Office of the **Queensland Chief Scientist**

Revised Queensland Science and Research Priorities

Office of the Queensland Chief Scientist

5 June 2015

Queensland Government

About this document

The Queensland Government has a plan to create knowledge-based jobs, drive productivity improvements and build on our natural advantages. *Advance Queensland* will deliver a suite of programs that are specifically designed to encourage research and innovation, particularly in areas where our state has a competitive advantage.

In the past, Queensland has witnessed significant investments in science, research and innovation which have placed us firmly on the world stage. Further investment in this area is necessary to maintain momentum and to ensure that Queensland's world-class science and research capability is effectively translated into positive outcomes. Placing us in a position to compete with other knowledge-based economies will enhance the lives of all Queenslanders.

To ensure any future investments provide value for money and are well aligned with Queensland Government objectives, the Queensland Chief Scientist has reviewed Queensland's Science and Research Priorities to ensure they are focused on well-defined areas, use our competitive advantages, and reflect identified needs and activities the government considers important. These priorities were developed with industry, academia, and the university and research sector after an extensive consultation process. The priorities will be used in the assessment of applications under the Queensland Government's Advance Queensland program.

Underpinning all of our priorities is the need to remain internationally competitive by attracting and retaining science and research talent. This will occur through Advance Queensland and through targeted investment by government departments. If we are to create jobs in this economy we must encourage research-focused mobility and the effective translation of research between industry, academia and government.

On pages 3 and 4, are the four 'Decision Rules' for investment (or R.E.D.S.). In essence, these rules guide our evaluation, prioritisation and decision-making around future investment. These rules were developed after extensive consultation with the research and university sectors, government and industry.

We welcome feedback on the detail around each of the priorities - and updated versions will be published periodically.

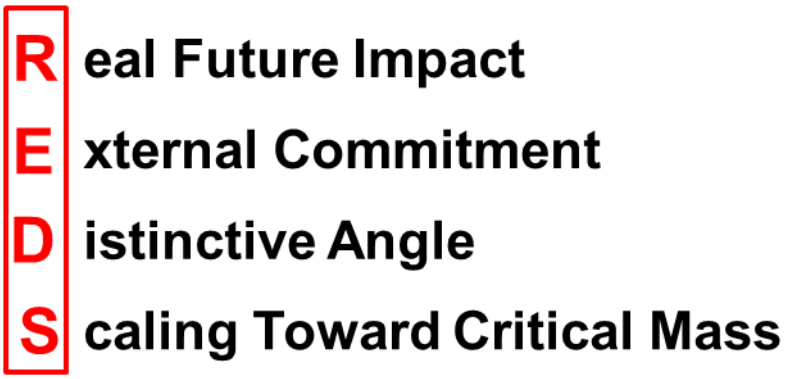
Contents

The R.E.D.S. Decision Rules

The Queensland Government invests in research and development (R&D) and partners with Queensland's universities and research institutions to deliver practical research that benefits Queenslanders. While we can use much of the knowledge and tools developed nationally and internationally, Queensland is impacted by specific issues and opportunities which require focused R&D efforts.

The *R.E.D.S Decision Rules* were developed to ensure our R&D investments are targeted and impactful. The rules can be used to assess an entire portfolio or a single project. When used in conjunction with the *Queensland* Science and Research Priorities the rules aim to create a research and innovation community that delivers great outcomes locally, nationally and internationally.

The science and research investment decision rules (R.E.D.S.) are:



- **Real future impact:** What will be the tangible benefit for Queensland, and how long will it take to happen?
- **External commitment**: What is the involvement of, and commitment from, your external collaborative partners and end-users?
- **Distinctive angle:** What is in it for Queensland, and why is Queensland the place to conduct the research?
- **Scaling towards critical mass**: How, and with whom, will you be collaborating on your research, locally (i.e. state-wide) as well as nationally or internationally, to achieve quality and significant capability in Queensland?

R.E.D.S. Definitions

Real Future Impact

What will be the tangible benefit for Queensland, and how long will it take to happen?

- The impact can be economic, environmental and/or social.
- Impact needs to be measurable and advocates should propose the best metric(s) in each domain.
- The mechanism for knowledge exchange and translation of research findings to the commercial/policy/end use environment is planned, up front, and continually 'top of mind'.

External Commitment

What is the involvement of, and commitment from, your external collaborative partners and end-users?

- Capital and resources (including Leadership and manpower) must actually be committed, not contingent (or promised).
- The share of external contributions will typically increase over time, and should be planned accordingly.
- Commitment should be sufficient to see the project through to effective translation.

Distinctive Angle

What is in it for Queensland, and why is Queensland the place to conduct the research?

- Distinctiveness might be based either on natural, comparative advantage(s) and/or uniqueness of the research direction.
- Distinctiveness should not readily be imitated by others.
- Quality of the proposal, proposers and collaborators is pivotal; track record is the best indicator of future performance in this regard.
- Consistency with national objectives - for example helping build relevant national capacity - requires due consideration.

Scaling towards critical mass

How, and with whom, will you be collaborating on your research, locally (i.e. state-wide) as well as nationally and/or internationally, to achieve quality and significant capability in Queensland?

- Collaboration and (potentially) co-location are to be rewarded. This should not only include collaboration between researchers and researchers, but also researchers and end-users or industry.
- People mobility, 'both ways', is key to quality translation and knowledge exchange (for commercial, policy and end use uptake).
- Critical mass, and significance, needs to be measured in both a detailed manner, as well as a global manner. We need to be particular. For example, we should assess our specific capabilities in 'gene silencing' in a global context, rather than assessing our 'biotech' capacity in the region.

Queensland Science and Research Priorities

- Delivering productivity growth and jobs for Queensland by developing **enhanced production technologies, tools and practices** particularly in the **agricultural**, **mining, advanced manufacturing** and supporting sectors including **engineering services** (page 6)

- Growing our **knowledge intensives services** through **science, research and innovation** (page 12)

- **Protecting our biodiversity** and heritage, marine and terrestrial, with particular focus on the **Great Barrier Reef** (page 16)

- Natural advantage **cleaner, and renewable energy technologies** development (e.g. gas, solar, biofuels) (page 19)

- Ensuring the **sustainability of our physical** and especially our **digital infrastructure** critical for research and - correspondingly - strategically leveraging national programs (including making use of 'big data') (page 22)

- **Building resilience and managing climate risk**, through the design and development of construction technologies for extreme weather event resistance (floods, cyclones, droughts), **particularly in tropical environments** (page 25)

- Supporting the **translation of health and biotechnology** research where Queensland has a particular interest or specific expertise, such as vaccine/drug development, age-related and tropical diseases, and skin cancer (page 28)

- Improving **health** data management and **services delivery** (including telemedicine) (page 31)

- Ensuring **sustainable water use** and delivering **quality water and water security** in a variable climate and in a resources-intensive economy (page 33)

- **Digitally-enabled technologies**, e.g. the development and application of advanced modelling, visualisation, sensing and simulation technologies, tools and practices, including robotics (page 36)

Science and Research Priority

*Delivering productivity growth and jobs for Queensland by developing **enhanced production technologies, tools and practices** particularly in the **agricultural**, **mining, advanced manufacturing** and supporting sectors including **engineering services**.*

In Summary

As a long term driver of more than 60 per cent of Australia's productivity growth, innovation has the greatest potential to increase the state's productivity.

Queensland has traditionally relied on the mining and agriculture sectors to drive our economy. Our manufacturing industries are struggling. Each of these sectors has ambitious targets, where well-focused research agendas combined with close cooperation with industry can, and must, play a key role in the development and application of innovative productivity-enhancing technologies and processes. In addition, engineering has underpinned the productivity/success in the resources sector and will continue to play a critical role as the mining sector moves from a focus on construction to production.

Advanced technologies can help reduce the impact of declining multi-factor productivity which has become a feature of the domestic economy in recent years. Technology has the potential to create spin-offs and drive hi-tech jobs through attraction of global capital and multinational branch companies.

Correspondingly, a commitment to reducing waste (for example, across the whole food cycle, currently estimated to be approaching 40 per cent worldwide) and a relentless search for innovations that add value to our bountiful natural resources will help fuel economic growth. A number of Queensland-based research institutes are already well-placed and have the capacity and capability to help drive innovation and boost our productivity and competitiveness.

Why should this be a Science and Research Priority for Queensland? What is the problem we are trying to solve?

Mining

The Queensland Resources Council has calculated that in 2011-12 the resources sector injected some $36 billion into the Queensland economy, easily surpassing the $25.5 billion total from 2010-11. This sector has well established projects already underway with more to be developed in the future. Supporting this sector are substantial research and educational capabilities available at various universities. As we further develop this sector, this research is essential to deliver innovative technologies and new infrastructure, provide water security, minimise environmental impacts and reduce our energy and water footprint.

Engineering

Engineering is often a fundamental component of product and systems innovation. Between 72.5 and 75 per cent of the businesses in the engineering sector innovated over the three years to 2011, compared with 61 per cent for all industries in Queensland. Engineering is a growing component of the Queensland economy[1]. Mining, construction and manufacturing are engineering intensive industries and contribute the greatest share to gross state product. Queensland's resource endowment (second only to Western Australia) could lead the nation

[1] Engineering Queensland. The Smart Engineering State (Schaffer, 2012) http://www.chiefscientist.qld.gov.au/images/documents/chiefscientist/reports/smart-engineering-state-report.pdf

in providing long term wealth and energy security. Tapping this potential requires technologies and tools to improve prospectivity, productivity and public confidence, to ensure that resources are developed responsibly and can deliver agriculture, food production and water security objectives.

Agriculture

The state has well-established agricultural industries and land suitable for agriculture in tropical areas that could support substantial increases in production. Sustainable development of these regions requires significant research, development and innovation to realise their full potential. Subtle changes in environmental conditions driven by a variable climate, on-farm efficiencies and changing dietary preferences create important opportunities to integrate new production systems and technologies into this dynamic environment. As we invest in the mining sector and develop arable land, sustainable and economic development will be essential in advancing and diversifying the Queensland's economy.

Advanced manufacturing

Collaborative initiatives between the Australian and Queensland Governments, established the Australian National Fabrication Facility (ANFF) which provides leading-edge nanofabrication facilities for academia and industry in Queensland. In collaboration with other national groups, these facilities have been delivering world-class innovation and service to local industry, and advancing the federal target of 'Boosting the commercial returns from research'. Queensland has a unique opportunity to build further upon this active platform and academia-industry links.

What opportunities exist in Queensland?

Mining

Queensland's unconventional gas resources may be larger than any other state and have the potential to provide both Queensland and Australia with a cleaner transitional energy source that will replace coal for the coming decades, while delivering great wealth from export earnings. The state's potential geothermal energy resources are unparalleled. Vast tracts of Queensland's energy resources are largely underexplored, but may host Australia's next supergiant ore deposit on the scale of South Australia's Olympic Dam Mine (the largest known single deposit of uranium in the world to date, producing 6 per cent of the world's uranium).

Agriculture

Global demand for food, particularly protein-rich, high-value foodstuffs, will continue to expand, driven by increasing average global incomes. This is particularly the case in Asia, where Queensland is well positioned to supply high-quality foodstuffs into niche markets, if an appropriate supply chain can be established. The development of new plant and animal varieties and new farming systems - that sustainably deliver new products and ensure long-term productivity - will be essential if Queensland is to benefit from this.

Advanced manufacturing

Currently, the Queensland manufacturing sector is dominated by small and medium-sized enterprises (SMEs) with a relatively low spend on R&D. This underinvestment places the state's manufacturing industry at considerable economic risk from global and national competition. The spectrum of manufacturing R&D is skewed towards traditional disciplines which face obsolescence from more advanced manufacturing technologies from more innovative competitors such as the Southeast Asian region. Currently, over 60 per cent of

the R&D spend in Queensland is on 'Machinery and Equipment Manufacturing' and 'Food Product Manufacturing'.

What is the current activity in this area in Queensland and who are the main players?

Mining

Queensland leads the nation in unconventional energy production, currently dominated by Coal Seam Gas (CSG) until shale gas reserves are more broadly developed. Energy and minerals research is conducted at The University of Queensland (UQ), QUT, James Cook University (JCU), CQUniversity Australia (CQU), CSIRO (Commonwealth Scientific and Industrial Research Organisation) and the Geological Survey of Queensland within the Department of Natural Resources and Mines. The Queensland Geothermal Energy Centre of Excellence at UQ and CSIRO conduct geothermal research. Autonomous systems supporting energy and minerals exploration and production are studied at QUT and CSIRO's Queensland Centre for Advanced Technologies (QCAT). CQU researchers are leading experts in the area of fatigue risk management in shiftworking operations, an essential component of sustaining health and safety for mining personnel, particularly in long-distance commuting operations.

Agriculture

UQ is one of the world's top ten universities in agriculture[2]. The Queensland Alliance for Agriculture and Food Innovation (QAAFI) is a world-leading institute in tropical agriculture and food production using genetics and biotechnology. Considerable expertise supporting animal and plant health, especially tropical diseases and pests, exists in UQ, QAAFI, the Queensland Department of Agriculture and Fisheries (DAF) and CSIRO. QAAFI joined CSIRO and DAF in the Northern Beef Research Alliance. CQU is ranked by the Australian Research Council as 'well above world standard' for its applied agricultural research. Research at CQU's Institute for Future Farming Systems focuses on using technology to deliver practical solutions and extension to Queensland's tropical horticulture and livestock regions.

Advanced manufacturing

The Queensland Government has invested over $5 billion in R&D and innovation over 14 years (1998-2012) which has supported more than 40 new research institutes and created construction opportunities. Activity in advanced manufacturing in Queensland is centered on the ANFF which has nodes at at UQ and Griffith University (GU). Queensland also has capacity in this area within the Australian Research Centre for Aerospace Automation (ARCAA), the Cooperative Research Centre (CRC) for Advanced Composite Structures, and the Queensland Centre for Advanced Materials Processing and Manufacturing (AMPAM). The Centre for Railway Engineering at CQU is an essential partner in the Rail Manufacturing CRC that develops products, technologies and supply chain networks to increase the capability and globally competitive position of the rail industry.

Engineering

Significant research underlies the development of this state's engineering sectors. Both UQ and CSIRO have major mining and related research activities and the CRC Mining and the CRC for Optimising Resource Extraction (CRC ORE) are both headquartered in Brisbane and undertake much of their research in Queensland. Expertise is also available at GU's Sir

[2] QS World University Rankings by Subject http://www.iu.qs.com/university-rankings/subject-tables/

Samuel Griffith Centre and QUT's Sustainable Built Environment National Research Centre (SBEnrc).

What is the proposed scope of the science and research activity for Queensland?

Agriculture and mining

It is essential that we drive productivity growth across the supply chain of the state's mining and agricultural sectors. Research and innovations from the engineering sector will strongly support development of new technologies, tools and practice in these areas. In agriculture these innovations should:

- optimise the costs of production
- sustainably produce new plant and animal varieties with attributes attracting a premium price at market[3]
- develop technologies to support production of novel high value food and biomaterials using farm produce with unique attributes
- reduce waste - and better manage the waste we do produce.

A more innovative mining sector should be enabled by**:**

- developing automated core characterisation
- enabling next-generation autonomous exploration tools and improving mining and port infrastructure systems
- processing minerals using next-generation online tools
- removing miners from hazardous environments, managing risks to health and safety of personnel (safe and healthy resources industry) and replacing fly-in fly-out workers with automated operations
- reducing energy needs
- sustainably and productively using land and water resources[4].

Advanced manufacturing and Engineering

Advanced manufacturing has a wide range of applications when underpinned by transformative high value-adding technologies such as nanotechnology. Australia's manufacturing industries are looking for opportunities. Despite widely held perceptions, Australian manufacturers are innovative and are second only to service industries in terms of expenditure on R&D[4]. Nevertheless, R&D in nanotechnology is a very expensive endeavour, not feasible for individual SMEs. Creating a platform to enable SMEs to collaborate with each other and with researchers needs to be a high priority, given the often lengthy (decade or more) cycle for product development.

Leveraging the Queensland Government's contribution will be a prerequisite to build scale and scope. Thus, industry contributions and 'skin in the game' as well as some co-investment from research providers will be essential. This includes leveraging the *Advanced Manufacturing Industry Growth Centre* identified under the $188.5 million industry policy recently announced by the Australian Department of Industry. This nexus is therefore likely to provide additional opportunities to leverage funding from the federal government's Industry Innovation and Competitiveness Agenda.

[3] Agri-Science Queensland (http://www.daff.qld.gov.au/research/strategy-and-direction)
[4] Department of Industry, R&D tax incentive data.

How does any proposed investment in this priority satisfy the R.E.D.S. decision rules?

Real future impact: Becoming a leader in sustainable resource management and protection of our environmental resources will create a better environment for future generations and will deliver immediate economic benefits[4]. Doubling Queensland's agricultural production and providing lower cost, higher-quality food to consumers will boost the economic performance and environmental sustainability of the Queensland food and agri-business sector. Transformative technologies and high value-add manufacturing will stimulate new industries and a growing and more prosperous economy.

External commitment: Our university and government research providers have traditionally strong links with the mining, agricultural, advanced manufacturing and engineering sectors. Targeted federal and industry funding has been obtained by major players and there is further capacity to leverage these funds in the near future. International and national research links are robust and strengthening, for example, the Collaborative Research Networks program is designed to develop the research capacity of smaller, less research-intensive and regional higher education institutions. It encourages these institutions to adapt to an outcomes-based research system by teaming up with other institutions in areas of common interest.

Research outcomes in mining are delivered by the business sector with strong linkages with universities and public sector researchers. As an example, JKTech, the technology transfer company for the Sustainable Minerals Institute (SMI) at UQ, has established an office overseas in an effort to bring discoveries to the industry sooner. Similarly, CRC Mining, headquartered in Brisbane, has been collaborating and facilitating industrial-research collaborative activities for two decades. Simtars, in Queensland's Department of Natural Resources and Mines, has developed ground-breaking research and development programs thought its collaborations with industry, including post disaster mine navigation and programs on the survivability of equipment post-disaster.

Our leading position in tropical and sub-tropical agricultural research will drive increasing global investment. Queensland should maintain this lead. In addition, various large federally-funded infrastructure projects are underway. With growing confidence and an industry focus, Queensland could encourage direct investment from the private sector to match public investment. Leading expertise already exists within the Centre for Tropical Crops and Biocommodities at QUT, QAAFI, and the Agricultural Production Systems Research Unit - a collaborative organisation with researchers from CSIRO, UQ and the Queensland Government, and the CQU Institute for Future Farming Systems, in partnership with AgForce, in building the nexus between agricultural research and education.

Distinctive angle: Our natural advantages include a vast resource endowment and world-class research centres. Queensland has a unique production environment and biodiversity that can contribute to clean, safe, high-value agriculture, with significant potential for technology development and export. Queensland also plays a leading role in tropical and sub-tropical agriculture in Australia. There is an enormous potential for Queensland to export development technologies internationally in, for example, sub-tropical and dry land farming systems, capacity development and food security.

Engineering is a growing component of the Queensland economy. The increase in mining infrastructure development in Queensland contributed to significant demand for both engineering services and professional engineers. As the state remains a significant force in mining production, there are opportunities for Brisbane to become a world engineering city and a centre of excellence for the global provision of engineering services.

Queensland has distinctive advantages in many industries. Through the National Primary Industries RD&E Framework, Queensland plays a lead role in research on beef production and tropical fruit and vegetable crops, while the Centre for Coal Seam Gas at The University of Queensland, brings together leading researchers to tackle the major challenges facing this industry.

Scaling towards critical mass: Queensland is recognised internationally for its research in mining and engineering. Through a host of institutes and joint ventures - such as QCAT and UQ's SMI - CSIRO, CQU, UQ and QUT have a critical mass of research providers to develop the requisite new technologies and bring them to commercial success.

The UQ-Queensland Government alliance through QAAFI helped establish Queensland as one of the world's leading agricultural research centres. Proposed expansion of the QAAFI model to establish further critical mass will ensure this position is retained long term. CQU-QDAFF joint research appointments are strategically using research to deliver practical solutions to horticultural challenges in the tropics.

Continuing Queensland Government and federal funding to support ventures such as the ANFF nanofabrication facilities will help local industries to benefit from the consolidation and expansion of cutting edge innovation and services. Additionally, developing strong links with SMEs and these institutions will be critical in establishing a critical mass in this area of research.

What is a suitable (SMART[5]) target for this science and research activity?

Mining and Engineering sectors: the development of tools and infrastructure for: exploring and discovering new mineral deposits to fill the depleted pipeline of the state's known mineral resources; building the next generation of autonomous and/or remotely operated systems for surface and underground mining; removing miners from hazardous environments; and developing remote operation technologies.

Agriculture: increasing support for significant expansion in agricultural biotechnology (agricultural and food genomics), plant and animal health, bioinformatics, modelling, remote sensing and automation in agriculture and food production; and developing high value and novel foods based upon local competitive advantages.

Advanced Manufacturing: a thriving Queensland advanced manufacturing sector underpinned by transformative technologies, such as nanotechnology, that are delivering innovative products to the world, creating jobs, and attracting the establishment of world-leading companies in the state.

[5] SMART – *Specific*, *Measurable*, *Attainable*, *Realistic*, *Time-bound*

Science and Research Priority

Growing our knowledge intensives services through science, research and innovation[6].

In Summary

The services sector is a primary contributor to the Australian economy and is consistently among the fastest growing sectors in terms of domestic economy and trade. According to the Australian Bureau of Statistics, the Gross Value Added contribution of the services sector in 2012 was 71.2 per cent[7]*. Services are also critical to prosperity (comprising 85 per cent employment) and community well-being.*

The services sector is growing rapidly internationally and services are an increasingly dominant and pervasive feature of advanced economies. Knowledge-intensive services (KIS) are an important part of this growth. KIS are regarded as those services that use more research and development, more technology and more highly skilled workers in comparison to other service industries[8]*. KIS are provided by private sector businesses, commercial public sector organisations and research bodies that use knowledge and technology to drive their business while facilitating innovation and productivity in traditional and emerging industries. They are considered to be especially important in the creation of high-value knowledge-based jobs in mature economies. In addition, continued global expansion of the knowledge-based economy, combined with increased economic globalisation, is raising the importance of KIS activities in contributing to innovation*[9]*.*

Science and technology are fundamental to the success of many services as they provide the product, platform or knowledge from which the service can be developed or delivered. It is difficult to identify a service that is not in some way dependent on products and/or platforms developed through science and technology. They change the way we operate, think and innovate in all sectors, including KIS.

Science and Technology and research can drive services innovation in two ways[1]*:*

- *Innovation in service industries - where innovation is applied to an industry regarded as service based, or innovation results in a new service-based industry*
- *Innovation through services - where the application of a service results in innovation in a non-service-based organisation/business/industry.*

Why should this be a Science and Research Priority for Queensland? What is the problem we are trying to solve?

Strong employment growth is expected in the services sector in Australia (and around the world) over the next 10 to 20 years[10,11]. KIS are already a critical contributor to productivity, economic growth and competitive advantage in Queensland and the state will benefit significantly from aligning itself with the growing importance of services in the global economy.

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[6] Smarter services – future jobs and growth for the smart State. Smart State Council Working Group. Queensland Government 2006. http://ict-industry-reports.com/2006/12/08/smarter-services-report-queensland-smart-state-council-2007/

[7] Strategic focus of the Industry Innovation and Competitiveness Agenda misses the opportunity to grow the economy. Australian Services Roundtable Bulletin October 2014.

[8] Science and technology-lead innovation in services for Australian industries. PMSEIC Working Group. Australian Government 2008. http://www.industry.gov.au/science/PMSEIC/Documents/ScienceAndTechnologyLedInnovationForAustralianIndustries.pdf

[9] Innovation and Knowledge-Intensive Services Activities. OECD Publishing 2006. http://www.oecd.org/science/inno/innovationandknowledge-intensiveserviceactivities.htm

[10] Positioning for prosperity? Catching the next wave. Building the Lucky Country - Report #3. Deloitte Touche Tohmatsu. 2014. https://www2.deloitte.com/content/dam/Deloitte/au/Documents/Building%20Lucky%20Country/Deloitte_au_business_positioning_for_prosperity_2014.pdf

[11] Australia's skills and workforce development needs. Discussion Paper. Australian Workforce and Productivity Agency. July 2012. http://www.awpa.gov.au/publications/documents/Future-Focus-Australias-skills-and-workforce-development-needs-Discussion-Paper.pdf

In recent years, disruptive digital technologies have drastically changed the nature of the services (and KIS) sector and of service delivery.

The PricewaterhouseCoopers (PwC) report A Smart Move: Future-proofing Australia's Workforce identifies the following key findings:

- 44 per cent or 5.1 million current Australian jobs are at risk from digital disruption in 20 years
- 75 per cent of the fast growing occupations require STEM skills
- Changing 1 per cent of the workforce into STEM roles would add $57.4 billion to GDP.

If we are to maintain and improve the competiveness and profitability of Queensland's KIS businesses in this environment, defend existing market share, and grow new markets, then the application of science, research and innovation will be critical. Growing our KIS through science, research and innovation will influence both Queensland's future position in the world market and our ability to deliver effective, state-of-the-art domestic services.

The Organisation for Economic Cooperation and Development research shows innovation accounts for at least 62% of Australia's productivity growth over the longer term, and that future growth must increasingly be innovation-induced. However, evidence shows that productivity growth in Queensland and Australia is declining and that declining productivity will erode Queensland competitiveness and prosperity. Therefore, Queensland must focus on designing, developing and commercialising globally relevant products, services and processes to maintain a competitive edge.

However, the application of science and research to innovation in the KIS sector is poorly understood, a serious deficiency given this growing global services revolution. Queensland is well placed to capitalise on the growth in the KIS sector, leveraging our strong underpinning base of R&D expertise and supporting infrastructure and the market leading KIS companies in the state.

What opportunities exist in Queensland?

The application of science, research and innovation to our KIS sector will contribute significantly to growth in high-value knowledge-based jobs, drive productivity improvements, and provide the opportunity for Queensland to capitalise on our strengths and expertise - particularly where they relate to the challenges associated with a tropical/sub-tropical environment and a highly regionalised population.

Supporting a sustainable competitive advantage for the KIS sector in Queensland can be achieved by identifying high-value, knowledge-intensive services with global markets. Examples of potential areas that meet these criteria for Queensland include:

- health service delivery to remote communities and via telehealth
- solutions for delivering education services in remote communities
- design and management of infrastructure in tropical and subtropical climates
- sustainably exploiting our resources (e.g. minerals, oceans, agriculture)
- environmental challenges and services (e.g. water, bushfires, coastal/marine and desert sectors)
- transport and logistics services (e.g. in sparse geographies).

What is the current activity in this area in Queensland and who are the main players?

KIS industries active in Queensland include (but are not limited to):

- specialist education (e.g. The Curriculum in to the Classroom - C2C - project that provides online planning resources to assist Queensland teachers implement the Australian curriculum in state schools)

- specialist medical technology and health (e.g. Queensland Health's Rural Telehealth Service - one of the world's most advanced managed telehealth networks linking over 1500 videoconferencing systems deployed in more than 200 hospitals and community facilities in rural and remote Queensland)
- digital content services (e.g. Wotif - Australasia's leading travel website)
- creative services, including architectural and fashion services
- legal, finance, insurance, accounting, marketing and business services (e.g. GBST – provider of software and services to the global financial services industry)
- agriculture services (e.g. scientific and R&D consulting, monitoring services)
- technology and innovation in the mining/resources sector (e.g. Deswik – Queensland-based global company delivering mine planning techniques and next generation software, including a mine visualization and scenario planning tools approach to mine development, for the resources sector)

What is the proposed scope of the science and research activity for Queensland?

The proposed scope of the science and research activity is as broad as the KIS industries listed above. We need to identify where science, research and innovation can drive growth in high value jobs, and increase productivity and economic output in a KIS industry. To do this and to develop successful, sustainable and innovative science and research-led KIS opportunities in the state we need to consider the following identifiers:

- where we have domain knowledge, access to R&D talent and an appropriate skills-base
- where the opportunity is not easily replicable and is unique to Queensland
- where we are either already ahead of the game or are likely to get ahead of the game
- where a strong, high-value global market opportunity exists
- where there is exportability.

How does any proposed investment in this priority satisfy the R.E.D.S. decision rules?

Real future impact: This priority has the potential to deliver on job creation. In mature economies, growth in services - especially knowledge-intensive services - contributes significantly to increases in the number of high-value, knowledge-based jobs, compared with growth in capital-intensive manufacturing and primary industries.

External commitment: Aligned with the types of KIS businesses outlined above, the following are some examples of centres of research excellence that are driving improvements in the productivity and/or delivery of KIS in Queensland:

- Creative industries: The Centre for Subtropical Design, QUT
- Health services:
  - The Australian e-Health Research Centre
  - UQ's Centre for Online Health
- Education: Centre for Educational Innovation and Technology (CEIT), UQ
- Resources:
  - Safety in Mines Testing and Research Station (Simtars), Queensland Government
  - Sustainable Minerals Institute, UQ
  - Queensland Centre for Advanced Technologies (QCAT)
- Environmental: Ecosciences Precinct, Queensland Government and CSIRO
- Agriculture: QAAFI, UQ, Institute for Future Farming Systems CQU
- ICT and digital content: National ICT Australia (NICTA).

Distinctive angle: Queensland's strength in the KIS sector e.g. mining, health, educational and environmental services – and the challenges to service delivery inherent in a state with tropical expertise and a geographically dispersed population. Queensland also has very

strong links into our Southeast Asian neighbours and the demand in this region for high value KIS is significant, and growing.

Scaling towards critical mass: Queensland already has a critical mass of R&D excellence with global impact, aligned to and engaged with the following KIS industries: Mining and Equipment, Technology and Services (METS); telehealth and health services delivery; and subtropical, tropical and/or sustainable design.

There is capacity to exploit science, research and innovation to grow other KIS industries, where we can address a global market and where we have emerging R&D capability and capacity. These include education, financial and business services, and agricultural services.

What is a suitable (SMART[5]) target for this science and research activity?

We should aim to grow the number of knowledge-based jobs in Queensland and increase our export of KIS over the next 10 years.

Science and Research Priority

Protecting our biodiversity *and heritage, both marine and terrestrial, with particular focus on the* ***Great Barrier Reef.***

In Summary

Queensland is a world leader in biodiversity conservation. With a rich, internationally-renowned biodiversity from species to ecosystems, this unique set of assets must be maintained and managed, while supporting our economy and lifestyle. Effective biodiversity conservation and management in Queensland is hindered by a lack of adequate, robust baseline information and clear measureable objectives.

The evidence base to support conservation decision making is limited by critical gaps in knowledge about biodiversity and ecosystem function and processes, especially in our understanding of the cumulative impact and appropriate management of multiple stressors. Part of this evidence base can be built by focusing research on key areas including: biodiversity conservation and ecosystem health; optimal resource allocation; and environmental information. We must also develop tools and skills to support transparent, robust and accountable decision-making. Research into biodiversity and its management will ensure our ecosystems are used and developed sustainably and the unique ecosystem services they provide are retained.

Why should this be a Science and Research Priority for Queensland? What is the problem we are trying to solve?

Queensland is one of the fastest growing regions in Australia, with over 2.7 million people impacting on native vegetation, marine areas and ecosystems. Better management and sustainable use of ecosystems and ecosystem services for business, agriculture, tourism and the community will be essential to ensure the security of our biodiversity. The Great Barrier Reef is a vital and economically valuable asset to the Queensland economy and the millions of people that rely upon its existence to bring in significant tourism dollars.

What opportunities exist in Queensland?

Queensland has a richer biodiversity of species to ecosystems than anywhere else in Australia and is comparable to anywhere overseas. This includes iconic World Heritage areas (for example, the Great Barrier Reef, rainforests, Fraser Island, Riversleigh World Heritage Fossil site) that make significant recurrent contributions to the Queensland economy (for example, the net present value of the Great Barrier Reef is estimated at $51.4 billion[12]). Additionally, we have a highly skilled scientific workforce supported by world-class infrastructure.

Developing the knowledge necessary to overcome the management challenges to reduce threats to biodiversity assets will ensure the sustainable use and retention of the ecosystem services that our biodiversity provides. It will also help drive the ongoing sustainable development and management of these unique assets.

What is the current activity in this area in Queensland and who are the main players?

Queensland has world-class research and research institutions working in the area of biodiversity and marine diversity:

[12] Oxford Economics. 2009. Valuing the effects of Great Barrier Reef Bleaching. Report prepared for the Great Barrier Reef Foundation. Australia.

- Queensland Government: DSITI and DAF
- Universities include: UQ (Ecology Centre, Centre for Marine Science, GCI); GU (Environmental Futures; Australian Rivers Institute); JCU (Centre for Tropical Biodiversity & Climate Change, TropWater, Centre for Tropical Environmental and Sustainability Studies); CQU; USC; USQ and QUT
- ARC Centre for Coral Reef Studies - a partnership of JCU, the Australian Institute of Marine Science (AIMS), The Australian National University, the Great Barrier Reef Marine Park Authority (GBRMPA), UQ and the University of Western Australia.
- Publicly funded research agencies: AIMS, CSIRO (Sustainable Ecosystems, Marine and Atmospheric Research)
- Others: GBRMPA; Integrated Marine Observing System. CQU Coastal Restoration and Marine Tidal Mesocosm Facilities.

What is the proposed scope of the science and research activity for Queensland?

Development of sustainable management strategies and technologies for the state's biodiversity in order to provide improved ecosystem services to business, agriculture and the community.

This should include:

- Food security research: enhancing the productivity, profitability and environmental performance of Queensland's aquaculture industries; researching the status and ensuring the sustainability of our marine, estuarine and freshwater fisheries resources[13]
- Biodiversity conservation and ecosystem health analysis of biodiversity in unexplored areas; developing functional understanding of key species and ecological communities; participating in the development of national efforts in environmental monitoring; and developing of tools to predict the nature and consequences of changes in biodiversity as a result of human intervention[14]
- Dealing with a changing climate: refining understanding of the impacts of a changing climate on biodiversity to support government efforts to mitigate and adapt[12]
- Optimal resource allocation: addressing critical policy and management issues by integrating social and economic factors
- Gathering environmental information and developing tools and skills to assist in transparent, robust and accountable decision-making.

How does any proposed investment in this priority satisfy the R.E.D.S. decision rules?

Real future impact: Work in this area will result in better knowledge, management and protection of our wildlife and national parks; sustainable recreational, commercial and indigenous use of our landscapes; species conservation; and more sustainable use of the state's biodiversity.

External commitment: Queensland researchers are already working with partners (including natural resource management groups, local government and non-government organisations) and commonwealth funding is available to improve biodiversity outcomes.

Distinctive angle: Queensland has a natural advantage given the richness of its ecosystem and species and its position in the tropics. It also has a technical distinctive angle in its research centres such as: GCI, Australian Rivers Institute (GU), Institute for Future Environments (QUT), Australian Centre for Sustainable Catchments (USQ), Centre for Tropical Biodiversity & Climate Change and TropWater.

[13] Fisheries and aquaculture research (http://www.daff.qld.gov.au/fisheries/research)
[14] DSITIA Science Delivery Division Audit. Final Report (2012) (http://

Scaling towards critical mass: Strong partnerships already exist between government, universities and other researchers. These can be enhanced to provide critical knowledge, and to develop tools and novel technologies.

What is a suitable (SMART[5]) target for this science and research activity?

Queensland's R&D sector should be focused on ensuring that Queensland's:

- ecosystems and species are the best understood, monitored and managed in Australia and the world
- State of Environment reports show continued and sustained improvements in Queensland's biodiversity assets
- maintenance of the ecosystem services provided by its biodiversity assets encourages continued growth in the economic value of those services.

Science and Research Priority

*Natural advantage **cleaner**, and **renewable energy technologies** development (e.g. gas, solar, biofuels)*

In Summary

Queensland has two powerful natural advantages in cleaner and renewable energies: our comprehensive resource base (gas, solar, wind, biofuels and geothermal); and our close proximity to and relationships with the emerging Asian economic powerhouses. These advantages can only be exploited if we develop a long-term approach to managing our energy future. Short-to-medium term innovation is needed to achieve sustainable exploitation of our conventional resources. This should include a long-term, system-oriented, multi-disciplinary strategy which incorporates the development, demonstration and export of conventional and emerging renewable energy technologies.

Our key research organisations in these areas have individual skills and capacity across several pivotal technology areas and are well connected to the world's best research centres. Coordinating this expertise, connecting researchers with our resources and generation industries, and better bridging the deployment gap from laboratory to production will provide a more coordinated portfolio approach to deliver medium-term emissions reductions, and position Queensland as an Asian energy super-state for the carbon-constrained decades to come.

Why should this be a Science and Research Priority for Queensland? What is the problem we are trying to solve?

About 81 per cent of the state's electricity is generated by coal-fired power stations, with around 43 million tonnes of carbon being released into the atmosphere each year directly from this source[15]. Queensland is also a major exporter of fossil fuels for energy production. The International Energy Agency (IEA) predicts the world will continue to rely on fossil fuels, for the majority of its energy needs, for several decades to come[16].

However, in a carbon constrained future, our state's challenge is two-fold: we must reduce our own greenhouse gas emissions across all activities (not just electricity production); and we must position ourselves as an energy innovation powerhouse - providing resources, technology and maybe even clean electricity to the emerging Asian region. We must view our responsibilities and opportunities within a national framework (for example the Australian Government's 20 per cent renewable target by 2020[17]), and also within the emerging global context of wholesale emissions reductions and carbon markets.

What opportunities exist in Queensland?

'*Queensland has vast and largely untapped low pollution energy sources. This includes renewable energy options such as geothermal, solar, wind, hydro and bioenergy, as well as large reserves of gas… By 2030, close to 35 per cent of Queensland's electricity could be produced from renewable energy sources…*'[17]. However, such ambitions will require a significant reduction in the cost of renewable energy and advances in power systems and energy storage to cope with the intermittency of renewable energy resources such as wind and solar. Queensland has the potential to take a leadership position in the development of

[15] Clean Energy Jobs in regional Australia. Spotlight Report. (2011) Queensland Snapshot. The Climate Institute. http://www.climateinstitute.org.au/verve/_resources/cleanenergyjobssnapshot_queensland.pdf
[16] International Energy Agency, 2012. *IEA World Energy Outlook 2012*
[17] http://www.climatechange.gov.au/reducing-carbon/renewable-energy/renewable-energy-target (under review)

sustainable production of unconventional gas and carbon geosequestration which the IEA considers essential to achieving deep cuts in global emissions.

Couple this natural resource advantage with our close proximity and relationships with the emerging Asian economies and a massive opportunity emerges for Queensland as an energy super state.

What is the current activity in this area in Queensland and who are the main players?

Research institutions in Queensland have world-class capacity in cleaner and renewable energy technologies. These include:

- clean coal/energy technology - Carbon Energy Research Centre *(*UQ); Centre for Clean Environment and Energy (GU), and Institute for Resource Industries and Sustainability (CQ University (CQU)); QCAT
- gas (natural and unconventional) - Centre for Coal Seam Gas (UQ), the largest unconventional gas research program in Australia
- renewable energy technologies - Hydrogen storage and microgrid research and the (GU)
- solar - UQ Solar, the largest solar research program in Australia and the demonstration scale solar-hydrogen technology in the Sir Samuel Griffith Centre (GU)
- geothermal - Queensland Geothermal Centre of Excellence (UQ)
- biofuels and biogas - Syngenta Centre for Sugarcane Biofuels Development (QUT), Australian Institute for Bioengineering and Nanotechnology (AIBN), the Institute of Molecular Biosciences (micro-algal biofuels) (UQ), QAFFI, the High Energy Algal Fuels Project (JCU); Biodiesel (CQU Institute for Future Farming Systems) and UQ Biogas
- ancillary power systems - next generation power systems for renewable energy (UQ and QUT), new market economics (UQ Energy Economics), and the QUT Institute for Future Environments
- energy storage - electrochemical energy storage and conversion groups (UQ and AIBN).

What is the proposed scope of the science and research activity for Queensland?

Queensland's energy-related R&D activity should focus upon:

- utilising Queensland's cleaner and renewable energy resources with a portfolio approach of near-term to blue-sky opportunities - including hybrid systems and the use of conventional stranded assets
- characterising Queensland's carbon geostorage potential and proving the technical, environmental and social acceptance of carbon capture and storage
- supporting the sustainable production and utilisation of our unconventional gas resources
- addressing the important challenges associated with integration of emerging renewable electricity generation into our grid and market systems
- promoting development and deployment to pilot-scale for key new technologies by connecting with the federal funding base
- creating a coordinated statewide approach to skill-creation and utilisation in the sustainable energy technologies.

How does any proposed investment in this priority satisfy the R.E.D.S. decision rules?

Real future impact: By developing a portfolio approach to our resource utilisation and technology development, Queensland could be an energy leader in the Asian region - with positive not negative total emissions impact.

External commitment: We need to focus on coordinating and utilising our powerful resources and generation sector, integrating our emerging technology base and connecting with the federal agenda.

Distinctive angle: Queensland has a unique combination of advantages: massive natural resources and close proximity to the emerging economic powerhouses of Southeast Asia.

Scaling towards critical mass: QCAT, UQ and QUT have a critical mass of world-class scientists and engineers in gas, solar, clean coal, biofuels and geothermal technologies. However, pilot-scale test facilities are few and far between and represent a substantial deployment gap.

What is a suitable (SMART[5]) target for this science and research activity?

Queensland's R&D sector should focus on ensuring that our state:

- develops a visionary portfolio of sustainable, low emissions energy technologies for internal consumption and export
- bridges the scale-up gap between laboratory and deployment via innovative and cost effective pilot-demonstrations
- takes a holistic view of the 'power system' - understanding and addressing integration and market failures
- takes a broader international view of the economic opportunities for a clean energy future by developing now the technology and strategies to promote our leadership in the Asian region.

These measures will deliver near-term emissions reduction (for example, the 20 per cent renewable target by 2020[18]) and a means to transition our economy in the medium-term for a constrained carbon future.

Science and Research Priority

*Ensuring the **sustainability of our physical** and especially our **digital infrastructure** critical for research and - correspondingly - strategically leveraging national programs (including making use of 'big data')*

In Summary

International competitiveness and progress across Queensland's Science and Research Priorities are increasingly dependent on the ready availability and expansion of powerful digital infrastructure. Over the past 15 years, the Australian Government has invested more than $50 million in Queensland to co-fund high performance computing, cloud computing, massive data storage and associated research services and capability. These facilities include research access to another $350 million of capacity nationwide.

Infrastructure includes the computational and big data complex managed through Queensland Cyber Infrastructure Foundation, the establishment of NICTA in Queensland, and the federally-funded Research Data Storage Infrastructure and Terrestrial Ecosystem Research Network. It has also been developed by CRCs and their affiliates, such as the SBEnrc, the Smart Transport Research Centre and university-based engineering infrastructure.

Future-proofing these facilities requires business planning for the funding of operational sustainability, replacement and growth to meet changing technology innovation and obsolescence and increasing demand.

Why should this be a Science and Research Priority for Queensland? What is the problem we are trying to solve?

Quality physical and digital infrastructure provide the backbone for our science and research activities and are therefore critically important to Queensland's economy and its communities.

Through facilities funded by commonwealth and state grants, Queensland has achieved the physical and digital infrastructure foundation to excel. These require substantial additional ongoing funding for skills development to maximise the substantial funding which went into their establishment.

What opportunities exist in Queensland?

Many strong research areas exist for further development in Queensland, including: simulation and modelling (for example in construction and resources); visualisation (health, environment, construction); data mining and analytics using big data (urban research, tropical research, genomics, asset management, spatial data); and mechatronics (mining, agriculture, unmanned aircraft) among many others.

Queensland should aim for and achieve at least 20 per cent of future commonwealth funding for infrastructure, consistent with our share of Australia's GDP, and population. Funding sought should also offer quasi-commercial returns which will benefit future funding. The Australian Government recently announced continued funding for the National Collaborative Research Infrastructure Strategy (NCRIS), which supports major research infrastructure to encourage world-class research through collaboration between the research sector, industry and government in Australia. The renewed NCRIS will secure Australian researchers' access to current major research facilities and the supporting infrastructure and networks necessary to undertake world-class research.

What is the current activity in this area in Queensland and who are the main players?

High performance computing (HPC):
- The Barrine 3,000 node HPC at UQ
- the 1,300 node HPC at QUT
- The National Computation Infrastructure specialised facility in bioinformatics
- the European Bioinformatics Institute Mirror at UQ
- Data-intensive computing - an Australian Research Council, Linkage Infrastructure, Equipment and Facilities application for a data-intensive HPC unique to Australia.

Research cloud computing: A 4,000 core cloud computing facility managed by Queensland Cyber Infrastructure Foundation (QCIF) funded by the commonwealth NeCTAR program.

Research data storage:
- a 20 petabyte data storage capability managed by QCIF at UQ and JCU funded by the Commonwealth Research Data Storage Infrastructure (RDSI) program
- The Commonwealth Terrestrial Ecosystem Research Network (TERN) program lead agent at UQ
- genomics, biodiversity, climate change virtual laboratories at UQ and GU
- The Smart Transport Research Centre at QUT
- Water Informatics at UQ and GU
- Tropical Data Hub at JCU
- Imaging infrastructure at the Centre for Advanced Imaging and Microscopy and Microanalysis.

What is the proposed scope of the science and research activity for Queensland?

- Re-growth and sustainability of the commonwealth-supported facilities established in Queensland, and their intensive application to key areas of research and innovation for the state
- Release of large reservoirs of government data for use in research
- Capitalising on strength in spatial and environmental data. Re-investment in SBEnrc, bringing the national headquarters back to Queensland.

How does any proposed investment in this priority satisfy the R.E.D.S. decision rules?

Real future impact: Maintaining and growing Queensland's physical and digital infrastructure will underpin large scale digitally-enabled research critical to Queensland, and will be instrumental in attracting research investment and talent.

External commitment: We need to build on the strong collaborations already in place (for example, RDSI, TERN and NICTA) which demonstrate viable external commitment, and increase our proportion of external funding to ensure Queensland's expenditure on science and research matches or exceeds that of other states.

Distinctive angle: Queensland has data-intensive computation backed by excellent facilities applying big data in every priority research area. We also have the capabilities to ensure efficient design and construction and have sophisticated transport infrastructure.

Scaling towards critical mass: We must continue building critical mass as exemplified by the strong alliances that already exist in Queensland (for example, TERN, SBEnrc, NICTA and QCIF) which provide cloud computing and data storage. These could scale up further to

incorporate government and industry data in a trusted facility that delivers more efficient and beneficial outcomes.

What is a suitable (SMART[5]) target for this science and research activity?

We should be aiming to:

- deliver sustainable usage and operations for existing cloud and data storage facilities and delivering 100 per cent growth by 2020
- increase the number of skilled staff by 100 per cent by 2018
- re-host the national leadership of SBEnrc
- secure at least 20 per cent of further Australian Government-funded facilities.

Science and Research Priority

Building resilience and managing climate risk**, through the design and development of construction technologies for extreme weather event resistance (floods, cyclones, droughts), **particularly in tropical environments

In Summary

Queensland is exposed to a highly variable climate, with droughts, floods and cyclones regularly impacting communities, the economy and environment. A changing climate will exacerbate the intensity of these extreme events and bring new risks, such as increased health costs and significant damage to ecosystems like the Great Barrier Reef (through more intense cyclones, floods, and thermal stress). This will create challenging conditions for our mining, tourism and agricultural sectors.

In Queensland, science and research will play an increasingly vital role in helping craft innovative solutions to these climate challenges through, for example: developing new technologies, designs and materials for construction; improving urban and regional planning; developing plant varieties that are 'climate ready'; building state-of-the-art early warning and information systems for emergency services and residents; designing new ways of managing and protecting our unique ecosystems; and reducing the incidence of vector-borne and infectious diseases and heat-related hospital admissions.

There are also significant opportunities for Queensland to develop new lines of business associated with novel technologies and strategies that can be adopted by tropical and sub-tropical countries attempting to build resilience and adapt to a changing climate.

Why should this be a Science and Research Priority for Queensland? What is the problem we are trying to solve?

Queensland is exposed to a highly variable climate, with droughts, floods and cyclones regularly impacting on the economy, environment and local communities. For example, 37 people died from flood and cyclone-related events in Queensland in 2011 and the economic damage from these events was estimated to be $6 billion. Changes in our climate will exacerbate the intensity of these extreme events and bring new risks and significant damage to key ecosystems such as the Great Barrier Reef, increased health costs (heat stress, spread of tropical disease), coastal inundation, more intense storms, and more challenging conditions for agriculture, fisheries and aquaculture.

What opportunities exist in Queensland?

Queensland has a long history of investing in research and innovation to understand the drivers of both climate variability and change, and in developing practical solutions to address these challenges. Given Queensland's geographic location it can, and is, providing global leadership in understanding and managing climate impacts in the tropics in areas such as: flood and cyclone prone built environments; unique rainforest and reef ecosystems; agriculture and animal production; and vector-borne diseases. Solving these challenges with appropriate investments can lead to new technologies and industries that can potentially bring valuable business to Queensland, and deliver solutions to reduce our vulnerability to climate and extreme weather events.

What is the current activity in this area in Queensland and who are the main players?

Queensland's institutes undertake a broad array of research in understanding climate impacts and developing adaptation solutions. Four institutions (UQ's GCI, GU's Global Change Response Program, the National Climate Change Adaptation Research Facility and

CSIRO's Climate Adaptation Flagship) are taking a broad cross-sectoral approach, recognising that it is an issue that affects all sectors and plays out at local scales where cross-cutting approaches are essential. The Appleton Institute and key researchers at CQU are involved in disaster resilience projects in collaboration with the Bushfire and Natural Hazards CRC and is working with communities post-disaster to build resilience.

In addition, a number of institutions have expertise in particular aspects of climate adaptation. These include:

- Tropical ecosystems - The Ecology Centre (UQ), AIMS, Centre for Tropical Biodiversity and Climate Change (JCU), Environmental Futures Centre (GU), GBRF
- Tropical agriculture - Institute for Future Farming Systems (CQU), QAAFI (UQ), Sustainable Agriculture Flagship and Food and Nutritional Sciences (CSIRO), Centre for Tropical Crops and Biocommodities (QUT)
- Water resources - Australian Rivers Institute (GU), Advanced Water Management Centre and the Centre for Water Futures (UQ), Centre for Tropical Water and Aquatic Ecosystem Research (JCU), Australian Centre for Sustainable Catchments (USQ)
- Urban planning and communities - Sustainability Research Centre (USC), the Urban Research Program (GU), the Urban Systems Research Program (CSIRO)
- Built infrastructure - Cyclone Testing Station (JCU), Institute for Future Environments (QUT)
- Health - Institute for Health and Biomedical Innovation (QUT), Queensland Tropical Health Alliance (JCU, QIMR Berghofer, QUT, UQ) and Appleton Institute (CQU).

Queensland is also showing national leadership in mitigation technologies such as geothermal, solar thermal and large-scale photovoltaic power generation. There needs to be recognition that pursuing these technologies ultimately reduces the costs associated with adaptation to a variable climate.

What is the proposed scope of the science and research activity for Queensland?

There are three areas of priority research for Queensland in this area.

1. Technologies, strategic decision making, planning regulations and policies within important sectors such as the built environment (especially in coastal regions), water security, health, fisheries, aquaculture and agriculture.
2. The need to develop innovative approaches that go beyond existing initiatives to assist key ecosystems adapt to climatic variation to increase ecological resilience.
3. Integrating approaches to managing climate impacts at local and regional scales to avoid maladaptation and to build resilience in communities.

How does any proposed investment in this priority satisfy the R.E.D.S. decision rules?

Real future impact: We could make significant reductions in the costs of climate impacts that would otherwise occur through a lack of adaptation planning or through reactive adaptation. For example, reducing costs through new design and engineering approaches to infrastructure following extreme events rather than rebuilding as before.

External commitment: Queensland researchers are well engaged nationally and internationally and many research initiatives work closely with end-users across all sectors, for example: Global Change Response Program (GU), CSIRO's Climate Adaptation Flagship and the National Climate Change Adaptation Research Facility (NCCARF) (headquartered at GU with Commonwealth support). Phase 1 of NCCARF was supported by the Queensland Government and the focus of phase II is the development of coastal adaptation management tools.

Distinctive angle: Queensland researchers have a strong track record in understanding climate impacts and developing adaptation solutions in tropical environments - with many groups working in this space.

Our state has a wide variety of climate zones (hot arid, warm temperate, sub-tropical and tropical) which make it impossible to produce an all-in-one solution to climatic events. Our unique location means that Queensland should be the leader for our country and the rest of the world in developing solutions and building resilience into our society.

Scaling towards critical mass: Queensland has been prominent in leading national initiatives in this science priority (National Climate Change Adaptation Research Facility and CSIRO's Climate Adaptation Flagship), and as a consequence has developed well-coordinated critical mass across institutions with strong industry and public-private partnerships.

What is a suitable (SMART[5]) target for this science and research activity?

Queensland's R&D sector should be focused on ensuring that:

- a full risk assessment under different climate scenarios for Queensland has been developed and has been included in Queensland state planning by 2020.
- as a result of innovative adaptation solutions there are net benefits of $3 billion per annum by 2030[18] from a reduction in the costs associated with dealing with our variable climate and extreme weather events.
- the rate of loss of mangroves, salt marshes and seagrass beds (currently 1 - 2 per cent per year) has been stopped by 2025 and that some ecosystems are recovering by 2035[19].
- Queensland has distinguished itself as a key hub for R&D in adapting tropical and subtropical environments to climate change.

[18] Delivering on Australia's National Challenges by developing globally competitive ICT - through an innovative approach to ICT. (Zelinky, A.) http://www.nicta.com.au/__data/assets/pdf_file/0014/21740/ZelinskySlides.pdf

[19] Blue Carbon – Opportunities for the Regional Seas Conventions and Action Plans (2012) 14th Global Meeting of the Regional Seas, Conventions and Action Plans, Nairobi, Kenya 1st – 3rd October 2012. (http://www.unep.org/regionalseas/globalmeetings/14/RS.14_WP.4.RS.pdf)

Science and Research Priority

*Supporting the **translation of health and biotechnology** research where Queensland has a particular interest or specific expertise, such as vaccine/drug development, age-related and tropical diseases, and skin cancer*

In Summary

Good health is the basis for long, productive and enjoyable lives. Yet, as the population ages and grows (both in number and weight), and the resource intensity of treatments increases, our current healthcare system is becoming unsustainable. The Australian Bureau of Statistics predicts that the proportion of Australians over 65 years could increase from 13 per cent to 25 per cent by 2056. To help ensure these people live enjoyable and productive lives, research into treating or preventing conditions such as Alzheimer's disease and other forms of dementia will be a priority.

In addition, Queensland should focus its research on diseases that represent a particular burden on its people. For example two in three regional Queenslanders are overweight or obese, the worst in Australia; and more than a quarter of children are obese or overweight, the second highest in the country. Prevention strategies to address poor health as a result of Queensland's dominant diseases will be required.

Queensland's location also impacts upon health. For example, Queensland has the highest rate of skin cancer in the world with more than 3,000 Queenslanders diagnosed with a melanoma of the skin in 2009. Furthermore, we are subject to endemic and epidemic tropical and emerging diseases such as Dengue fever, Ross River fever, malaria, tuberculosis, rabies, avian influenza, bat-borne viruses and newly emerging pathogens. In 2010, the World Health Organisation estimated there were 219 million cases of malaria worldwide, leading to an estimated 660,000 deaths. The development of tropical health solutions is not only critical for the health of Queenslanders and Australians, but also for our tropical neighbours.

Why should this be a Science and Research Priority for Queensland? What is the problem we are trying to solve?

- The strength of our economy is underpinned by the need for a healthy population, and productivity of this population is inherently sensitive to infectious diseases, mental health wellbeing and major diseases such as cancer. Cancer alone incurs a total burden of disease of 2.9 million DALYs (a DALY is one year of 'healthy life' lost to a disease). This has a significant impact to the Australian economy[20].
- The current health system is not sustainable, with the significant projected growth in demand outstripping our ability to meet it.
- The aging population in Queensland (including incoming residents migrating here) will exacerbate the state's need to address chronic diseases experienced by aging populations, including dementia.
- Queensland dominant diseases need to be addressed in Queensland, for Queenslanders. Issues such as tropical diseases, skin cancer, and other diseases adversely impacting Queenslanders to a greater extent than the rest of Australia must be the focus.

What opportunities exist in Queensland?

- There is a substantial opportunity for more efficient health care with a greater emphasis on prevention and integrated care.

[20] Cancer in Australia: an overview 2012 http://www.aihw.gov.au/WorkArea/DownloadAsset.aspx?id=60129542353

- Our understanding of the interplay between external factors (for example, diet and environment) and the onset of disease is advancing and will allow evidence-based steps to be taken to prevent health problems.
- Advances in e-Health and Telehealth will allow citizens in remote locations the same level of care as those in city centres.
- The highly qualified researchers and health providers in Queensland have a very good reputation for collaboration and will continue to build upon this.

What is the current activity in this area in Queensland and who are the main players?

- Queensland has invested significantly in building state-of-the-art institutes relevant to the medical field. These include:
  - The UQCCR
  - TRI
  - QIMR Berghofer.
- University and medical research institutes have skills that contribute to the objective.
- CSIRO e-Health and Queensland Health Telehealth have strong capabilities to assist in the de**l**ivery of the research objectives.
- Glycomics and Eskitis (GU). Glycomics is the only glycoscience institute in Australia and one of only 5 in the world. Eskitis houses Nature bank and the Queensland Compound Library (conduits for the commercialisation of Queensland Biodiscovery resource). Both are foci for significant Queensland-China partnerships.
- Australian Centre for Health Services Innovation (QUT and Queensland Health) can provide an essential focus on economic planning and assessment.
- CQU-led 10,000 Steps program in workplaces and communities over several years.

What is the proposed scope of the science and research activity for Queensland?

- The links between what we eat and how we behave give rise to changes at the epigenetic level. Studies in this area will be essential in integrating different components of research that embrace both the environment and genetics.
- The availability of full DNA sequencing will provide new information to clinicians and drive forward molecular pathology diagnostics and advance the development and use of new therapeutics.
- Imaging will provide an enhanced understanding of the core problems in many diseases and we will have to provide for facilities to integrate both imaging and genetic analysis into the hospitals of the future.
- In a shift towards prevention, individuals will increasingly take personal responsibility for monitoring their health through point of care diagnostics. Behavioural and social science with an emphasis on technology will be crucial.
- Infectious diseases are frequently delivered by vectors such as mosquitoes. Work on the elimination of these vectors will be essential to the eradication of such infectious diseases.

How does any proposed investment in this priority satisfy the R.E.D.S. decision rules?

Real future impact: Queensland should become the model for a healthy, long living, responsible population. With this will come reduced health care bills, reduced loss of productive work time and increased efficiency. This will foster a strong economy through investment in development and delivery of innovative solutions. In addition, a strong emphasis on translation is developing, in infrastructure and capability, through the TRI and health departments' investment in highly proactive clinical research fellowships.

External commitment: Community engagement will be built upon as will the commitment by the clinicians, healthcare workers, educators and researchers to achieve an advanced and integrated approach to health in Queensland.

Distinctive angle: Queensland is at greater risk to many emerging tropical diseases due to its location in the tropics. With the growth of commerce, tourism and travel to and from Asia there will be a greater influx of atypical medical conditions. These may have to be treated in Queensland initially and subsequently in all of Australia. Beneficially, our proximity to Asia will also foster strong collaboration, including potentially collaborative research approaches for solutions to these health threats.

Scaling towards critical mass: Over the past decade substantial capability has been assembled, and world-class infrastructure developed. Recent investment by the state and commonwealth (for example, in the Australian Institute of Tropical Health and Medicine, JCU) continues to build on this critical mass. Queensland should be an early adopter of the proposed linkage between healthcare expenditure and research investment (McKeon Review[21]).

What is a suitable (SMART[5]) target for this science and research activity?

Queensland must aim to combine an increased life expectancy with a diminished per capita healthcare expenditure and improved quality of life. This, as a prerequisite, means we must achieve greater net productivity from research and the healthcare system, and integrate consumer-driven prevention measures and professional treatments with evidence-based public policy.

[21] Strategic Review of Health and Medical Research – Better Health through Research (2013). Commonwealth of Australia

Science and Research Priority

*Improving **health** data management and **services delivery** (including telemedicine)*

In Summary

In Queensland, demand for health care services has been growing faster than our ability to pay for them. Scarcity of resources will require more efficient ways of delivering health care services and we need the evidence base to make these sometimes difficult decisions and choices. Despite its importance, health services research is neglected in Australia. The National Health and Medical Research Council (NHMRC) allocates only 4 per cent of funding for health services research (in 2012, 26 health services research applications were funded out of 731[22]). In contrast, more than 80 per cent is directed to basic science and clinical medicine areas.

Building from a talented and productive community of researchers, there is an opportunity for Queensland to show leadership in this area, leveraging the potential of 'open data' and building strong research partnerships between clinicians and academics to make sure the health benefits from a finite budget are maximised in a fair way.

Why should this be a Science and Research Priority for Queensland? What is the problem we are trying to solve?

Queensland's health institutes and universities have relatively few health services research groups, and this reflects the national picture. The NHMRC allocates only 4 per cent funding for health services research and over 80 per cent to basic science and clinical medicine. Doing research in hospitals, led by those who understand how to improve health services, is important as demand for health services is growing faster than spending can be allocated. Scarcity of health care resources can cause decisions to be reactive, rather than strong, rational and evidence-based responses to the questions of services delivery. Ensuring strong research outcomes in this area can ensure the best choices are made.

What opportunities exist in Queensland?

Reducing risks of healthcare acquired infections, faster diagnosis of chest pain patients in the emergency department, improving the health of elderly patients prior to discharge, providing gold standard care for chronic wounds and using minimally invasive surgical techniques for endometrial cancer have all been shown to save millions of dollars and improve patient outcomes. Yet their adoption in health services is slow for these reasons: investing in good services means disinvesting in less beneficial services and this is difficult to manage; large evidence gaps regarding the cost-effectiveness of health services exist; doctors and other health care professionals are rarely given incentives to maximise health benefits for populations.

What is the current activity in this area in Queensland and who are the main players?

Despite the slow adopting of new technologies referenced above, talented people in Queensland at UQ, GU, QUT and Royal Brisbane Women's Hospital are currently leading research in this area. Practising clinicians need to partner with health economists, statisticians, epidemiologists and psychologists to quantify and disseminate the evidence for improvements. Two Queensland groups that support collaborative research to improve health services are the clinical re-design initiative managed by Queensland Health and the

[22] http://www.nhmrc.gov.au/grants/research-funding-statistics-and-data/summary-funding-data/nhmrc-project-grants-success-rate-b

Australian Centre for Health Services Innovation who have supported 25 separate initiatives to improve health services in the last 18 months.

What is the proposed scope of the science and research activity for Queensland?

The volume of existing data that describes health services in Queensland is staggering, yet most of this is hard to access. An era of 'open data' holds great promise and the removal of barriers to sharing data cannot come soon enough. Queensland the opportunity to show leadership by developing strong teams of clinicians and academics to do research that shows how to make health services better and cheaper. An improved public understanding of rationing and scarcity is also critical to improving health services.

How does any proposed investment in this priority satisfy the R.E.D.S. decision rules?

Real future impact: Using research evidence to improve the way we organise and deliver health services will save costs and improve health outcomes among many populations.

External commitment: Engagement is occurring between national and international funding agencies and the private health care industries, and this will continue to increase. The need for better information about health services applies equally to public and private sectors.

Distinctive angle: Queensland has an opportunity to be the first state or territory to make health care rationing explicit, evidence based and driven by the principles of cost-effectiveness and fairness.

Scaling towards critical mass: Queensland has one of the largest managed Telehealth networks in Australia, with more than 1,500 systems deployed in over 200 hospitals and community facilities. There are many health care professionals with great ideas to improve health services, but there needs to be quantification of the ideas, and stronger translation of this evidence. In addition, programs to train the next generation of health services researchers are required and clinicians with good ideas need to be given incentives to pursue them.

What is a suitable (SMART[5]) target for this science and research activity?

Queensland's research sector should be focused on ensuring that Queensland's health costs remain stable or their growth is slowed and health benefits from a finite budget are maximised in a fair and equitable way.

Science and Research Priority

*Ensuring **sustainable water use** and delivering **quality water and water security** in a variable climate and in a resources-intensive economy*

In Summary

Queensland has a highly variable climate. Recent flooding, following a decade-long drought, has highlighted the economic, social and environmental imperative to ensure the state's water security, in terms of both quantity and quality.

Our growing economy is fuelling an increasing demand for water. We face the challenge of meeting this demand without degrading the freshwater and coastal ecosystems that sustain biodiversity and underpin recreational and commercial fisheries and tourism. We also need to improve the resilience of our catchments and waterways to extreme flood events. These same issues affect many parts of the globe and more than 3 billion people, especially those with similar climatic regimes to our own.

Our Queensland-based expertise and critical mass in sustainable water use and management can continue to help lead international research, education and training. Further research focus is required to improve water management in urban, agricultural, mining and energy sectors to reduce their growing environmental footprint on fresh water resources. We also need an improved understanding of surface-groundwater interactions, especially given the critical importance of groundwater in large areas of the state, and the growing pressure from mining, coal seam gas industries and underground coal gasification.

Why should this be a Science and Research Priority for Queensland? What is the problem we are trying to solve?

Recent severe flooding has highlighted the economic, social and environmental imperative to ensure Queensland's water security (both quantity and quality). We must continue to explore ways to improve water use efficiency so that scarce supplies can support growing urban, industry and agricultural needs without degrading the freshwater and coastal ecosystems that underpin significant recreational and commercial fisheries and tourism. We also need to improve the resilience of our catchments and waterways to extreme flood events to minimise the risk to drinking water supplies, critical infrastructure, life and property.

Queensland has commitments under the National Water Initiative to address over-allocation of ground and surface water systems and to better integrate the energy and minerals industries into water management. We also have significant national and international obligations to protect coastal ecosystems, including the Great Barrier Reef and Moreton Bay, from land-based pollution.

What opportunities exist in Queensland?

Queensland has few water stressed catchments. This gives us the opportunity to demonstrate how water resources can be developed and managed to support communities and a strong resources-intensive economy without degrading significant water-dependent environmental assets. There is also opportunity to deliver innovative water treatment options that reduce future costs and develop the knowledge and tools to tackle these issues at the source, rather than down through the pipeline. With our variable climate we also have the opportunity to ensure water quality for communities during flood events.

What is the current activity in this area in Queensland and who are the main players?

- GU's Australian Rivers Institute is the largest research group in Queensland focused on catchment, river and coastal science.
- UQ is one of Australia's leading institutions in urban water and mining-related groundwater research.
- JCU also has significant expertise in tropical freshwater systems and water quality.
- CQU has considerable expertise in mine water research and works with Queensland mining industries in managing water quality.
- DSITI's Science Delivery Division has expertise in water quality monitoring and science to underpin water planning.
- The International Water Centre offers an important vehicle for internationalisation of water research, as well as training and capacity building.
- The SmartWater Research Centre involves GU, USC, CQU and several Queensland industry partners.

What is the proposed scope of the science and research activity for Queensland?

Research should focus on water sustainability and quality and on improving water use and management in urban, agricultural and mining/energy sectors to reduce their growing environmental footprint on freshwater resources. An important goal is to improve our understanding of surface-groundwater interactions. An urban challenge is the integration of centralised and decentralised systems and dealing with water-energy nexus issues. There is also a need for robust and spatially explicit planning tools to optimise investments in catchment and waterway protection or restoration to achieve multiple water management objectives at least cost.

How does any proposed investment in this priority satisfy the R.E.D.S. decision rules?

Real future impact: Targeted investments in waterway management - underpinned by good science - will lessen the risk to water supplies, minimise flood damage, reduce the loss of farmland, and protect receiving waterways.

External commitment: Queensland researchers are already engaged with the water industry through several research partnerships (Healthy Waterways, Australian Water Management Centre, SmartWater Research Centre) and there are significant opportunities for commonwealth funding (for example, Australian Agency for International Development, Australian Centre for International Agricultural Research, Cooperative Research Centre programs). There are also several international funding opportunities.

Distinctive angle: Queensland researchers have considerable expertise in tropical and arid zone systems in a highly variably climate. The world's most water vulnerable regions are found in ecosystems with similar climatic constraints and Queensland is well placed to become a world leader in research, education and training in this area.

Scaling towards critical mass: GU and UQ are recognised national leaders in water science, with significant capability and complementary expertise. They have a long history of collaboration through many formal partnerships; several involving JCU, DSITI and CSIRO (for example, International Water Centre, Australian Water and Environmental Research Alliance, Tropical Rivers and Coastal Knowledge research hub, Urban Water Security Research Alliance, Healthy Waterways Partnership and the SmartWater Research Centre).

What is a suitable (SMART[5]) target for this science and research activity?

- Research to underpin a 50 per cent reduction in sediment and nutrient pollution into coastal waterways and drinking water supplies, with a similar reduction in costs of drinking water treatment over the next 20 years.
- Improved understanding of ground- and surface-water systems so they are managed to meet the state's National Water Initiative commitments by 2020.
- A 10 per cent increase per annum in international education and training income in water resource management.

Science and Research Priority

***Digitally-enabled technologies**, e.g. the development and application of advanced modelling, visualisation, sensing and simulation technologies, tools and practices, including robotics*

In Summary

With the increasingly pervasive nature of digital technologies, research and development into application-oriented information technology it is vital for Queensland to maintain and grow its world-class research capabilities. It is also essential to focus on collaborative partnerships with scientists, engineers and experts from areas that apply digital technologies to solve complex systems challenges. Problems in diverse fields should also be used as motivation for further research into new digital technologies.

Queensland already has impressive research capacity, with computer scientists, software engineers, interaction designers and mathematicians collaborating as equal partners with researchers in appropriate applications in areas of science and engineering. We must build from this excellent foundation and collaborate closely with the business sector to develop and exploit new business opportunities in areas as diverse as automated agriculture, the creative industries, niche manufacturing, tourism and specialised applications in aviation.

Why should this be a Science and Research Priority for Queensland? What is the problem we are trying to solve?

A rapid shift in research methodology means that a computational element to all science, technology, engineering and mathematics (STEM) research is now essential. We aim to improve the ability of Queensland's STEM researchers to deliver high-impact results through simulation, modelling and visualisation techniques. Further, transformation to a digital economy is required to underpin future growth in Queensland. For this, we need strong research in digital technologies.

What opportunities exist in Queensland?

A recent Australian Academy of Science report[23] argues computational science and engineering are essential to solve the big challenges facing Queensland. These include the development and operation of: smart infrastructure, electricity and transport systems; personalised health care; energy security; resource exploration and management; disaster management; environmental management; and the future digital economy. In short, effective modern science and engineering research requires modelling of the complex interactions of natural, built and virtual systems. Queensland's investments in growing capacity over the past decade provide the foundation for researchers to contribute to partnerships in areas where our ability to simulate, model and visualise the operations of the pillars of our economy can lead to improvements in the quality of our lives.

What is the current activity in this area in Queensland and who are the main players?

Queensland has significant capacity in this area, including multi-disciplinary groups at many universities. QUT has recently partnered with PwC, Brisbane Marketing and the Queensland Government's Department of Science, IT and Innovation to create the PwC Chair in Digital Economy). JCU has Australia's first Internet of Things in its Engineering faculty and is seeking to become the first Australian University to introduce a new Engineering programme

[23] See http://science.org.au/policy/documents/fs-computerscience.pdf

(in Cairns) in the field of Electronic Systems and the Internet of Things to start in 2016. CSIRO has the Centre of Advanced Technology and the Digital Productivity Flagship.

Queensland's research base in this area already has the right 'shape' - computer scientists, software engineers, interaction designers and mathematicians collaborating as equal partners with researchers in appropriate areas of the sciences, engineering, and social sciences. This has had significant impact in areas such as environmental monitoring, resource exploration, e-health research, bioinformatics, disaster management and the development and operation of transport systems and other infrastructure.

What is the proposed scope of the science and research activity for Queensland?

Queensland's R&D activity should focus on enabling success in other research activities through collaborative development of capabilities and solving foundational problems in:

- big data: data science and analytics; exascale, federated storage and access
- computation: domain-specific modelling and simulation capability; new engineering methodologies for reliable, scalable and massive simulations; optimisation techniques to focus models and simulations
- interaction: visualisation, sensor technologies, control systems, advanced human-computer interaction paradigms.

How does any proposed investment in this priority satisfy the R.E.D.S. decision rules?

Real future impact: A focus in this area will enable greater impact of research outcomes across various areas (medicine, engineering, ICT, etc.) with the ability to do more, and faster, through modelling and simulating the systems that underpin our economy.

External commitment: Significant external funding could be available through partnerships with QCIF, NICTA and CSIRO. Infrastructure strategies and initiatives such as NCRIS and the Australian Urban Research Infrastructure Network have leveraged external investment.

Distinctive angle: The Queensland and Australian Governments have invested heavily over the last decade to deliver infrastructure which encourages collaboration among researchers. There is already a large mass of researchers in Queensland with UQ, QUT and GU having world-class specialist capacity in this area. NICTA has world-leading capacity focused on smart infrastructure, environmental science, broadband and health. CSIRO has expertise in computational informatics. There are also several innovative start-ups (for example, Remote Observation Automated Modelling Economic Simulation and Real Serious Games).

Scaling towards critical mass: Queensland should maximise its competitive advantage. Our focus should be on utilising the vast mass of researchers and infrastructure Queensland already has in this area, emphasising partnerships between researchers and end-users from relevant opportunity and priority areas.

What is a suitable (SMART[5]) target for this science and research activity?

This research is inherently collaborative and further development of this priority is reliant on researcher needs (in challenge areas) and advancements in technology. As such, this priority 'inherits' the SMART targets for each of the other science and research priority areas.

Acronyms

AIBN	Australian Institute of Biotechnology Network
AIMS	Australian Institute of Marine Sciences
AMPAM	Advanced Materials Processing and Manufacturing
ANFF	Australian National Fabrication Facility
APSRU	Agricultural Production Systems Research Unit
ARCAA	Australian Research Centre for Aerospace Automation
CQU	CQ University
CRC	Cooperative Research Centre
CSG	Coal Seam Gas
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DAF	Department of Agriculture, Fisheries and Forestry
DSITI	Department of Science, Information Technology, Innovation and the Arts
GCI	Global Change Institute
GSP	Gross State Product
GU	Griffith University
JCU	James Cook University
NCRIS	National Collaborative Research Infrastructure Strategy
NICTA	National ICT Australia
PwC	PricewaterhouseCoopers
QAAFI	Queensland Alliance for Agriculture and Food Innovation
QCAT	CSIRO's Queensland Centre for Advanced Technologies
QCIF	Queensland Cyber Infrastructure Foundation
QIMR Berghofer	QIMR Berghofer Medical Research Institute
RDSI	Research data storage infrastructure program
SBEnrc	Sustainable Built Environment National Research Centre
SMI	Sustainable Minerals Institute
TRI	Translational Research Institute
TropWATER	Centre for Tropical Water & Aquatic Ecosystem Research
UQ	University of Queensland
UQCCR	University of Queensland Centre for Clinical Research
USQ	University of Southern Queensland