



Natural Resources  
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Ressources naturelles  
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# NRCAN ANNUAL REPORT ON SCIENCE AND TECHNOLOGY



2013-2014

Canada





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## Foreword

Natural Resources Canada (NRCan) works with a wide range of partners in the pursuit of complex, multi-disciplinary scientific knowledge that is applied to the responsible development and use of Canada's natural resources – a priority of the Government of Canada. The department is well-known as one of the Government's leading science and technology (S&T)-based organizations. S&T accounts for about half of the department's operating budget, about \$460 million in 2013–2014, and more than half of NRCan employees are involved in S&T. This report demonstrates that S&T makes a significant contribution to the achievement of the department's three strategic outcomes while maintaining alignment with federal S&T priorities.

NRCan delivers S&T to benefit Canada and Canadians. This function demands strong governance of S&T to ensure the best return from our ongoing investment in these critical assets. In March 2011, the first meeting of the NRCan Science and Technology Board was convened. The Board was comprised initially of the department's four assistant deputy ministers who are responsible for S&T. Later in 2011, three external members joined the Board, each an expert in the management of S&T but from different perspectives across Canada's innovation ecosystem. The Board has been the main vehicle for overseeing and enhancing the management of NRCan's S&T.

At about the same time, NRCan was developing its suite of corporate priorities, the product of a series of discussions at our executive table, and in dialogue with the leadership of the department from across the country. In recognition of the importance of the S&T efforts, one of the four corporate priorities identified was Mobilizing Our Science and Technology (MOST). The S&T Board was identified as the governance body responsible for coordinating the implementation of this priority.

One of the first tasks was to find a convenient way to provide a clearer view of NRCan's S&T. As it turns out, the department's program alignment architecture (PAA), used in reporting to Parliament through the *Report on Plans and Priorities* and the *Departmental Performance Report*, provided a natural, complete and detailed layout of all NRCan 's S&T activities. Twenty-three Signature S&T projects, each nested within the structure of the PAA, were identified that, in a sense, provide a portal into NRCan's S&T. The Signature S&T projects provide a backdrop against which management tools can be applied for improving the management of S&T and for department-wide, horizontal approaches.

This first *NRCan Annual Report on Science and Technology, 2013–2014* provides an overview of the 23 Signature S&T projects, their accomplishments and impacts. The report describes the work of the S&T Board to date. It also takes the Blueprint 2020 initiative as a starting point for looking at government science, and therefore NRCan science, toward the year 2020.

Annual reporting on S&T is an ongoing enterprise. Every year, NRCan will strive to improve and refine the report and bring forward the very best means to plan, deliver, measure and communicate our science in the interest of serving well, and always better, our fellow Canadians.

**Bob Hamilton**  
Deputy Minister  
Natural Resources Canada

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Chief Scientist and  
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## 1. Introduction

To fulfill the responsibilities of its legal mandate, NRCan program alignment architecture<sup>1</sup> identifies three strategic outcomes for the department:

- Canada's natural resource sectors are globally competitive.
- Natural resource sectors and consumers are environmentally responsible.
- Canadians have information to manage lands and are protected from related risks.

The department's S&T plays a central role in achieving these strategic outcomes.

NRCan is one of several federal science-based departments and agencies (SBDAs). SBDAs undertake two broad categories of S&T: research, development and demonstration (RD&D) and related scientific activity (RSA). RD&D includes the development, testing and application of new knowledge. For example, RD&D can take the form of improvements to industrial papermaking processes or the invention of technology to harness new, cleaner sources of energy. Using evidence gathered under RD&D, RSA includes such endeavors as mapping of Canada's land mass and the use of scientific methods for regulation and testing.

Canada's resource industries are global in nature and employ about 1.8 million people both directly and indirectly. Canadians benefit from NRCan's S&T-driven innovation through job creation, cost reduction, improvements in product quality, the production of unique, higher-value products, and the reduction of the environmental footprint of natural resources and other industries.

The department draws on internal scientific expertise when representing Canada at international fora related to natural resources. Moreover, NRCan values collaboration with foreign partners and has several active memoranda of understanding and international agreements with foreign partners, many of which involve significant S&T activities. For example, NRCan partners with the South Korea Ministry of the Knowledge Economy on clean energy technologies to enhance energy efficiency and the security of energy supply as well as to reduce greenhouse gas (GHG) emissions from both countries.

Internal S&T is performed at 19 major scientific establishments (see the map) supported by smaller facilities, research sites and permanent sample plots that are found from coast to coast to coast across Canada. In these diverse facilities, the department conducts innovative science to generate and transfer new knowledge, technologies and tools as well as develop S&T products and services to support regulations and standards.

<sup>1</sup> The department's program alignment architecture (PAA) is used in reporting to Parliament through the *Report on Plans and Priorities* and the *Departmental Performance Report*.





NRCan has the capacity to evaluate research questions of national significance and scale in multiple domains, including earth science, energy, minerals and materials, and forestry. NRCan's S&T effort covers a broad range of disciplines and must respond to regional differences in geography and differing patterns of natural resource availability and use across the country. According to a 2011 Science-Metrix bibliometric analysis of NRCan's scientific output, peer-reviewed scientific papers produced by researchers at NRCan had scientific quality and scientific impact scores competitive with, and, in some cases, far exceeding both world and Canadian levels.

## How NRCan manages its science and technology

Like all federal departments and agencies, NRCan is accountable to Parliament and the Canadian public for the activities it undertakes and the resources it spends. While the departmental strategic objectives provide an operational framework, it is NRCan's S&T Board that provides department-wide leadership and governance that is specific to S&T.

To provide a clear view of NRCan's S&T and to better understand our S&T investment, 23 Signature S&T projects have been identified that represent over 95 percent of the department's S&T. The Signature S&T projects provide a backdrop against which management tools can be applied for improving S&T accountability.

NRCan has created a financial expenditure tracking mechanism – an essential tool for ensuring accountability – to provide timely and accurate financial reporting for S&T activities. Beginning with fiscal year 2013–2014, reports can be obtained on the expenditures of 23 Signature S&T projects: salary, operations, grants and contributions, and capital. This expenditure tracking mechanism is the source of financial information included in this annual report.

A number of S&T management tools have been developed and are being implemented by the S&T Board, including

- The application of an S&T lens to bring together financial and non-financial information allows the department to report on S&T activities against PAA financial codes.<sup>2</sup> This information is used to make decisions about tactical and strategic S&T investment opportunities.
- The departmental Intellectual Property policy that was approved on October 10, 2013, will encourage the deployment of NRCan's intellectual property – achieving maximum impact for Canada through broad dissemination where suitable or through commercialization as needed to respect the investment of collaborators.
- To ensure that the department's international S&T collaborations are effective and support departmental priorities, an international S&T framework has been developed. The framework, while not a policy, guides decision making and provides useful tools to assist in the preparation of international S&T agreements.
- To effectively communicate NRCan's science both internally and to Canadians at large, while ensuring appropriate and consistent management of publications across the department, the S&T Publications policy was implemented on March 1, 2013.

Each of these tools is posted, for internal departmental use, on the NRCan wiki page called [Mobilizing Our Science and Technology](#) to provide a single point of access for all staff in the department.

## NRCan Signature S&T projects

To better understand the impact of our S&T investment, 23 Signature S&T projects have been identified. Capturing over 95 percent of the department's S&T, the Signature projects are aligned with the PAA and support progress toward achieving the department's three strategic outcomes.

The Signature projects represent the programs, projects and activities delivered by NRCan, in collaboration with our partners, and provide a solid foundation for the accountability of the department's S&T. They help to facilitate effective management and communicate how our S&T contributes to an innovative, knowledge-based economy that supports environmental and social objectives, providing benefits to Canadians.

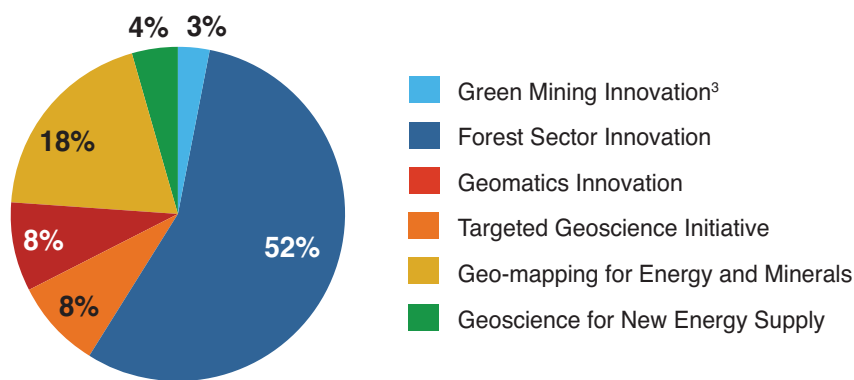


<sup>2</sup> PAA financial codes are used to report to Parliament through the *Report on Plans and Priorities* and the *Departmental Performance Report*. S&T expenditures are a subset of the department's total expenditures.

## Strategic outcome 1. Canada's natural resource sectors are globally competitive.

Under the rubric of activities intended to achieve the first strategic outcome are six Signature S&T projects, including support for innovation in three areas: the forest sector, geomatics and green mining. As well, there are three earth science projects in this group supporting efforts to achieve this strategic outcome: the Targeted Geoscience Initiative, Geo-mapping for Energy and Minerals, and Geoscience for New Energy Supply. The following pie chart provides a breakdown of S&T resources devoted to this outcome based on the 2013–2014 fiscal year.

### Resource sectors are globally competitive (\$139.3 million)



The **Forest Sector Innovation** Signature S&T project (2)<sup>4</sup> performs research and funds partnerships that develop new or improved products and processes and create new markets for Canadian forest products. This activity, over the last 10 years, has encouraged the industry to move away from process innovation toward product innovation such as the development of nanocrystalline cellulose. NRCan also played a pivotal role realigning forest sector S&T institutions to reduce fragmentation in forest sector R&D. This was accomplished through the consolidation of three national forest sector research institutes – the Forest Engineering Research Institute of Canada (FERIC), Forintec and Paprican – into FPInnovations. The department was also instrumental in the creation and integration of the Canadian Wood Fibre Centre into FPInnovations.

### Nanocrystalline cellulose

Nanocrystalline cellulose (NCC), derived from the cell walls of trees and plants, has special properties that make it suitable for new and advanced bio-products. The potential for the use of NCC in materials development is wide and varied. Reinforced polymers, high-strength textiles and advanced composite materials are being explored for potential use of NCC. It could also enhance the properties of paints, varnishes and other coatings. Eventually, NCC could be used in the manufacture of lightweight components for automobiles and airplanes, leading to much lighter, more durable and greener products. The estimated North American market potential is more than \$1 billion annually.

<sup>3</sup> The Green Mining Innovation Signature project supports both strategic outcomes 1 and 2.

<sup>4</sup> This number represents the Signature S&T project and corresponds to the table on page 17.



## Ventilation on demand systems

NRCan has worked with mining companies and their suppliers to develop and demonstrate ventilation on demand systems. For a large underground mine site, these systems would have an annual energy savings potential of up to \$4 million, significantly reduce GHG emissions and decrease the mine's overall environmental impact.

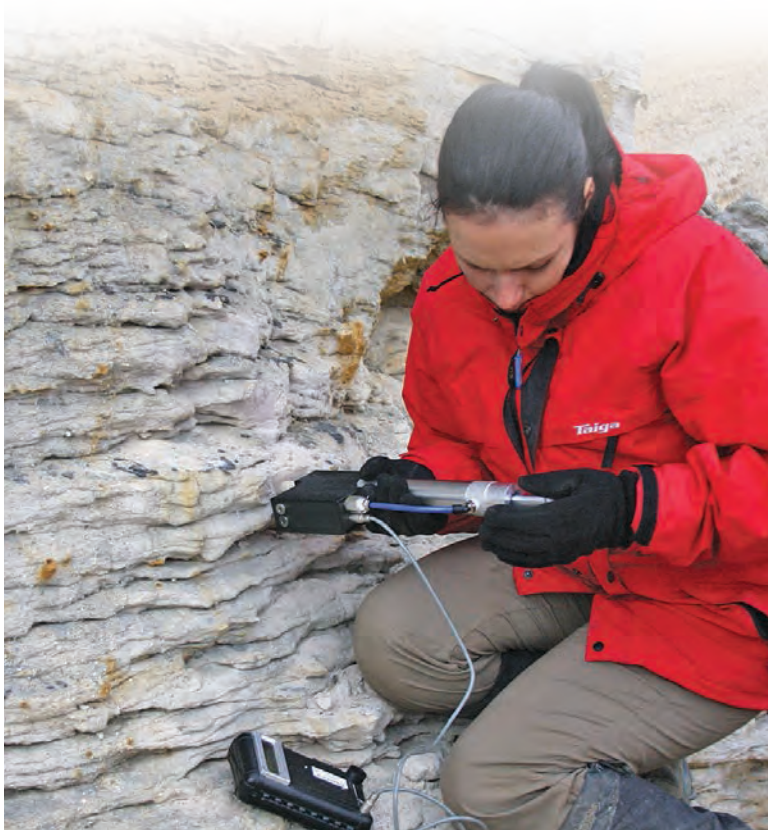
In a joint effort with the Natural Sciences and Engineering Research Council (NSERC) and FPInnovations, NRCan worked to create a forest sector R&D initiative with a commitment from NSERC of \$34 million over five years. This R&D initiative supports four existing forest research networks and created four new networks: NSERC Innovative Green Wood Fibre Products Network; NEWBuildS – NSERC Network on Engineered Wood-based Building Systems; NSERC Value Chain Maximization Network; and Lignoworks – the NSERC Biomaterials and Chemicals Network. Collectively, the eight networks provide opportunities for research and training of 400 graduate students in forestry-related fields. The networks also will improve the technology transfer process by integrating university researchers with industry and government organizations.

A significant part of the **Green Mining Innovation** Signature S&T project (1) is the Green Mining Initiative (GMI). Through the GMI, new mining technologies and processes are developed to improve energy efficiency and to reduce GHG emissions and other environmental impacts. The GMI works to protect ecosystems in areas close to mining sites, such as in northern and remote communities, in support of socially responsible mining practices in Canada and abroad. The initiative addresses the full life cycle of the mine, from exploration to extraction to mine closure and addresses clean water, environmental management, energy efficiency, metals processing, northern mineral development and radioactive waste management. The GMI works to reduce operating costs for the mining industry and improve the competitiveness of the Canadian mining sector. This activity also supports priorities of Atomic Energy of Canada Limited (AECL) and decreases the cost of long-term disposal of spent nuclear fuel and associated risks to the health, safety and security of Canadians.

The **Geomatics Innovation** Signature S&T project (3), which includes the Emergency Geomatics Service (EGS), leverages NRCan's unique capabilities to gather, analyze and disseminate geographic information. The department is the single largest generator and custodian of geospatial data in the federal government. Its information holdings include the positions of energy transmission lines, railways and transportation infrastructure, as well as public safety and security data related to earthquakes, space weather and flood events derived from satellite sensors, to mention just a few examples. The department leads the development of systems and tools for more efficient and effective use of vast geospatial data assets across the federal government, in accordance with the concept of open science. For example, over the last 15 years, NRCan has been developing operational policies, standards and framework data to manage geospatial information nationally. This work is the basis of Canada's contribution to the international Arctic Spatial Data Infrastructure (Arctic SDI) project.

The Arctic SDI allows the mapping agencies of the eight circumpolar countries to work together on common projects and issues that cross borders, such as search and rescue response, pollution monitoring, and changes in biodiversity.

The **Geoscience for New Energy Supply** Signature S&T (6) project generates knowledge about petroleum resources located in shale formations and in Canada's northern frontier basins. This knowledge helps decision makers determine which areas within a region or basin are viable for exploration by private sector firms. The program provides assessment methodologies to reduce uncertainty and exploration risk and, in the process, attract investment. NRCan's development of this targeted, national, pre-competitive energy geoscience contributes to decision making by governments and companies. NRCan brings together partners in the energy geoscience community for collaboration and collective research priority setting. NRCan expertise contributed to the "Scotian Slope" reassessment in Nova Scotia's offshore that fostered renewed investment in exploration of Nova Scotia's petroleum resources.



## Emergency geomatics service

NRCan's EGS enables geomatics specialists in emergency management agencies to download large digital files derived from satellite imagery. The 2013 spring flood season was the first test – a successful one – of operations of this new service, with the aim of faster information processing to allow for more strategic emergency management and response.

## The GEM program identifies petroleum resources

A petroleum resource assessment for the Mackenzie Valley released under the Geo-mapping for Energy and Minerals (GEM) program in 2010, along with various other publications, indicated large undiscovered reserves of oil and natural gas. Recent exploration licences acquired by five companies are in the area of GEM work, including an airborne gravity survey in the area south of Norman Wells.

Two other earth sciences Signature S&T projects work toward the competitiveness strategic outcome: the **Targeted Geoscience Initiative 4 (TGI-4)** (4) and the **Geo-mapping for Energy and Minerals (GEM)** (5) program. Both of these involve the gathering, analysis and dissemination of geological information. The GEM program is focussed on upgrading geological knowledge in northern Canada to modern standards. Using ground field observations as well as a customized array of modern geoscience techniques, NRCan provides state-of-the-art geological models for poorly known areas in the North. The GEM program provides evidence for resource investment and land-use planning, enabling northerners to make knowledgeable choices about their future prosperity and well-being. The TGI-4, the fourth in a series of such programs, undertakes fundamental research on the geological processes that lead to the deposit of ore systems deep inside Canada's geology.

### TGI-4 – Three ways of detecting ore

Projects were completed using high resolution gravity surveys, multifaceted seismic surveys and geochemical analysis. For example, data acquired using a gravity technique was the catalyst for MacDonald Mines' use of the technique to determine the extent of the large mineralized area over the Ring of Fire region of northern Ontario.

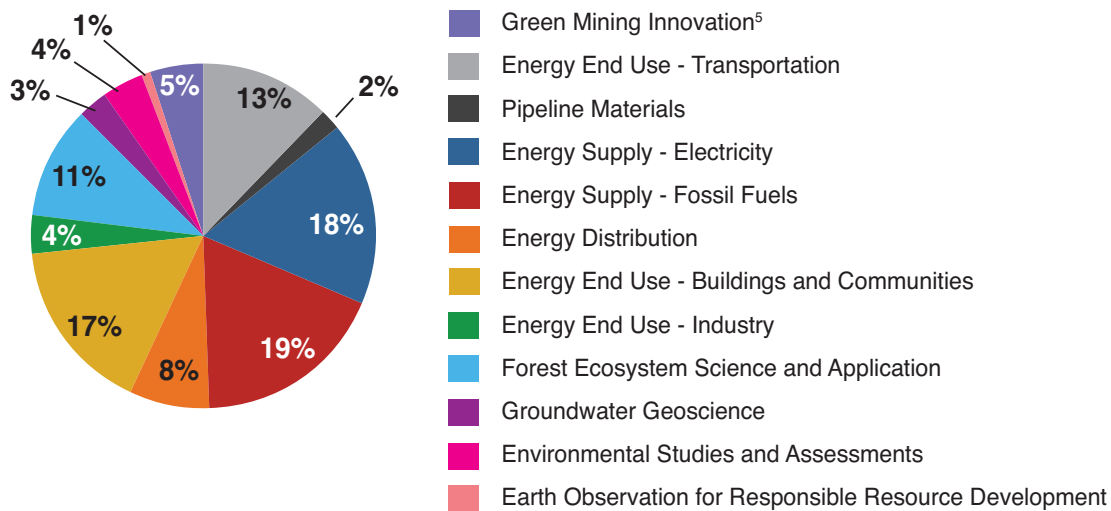
The program develops innovative methods, tools and techniques to improve detection of ore deposits and shares this knowledge with the mineral exploration industry to allow more effective discovery of new or deeply buried mineral deposits in Canada. NRCan releases national geological maps, surveys, mineral resource assessments and methodologies that help to attract mineral exploration investments.



## Strategic outcome 2. Natural resource sectors and consumers are environmentally responsible.

Work under this strategic outcome includes 11 Signature S&T projects in the fields of energy, forestry, environmental studies, ground water and earth observation. The following pie chart provides a breakdown of S&T resources devoted to this outcome based on the 2013–2014 fiscal year.

### Improved environmental responsibility (\$187.2 million)



Seven of the 11 Signature S&T projects deal with various aspects of energy supply and consumption.

**Energy Supply – Fossil Fuels** (10) supports research and development (R&D) into secure, affordable and cleaner fossil fuels. Canada’s fossil fuel resources include oil sands, shale oil and gas, tight oil, gas hydrates, conventional and offshore oil, and clean coal. Technologies and methods developed by NRCan laboratories in cooperation with industry enable the Canadian unconventional oil and gas industry to improve its environmental performance as measured by impacts on air, water and land.

The paraffinic froth treatment technology, which improves product quality and energy efficiency in oil sands production, was developed relatively rapidly at CanmetENERGY, in less than 10 years from the fundamental research to the full-scale implementation by Shell at its Athabasca oil sands project and more recently by Imperial Oil. This technology made it possible to upgrade bitumen using less water and producing less waste while increasing energy efficiency. NRCan laboratories have become the preferred locations for industry to test new oil sands-related technologies because these laboratories have developed unique facilities for this purpose and have long-term

### Clean energy R&D program (examples)

- oil sands water and tailings management
- bitumen and heavy oil conversion
- emissions reduction and life cycle analysis
- unconventional gas resource mapping
- health and safety of off-shore and northern development

<sup>5</sup> The Green Mining Innovation Signature project supports both strategic outcomes 1 and 2.

research programs related to oil sands. State-run Japan Oil, Gas and Metals National Corporation and JGC Corporation (formerly Japan Gasoline Corporation) have partnered with CanmetENERGY to test their new oil sands steam-assisted gravity drainage (SAGD) and supercritical water cracking technologies, which, if proven and commercialized, will significantly reduce emissions and waste products from SAGD operations.

The **Energy Distribution** Signature S&T project (11) brings information and communications technologies to the energy transmission industry to support the creation of smart grids. The smart grid refers to links up and down the electricity supply chain from generation to transmission to distribution and ultimately to the meter. The smart grid includes customer-owned distributed energy resources to ensure reliability, adequacy and environmental performance. Work under this Signature S&T project has resulted in the creation of the Smart Grid Standards Roadmap for Canadian participation in North American smart grid standards and advanced smart grid standards development. The project also created the Smart Grid Project Repository to share results and knowledge from projects in Canada as well as from abroad.

The **Energy Supply - Electricity** project (9) supports the reduction of GHG emissions in electrical power generation. It involves several NRCAN laboratories, including CanmetENERGY and CanmetMATERIALS as well as Earth Sciences and the Canadian Forest Service. NRCAN delivered 71 demonstration projects, including award-winning renewable energy technology demonstrations in areas such as innovative hydrokinetic turbines, anaerobic digestion, biomass gasification, and thermal and electrical power production from solar energy. NRCAN's role in clean fossil-fuel power generation is primarily as a performer of R&D. CanmetENERGY's world-class clean coal and carbon capture test facilities are also an important demonstrator and funder, notably, of carbon capture and storage technologies. This NRCAN research establishment is an enabler in the design of technologies and systems for efficiency improvements in existing electricity generation and in proving new technologies at the pilot scale. This latter work helps to increase the confidence of electrical utilities and investors, which is important for market development.



The **Pipeline Materials** Signature S&T project (8) advances materials development and improves the integrity and reliability of pipelines for pipeline safety and reduced environmental impacts. As an example, NRCAN has patented a bio-corrosion probe to monitor bacterial activity and corrosion simultaneously. The probe allows for early detection and prevention of corrosion induced by microbes in pipelines that can lead to oil leaks and spills.

Three other Signature S&T projects deal with other aspects of energy supply and clean energy S&T.

**Energy End Use - Transportation** (7) delivers clean energy technology R,D&D to the benefit of vehicle





and parts manufacturers for reduced fuel consumption and emissions in Canada. Areas of R&D include advanced fuels, exhaust after-treatment, advanced materials and electric mobility. Magnesium casting and corrosion technology, developed by NRCan with Canadian industry and United States government partners, led to the design of a magnesium engine cradle with a reduced weight from 17 kilograms (kg) to 9 kg, or 47 percent lighter than the previous assembly. The technology was transferred to an original equipment manufacturer for production on the current model of one of its feature vehicles.

**Energy End Use - Buildings and Communities** (12) develops energy-efficient technologies, processes and enhanced performance systems for market adoption in the Canadian residential and commercial building sector and communities. Areas of R&D include advanced heating, cooling and refrigeration, building controls and energy management, improved insulating systems, the use of renewable energy technologies (such as solar energy), high performance building design and integrated community energy systems.

**Energy End Use - Industry** (13) is working to improve industrial processes by better integrating and operating existing equipment. Many industrial plants continue to use technology current at the time of their construction, typically more than 50 years ago. NRCan's Process Integration Incentive Program, for example, has had an impact of more than \$100 million in industry investments, energy savings of 6,600 terajoules in fuel energy annually and increased power generation capacity of 50 megawatts. This translates into total financial benefits of \$75 million annually and total GHG emission reductions of more than 400 kilotonnes per year.

### A cool solution for buildings and communities

CanmetENERGY has contributed to the transformation of commercial refrigeration in Canada by developing CoolSolution®, a technology that reduces energy consumption and GHG emissions by 30 to 50 percent. The technology is based on increasing the use of natural refrigerants and includes heat recovery from the refrigeration system to provide building heating requirements and adaptation of the operation to the Canadian climate.

The **Forest Ecosystem Science and Application** Signature S&T project (14) generates knowledge about forest ecosystems and develops technology transfer tools for use in forest management policies and practices. This knowledge is essential for tracking Canada's progress in addressing climate change and to fulfil national and international reporting requirements for forest-related carbon and GHG estimates. The forest industry's competitiveness benefits from this initiative as a result of better understanding of the environmental and the socio-economic factors affecting forest health that are needed to ensure the sustainable management of forests.

### Canada's national forest carbon monitoring, accounting and reporting system

This system was developed to improve the forest carbon and GHG estimate for use in analysis and international reporting. This system includes refinement of the Carbon Budget Model of the Canadian forest sector and the development of a national deforestation monitoring program.

The **Environmental Studies and Assessments** Signature S&T project (16) also targets environmental responsibility. This involves the conduct of environmentally oriented geoscience research activities and provides expertise on potential environmental impacts of new or proposed projects, as well as resource assessments for crown lands where federal protected areas are to be defined. Among these, the mineral and energy resource assessment results made a significant contribution to support the federal decision on boundaries for Nahanni National Park and the announced Nááts'ihch'oh National Park Reserve. The assessment provided information for resource extraction and the protection of biodiversity. In another example from this Signature S&T project, NRCan's technical expertise has led to the improved protection of Sydney Harbour in Nova Scotia during the Sydney Tar Ponds cleanup. Reviews of the environmental impact statement, monitoring plans and annual reports for the cleanup have led to changes in the design of the sampling plans, field methods and data analysis to better protect the harbour during remediation.

The **Groundwater Geoscience** Signature S&T project (15) applies NRCan's expertise in hydrogeology, mapping and remote sensing to raise understanding of groundwater issues across regions and at a national scale. NRCan maintains an inventory of waters with data about the quality and quantity as well as distribution and use of those waters. Provinces and territories, as managers of water resources, have direct access to NRCan's groundwater S&T through the Groundwater Information Network (GIN). GIN partners coordinate activities and standardize and share data for the purpose of knowledge transfer.



The **Earth Observation for Responsible Development of Natural Resources** Signature S&T project (17), new in 2013–2014, conducts R&D that leverages the power of satellite data to support regulatory compliance monitoring and environmental impact assessment; work is currently focussed on the Alberta oil sands region. The project uses radar and optical satellite data, including NRCAN's long-term satellite data records with more than 30 years of daily national coverage. Several activities are underway with provincial/territorial, federal and academic partners. These include detecting changes in infrastructure (e.g. buildings, roads, tailings ponds) to monitor expansion of industrial activity and complying with regulatory approvals. The project is also identifying changes in vegetation type and productivity; assessing elements of regional hydrology to understand regional baselines and changes; and detecting ground deformation linked to steam-assisted extraction techniques to improve the understanding of the impacts and risks of these approaches in varied geological circumstances.

## Understanding contaminants in groundwater

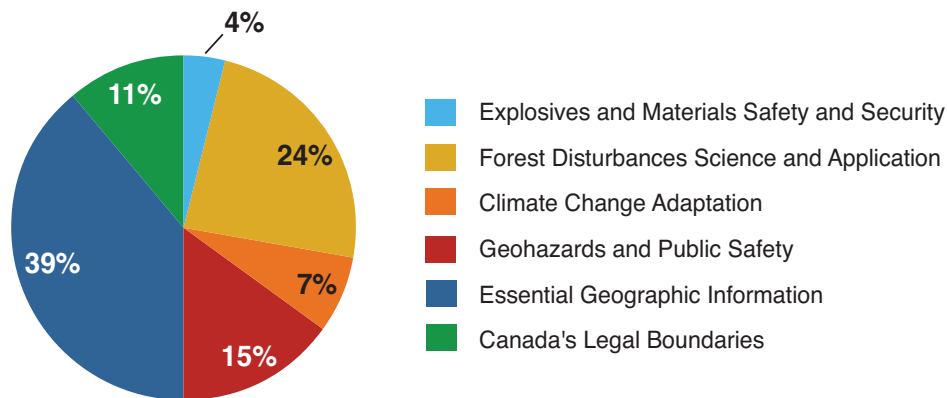
A study in the Athabasca oil sands region developed new methods for detecting and differentiating the source of contaminants as naturally occurring or mining-related. Researchers have investigated contaminants in lake sediment and tree ring cores to obtain a time perspective pre- and post-oil sands activity to be able to determine the impact of development of this resource on the environment. The study's results are used in environmental management decisions and help to improve the design of controls and monitoring programs.



### Strategic outcome 3. Canadians have information to manage lands and are protected from related risks.

In working to achieve the third strategic outcome through six Signature S&T projects, NRCan gathers and disseminates information for the management of lands and natural resources and for helping to protect Canadians and Canadian resources from risks ranging from those anticipated and those yet to be encountered. The following pie chart provides a breakdown of S&T resources devoted to this outcome based on the 2013–2014 fiscal year.

#### Information to manage lands (\$129.8 million)



#### Asian long-horned beetle – The long and winding road

NRCan science, conducted in cooperation with the Canadian Food Inspection Agency, Health Canada, municipalities and the province of Ontario, resulted in the eradication of the Asian long-horned beetle from Canada. The economic return on forest pest S&T investments is conservatively estimated to be 2:1 in avoided costs. Unfortunately, a novel invasion of the Asian long-horned beetle was detected in mid-August 2013 in Mississauga, Ontario. Efforts to delineate the infestation and eradicate this pest continue.

The **Forest Disturbances Science and Application** Signature S&T project (19) supports federal regulations and policies to prevent, manage and control natural and human-caused disturbances in Canada's forests. For example, NRCan developed and enhanced the Canadian Wildland Fire Information System and the Canadian Forest Fire Danger Rating System. These Web-based information systems are used to track and forecast fire danger nationally. These tools contribute to improved emergency preparedness and response programs for community planning and development.

As a result of changing climate and increased trade, Canada faces a higher risk of forest pathogens. In response, scientists at NRCan developed a genomics tool to detect a fungus that causes sudden oak death that could pose a threat to hardwood forests. The use of this tool enables Canadian horticultural nurseries to certify that their products are free of the disease through phytosanitary certification and regulatory compliance.

Four earth sciences Signature S&T projects contribute to achieving this strategic outcome. Activities under **Climate Change Adaptation** (20) include scientific analysis on climate change issues affecting Canada north of 60° latitude as well as partnership development work to integrate practical adaptation planning into community

management strategies. Science and information products are provided to governments (territorial, provincial, other federal departments and agencies), decision makers and project collaborators to improve land and natural resources management and reduce risks to infrastructure caused by climate change.

**Geohazards and Public Safety** (21) researches and monitors natural, geological hazards such as earthquakes, tsunamis, volcanic eruptions, landslides, and geomagnetic storms to understand their underlying causes and impacts and the probability of their occurrence. The department's Canadian Hazards Information Service provides real-time information to emergency response organizations and critical infrastructure operators to help them manage and respond to hazardous events more effectively. NRCan's research has contributed to hazard mitigation plans for northern pipelines, for power generation with BC Hydro for seismic hazards related to dams, for power systems with Ontario's Hydro One and Manitoba Hydro, and for air navigation and airlines, among other industries. Critical infrastructure operators have used alerts and warnings developed by NRCan to protect infrastructure from the impact of natural hazard events, reducing the costs and the time required for business resumption.

**Essential Geographic Information** (22) involves the collection, analysis and dissemination of information and data products to support social, environmental and economic decision making by governments and others. NRCan coordinates federal government activities and complements work by provincial and territorial mapping agencies under the Geomatics Accord. NRCan directs its efforts and funding to priority areas where provinces and territories are not actively providing data to ensure Canada's vast geography is covered. NRCan works with them to ensure efficient data collection, data sharing and standards development to ensure that datasets from different sources can work together.

**Canada's Legal Boundaries** (23) applies S&T to deliver an integrated and modernized survey system to support sovereignty and the administration and management of real property in the North and on Aboriginal lands. This project is creating a framework to identify, document, register and protect boundaries and property rights. For example, from 2009 to 2013, NRCan provided 77 land descriptions for First Nation reserves and managed 210 surveys of boundaries for those reserves and adjoining provincial lands.

## Geomagnetic effects on pipelines

The proposed Alaska Highway pipeline, which would, if built, cut across Yukon and northeast British Columbia to meet up with the Alberta system, is vulnerable to geomagnetic effects because of its position in the zone that is subject to the precipitation of particles from the sun, the same ones that cause the aurora borealis (northern lights). NRCan made a comprehensive assessment of the geomagnetic effects, including construction of Earth models to calculate electric fields and use of these as inputs to a pipeline model. This assessment was combined with statistical analysis of geomagnetic activity to provide an overall assessment of geomagnetic impact for use in the design of the proposed pipeline.



## Going to more accurate heights

Traditional surveying techniques relied on accessing the nearest of 80,000 fixed brass survey monuments to get a measurement of relative height. These physical sites required regular maintenance by ground crews, adding to the costs of keeping the reference system useful. NRCan took the decision to move to a new height reference system that more accurately accounts for the dynamic movement of the Earth's crust, a system that uses global navigation satellite systems and approximately 250 federal survey stations. Use of this model gives more accurate and consistent height values, reduces surveying costs in the North and puts our country at the global forefront of implementing this approach.



NRCan provided legal survey advice and created the legal description for the lands for the Whitecap Dakota First Nation of Saskatchewan. Having certainty through a legal description has allowed the First Nation to implement their land code and manage their own lands, resulting in economic opportunities of more than \$100 million in investment and more than 650 jobs.

## Testing new armour

New ceramic armour materials fabricated at CanmetMATERIALS were found to have equivalent or better mechanical properties than those commercially available. Composite armour plates and new steels are being tested for protection against increasingly powerful explosive devices while also reducing the weight of personnel armour.

The **Explosives and Materials – Safety and Security** Signature S&T project (18) supports achievement of this strategic outcome and is undertaken by CanmetEXPLOSIVES and CanmetMATERIALS. This initiative involves explosives research and technology development to improve the safety and security of mining and infrastructure as well as for personnel protection and armoured vehicles. Explosives testing for Canada is conducted to determine whether an explosive is safe to be used. Research on blast effects on buildings is also undertaken to improve the resistance of federal infrastructure to attack using explosives. Research on defence materials supports Canadian manufacturers in producing defence products comprising ships, submarines, light military vehicles and weapons systems for the Department of National Defence.

## Signature S&T project expenditures fiscal year 2013–2014 summary report As of March 31, 2014 (Year-end final)

Expenditures					
Signature Project number	S&T project	Operating (\$)	Capital (\$)	Transfer payments (\$)	Grand total (\$)
1	Green Mining Innovation	3,677,438	947,522	-	4,624,960
2	Forest Sector Innovation	24,814,203	-	52,716,384	77,530,586
3	Geomatics Innovation	11,204,161	-	733,354	11,937,515
4	Targeted Geoscience Initiative	11,978,722	-	431,360	12,410,082
5	Geo-mapping for Energy and Minerals	26,074,542	-	96,400	26,170,942
6	Geoscience for New Energy Supply	6,593,043	-	-	6,593,043
<b>Strategic Outcome 1 Total</b>					<b>139,267,128</b>
1	Green Mining Innovation	9,628,493	-	251,000	9,879,493
7	Energy End Use – Transportation	15,438,025	1,304,677	5,472,024	22,214,727
8	Pipeline Materials	2,815,318	1,304,677	-	4,119,996
9	Energy Supply – Electricity	12,489,380	1,304,677	19,026,667	32,820,724
10	Energy Supply – Fossil Fuels	25,192,325	-	8,558,299	33,750,624
11	Energy Distribution	2,394,906	-	12,534,489	14,929,395
12	Energy End Use – Buildings and Communities	20,755,143	-	8,802,516	29,557,659
13	Energy End Use – Industry	6,913,007	-	18,058	6,931,065
14	Forest Ecosystem Science and Application	17,641,111	-	1,902,055	19,543,165
15	Groundwater Geoscience	4,524,619	-	-	4,524,619
16	Environmental Studies and Assessments	7,177,692	-	10,000	7,187,692
17	Earth Observation for Responsible Resource Development	1,781,235	-	-	1,781,235
<b>Strategic Outcome 2 Total</b>					<b>187,240,394</b>
18	Explosives and Materials – Safety and Security	5,341,132	39,882	-	5,381,014
19	Forest Disturbances Science and Application	30,872,159	-	307,505	31,179,664
20	Climate Change Adaptation	5,107,463	-	4,297,080	9,404,543
21	Geohazards and Public Safety	18,980,336	519,569	91,570	19,591,474
22	Essential Geographic Information	33,018,373	16,410,676	250,000	49,679,050
23	Canada's Legal Boundaries	14,613,585	-	-	14,613,585
<b>Strategic Outcome 3 Total</b>					<b>129,849,330</b>
	Office of the Chief Scientist (OCS)*	2,021,920		574,981	2,596,902
<b>Grand total</b>		<b>321,048,333</b>	<b>21,831,681</b>	<b>116,073,742</b>	<b>458,953,756</b>

• Signature S&T projects 7, 8 and 9 include \$3.9 million in capital for the CanmetMATERIALS laboratory relocation to Hamilton, Ontario.

• The Green Mining Innovation Signature project supports both Strategic outcomes 1 and 2.

\* OCS expenditures support the corporate priority of Mobilizing our S&T and do not represent a Signature S&T project.



## 2. Future directions

### S&T forward agenda

The future will bring new opportunities and challenges related to managing NRCan's S&T. It is one of the roles of the S&T Board to review departmental S&T policies on a continuing basis and to guide the implementation of the Mobilizing Our Science and Technology (MOST) priority within NRCan. With governance and management tools in hand, and with more to follow, the S&T Board is better positioned to strategically manage the department's S&T investments as described by the 23 Signature S&T projects. For the coming year, the S&T Board will be focused on

- S&T human resources issues – including development of guidelines for emeritus scientists and establishing a policy with respect to adjunct professorships
- S&T performance measurement – based on the relevance, impact and quality of NRCan S&T
- S&T outreach strategy – bringing departmental S&T to Canadians, especially to students, with a view to encouraging careers in science and engineering
- Destination 2020 – delivering on S&T-related components of the departmental action plan

### Destination 2020

In his *Twentieth Annual Report to the Prime Minister on the Public Service of Canada*, the Clerk of the Privy Council called for a clear and shared vision of what Canada's public service should be and for an action plan on how to make it happen. NRCan's Action Plan on Blueprint 2020 responds to the four guiding principles identified by the Clerk:



- an open and networked environment that engages citizens and partners for the public good
- a whole-of-government approach that enhances service delivery and value for money
- a modern workplace that makes smart use of new technologies to improve networking, access to data and customer service
- a capable, confident and high-performing workforce that embraces new ways of working and mobilizing the diversity of talent to serve the country's evolving needs



Destination 2020, the plan that will help to build a public service that incorporates the four guiding principles of Blueprint 2020, identifies five priority areas for action:

- innovative practices and networking
- process and empowerment
- technology
- people management
- fundamentals of public service

The priorities identified in NRCan's Action Plan on Blueprint 2020 are well aligned with these five themes. NRCan's priority areas are talent development; establishing an enabling environment; and science, policy and program entrepreneurship.

Through conversations about the NRCan Action Plan on Blueprint 2020 and discussion documents such as *Government Science 2020*, the department's S&T Board is catalyzing a vision of the future for S&T at NRCan.

## Whole-of-government approach

Blueprint 2020 calls for a whole-of-government approach, enterprise-wide solutions and consolidated operations. These ideas can and should be adapted to and applied to government science, its governance and management. Addressing complex challenges such as climate change, sustainable development and public security requires coordination across the entire science and innovation ecosystem.

Various components for whole-of-government S&T are in place already, including a well-functioning Assistant Deputy Minister S&T Integration Board, which responds to the Deputy Minister Committee on S&T.

A well-structured system within the federal government is not enough; adaptive research networks of scientists from government, universities, the private sector and non-governmental organizations are one way to access the expertise and resources needed to solve multifaceted research questions.





## Open and networked environment

NRCan is building on the expertise of sectors and regional centres by engaging with strategic partners and supporting the broader innovation ecosystem. The new Leadership in Energy and Environmental Design (LEED)-platinum certified CanmetMATERIALS laboratory in Hamilton, Ontario, provides key technology and innovation support to industries that manufacture mineral and metal products in southwestern Ontario and across the country.

Building on the Open Government initiative lead by Treasury Board, NRCan will continue to work toward the advancement of

- open access to government science publications
- easy access to published government datasets
- open science, meaning wider collaboration in the funding of, and participation in, the conduct of science

NRCan has already taken the first steps with the updating of its Intellectual Property policy and the introduction of the new S&T Publications policy, both of which will improve access to NRCan science and technology.

While great potential for innovation exists through collaborative co-production of knowledge, crowdsourcing, innovation prizes and citizen science, success for NRCan will depend on enabling technologies both to attract talent and to reach out to potential collaborators.

## Modern workplace with smart use of technology



Developing a truly network-based approach to federal science is a long-term effort that involves overcoming barriers and creating new connections and working relationships. As a partner organization to Shared Services Canada (SSC), NRCan will continue to work with SSC to develop and share a clear understanding of internal and collaborative scientific and critical computing requirements.

Social media and Web 2.0 technologies provide the capability for organizing scientific work in new ways. For government science to retain relevance, achieve excellence and deliver impact into the first half of the twenty-first century and beyond, NRCan and other federal agencies will have to adopt and adapt to evolving technology as well as changes in the public service workforce.

## High-performing workforce

NRCan's S&T activities depend on a professional scientific and technical workforce that scans the horizon for emerging S&T, identifies opportunities for natural resource development, and adapts to new ways of working. Current initiatives underway, including the Directive on Performance Management and the development of community generic job descriptions, are intended to improve human resources management in the federal public service.

For the S&T community, finding solutions to specific concerns about the work environment (including information management and information technology, open communication and networking with colleagues from outside of government) that were revealed in a Blueprint 2020 survey of S&T employees, will help to attract and retain scientific and technical experts.

## 3. Conclusion

NRCan's S&T activity extends across the vast land mass of Canada, addressing innovation and public science needs in energy, mining and minerals, forestry, and earth sciences. Reporting on Signature S&T projects by using financial management tools has already improved accountability for the department's S&T activities.

NRCan will continue to exert S&T leadership in dealing with natural resources challenges on the horizon as well as those currently unforeseen. Some opportunities already known and likely to become more significant include the opening of the North and reduction of the environmental footprint of resource industries. Federal S&T will see greater networking of research activity, stronger collaboration in the conduct of research, and dispersion of responsibilities amongst many players.

Whether working with industry to improve competitiveness or undertaking the surveys and data gathering that are essential public goods, NRCan will continue to mobilize its S&T for the benefit of Canadians.

