STATEMENT OF CORPORATE INTENT

2012-2015

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 2012-2015

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
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
MoE	Ministry of Education
MoH	Ministry of Health
MoT	Ministry of Transport
MPI	Ministry for Primary Industries
MSI	Ministry of Science and Innovation
OECD	Organisation for Economic Co-operation and Development

1 Introduction

1.1 Legal 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 section 16 of the Crown Research Institutes Act 1992 (CRI Act). It describes our plans for the coming three years, states how we will measure our performance, and specifies how we will use the Direct Crown Funding[1] that forms part of the total revenue we need to fulfil our core purpose (Section 2).

In 2012-2013 Direct Crown Funding is expected to provide 36% of our total revenue, with the remainder coming from the provision of contestable research (18%) and technology transfer (46%) to a wide range of government agency, local body and private-sector users.

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 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 cause the volcanoes, earthquakes, tsunami, floods and landslides that threaten the industries and people that they sustain.

We are the research institute that meets 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 technology and information transfer, product development, and consultancy services that create wealth, protect the environment, and improve the safety of people. With our predecessors, we have been fulfilling this role for over 140 years.

In addition to undertaking scientific research, and applying it for the benefit of New Zealand, we also hold stewardship for the following national facilities (Section 6) that have many other users:

- 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
- National Geological and Geophysical Maps and databases.

[1] Direct Crown Funding is the funding provided to the Company under the Core Funding Agreement, dated 27 June 2011, between the Company and the Minister of Science and Innovation

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
- financial discipline to provide for future capital needs and ensure our on-going viability.

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

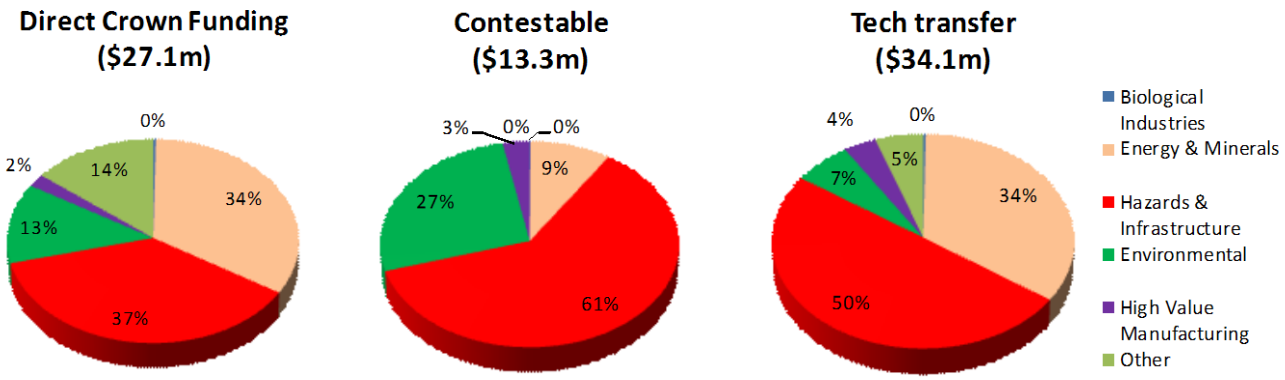
- our connections with Crown and private sector stakeholders show that our research will benefit New Zealand
- we will continue to maintain strong, long-term partnerships with Crown and other key stakeholders, including industry, government and iwi/Māori – our work with them to set research priorities 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 our 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.

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 ($k)	Contestable MSI & Marsden ($k)	Tech Transfer ($k)	Total ($k)	Outcome Areas
Biological Industries	87	13	100	200	C
Primary	*0*				
High value food	*87*				
Energy & Minerals	9,095	1,206	11,704	22,005	A
Energy Resources	*3,504*				
Sustainable Energy	*3.305*				
Mineral Resources	*2,286*				
Hazards & Infrastructure	10,075	8,161	17,005	35,241	D,E
Hazards & Infrastructure	*9,441*				
Urban Development	*634*				
Environmental	3,442	3,559	2,203	9,204	B,C,F
Antarctica	*609*				
Climate & Atmosphere	*2,041*				
Land & Freshwater	*414*				
Terrestrial Ecosystems	*378*				
High Value Manufacturing	548	403	1,240	2,191	C
Novel Materials	*548*				
Other	3,868	0	1,811	5,679	A,B,D,E,F
Collections & Infrastructure	*2,784*				
Capability	*1,084*				
TOTALS	**27,115**	**13,341**	**34,063**	**74,519**	



5 Key stakeholders

Our key stakeholders are:

- Minister of Science and Innovation and the Minister of Finance (Crown shareholders)
- other Ministers, through their Ministries and Departments, specifically:
    - Minister for Canterbury Earthquake Recovery (CERA)
    - Minister for Economic Development (MED) and Minister for Tertiary Education, Skills and Employment (Universities)
    - Minister of Foreign Affairs (MFAT, NZAID)
    - Minister for Climate Change Issues (MfE)
    - Minister of Energy and Resources (MED - New Zealand Petroleum & Minerals)
    - Minister for the Environment (MfE)
    - Minister of Civil Defence (MCDEM)
    - Minister for Building and Construction (DBH) and Minister for Land Information (LINZ)
- public-good research funding agencies
- 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, research associations)
- employees.

Our stakeholder strategy involves continual engagement with our staff interacting with stakeholders throughout the year. This builds these 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 perspective on groundwater quality, links its quality with anthropogenic influence, and develops best-practice methods for sampling, monitoring, and data interpretation
- the National Paleontology, Petrology and Minerals Collections that underpin all New Zealand's earth science research, resource development, and hazard assessment
- the National Geological and Geophysical Maps and Databases that underpin all New Zealand's earth science research, resource development, and hazard assessment.

7 Strategic issues

We take into account the following issues in planning the delivery, as described in the following Sections 8-13, of the outcomes expressed in our Statement of Core Purpose.

7.1 Governance of Direct Crown Funding in conjunction with MSI contracts

We expect Direct Crown Funding (36%) and MSI research revenue (18%) to provide 54% of our total revenue. The agreement with the Minister of Science and Innovation provides certainty over the former, but the latter depends on success in a contestable environment. We will exercise due diligence in the use of revenue from these sources by:

- aligning its use, internally and for collaborations, with our Statement of Core Purpose
- taking into account the global state of scientific knowledge in each area
- considering advice received from external advisory panels
- proposing research programmes to address New Zealand's present and future needs
- the Board considering and approving programmes that utilise Direct Crown Funding, and management reporting quarterly to the Board on progress
- making best efforts to satisfy MSI requirements to enhance likelihood of winning MSI contestable contracts, and satisfying MSI's reporting procedures
- exploring opportunities to use either Crown resource as co-funding leverage for investment in research and development by our end-user sectors
- ensuring we maintain and enhance our research and technology transfer capabilities
- recognising the internal and external availability of human and capital resources
- using appropriate project management and financial monitoring systems.

7.2 Technology transfer[3]

We expect the remaining 46% of our revenue to come from technology and information transfer to a wide range of government, local body and private-sector commercial clients, and in the latter case contracts are usually of a commercial-in-confidence nature. Within this framework, we will accelerate the transfer of value from our science to the economy by:

- building enduring relationships with New Zealand's energy, minerals, natural hazards and industrial sectors
- marketing our consultancy services to those sectors
- commercialising our product developments for those sectors
- ensuring there is a sound business case (resources, technical risk, commercial risk, market options) for new relationships, including appropriate protection of intellectual property and an exit strategy for any joint ventures we enter
- considering likely long-term outcomes for New Zealand and returns for the Company.

[3] We use the term "technology transfer" to refer to the transfer of applied science information to any of our stakeholders, whether public or private sector, through consultancy, product development and commercialisation, access to data, or education

7.3 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" [4]. The culture of research ("open enquiry, publication when new knowledge is found or a problem is solved") differs from that of commercial technology transfer ("limited scope, on time, on budget"). Over the last ten years our technology transfer has been so successful that the revenue from those activities has grown at over twice the rate of revenue growth from our more basic research activities. As this trend continues, technology transfer will increasingly dominate and maintaining a research culture will require greater attention and support. We will do this by:

- continuing to recruit the best scientists we can from the global pool
- improving alignment of individuals' tasks with the research, public service and commercial components of their job descriptions in order to better manage any essential changes
- seeking commercial opportunities that have high research content.

7.4 Public-good role in the present public sector environment

We will continue to enhance our relationships with Crown agencies, local government and iwi/Māori groups. 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 [5]. This recommendation arose from a long-standing issue where some of those agencies' budgets and cultures 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, by:

- better articulating the value of our work to New Zealand and to iwi/Māori
- using portions of Direct Crown Funding, where appropriate, as research co-funding to demonstrate our commitment to stakeholder needs, especially those in the public sector.

7.5 Capability and capacity

We will continue to maintain and enhance our world-class capabilities. We have world-leading and nationally important capabilities in all of the resources, isotope 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. Direct Crown Funding, which came into effect from 1 July 2011, gave the Company direct control over this issue. We will address this issue by:

- enhancing graduate student connections
- recruiting pro-actively for succession before retirements
- improving alignment of individuals' tasks with the research, commercial, and public information components of their job descriptions in order to ensure capacity in vulnerable areas is maintained.

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

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

7.6 Productivity and financial viability

We will continue to improve our productivity to ensure continued financial viability as the national and global economies recover. Our productivity and financial viability are strongly dependent upon the efficient use of staff time, charged at competitive rates, and effective deployment of capital. Specifically, we will address this issue by:

- seeking appropriate opportunities to enhance our revenue streams
- reducing the inefficiency of time fragmentation that comes from individuals working on a large multiplicity of projects, by focusing the bulk of each scientist's time commitment around a small number of major projects
- considering different incentive schemes for the different types of work we undertake (research, technology transfer, product development, public information)
- ensuring we gain greater benefit for New Zealand and the Company from our intellectual property
- maintaining an appropriate level of gearing.

7.7 Projects with iwi/Māori communities

We recognise the potential that exists within the Māori community, and therefore continue to work collaboratively on projects of relevance to Māori. Groups we work with include iwi, hapū, rūnanga, marae and Trust/Incorporations. Existing programmes already contribute to environmental, economic and social outcomes for Māori. We expect future work to remain in these areas with specific emphases on geothermal, mineral and water resources.

We are committed to increasing the capability and capacity of iwi/Māori to utilise research outcomes to grow and sustain future economic development opportunities. We do this by developing effective relationships with iwi/Māori from the outset for relevant projects, in order to establish and achieve mutually beneficial research outcomes.

We will focus on the following three areas:

- exploring the contribution that traditional Māori knowledge (Mātauranga Māori) may make to our research programmes
- undertaking research that delivers opportunities and outcomes for iwi/Māori, the Company and New Zealand
- working with iwi/Māori on a commercial basis in relevant research areas, especially geothermal, mineral and water resources including increased knowledge of resource potential in central North Island lakes.

These considerations underlie the discussion of each outcome in the following Sections:

Section 8: Outcome A: Economic benefits from geological resources

Section 9: Outcome B: Sustainable management of groundwater

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

Section 11: Outcomes D & E: Resilience to hazards and enhanced geotechnical engineering

Section 12: Outcome F: Understanding geology and past climates

Section 13: Additional outcomes: Outreach and education

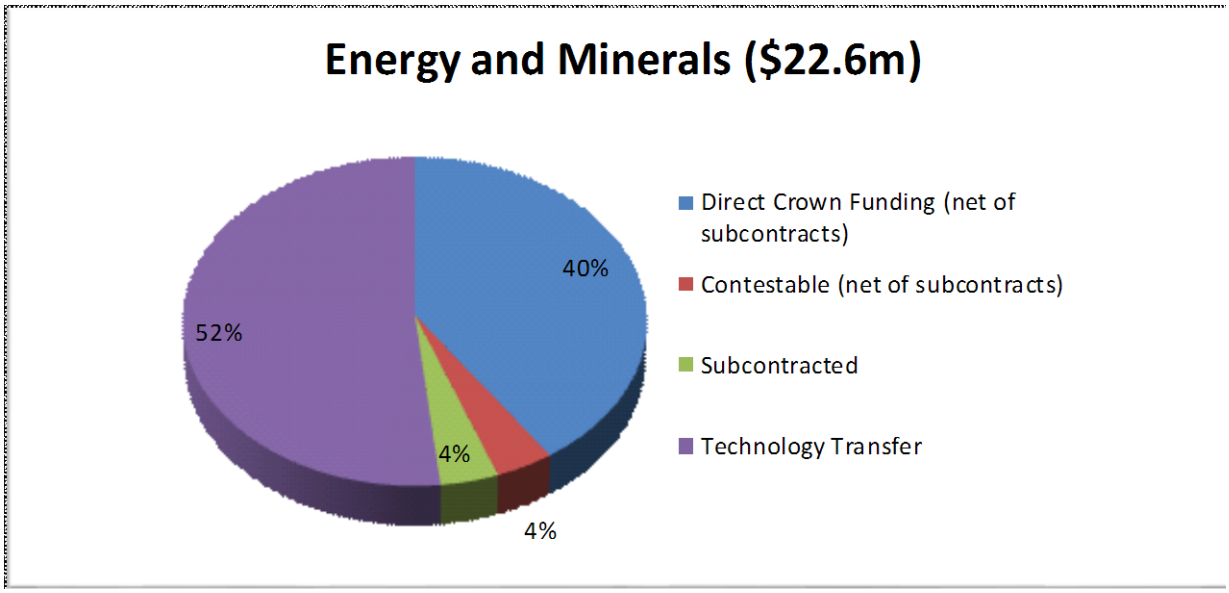
The near, medium and long-term goals and impacts are summarised in the fold-out chart.

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	Quantified critical parameters that control petroleum formation, migration, and confinement with calibration to empirical industry data and known accumulations in Taranaki	Key petroleum systems parameters evaluated in basins outside Taranaki to reduce subsurface geological risk 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	Advanced understanding of the geological framework and petroleum prospectivity in the East Coast, Pegasus, Reinga and Northland basins	Advanced understanding of the geological framework and petroleum prospectivity in the Canterbury, inner Bounty, Solander, Challenger, New Caledonia basins	Advanced understanding of the geological framework and petroleum prospectivity in the Northland, Campbell, Pukaki, Monawai, outer Bounty basins	
	Emerging energy technologies	Environmental and production parameters established for east coast (NI) gas-hydrate reservoirs Provision of expert advice to government on CO2 storage in sedimentary basins	Identification and ranking of gas-hydrate exploration targets leading to scientific drilling of the resource Feasibility established for CO2 storage in NZ sedimentary basins	Sufficient understanding of the gas hydrate resource for commercial extraction to begin Sufficient understanding of potential sinks to support industrial CO2 sequestration	
Geothermal	Resource characterisation	Enhanced understanding of the physical and chemical nature of fluids and flow pathways below existing drilling depths Full establishment of an operational laboratory that simulates chemical changes at deep crustal temperatures and pressures	Defining the nature of the regime between currently drilled depths and the transition to ductile behaviour Drilling a 4km well with industry and the International Continental Scientific Drilling Program (ICDP) New knowledge and methods enhancing drilling efficiency and well performance	Comprehensive definition of Taupo Volcanic Zone geothermal systems to guide exploration by New Zealand companies Development of a 3D picture of conductivity structure down to the brittle-ductile transition	
	Physical & biological surface effects	Identification of the top twenty candidate geothermal features for microbial diversity Promotion of the understanding and application of low temperature geothermal resources Better knowledge of how subsidence affects surface features and ecosystems, and reinjection mitigation	Microbial extremophile cultures available for industrial biotechnologies A GIS-based geothermal database of geological, physical, chemical and microbiological descriptors Improved understanding of geothermal fluid reinjection leading to reduced environmental impacts	Provision of a web-enabled GIS database of TVZ geothermal features incorporating geochemistry, geophysics, and microbial diversity, and expanded to include offshore EEZ and NZ territories in Antarctica Enhanced knowledge of low temperature geothermal resources	
	Sustainable development	Assessment of productivity and sustainable development of geothermal resources in NZ	Incorporation of new knowledge and techniques to better control corrosion and scaling problems Modelling impacts of sub-surface heat flow on ground source heat pump systems	Assessment of opportunities for developing deep geothermal resources Development of long-term geothermal utilisation strategies	
Minerals	Onshore prospectivity	Provision of new geochemical, aeromagnetic and radiometric information to government and industry	Production of an aeromagnetic minerals map of NZ Knowledge of resource potential in central NI lakes	Full assessment of New Zealand's onshore mineral potential	
	Submarine exploration	Provision of new geochemical offshore information to government and industry Determination of the geothermal/mineral potential of one Taupo Volcanic Zone lake	Increased knowledge of mineral potential of the Kermadec arc, especially massive sulphide deposits Determination of the geothermal/mineral potential of three other Taupo Volcanic Zone lakes	Increased understanding of seafloor massive sulphide deposition	
	Exploration pathfinders	Improved access to mineral resource data by explorers, government agencies and the public	Generation of high-resolution geochemical maps for enhanced mineral exploration	New methods established to process zeolites for industrial use	
Groundwater		Improved operation of the National Groundwater Monitoring Programme and the Water Dating Laboratory	Expansion of analytical services, including assessment of security of supply that meets drinking water standards	Development and wider application of innovative techniques to map and characterise aquifers in three dimensions	Improved management and increased economic return from groundwater
Isotope and ion-beam technology	Air particulate pollution	A high-resolution air particulate model that explains concentrations, sources, and transport paths	Analyses of air particulate number and size distributions to identify health risks and discover the impact of carbonaceous aerosol on climate change	Establishment of a source-fingerprint database of fine and coarse air particulate matter underpinning policy implementation	Economic value created for industry through the use of isotope and ion-beam technologies.
	New materials	Development, with industry, of a magnetic field sensor using ion-beam implantation technology	Recognition as an established provider of ion-beam technology for high-value industrial sensors	Applications of ion beam technology for heavy metal manufacturing, biotechnology, and electrical storage	
Geohazards	Hazard monitoring	Faster real-time coverage of monitoring technologies in the mid-upper South Island Improved speed of earthquake location and provision of more detailed derivative information	Updated technology and enhanced operations of the GeoNet facility	Capability improvements, including use of borehole sensors, capability for enhanced local tsunami warning, and provision of high-precision geospatial information	Increased resilience to natural hazards and reduced risk from earthquakes, volcanoes, landslides and tsunamis
	Geological hazards	Better physical understanding of volcanoes, earthquakes, landslides and tsunami, with a focus on seismicity in Canterbury	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 more comprehensive asset data leading to wider uptake of the Riskscape multi-hazard assessment tool by local authorities Continued support of Christchurch recovery through social science on psychosocial recovery, community resilience, public policy and land-use planning	Enhanced Riskscape multi-hazard and risk assessment tool demonstrating vulnerabilities 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	Establishment of quantitative options for hazard mitigation, and advocacy of appropriate reduction, readiness, response and recovery activities Social science research that leads to engaged communities and better understanding of cultural and economic needs for disaster management systems	
Geotechnical engineering	Resilient buildings and infrastructure	Assessment of responses of engineered structures to different ground conditions, based upon Canterbury earthquake 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 past climates	Isotope biogeoscience	Enhanced understanding of soil carbon dynamics and fossil fuel CO2 emission inventories Identification of land-to-water nitrogen transfers, contributing to the mitigation of nitrate pollution Capability for *in-situ* 10Be and 26Al dating of exposures and erosion, with Victoria University of Wellington	Initial maps of isotope distributions to identify sources of food and fibre, and monitor global-change Methods to manage the carbon cycle within the emission trading scheme Methods to determine the sources and fate of nitrates in groundwater and surface water interactions Establishment of compound specific applications for both stable isotopes and radiocarbon dating	Development of significant new cosmogenic nuclide techniques for surface dating and erosion research relevant to multiple disciplines and outcomes Development of additional isotope techniques to track the sources and fate of carbon and nutrients in our region's biosphere and geosphere	Enhanced scientific understanding of geology and past climates
	Paleoclimate	Enhanced interpretation of sedimentary archives and new analyses of ice cores for climate reconstruction and testing of climate models Establishment of DrillNZ to coordinate scientific drilling infrastructure and international projects Continued contribution to the Intergovernmental Panel on Climate Change (IPCC)	Long-term membership of IODP and ICDP secured through government and research sector funding Continued leadership of DrillNZ New analyses of ice cores, recognised and used internationally as key records of southern mid- to high latitude past climate change	Continued participation in ANDRILL, IODP and ICDP, and leadership of DrillNZ Sea-floor drilling data analysed for a better understanding of climate change Participation in and contribution to future IPCC and related international and national fora	
	Biostratigraphy	Enhancement of the Fossil Record File and the National Paleontology Collection Revision of the NZ geological timescale in light of a major revision of the international timescale Enhanced interpretation of sedimentary archives for petroleum exploration	A broader range of tools available for determining ages of sediments and sedimentary rocks Development of the Fossil Record File as a repository of information on the biological and environmental history of the southwest Pacific	Upgrading of the NZ geological timescale	
	Regional geology	Delivery of the QMAP series online with a seamless GIS dataset Geological map of South Victoria Land completed Enhanced National Petrology Reference Collection and National Rock and Geoanalytical Database	Geological datasets and 3D models for Christchurch Regional Geological Map Archive and Data File archived with scanned images available online Urban and resource-focused geological maps published for selected regions of New Zealand	Detailed geological datasets, including 3D models, available for the main cities and resources areas Further regional airborne geophysics and national geochemical surveys acquired and integrated with geological map data	
	Tectonics, structure and landscape evolution	Improved understanding of crustal motion, and its application to hazard and resource assessment Increased understanding of Waipaoa and Waitaki tectonics and sediment transport	Improved national surveying datum, and precise monitoring of true sea-level change Acquisition of data to prepare for deep drilling Documentation of historical landscape response to earthquakes and volcanism	Participation in ICDP and IODP expeditions, with drilling completed on the Alpine Fault and Hikurangi subduction interface	
All science areas	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



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. Government policy is focused on the need for New Zealand to benefit from its geological endowments of energy and mineral resources (*New Zealand Energy Strategy,* 2011). Our role in energy research is largely in the areas of hydrocarbons and geothermal energy. Increased geothermal energy production is also consistent with longer-term societal preferences for renewable and low green-house gas emitting energy sources. In this context, we can also contribute to developing biofuel technologies using geothermal enzymes, and to research on geo-sequestration of carbon dioxide to mitigate the atmospheric effects of fossil fuel use. Our role in minerals research is in identifying the extent and grade of mineral resources, both onshore and offshore. 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 undertaking modern research on, for example, coal gasification and combustion.

Within this context, 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, physical and biological surface effects, sustainable development)
- minerals.

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

The **benefits** that will accrue from our research programme 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
- bridging to a low-carbon economy and 90% renewable electricity supply through the use of natural gas instead of coal to minimise detrimental effects on the environment, particularly when used along with CO_2 capture and storage.

Situation

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

We undertake research into the geological and geochemical processes that result in the formation of oil and gas accumulations to support the petroleum industry in optimising exploration efficiency and the chances of new discoveries being made. This research underpins our work with MED (New Zealand Petroleum & Minerals) to attract investment to New Zealand for new oil and gas exploration, in order to buffer the high costs of oil importation and to eliminate the potential need for LNG imports. Our research capabilities align with the *New Zealand Energy Strategy* (March 2011) and are an essential element for the implementation of MED's *Petroleum Action Plan*. A major component of our research is centred on Taranaki Basin, due to industry interest and because this area contains most of the empirical data from which new petroleum exploration concepts can be formulated. However, in keeping with the expanding geographic focus of MED and industry, our research attention will be increasingly turned to frontier offshore petroleum basins away from Taranaki over the next few years[6].

Our research is also positioning New Zealand to be a fast follower with respect to global exploitation of gas hydrate deposits as this becomes economically viable. 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, may be among of the largest in the world, with the most promising deposits potentially being significantly greater than the Maui field.

Work programme

1: Petroleum systems

This research addresses fundamental problems and geological uncertainties (technical 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

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

parameters that control how petroleum forms, migrates and is trapped in rock structures. The aim is to improve prediction of petroleum accumulations and to expedite their discovery. We will add value to the empirical knowledge base from Taranaki Basin to assist in the search for new accumulations there. In addition, we will use this knowledge and undertake corresponding research in other areas, to identify the next petroleum basin for development in New Zealand. Whilst our contribution to petroleum supply is focused on finding new reserves, we hope eventually (contingent on new funding streams) to 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.

2: Frontier provinces

This research focuses on establishing the geological fundamentals for discovering petroleum in largely unexplored offshore sedimentary basins. Research will delineate and semi-quantify critical parameters for ranking the prospectivity of these frontier basins. This will provide a technical basis for helping government and industry to prioritise future research and exploration investment. Our initial focus will be on completing interpretations of the East Coast/Pegasus Basin and the Northland/Reinga Basin, and undertaking a new studies of the Canterbury/Bounty/Great South basins. The results will be integrated with refined models of the tectonic evolution of New Zealand [see *Outcome F*]. This knowledge will improve predictions of the timing and volume of oil and gas generation throughout the region. Later, the focus will move to other frontier basins such as Solander Basin, Challenger Plateau, New Caledonia Basin, Northland Plateau, Campbell Plateau basins, Pukaki basins, Monawai Basin, and the outer Bounty Trough. This work will require the acquisition of new data through MED's Petroleum Action Plan, international academic research voyages, or industry non-exclusive speculative surveys. The research priority for these remote basins will be determined in consultation with the relevant Ministries and the Petroleum Advisory Group.

3: Emerging energy technologies

This research is aimed at understanding New Zealand's gas hydrate resources, and the environmental issues associated with their presence and future extraction. The immediate task is to acquire and evaluate data from selected offshore regions, in order to assess the distribution and quality of potential reservoirs, provide baseline environmental information, and compile critical parameters for modelling gas production. This will provide sufficient understanding of the gas hydrate systems to identify and rank exploration targets, to undertake scientific drilling to characterise those resources and, finally, to help achieve production of natural gas from the resource by 2021. Whereas the Hikurangi Margin east of the North Island is the current focus area, we will continue analysing information from other parts of New Zealand's EEZ for gas hydrate occurrences, based mainly on the availability of data from "ships of opportunity". Success would unlock a new source of indigenous fuel leading to energy self-sufficiency and the creation of a new export industry.

In partnership with Australian agencies, parallel petroleum research skills will be applied 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 will improve the speed with which CO_2 storage can be implemented in New Zealand, by maintaining and developing expertise and data on potential sites, assisting in ranking site options, and providing independent advice to government. Geo-sequestration provides alternatives to dams and other renewable options that have their own environmental impacts at the earth's surface.

8.2 Geothermal

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

- increased renewable electricity generation, reducing New Zealand's carbon dioxide emissions
- increased direct geothermal use
- distributed electricity generation to reduce dependence on the national grid
- formation of new industries and applications based on geothermal resources, leading to economic growth in the regions and for iwi/Māori
- applications in the biotechnology sector such as bioremediation and novel drugs
- identification of research enzymes and processes that may assist in biofuel production
- provision of environmental indicators for informing policy development and sustainable management.

Situation

Geothermal energy is an indigenous, renewable resource that can provide long-term, reliable base-load electricity generation, with lower environmental impact and development costs than most other sources. Geothermal resources are supplying an increasing fraction of New Zealand's electricity needs, having risen from 10% to 14% over the past five years, and being expected to supply 20% within the next ten years. The renewable nature of the resource, with low greenhouse gas emissions, and the potential for direct use of the heat being more efficient than 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. GNS Science is the only national research provider with the breadth of experience and disciplines required to support the geothermal industry in its quest for new deep and low-temperature resources.

Work programme

1: Resource characterisation

This research will increase developers' levels of confidence in exploration strategies, thereby reducing risks associated with deep drilling and energy production. Regional field-specific investigations based on combined geoscientific analyses will provide definition of New Zealand's geothermal systems and resources with respect to their permeability, flow pathways, and fluid-rock interaction. Through geological (petrology, structure), geophysical (magnetotelluric, seismic, gravity, borehole logging), and geomechanical, fluid-flow and heat-flow modelling, we will discover the mechanisms controlling the flow of fluids and heat at 3-7 km depth. We will also propose a deep 4-km well drilled in partnership with industry and the International Continental Scientific Drilling Program (ICDP) to investigate potential use of the deep geothermal resource beneath the Taupo Volcanic Zone. The research will be supported by high-tech laboratory experiments that simulate the chemistry of geothermal systems at the elevated temperatures and pressures encountered at these crustal depths.

2: Physical and biological surface effects

We anticipate that by 2025 use of low temperature geothermal resources will increase by at least 20% (i.e. an additional 2PJ, to 12PJ). This increase, and the development of new applications, will be supported by research that leads to a better understanding of shallow

aquifers. We will quantify environmental and ecological impacts of geothermal development in New Zealand, including ground deformation, induced seismicity, alteration of thermal features, ecological adaptation, and sustainability of microbiological biodiversity within geothermal systems. We will continue to develop a knowledge-base of the microbial ecology of geothermal systems in New Zealand. These data will assist in understanding the drivers that define microbial community makeup and how microbes alter geothermal features, as well as the identification of unique microbial strains and description of the biodiversity of geothermal features and systems.

3: Sustainable development

Improved efficiency of geothermal energy extraction and enhanced security of supply will come from long-term strategies for the full range of geothermal resource use, including engineering management protocols and socio-economic policy frameworks. Chemical research to reduce scaling and corrosion, and other innovative technologies will improve the viability of the industry and increase the use of geothermal energy. Social science research will help us understand cultural relationships with geothermal resources, the policy and economic context in which these resources are managed and implications for future development. Engagement and outreach with end-users will foster partnerships, increase awareness and acceptance of use of the resources, and assist in identifying and establishing new opportunities for their use and development of associated technologies.

8.3 Minerals

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

- growth of New Zealand's economy from increased royalties, taxes, regional employment, improved export earnings and import substitution derived from sustainable and environmentally responsible extraction of minerals.

Situation

MED (New Zealand Petroleum & Minerals) has a major focus in its minerals strategy of improving knowledge through data acquisition to identify New Zealand's mineral resources on land, as well as offshore within our EEZ and Extended Continental Shelf. Our leading role is in geological mapping and deploying deep-sea expeditions, supplemented by our specific capabilities in assessing the size and grade of mineral resources, developing tools to locate these resources, and formulating models to predict their occurrence. These are essential contributions for the implementation of MED's strategy, and for the identification and management of these resources.

Work programme

1: Onshore prospectivity

We will provide to government and industry new geochemical, aeromagnetic and radiometric information on New Zealand's prospective mineralised terranes, commencing in Northland and the West Coast[7]. This targeted regional geological research of our continental basement is aimed at attracting mineral explorers and emphasising that, geologically, New Zealand is a part of mineral-prospective eastern Australia, and thus worthy of exploration investment.

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

We will also raise awareness of New Zealand's mineral potential by undertaking outreach activities and site-specific resource assessments, as well as by providing minerals information to local government for improving economic strategies and policies. Studies of selected mineral commodities (e.g. ironsands, clays, Platinum Group Elements, Rare Earth Elements) and localised deposits (e.g. at Reefton) complement the regional research.

2: Submarine exploration

We will undertake research on mineral prospects and deposits, principally seafloor massive sulphides, within New Zealand's expanded EEZ through the acquisition of high-resolution seafloor maps, and petrological, geophysical and geochemical analyses[6]. These surveys will be implemented through international collaborative use of state-of-the-art technologies, such as manned submersibles, AUVs (autonomous underwater vehicles) and ROVs (remotely operated vehicles). The aim is to provide information of sufficient quality that government agencies and stakeholders in the minerals industry can make informed decisions about the development of our offshore mineral resources.

A new initiative, taking advantage of knowledge and equipment gained from the submarine realm, is investigation of central North Island lake-beds for geothermal activity and associated mineralisation.

3: Exploration pathfinders

Successful testing and adaption of commonly used overseas exploration methods, both geochemical and geophysical, to conditions specific to New Zealand (e.g. high relief and rainfall, high vegetation, moderate exposure of outcrops) and development of existing, new and innovative ways of defining exploration targets will assist industry to more effectively realise their exploration goals. We expect to achieve a better understanding of the geological processes involved in producing mineral deposits through innovative use and integration of available geochemical and geophysical data. This research is underpinned by maintenance and further development of relevant mineral databases.

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
- 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

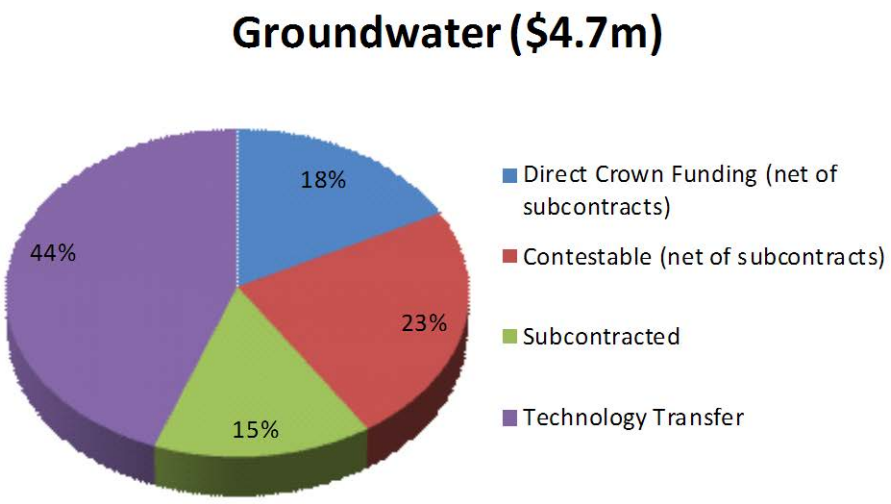
- MED (New Zealand Petroleum & Minerals)
- Crown Research Institutes (e.g. IRL, NIWA, Scion)
- New Zealand universities
- Australia-New Zealand Integrated Ocean Drilling Program (IODP) consortium
- Overseas universities (especially in Australia, Canada, Chile, France, Germany, Japan, Switzerland, UK,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

Key end-users

- Central government agencies (especially MED; also DOC, EECA, ERMA, 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** that will accrue from our research programme 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 $30 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 an ambitious forward work programme. All of these will rely on our research, which aims to assess the quantity and quality of groundwater resources across the country.

Work programme

We aim to significantly improve understanding of aquifer systems and 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 and reporting. Alignment with activities of regional authorities will support justifiable and sound management decisions related to groundwater resources. Our goal is to characterise New Zealand's aquifers and to map them in 3D at the national scale, using innovative approaches and a consistent data format. End users will rely on these aquifer maps for water management.

We will continue to operate the National Groundwater Monitoring Programme (NGMP) and maintain the associated database. The NGMP provides a national perspective on groundwater quality, identifies spatial and temporal trends in groundwater quality and relates them to specific causes.

We will also continue to operate the Water Dating Laboratory (WDL), retain its world-leading analytical accuracy, and expand its range of services, including assessment of security of groundwater supply in accordance with the New Zealand drinking water standards.

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

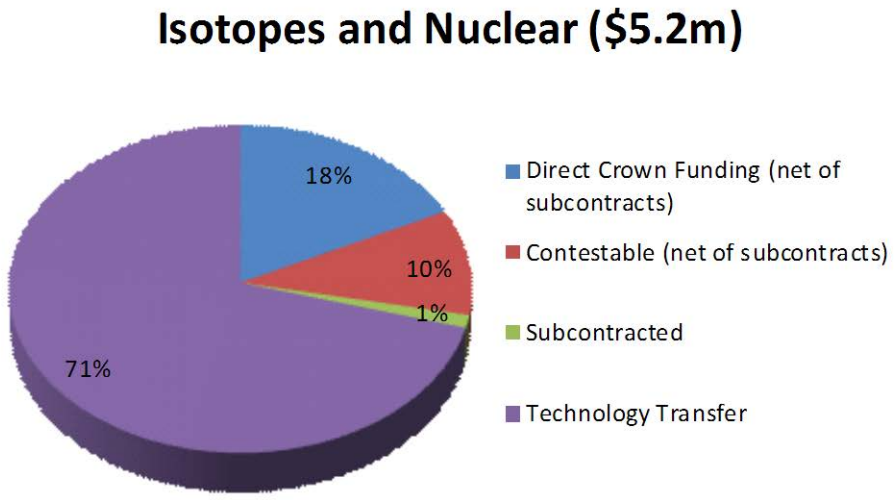
- New Zealand universities
- Overseas universities

Key end-users

- 15 regional authorities
- MfE
- MPI
- 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 applications of nuclear science with economic and environmental benefits, but that 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 use the same infrastructure and capability to gain other benefits for the country[8]. We are not engaged in routine monitoring of radiation, as this is done by the National Radiation Laboratory, nor in radiotherapy research, which is conducted within the universities and the health sector. Our programme of research and technology transfer to industry has the following components:

- air particulate pollution
- new materials
- isotope biogeosciences (discussed under Outcome F).

10.1 Air particulate pollution

The **benefits** that will accrue from our research programme 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

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

meet regulatory standards. Our fine-particle air-quality research underpins MfE's *National Environmental Standards for Air Quality* as applied to local government, and informs MfE, MoT and MoH about sources of air pollution for exposed populations. As current methods do not identify the sources of air pollution, the determination of particle composition is crucial to identifying the contributions from both anthropogenic and natural sources.

Work programme

Ion-beam technology allows us to efficiently measure the elemental composition of local, regional and transboundary particulate matter pollution. The critical components are hydrogen, silicon, sulphur, chlorine, iron, arsenic, lead, vanadium, nickel, copper, zinc and carbon compounds. We will continue developing a high-resolution air particulate model to explain the observed 24-hour airborne particle concentration pattern in urban air sheds and identify the sources and particle transport paths. We will compare diverse air sheds to cover geographic range and population densities. We will then 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. This will require a systematic sampling of air particulate matter at many sites, over at least four years, to include seasonal trends and transboundary air pollution events. This database would be the first of its kind and provide the baseline for further research to underpin policy implementation. We will also transfer our expertise into related areas of research, such as air particulate matter in ice cores, where the focus is on southern hemisphere circulation and the effect of carbonaceous aerosols on climate.

10.2 New materials

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

- development of new ion beam-based 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 are the needs of private-sector high-technology enterprises for which we are developing innovative nanomaterials. To secure financial support for the underlying research, we are contributors to several proposals submitted to the 2012 MSI contestable funding round, in which we propose the generation of IP centred on novel ion-beam methods for producing nanomaterials, and demonstration of their economic potential by building prototypes in collaboration with end-user partners. 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

At present the main application of our ion implantation technology 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 currently hampered by the otherwise extreme difficulty of controlled fabrication of these materials using methods that are non-toxic and suited to rapid uptake by microelectronics manufacturers. Our techniques overcome these hurdles. The research represents an opportunity to 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, and thereby provide a credible, rapid pathway to market. Ultimately, we expect 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 for demonstrating the applications of ion-beam coatings and ion implantations for the heavy metals industry (e.g. titanium and related alloy materials), biotechnology and medical applications and, further out, possibilities for enhanced electrical energy storage.

10.3 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. IRL, NIWA)
- New Zealand and overseas universities
- City councils (especially Auckland Council, Nelson City Council)
- Regional councils (especially Otago Regional Council, Greater Wellington Regional Council, Environment Canterbury)
- New Zealand Transport Agency

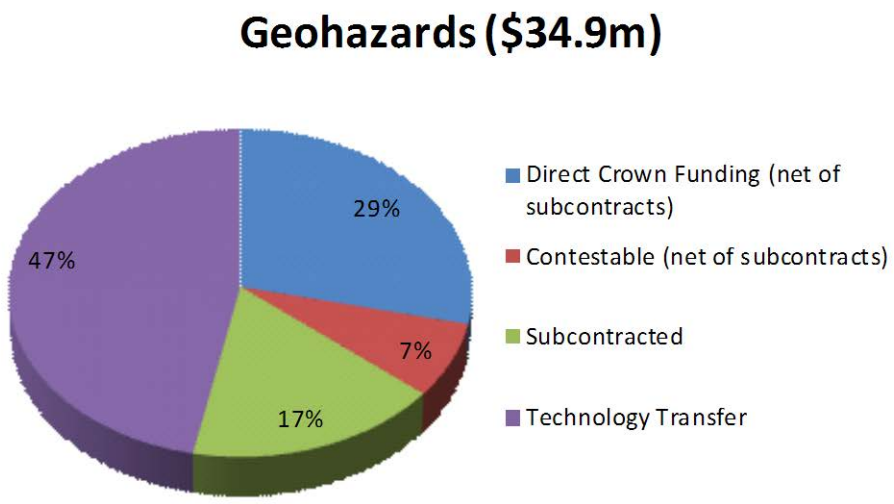
Key end-users

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

11 Outcomes D and E: Hazards and geotechnical engineering[9]

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** that will accrue from our research programme 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. Because risk is the product of hazard and vulnerability, we are also engaged in engineering vulnerability research to

[9] 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

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
- geological hazards
- risk and society
- resilient buildings and infrastructure.

11.1 Hazard monitoring

Situation

We design, install, and operate GeoNet, the national network that monitors earthquakes, volcanoes, tsunami, and landslides, funded by EQC and LINZ under long-term contracts. The GeoNet Project includes the communications infrastructure to transmit data to dual 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 strain build-up and release in the earth's crust
- 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 arrival and height of tsunami waves
- communication networks
- data management and processing centres
- on-call 24/7 duty staff.

Work programme

As the workload arising from the Canterbury earthquake aftershocks diminishes, we plan to accelerate more real-time coverage of the Canterbury region with all technologies and then move attention to coverage of the upper South Island. Improved speeds for earthquake location and increasing the depth of derived information, for example immediate ShakeMap information and short term earthquake probabilities, will be priorities. End-user linkages, technical research, and public outreach will remain important activities. At the same time significant research projects, especially scientific drilling, will be supported. 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. Capability improvements are also possible, such as more borehole sensors for seismic tremor research, ocean bottom sensors, near-instant earthquake location, local tsunami warning, earthquake early warning, and very precise geospatial information availability.

11.2 Geological hazards

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 physical processes driving the geological hazards and hence to estimate the future likelihood and size of their occurrence as an input to engineering design and risk assessment to inform insurance premiums. Our current work-plans are strongly influenced by requirements resulting from the on-going Canterbury earthquakes and the need to inform land-use and rebuild issues in Christchurch as the present high level of hazard decreases over the next few decades.

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 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 the geological hazards already discussed, as well as weather-related perils, for which NIWA undertakes the research. Policy and planning research aims to build knowledge about good practice and increase the uptake of hazard 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 aims to directly assist the CDEM sector in developing strategies to improve procedures, and crisis management methodologies, including warnings. Disaster recovery research aims to assist 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 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 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. Projects include site-specific investigations to inform construction design (e.g. for power generation), 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). 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[10]. The scope of our work is to support engineering consultancies through the provision of engineering geological information on, for example, geological structures and rock properties that underpin national standards and to 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 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.

11.5 Indicators, collaborations and end-users

Indicators of science quality

- Peer-reviewed journal papers
- Invitations to run international conferences, short-courses and workshops

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

- 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

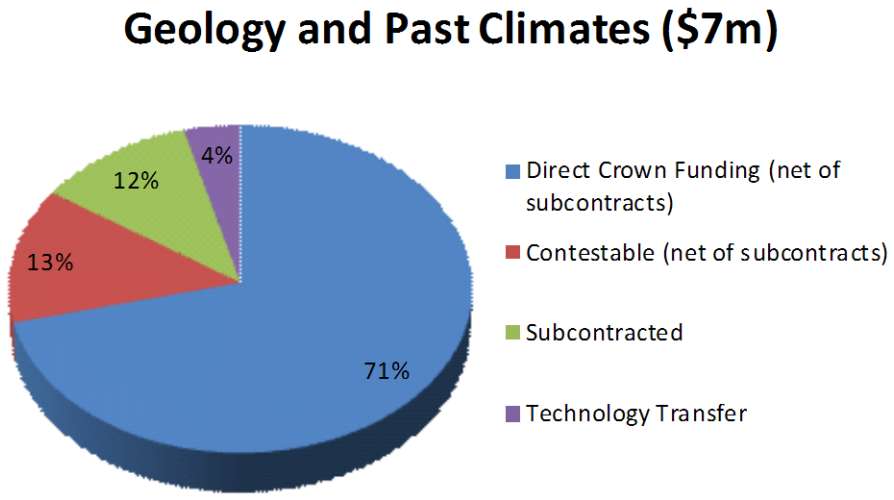
- End-users who provide data to be combined with our data
- New Zealand universities
- NIWA
- Central government agencies (LINZ, DoC, MCDEM, New Zealand Defence Force)
- Equipment and service providers

Key end-users

- Central government agencies (DBH, DoC, LINZ, MPI, MCDEM, MED, 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 (DBH, 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** that will accrue from our research programme include:

- provision of geological, geochemical and geophysical maps for other researchers whose work enhances geological resource evaluation and geohazard assessment
- 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 industry responses 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 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" or "tipping points" (episodes of abrupt, extreme, or step-wise climate change) 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, which employs 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 are created from measurements of isotopes as natural tracers that allow us to understand the development of environments across space and through time. Isoscapes also underpin research areas such as hydrology, petroleum exploration, forensics and biological product authentication.

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

- isotope biogeoscience
- paleoclimate
- biostratigraphy
- regional geology
- tectonics, structure and landscape evolution.

12.1 Isotope biogeoscience

Work programme

As initial steps toward the goal of creating national isoscapes, we are developing isotopic tools that will allow us to better understand stocks and flows of carbon, nutrients and water. 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. Our application of isotopes in nitrate will track the sources and fate of this pollutant, a key step towards reducing nitrate loads in freshwater from agricultural and other sources. Analysis of the hydrogen and oxygen isotope composition of precipitation will both underpin ice core research and will form a key part the isoscapes that are increasingly supporting hydrologic research and the authentication of sources of biological products. In the future, an array of such isoscapes will provide ongoing benefits to industry, with additional outcomes in the areas of monitoring global change, authenticating agricultural products, and exploring for oil and gas.

12.2 Paleoclimate

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 West Antarctic Ice Sheet and the magnitude of related sea-level change; (iii) identifying how past periods of global warming affected regional climate and ocean circulation; and (iv) contributing to research on the carbon cycle that underpins carbon accounting and modelling of productive and natural ecosystems. We will undertake biostratigraphic and paleoenvironmental interpretation of onshore and offshore sedimentary archives, 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 Biostratigraphy

Work programme

Research is focused on the provision of well-managed databases and collections for use by a wide range of in-house, academic, business and private researchers. Coupled to this is biostratigraphic research relating to the maintenance and development of the New Zealand timescale. As the national custodian of the Fossil Record File and the National Paleontology Collection, continued upgrading, refinement and development and associated taxonomic studies will be carried out.

12.4 Regional geology

Work programme

With the achievement over the last 15 years of the nationwide 1:250,000 geological mapping project that acquired and collated information on the distribution and composition of geological units of New Zealand and its territories, attention is now being concentrated on urban centres and areas of proven or potential geological resource. 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 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 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 modeling 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 will leverage 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)
- 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 (especially Landcare Research, NIWA)
- MED
- 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 production companies
- Industry, utility companies and consultancies
- IPCC
- International science community, especially Antarctic Climate Evolution community
- LINZ
- MPI
- 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

13 Additional outcomes: Outreach and education

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

13.1 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 immediate 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 local schools
- 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 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 world-class graduate education in New Zealand in areas where there are real employment opportunities through our linkages with our commercial clients. This is most effectively, but not exclusively, done under formal agreements with specific universities (Graduate Research School of Earth Sciences at Victoria University of Wellington, Joint Centre for Disaster Research at 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

14 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 not necessarily be measured every 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)
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 NZ
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)
Total number of international and significant New Zealand awards, and invitations to participate on international committees and editorial boards, per annum.
Number of new Marsden-funded projects
Narrative on key research results

15 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	2012 forecast	2013 budget	2014 outlook	2015 outlook
Return on equity	13.6%[1]	8.4%[2]	8.5%[2]	8.5%[2]
Non-government revenue [3]	43.8%	45.7%	47.0%	49.2%
Return on assets	9.2%	7.2%	7.7%	8.1%
Operating margin	12.8%	11.4%	11.7%	11.6%
NPAT margin	4.6%	3.1%	3.3%	3.4%
Profit [4] per FTE ($000)	25.2[1]	22.8	23.9	24.5
Chargeable time of science staff (%)	74%	>75%	>75%	>75%
Quick ratio	1.21	1.26	1.24	1.27
Equity ratio	58.3%	59.8%	64.3%	66.1%
Tech transfer & contestable revenue [5]	62.7%	63.6%	64.7%	66.3%
Revenue growth	11.6%[1]	2.6%	3.0%	4.9%
Tech transfer revenue growth	4.6%	9.5%	8.6%	12.8%
Capital renewal ($000)	5,200	6,900	5,600	7,000
Return reinvested	11.3%	7.5%	7.7%	7.7%

[1] includes profit on sale of property

[2] after development expenditure

[3] proportion of revenue that is not from Direct Crown Funding, contestable MSI contracts, or Marsden Fund projects

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

[5] proportion of revenue that is from commercial operations and contestable funding

16 Information to be reported

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 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, 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 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 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 Crown equity, dividend policy, and compensation

17.1 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.

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
- 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	2012 forecast	2013 budget	2014 outlook	2015 outlook
Equity ($000)	26,237	28,286	30,542	32,999
Dividends ($000)	550	250	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 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 2011. 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 re-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 seven 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 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.

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 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.

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 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:

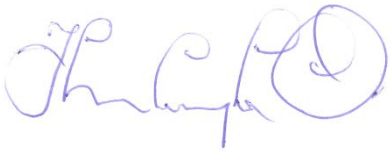
- Australian Institute of Nuclear Science and Engineering (AINSE)
- International Association of Geochemistry and Cosmochemistry (IAGC)
- International Association of Seismology and Physics of the Earth's Interior (IASPEI)
- International Association of Volcanology and Chemistry of the Earth's Interior (IAVCEI)
- International Atomic Energy Agency (IAEA)
- International 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)
- 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 (IAEA)
- Cooperative Research Centre for Greenhouse Gas Technologies (CO2CRC) (Australia)
- Geoscience Australia
- Chilean National Commission for Scientific and Technological Research (CONICYT)
- China Earthquake Administration (formerly State Seismological Bureau), China
- 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)
- 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).

20 Signatures



Tom Campbell, Chairman
Date: 30 June 2012

Ken Shirley, Director
Date: 30 June 2012