identify New Zealand's mineral resources both on land and offshore within its EEZ. Our leading role in geological mapping, supplemented by specific capabilities in assessing the size and grade of mineral resources, developing tools to locate these resources, and formulating models to predict their occurrence is essential for the implementation of MED's strategy, and for the identification and management of these resources.

Work programme

The research aims to achieve growth in the New Zealand economy through focused research on mineral deposits and prospects within New Zealand and it's expanded EEZ. Activities include on-shore and off-shore geochemical analyses and analyses of aeromagnetic and radiometric data, and the application of state-of-the-art technologies on loan from overseas collaborators, such as manned submersibles, AUVs (autonomous underwater vehicles) and ROVs (remotely operated vehicles).

In the longer term we will continue to provide information of sufficient quality and depth that government agencies, and stakeholders in the minerals industry can make informed decisions about exploitation of our mineral resources. We hope to secure funding to support the application of New Zealand-based deep-sea research vehicles (e.g. ROVs) in the exploration of seafloor massive sulfide deposits. We will also seek support for developing industrial mineral processing (e.g. adaptation of zeolites for multiple uses), and high-resolution geochemical mapping for mineral exploration.

9.7 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
- Invitations to collaborate in international research consortia
- Invitations to run international short-courses and field workshops
- Positive feedback from resource stakeholders (including conservation, governmental, iwi/Māori and industrial sectors)

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

- Reduced exploration risk associated with the search for oil and gas
- 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

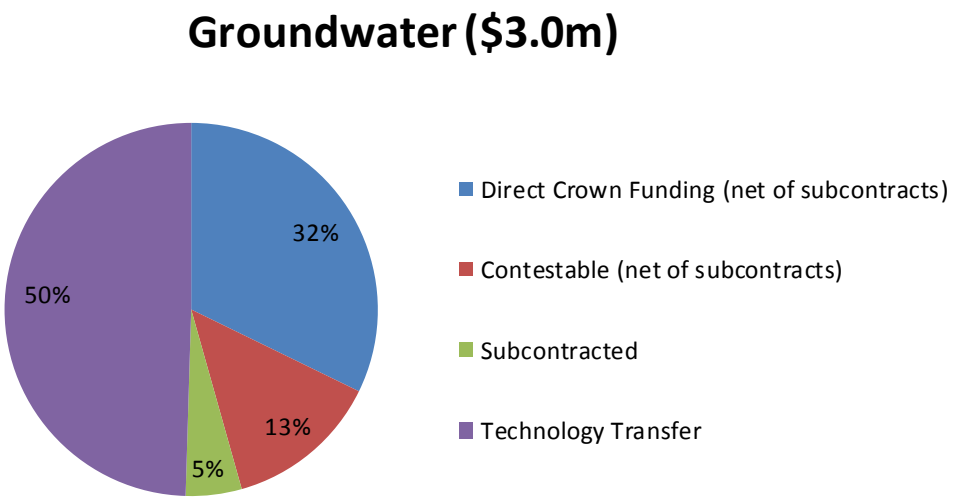
- MED (New Zealand Petroleum and Minerals business unit)
- Crown Research Institutes (eg IRL, NIWA, Scion)
- New Zealand universities
- Australia-New Zealand Integrated Ocean Drilling Program (IODP) consortium
- Overseas universities (especially in Australia, Canada, Chile, France, Germany, Japan, Switzerland,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

Key end-users

- Central government agencies (especially MED; also DOC, EECA, ERMA, MAF, 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 (e.g. Tuaropaki) and landowners with geothermal interests
- Biotechnology sector (biofuels, chemicals, drug discovery and enzyme providers)
- Mineral exploration and production companies
- New Zealand universities
- Overseas research institutions

10 Outcome B: Sustainable management of groundwater

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



10.1 Groundwater

Situation

Groundwater accounts for roughly 40% 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 ca. $30b. It 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. We assess the quantity and quality of groundwater resources. The 2006 Cabinet Paper, *"Sustainable Water Programme of Action – Implementation Package"* highlights the importance of our research.

Work programme

Our research will lead to significantly improved understanding of aquifer systems and will deliver tools for more effective management of groundwater resources. Our programme is structured to impart to key end-users best practice methods for groundwater mapping, monitoring, data interpretation and reporting. Alignment of our research with activities of regional authorities will support justifiable and sound management decisions related to groundwater resources.

In the longer-term New Zealand's aquifers will be characterised and mapped in 3D at the national scale, using a consistent data format. End users will rely on these aquifer maps for water management.

This will be achieved by:

- Continued operation of the National Groundwater Monitoring Programme (NGMP) and maintenance of its associated database. The NGMP provides a national perspective on groundwater quality, identifies spatial and temporal trends in groundwater quality and relates them to certain causes
- Continued operation of the Water Dating Laboratory (WDL), retention of its world-leading analytical accuracy, and expansion of its range of services, including assessment of security of groundwater supply in accordance with the New Zealand drinking water standards
- Development, validation and application of innovative techniques that can be applied to map and characterise New Zealand's aquifers.

10.2 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

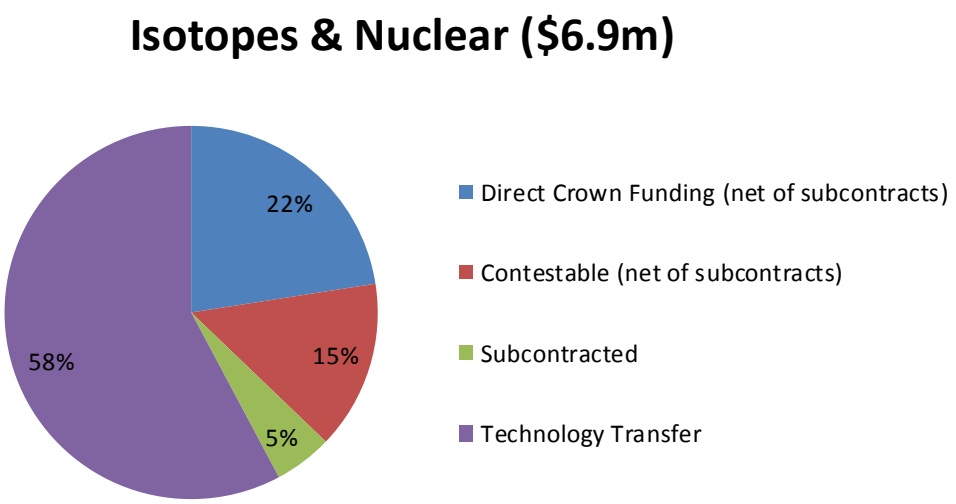
- New Zealand universities
- Overseas universities

Key end-users

- 15 regional authorities (Northland Regional Council, Auckland Council, Environment Waikato, Taranaki Regional Council, Bay of Plenty Regional Council, Hawke's Bay Regional Council, Gisborne District Council, Manawatu-Wanganui Regional Council, Greater Wellington Regional Council, Marlborough District Council, Tasman District Council, Environment Canterbury, West Coast Regional Council, Otago Regional Council, Environment Southland)
- MfE
- MAF
- Other research organisations

11 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



11.1 Isotope and nuclear science

Situation

New Zealand's positions on nuclear-based energy and defence are well known. However, there are many other applications of nuclear-based science that create economic and environmental benefits for New Zealand, but do not create societal or political concerns. We focus our effort on isotope and ion-beam applications that support the earth sciences in the broadest sense, and that leverage off that infrastructure and capability to gain other benefits for the country. We are therefore not presently engaged in routine monitoring of radiation, which is conducted by the National Radiation Laboratory, nor in radiotherapy research, which is conducted by the universities and within the health sector. Our programme of research and technology transfer has the following components:

- Isotope biogeosciences
- Air particulate pollution analysis
- New materials from ion-beam technology

11.2 Isotope biogeosciences

Situation

We develop, maintain and enhance the key national infrastructure to apply accelerator mass spectrometry (AMS) and isotope ratio mass spectrometry (IRMS) in the biogeosciences. Significant recent investment has provided our national facility with the ability to develop 2D and 3D "isoscapes" at catchment to continental scales. These are created from

measurements of isotopes as natural tracers that allow us to understand the development of resources, hazards and environments across space and through time. Isoscapes will underpin research areas such as hydrology, ice core research, petroleum exploration, paleoenvironment, forensics and natural product authentication. The benefits for New Zealand industry and government will be access to measurements that support fields such as oil and gas exploration and the authentication of New Zealand agricultural products.

Work programme

As the initial two steps toward the goal of developing national isoscapes we are developing isotopic tools that will allow us to better understand the carbon and nitrogen cycles.

One key component will be terrestrial carbon research with a dual focus on soil carbon dynamics and verification of fossil fuel CO_2 emission inventories using radiocarbon as a tracer. This will identify ways to manage the carbon cycle within the New Zealand emission trading scheme and future global agreements. The other key component is identification of land-to-water nitrogen transfers. This will enable the management of nitrate leaching from agriculture within schemes that cap total catchment nitrogen loads. The techniques we are developing in these areas will ensure New Zealand agriculture can continue to develop a global reputation for efficient production within environmental limits.

In the longer term we plan to deliver an array of isoscapes that demonstrate the value of isotope infrastructure and capability in delivering benefits to New Zealand industry, with additional outcomes in the areas of global change monitoring, agricultural product authentication, exploration geology, and paleoclimate research initiatives.

11.3 Air particulate pollution

Situation

Air particulate matter is a recognised health and environmental hazard, and two-thirds of New Zealanders live in urban areas that experience episodes of degraded air quality. Regulatory authorities will be required to manage air quality in their regions to meet the standard in the coming decade. Our fine-particle air-quality research underpins MfE's *National Environmental Standards for Air Quality* as applied to local government, and informs the Ministry of Transport, the Ministry of Health and the Health Research Council with respect to health effects in exposed populations. As current methods do not identify the sources of air particulate pollution, determining particle composition is absolutely crucial to identify the anthropogenic and natural source contributions.

Work programme

Ion-beam technology allows us to efficiently measure the elemental composition of local, regional and transboundary particulate pollution, the critical elements being hydrogen, silicon, sulphur, chlorine and carbon compounds. We are developing a high-resolution air particulate matter (HAPM) model to explain the observed 24-hour airborne particle concentration pattern in urban air sheds and identify the actual source contributions and particle transport paths. We will compare diverse air sheds to cover geographic range and population densities.

In the longer term, we will extend our capability to include particle number and size distributions to better identify the potential health risks to exposed populations. We envisage a source-fingerprint database of fine and coarse air particulate matter in urban and rural areas in New Zealand. This will require a systematic sampling of air particulate matter at a multiplicity of urban and rural areas in New Zealand stretching at least four years to generate

elemental data with seasonal trends and transboundary air pollution events. This database would be the first of its kind and provide the baseline for any further air particulate research to underpin policy implementation.

We will also transfer our expertise into related areas of research, such as air particulate matter associated with ice core research with a focus on southern hemisphere circulation and the effect of carbonaceous aerosol on climate.

11.4 New materials from ion-beam technology

Situation

We have nationally unique capabilities through our application of accelerator ion-beam implantation techniques. These allow us to alter a material's properties by implanting other elements, atom by atom, in its surface layers. The primary drivers for this work are identified needs of private-sector high-technology enterprises for whom we can develop innovative nanoscale materials. In this respect we are paying close attention to the outcomes of MSI's current *High Value Manufacturing and Services* review. We intend to generate IP centred on novel ion-beam methods for producing nanomaterials, and to demonstrate their economic potential by developing prototype devices in collaboration with end-user partners. We are members of the MacDiarmid Institute of Advanced Materials and Nanotechnology and the Materials Accelerator operated by the University of Auckland.

Work programme

One of our current applications is the development of magnetic nanocluster bands comprising nanometre-size clusters of magnetic atoms, such as iron or nickel, embedded in an insulating matrix (e.g. silicon). Magnetic nanocluster bands have recognised novel potential uses in magnetic sensors, miniature motors and data storage devices. The global market for magnetic nanomaterials is about $4b. However, expansion of the global market is currently hampered by the extreme difficulty of controlled fabrication of magnetic nanomaterials using methods that are non-toxic and suited to rapid uptake by existing microelectronics manufacturers. Our techniques address this difficulty.

This research represents a tremendous opportunity to generate significant revenue for New Zealand in part because there are established domestic companies that manufacture or use high-performance magnets and devices (e.g. our end-user collaborators), providing an internationally credible, rapid pathway to market.

In the longer term we expect to become an established provider of technology transfer to industry of high-value sensors for environmental applications, for example, in greenhouse gas detection and measurement. We also see potential for demonstrating the applications of ion-beam coatings and ion implantations for the heavy metals manufacturing, biotechnology and medical applications and, further out, possibilities for enhanced electrical energy storage using new materials.

11.5 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 through isotope applications

Key research collaborations

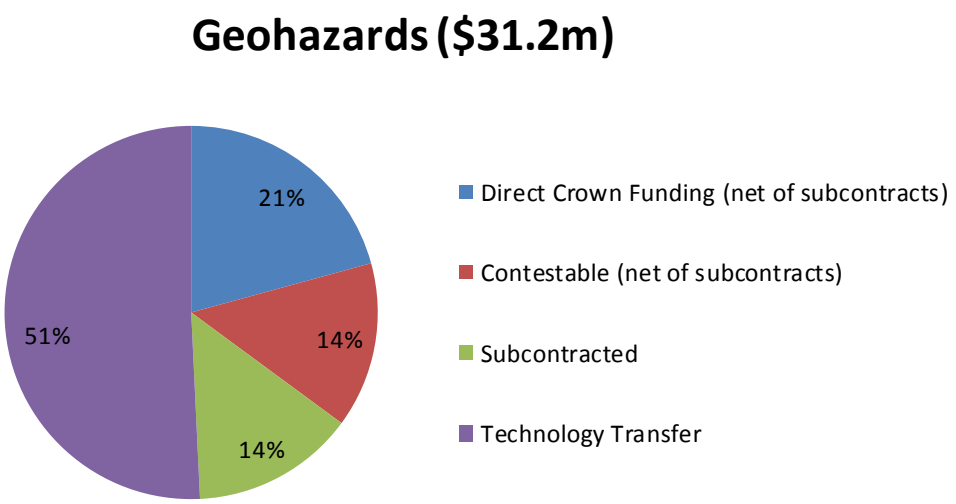
- Crown Research Institutes (eg IRL, NIWA)
- New Zealand universities
- Overseas universities
- City Councils (especially Auckland Council, Nelson City Council)
- Regional Councils (especially Otago Regional Council, Greater Wellington, Environment Canterbury
- New Zealand Transport Agency

Key end-users

- Farmers and industry organisations
- MAF
- MfE
- Ministry of Health
- Ministry of Transport
- Regional Councils
- Nanomaterial production industry
- Sensor manufacturing industry
- New technology industries
- Other research organisations

12 Outcome D: Resilience to natural hazards

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



12.1 Natural hazards

Situation

The *Civil Defence and Emergency Management Act 2002*, and national and international disasters, are changing emergency management in New Zealand and other countries exposed to natural hazards. In partnership with EQC, we operate the national GeoNet network of instruments to monitor earthquakes, volcanoes, tsunami, and landslides. The data from this network provide critical underpinning for all downstream research. We host the Natural Hazards Research Platform and therefore in addition to our geological hazard research contributions, we carry specific responsibility for its management. We are a principal adviser to local and overseas authorities and companies taking an "all-hazards" approach, and we advise the insurance industry and development agencies. Their interest is in risk, which is the product of both hazard and vulnerability. We are therefore also engaged in vulnerability research to underpin our advice in that area. Finally, we undertake social science research in order to underpin our advice to MCDEM and other agencies, and to promote appropriate societal preparation for, and response to, natural hazards.

The Canterbury earthquakes of September 2010 and February 2011 will for many years give this area a renewed national focus whose magnitude and importance cannot be overstated. Our programme of research and technology transfer has the following components:

- Geological hazard monitoring
- Natural Hazards Research Platform
    - Geological hazard assessment
    - Risk evaluation
    - Societal resilience

12.2 Geological hazard monitoring

Situation

We design, install, and operate GeoNet, the national network that monitors earthquakes, volcanoes, tsunami, and landslides. This is funded by our EQC and LINZ partners under long-term contracts. The facility includes communications infrastructure to transmit data to 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 in New Zealand or overseas, relies upon data from this network.

GeoNet comprises a broad range of infrastructure:

- Seismographs to measure the magnitude location and characteristics of earthquakes
- Global Position System (GPS) equipment to pinpoint where strain is building up or being released in the earth's crust
- Seismic, geochemical, GPS survey and remote sensing techniques for early detection and monitoring of volcanic unrest
- Survey equipment and mobilisation resources for a nationwide landslide monitoring and response team
- Strong motion recorders for buildings and bridges to monitor how structures perform in earthquakes
- Water-pressure sensors to detect the arrival and height of tsunami waves
- Communication networks
- Data management and processing centres
- On-call duty staff

Work programme

As the workload induced by the Canterbury earthquake aftershocks diminishes, we plan to accelerate more real-time coverage of all technologies in the Canterbury region and then move attention to coverage in the upper South Island. Improved speeds (particularly for earthquake locations) and increasing the depth of available derived information (eg: STEP, Shakemap) will be priorities. End-user linkages, technical research, and public outreach will remain important activities. At the same time support will be provided to significant research projects (e.g. scientific drilling programmes).

Our medium-term goals are 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.

In the longer term capability improvements would be possible (eg: many more borehole sensors for tremor research, ocean bottom sensors, almost instant earthquake locations, local tsunami warning, earthquake early warning, very precise geospatial information availability). However, the significant increase in required investment would likely be out of proportion to the investment the downstream research and would therefore be hard to justify to sustain.

12.3 Natural Hazards Research

Situation

Research conducted under the Natural Hazards Research Platform has the goal of mitigating for New Zealand the impacts of natural hazards. The research themes led by GNS Science focus on developing quantitative estimates of geological processes such as earthquake, volcano, flood, landslide, and tsunami activity in New Zealand. Our research also evaluates the risk to which New Zealand is exposed how well society is prepared for these and other weather-related perils. 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.

Detailed short and longer term work-plans are being strongly influenced by requirements resulting from the September 2010 – February 2011 Canterbury earthquakes.

Work programme

Data gathered by GeoNet and specific field projects will be analysed using methods developed both in New Zealand and overseas to understand why volcanoes, earthquakes, landslides and tsunami occur where they do, at what frequency, and in what 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. These 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 on New Zealand and the age and quality of buildings and infrastructure. These models are developed with continuous feedback from users, namely emergency management authorities, response planners, and lifeline utility operators. The output 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 society will have enhanced its overall resilience to natural hazards through prioritised expenditure and reduction of both social and economic impacts of at-risk communities.

Social science and land use planning applied to natural hazards are a distinctive and important part of the research. This research 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. Using the outputs of both the quantification of hazard events and the risks they create from the foregoing components, we will proceed with (i) engagement with communities of all types and stakeholders at all levels to better understand functions, needs, cultural and economic contexts; (ii) development of improved disaster management strategies; (iii) development of improved organisational systems to recover economic competitiveness after hazard events; (iv) development and quantitative assessment of options for hazard mitigation, and advocacy of the appropriate mix of reduction, readiness, response and recovery activity.

12.4 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

Key research collaborations

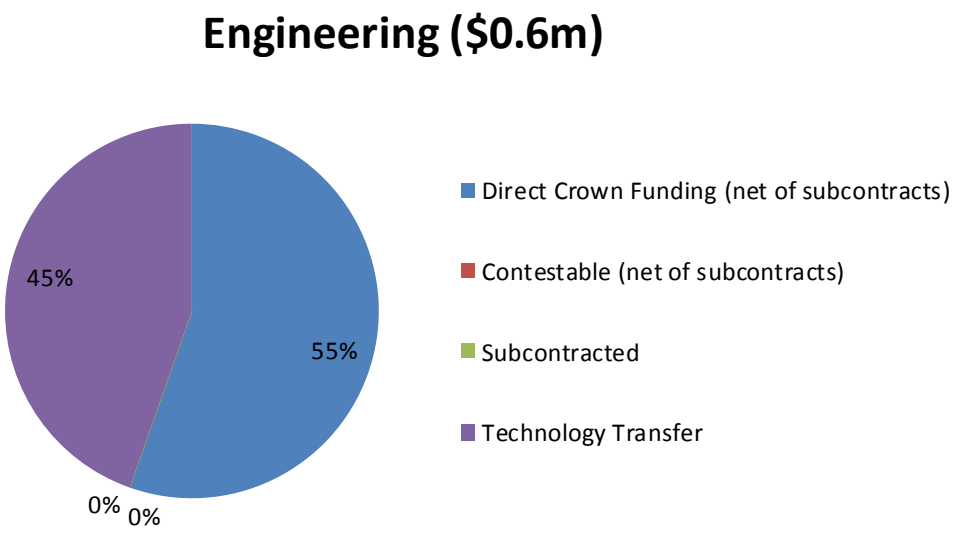
- New Zealand universities
- NIWA
- Central government agencies (LINZ, DoC, MCDEM, New Zealand Defence Force)
- Equipment and service providers

Key end-users

- Central government agencies (DBH, DoC, LINZ, MAF, MCDEM, MED, MFAT, Ministry of Health)
- 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, engineering consultancies, Lifeline Engineering Group)
- Transport sector (Civil Aviation Authority of New Zealand, airlines, Maritime New Zealand, New Zealand Transport Agency,infrastructure operators)
- Building industry (DBH, BRANZ, Standards NZ)
- Energy sector (DamWatch, production companies, infrastructure operators)
- Insurance sector (EQC, ACC, underwriters and re-insurers)
- Education sector (schools, polytechnics and universities)
- New Zealand researchers (eg universities, CRIs)
- New Zealand public (radio, television, electronic and print news media, general public)

13 Outcome E: Enhanced geotechnical engineering

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



13.1 Engineering geology

Situation

Engineering geology is an essential component that underpins all infrastructure projects, including those addressing geotechnical problems clearly related to natural hazards,. In many cases the distinction between natural hazards and human-induced hazards (e.g. poor engineering) need not be made. Projects include site-specific construction (e.g. for power generation), lifeline networks (e.g. for transport, electricity, gas, water), and regional assessments based on a common problem (e.g. low soil strength). While there have been few major infrastructure projects in New Zealand in recent years, research in this area remains essential. The recent Canterbury earthquakes have brought some of these issues to the attention of the public. The scope of our work is not in competition with engineering consultancies, but is designed to support them through the provision of engineering geological information on, for example, geological structures and rock properties that underpin nationwide standards.

Work programme

Our capability in ground-structure interaction, a key area of research if structures and lifelines are to remain operational, will over the next three years be largely diverted to issues arising from the 2010–2011 earthquakes in Canterbury. New knowledge gained from this work will in the future be applicable to other parts of the country.

That work programme will involve, with many collaborators, slope stability issues in the Port Hills, impacts of liquefaction on underground services, impact of ground conditions on building performance, and analysis of strong ground motions.

13.2 Indicators, collaborations and end-users

Key indicators of science quality

- Peer-reviewed journal papers
- Industry conference papers

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

- Results of research embedded in design codes and standards (e.g. NZS 1170.5 & NZS 3604)

Key research collaborations

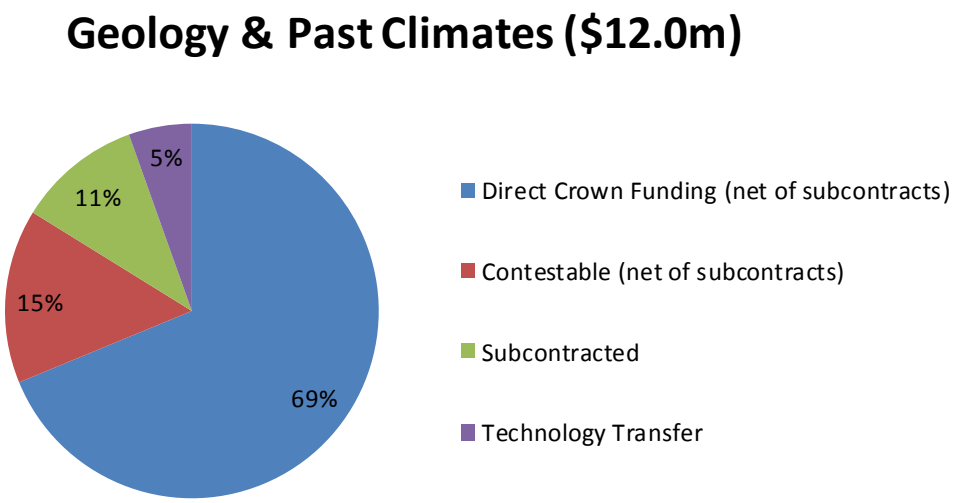
- New Zealand universities
- End-users who provide data to be combined with our data

Key end-users

- Department of Building and Housing
- MAF
- MED
- MCDEM
- Ministry of Education
- Standards New Zealand
- Geotechnical consultants
- Structural Engineers
- Construction industry
- Power generators
- Utilities operators
- Infrastructure operators
- Insurers

14 Outcome F: Understanding of geology and past climates

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



14.1 Geology and past climates

Situation

A crucial role for GNS Science in the earth sciences, both globally and in New Zealand, is to explore and compile onshore and off-shore maps in the New Zealand region, to understand the environmental history that is recorded in the geology, and to understand the dynamic processes acting at 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 natural resource evaluation, hazard assessment, and the definition of the nation's territorial and cadastral boundaries. Moreover, New Zealand has the fifth largest EEZ and Extended Continental Shelf in the world, but the geology and geological resources of this vast region, which represents 96% of our territory, remain poorly known and underexplored. Our programme of research and technology transfer has the following components:

- Geological Map of New Zealand
- Past life and past climates
- Impacts of plate tectonics on New Zealand
- Landscape evolution
- DrillNZ

14.2 Geological Map of New Zealand

Work programme

This research involves the acquisition and collation of information on the distribution and composition of geological units of New Zealand and its territories, particularly around urban centres and areas of proven or potential resource. The collated information is distributed principally via published geological maps. Other research into the age and origin of basement rocks involves petrological, geochemical and geochronological techniques that lead to improved understanding of terrane and igneous crustal processes. This work underpins several of our other outcome areas. Our immediate goal is to complete the QMAP Seamless GIS 1.0 dataset, publish the geological map of South Victoria Land, and deliver the QMAP series online.

In the longer term, we intend to have geological datasets, especially 3D models, available for Christchurch, the full Regional Geological Map Archive and Data File archived with scanned images available online, and other theme maps published. Eventually we hope to have detailed geological datasets, in formats that suit many user groups and including 3D models, available for all the larger cities and important resources areas.

14.3 Past life and past climates

Work programme

We will track past climate and environmental changes by:

- Quantifying the relative roles of high and low latitude drivers on climate change and variability in the New Zealand region
- Identifying factors that govern the stability of the West Antarctic Ice Sheet and the magnitude of related sea-level change
- Collecting regional data on past periods of modest to extreme global warming to determine parameters for CO_2 sensitivity, circulation and heat transport that are used in global numerical climate models
- Contributing to research on the carbon cycle that underpins carbon accounting systems and modelling of productive and natural ecosystems

We undertake organic, biostratigraphic and paleoenvironmental interpretation of onshore and offshore sedimentary cores, and physical, chemical and stable-isotope analysis of ice cores from New Zealand and Antarctica. These data support numerical modelling of climate and the carbon cycle. This research relies on our participation in international scientific drilling consortia, and makes extensive use of information from the New Zealand Fossil Record File and the National Paleontology Collection. A major challenge is to maintain our membership in order to benefit fully from the Integrated Ocean Drilling Program's (IODP) sea-floor drilling.

14.4 Impacts of plate tectonics on New Zealand

Work programme

Information on past and current crustal motion will be acquired from rock sampling, land and marine geological and geophysical surveys, investigation of ancient and active faults, earthquake occurrences over all magnitudes, and GPS and satellite observations. The results provide better understanding of the origin of natural resources, of geological hazards, and landscape processes. The research results and human capability underpin most of our other outcome areas and the research has specific outcomes that include improved surveying methods, a national surveying datum, and precise monitoring of true sea level change.

In the longer term we plan to leverage significant benefits from: the acquisition of extensive new geophysical datasets in collaboration with international scientists and New Zealand government departments; from participation in the International Continental Scientific Drilling Program (ICDP), to complete deep drilling of the Alpine fault; and from participation in the Integrated Ocean Drilling Program (IODP) to drill the Hikurangi subduction interface.

14.5 Landscape evolution

Work programme

In the face of global environmental change and increasingly intensive land-use, New Zealand needs to understand its landscapes and processes therein. This research will develop a quantitative understanding of how landscapes respond to ever-changing global environmental drivers and human intervention. Our immediate goal is to complete Waipaoa and Waitaki site work on sediment transport and initiate work at other New Zealand sites.

In the longer term, we plan documenting historical landscape response to earthquakes and volcanic eruptions, and thereby develop fully-coupled landscape evolution and tectonic models to advise on future environmental and land use change scenarios. Eventually we plan to develop fully-coupled source-to-sink numerical models of erosion and sedimentation.

This work would greatly enhanced with future investment in (i) acquisition of high resolution data such as river catchment-wide LiDAR and lake drill-cores would support quantitative sediment budgeting, (ii) intensive field-based studies and drilling to understand effects of subduction earthquakes, and (iii) real-time collection of data on suspended sediment loads before, during, and after contemporary earthquakes and volcanic eruptions.

14.6 DrillNZ

Work programme

We plan to provide coordination and leadership of information and infrastructure to facilitate scientific drilling, to gain maximum scientific advantage from industrial drilling, and to better inform and train both industry stakeholders and their regulators. Drilling is the primary method used to sample rocks and fluids or deploy instruments at depth within the Earth. Scientific drilling has played a key role in our exploration of the oceans and continents, in deciphering the geological history of our planet, and underpins a wide range of economic development activities. Drilling technology is widely used for petroleum and groundwater production, mineral and coal exploration, geothermal energy generation, and geotechnical engineering investigations. This work, therefore, underpins all other outcomes.

Major challenges for the future are to

- establish a clear scope for the DrillNZ initiative
- to establish coordination of existing infrastructure, data, samples, and relevant related information
- maintain memberships of international drilling consortia, especially the Integrated Ocean Drilling Program (IODP) and the International Continental Scientific Drilling Program (ICDP)
- develop adequate national infrastructure to store or analyse data and samples that have been collected by research projects and industry.

14.7 Indicators, collaborations and end-users

Key indicators of science quality

- Peer-reviewed journal papers
- Peer-reviewed geological maps
- Invited presentations at science conferences
- Invited presentations at government workshops
- Invitations to contribute to and referee IPCC (Intergovernmental Panel on Climate Change) 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)
- CRI and university partners in DrillNZ
- New Zealand, US, German and Italian partners in the ANDRILL program
- International paleoclimate researchers, including participants in IODP and ICDP
- Crown Research Institutes (eg Landcare Research, NIWA)
- MED
- National Science Foundation (US) research programmes
- New Zealand universities
- Partners in the Joint Antarctic Research Institute (VUW, NIWA, University of Otago, University of Canterbury)

Key end-users

- Energy production companies
- Industry, utility companies and consultancies
- Intergovernmental Panel on Climate Change (IPCC)
- International science community, especially Antarctic Climate Evolution community
- LINZ
- MAF
- MCDEM
- MED
- MFAT
- MfE
- Regional Councils and Territorial Authorities
- Local iwi/Māori
- Other GNS Science and university research programmes, especially those on petroleum, mineral wealth, groundwater and natural hazards
- Public and policymakers

15 Other outcomes: Outreach and education

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

15.1 Public knowledge of research results

It is essential that we communicate the results of our science to the public. We do this not only from a sense of social responsibility, but also because a better public understanding of science will result in economic, societal, and environmental benefits for New Zealand.

Work programme

Our communications programme comprises five main elements:

- provision of public information through our public websites (www.gns.cri.nz and www.geonet.org.nz) and authorship of books for mainstream publishing houses
- engagement with the news media to bring to the public's attention those of our achievements that are of current interest
- partnerships with the museum sector, especially Te Papa Tongarewa, to up-skill curators and provide visitors with object-focused information and experiences
- curriculum-linked educational outreach to primary and secondary schools, through engagement with teachers nationwide and, where possible, with schools locally
- having science staff available to speak to a wide range of audiences upon invitation, and organisation of the monthly Wellington and Lower Hutt Café Scientifique events

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

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

15.2 Graduate education

Our capabilities and facilities support earth science, isotope and ion-beam education in universities and make a key contribution to world-class graduate education in New Zealand. This is most effectively, but not exclusively, done under formal agreements with specific universities (Victoria University of Wellington, Massey University) to jointly manage graduate programmes. These involve 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 have particular economic, societal, and environmental interest for New Zealand, which 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

16 Science performance descriptors (metrics and narratives)

Tables 2-6 give the performance descriptors, including both metric and narrative information, upon which we will report annually. Other information, of a commercial-in-confidence nature, will be included in quarterly reports to the shareholders.

Implementation of our human resource policies, including recruitment, training and career path provisions, is designed to optimise talent recruitment, and our staff retention figures and other metrics show how we will measure our success in being a good employer.

Table 2: Human resources descriptors

Full-time equivalents (FTEs) Scientists and specialists Science support General support & management
Distribution of science effort (FTEs) Science Technology transfer
Staff turnover
Training & development ($000)
ACC workplace safety accreditation
Work days missed due to injury [1]
Staff engagement (% proud to work for GNS Science) [2]

[1] number of staff involved will also be reported

[2] this will be measured only every second year

Table 3: User input descriptors

Number of user Advisory Groups
Number of user Advisory Group meetings
Narrative on in-kind support provided by end-users (with dollar values if possible)
Narrative examples of input from Advisory Groups

Table 4: Research collaboration descriptors

Number and percentage of joint peer-reviewed publications with other NZ or international institutions
Number of visiting researchers hosted
Value of research contracts to other research organisations (incl % to NZ universities)
Value of research contracts from other research organisations (incl % from NZ universities)
Number of graduate scholarships funded
Number of graduate students supervised
Narrative on scientific facilities provided to other science organisations (with dollar value if possible)
Narrative on scientific facilities provided by other science organisations (with dollar value if possible)

Our technology transfer and science performance indicators show how we will measure our achievement of excellence in these areas.

Table 5: Technology transfer descriptors

Technology transfer effort (FTEs - from time sheets)
Number of commissioned reports to users
Total revenue received from clients
Number of new patents registered
Number and value of IP licensing (incl technologies, products, services) in NZ and overseas
Client feedback average score (out of 10) with standard deviation
Number of projects achieving outcomes or creating opportunities for iwi/Māori
Number of international fora with staff representing New Zealand
Database use • Number of databases accessible to the public via the web • Registered external users of GNS Science data • Number of users accessing the GNS Science website (per annum figure + daily peak) • Number of users accessing the GeoNet website (per annum figure + daily peak)
Narrative on in-kind support contributed by clients (with dollar value if possible)
Narrative on users who have adopted technology or knowledge

Table 6: Science descriptors

Science effort (FTEs – in preceding calendar year)
Number of peer-reviewed science papers and book chapters (in preceding calendar year)
Number of research monographs and maps (in preceding calendar year)
Number of other journal papers and publicly available science reports (in preceding calendar year)
Publication rate (peer-reviewed science papers/monographs/chapters per science FTE)
Total number of citations of science publications for each of the five preceding calendar years
Use of science - h_1-score (number of science publications cited at least this number of times)
Scientist visibility - h_2-score (number of staff with an *h*-score of at least this number)
Number of new Marsden-funded projects
Narrative on key research results

17 Financial performance indicators and targets

Our financial systems enable us to operate in a financially responsible manner and remain financially viable. We budget to deliver 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	2011 forecast	2012 budget	2013 outlook	2014 outlook
Return on equity	8.0%	9.0%	15.2%[1]	11.6%
Non-government revenue [2]	44%	44%	47%	49%
Return on assets	6.2%	7.1%	12.5%	10.5%
Operating margin	10.7%	11.3%	14.3%	12.9%
NPAT margin	2.6%	2.9%	5.3%	4.4%
Profit [3] per FTE ($000)	20.6	22.8	29.9	27.8
Chargeable time of science staff (%)	77%	78%	79%	80%
Quick ratio	1.2	1.1	1.2	1.3
Equity ratio	51.4%	52.7%	60.8%	63.9%
Tech transfer & contestable revenue [4]	92% [5]	64%	65%	66%
Revenue growth	9.0%	5.3%	3.9%	4.5%
Tech transfer revenue growth	1.2%	8.8%	15.0%	12.6%
Capital renewal ($000)	4,850	6,500	5,600	7,000
Return reinvested	6.5%	8.0%	13.1%	10.4%

[1] includes profit on sale of property

[2] proportion of revenue that is not from Crown (MSI and Marsden) research funding

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

[4] proportion of revenue that is from commercial operations and contestable funding, assuming constant Core Funding

[5] a significant part of contestable Crown funding has become Core Funding subsequent to 2011

18 Information to be reported

18.1 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 scientific and operational 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, 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.

18.2 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 targets in the SCI for the year, and the comparative figures for the previous year; this will include reporting on science performance in metric and narrative form
- a commentary on performance for the period
- an account of deployment of Core 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.

18.3 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.

19 Accounting, investment, and other business policies

19.1 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 are prepared in accordance with Section 17 of the Crown Research Institutes Act 1992, the Public Finance Act 1989, the Companies Act 1993 and 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 2010. No significant changes in accounting policies are envisaged between the above policies and the budget and forecast information included in this document.

19.2 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.

19.3 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.

19.4 Databases and collections

The Company has detailed policies on data and information ownership, access and pricing. We will comply with all relevant legislation and regulation pertaining to ownership, access and pricing of data and information. We will own and intellectually protect as much copyrighted data and information as it is reasonable to retain.

Allocation of a portion of Core Funding will enable us to maintain our databases and collections, and facilitate 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 PET 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 provide full access to data and information that has been funded by the Crown, unless this is not to New Zealand's benefit. Reasons for restricting access may include the potential loss of valuable intellectual property to other nations, public control when facing impending geological disaster, or management over newly discovered and valuable mineral resources. We will also provide specific access to data and information funded from our own resources, in compliance with the obligations of the Commerce Act, the Official Information Act and the CRI Act. The Company will charge an appropriate access fee for the data and information we own, depending upon the funding source and the nature of the end use.

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.

20 Crown equity, dividend policy, and compensation

20.1 Crown equity

The Board will conduct a review of the commercial value of the Company whenever it considers there to be a material change in the Crown's investment. The Board undertakes to fully consult with the shareholders at all stages of the valuation process and to provide shareholders with copies of all relevant reports.

No valuation exercise has been undertaken since formation of the Company on 1 July 1992.

20.2 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
- the rationale and analysis used to determine the amount of dividend.

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

Year ending 30 June	2011 forecast	2012 budget	2013 outlook	2014 outlook
Equity ($000)	23,389	25,331	28,894	32,065
Dividends ($000)	240	250	550	370

20.3 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.

21 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 well in advance 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, MED):

- Australia New Zealand Minerals and Energy Council Chief Government Geologists Conference (ANZMEC CGGC)
- Australian Institute of Nuclear Science and Engineering (AINSE)

- International Atomic Energy Agency Regional Co-operative Agreement (IAEA RCA)
- Incorporated Research Institutions In Seismology (IRIS)
- International Consultative Group on Food Irradiation.
- International Energy Association (IEA) Geothermal Experts Group
- OECD International Energy Agency Geothermal Annex (GNS Science holds Secretariat)
- Pacific Tsunami Warning and Mitigation System (Intergovernmental Oceanographic Commission, UNESCO)
- United Nations Comprehensive Test Ban Treaty Working Group

The Company is a Member of, or represents New Zealand, on unions and associations of the International Council of Scientific Unions (ICSU), and other international scientific committees, specifically:

- Australian Institute of Nuclear Science and Engineering (AINSE)
- 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 Geological Congress (IGC)
- International Union of Geological Sciences (IUGA)
- International Union of Geodesy and Geophysics (IUGG)
- Scientific Committee on Antarctic Research (SCAR)
- Southern California Earthquake Center (SCEC)

In addition, the Company has Memoranda of Understanding with the following overseas institutions. These usually provide for the exchange of staff between institutions on collaborative programmes and in some cases partial funding for new research initiatives:

- International Atomic Energy Agency
- Cooperative Research Centre for Greenhouse Gas Technologies (CO2CRC) (Australia)
- Geoscience Australia
- Chilean National Commission for Scientific and Technological Research (CONICYT)
- China Earthquake Administration
- China Geological Survey (CGS)
- 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 (MGMR)
- Nankai University (China)
- State Seismological Bureau, China (SSB)
- University of La Reunion (France)
- Helmholz Centre Potsdam GFZ German Research Centre for Geosciences
- Geological Survey of Japan (GSJ)
- Japanese National Institute of Advanced Industrial Science and Technology (AIST)

- Japan Marine Science & Technology Centre (JAMSTEC)
- New Energy and Technology Development Organisation, Japan (NEDO)
- Jeonnam Regional Environmental Technology Development Centre (JETeC, South Korea)
- Korean Institute of Geology, Mining, and Minerals (KIGAM)
- Korean National University
- Seoul National University (Korea)
- Instituto del Mar del Peru (IMARPE)
- Oxford University (UK)
- Ocean Technology Foundation (USA)
- United States Geological Survey (USA)
- University of Hawaii (USA)

22 Signatures

Tom Campbell, Chairman
Date: 30 June 2011

Ross Butler, Deputy Chair
Date: 30 June 2 011